An Exploration of Cloud-based Technology for enhancing Emergency Management: Cases from New Zealand

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ABSTRACT

Despite widespread acknowledgement of the disruptive effect cloud-based technologies have in business, little is known about the role they might play in emergency management, in particular in natural emergencies. This research addresses this gap by exploring emergency management professionals' perceptions of cloud usage in key emergency management lifecycle stages of preparedness and response. The Diffusion of Innovation theory is used as a theoretical lens to understand the factors that might influence emergency management professionals to utilise cloud-based technologies. It was employed as it focuses on understanding the adoption rate of an innovative technology.

A multiple case study approach was employed involving six key New Zealand emergency services organisations. Twenty-nine semi-structured interviews were conducted with emergency professionals at both managerial and operational levels combined with three focus groups and five exercise observations. Data were analysed through grounded theory analysis.

A comprehensive framework of multi-dimensional elements that influence the emergency professionals' perceptions of cloud-based technology deployment was derived from the data. Six key elements were found to have significant influences on the emergency professionals' perceptions against actual cloud-based technology usage in natural emergencies: *organisational readiness, coordination, cloud-based technology characteristics, individual perceptions, individual readiness and non- cloud-based technology redundancy*. *Organisational readiness* is shaped by four critical aspects: usage frequency, usage preparedness, organisational capacity, and training, which is a prerequisite for realising the success of cloud-based technology deployment when managing emergencies. Better *inter-agency coordination* enhances the emergency professionals' confidence in using cloud-based technologies during the response stage. The *cloud-based technology characteristics* also significantly influence cloud-based technology deployment, including perceived advantages, perceived disadvantages, usefulness, and the deployment model type. The *individual perception* of enhancement expectation reflects the emergency professionals' real needs in using cloud-based technologies when dealing with emergencies. The individual readiness includes human factors and knowledge, showing that personal attitudes towards cloud-based technology usage and cloud-based technology knowledge sufficiency influence cloud-based technology deployment for managing emergencies. *Non- cloud-based technology redundancy* eases the emergency professionals' concerns of using cloud-based technologies when unexpected situations occur during natural emergencies. The framework highlights the need for examining diverse elements in an integrated manner to understand the emergency professionals' utilisation patterns of cloud-based technologies for managing natural emergencies.

The thesis concludes that awareness of the emergency professionals' cloud-based technology utilisation patterns can help inform the use of cloud-based technologies to improve and integrate emergency preparations and responses. The research contributes to the body of knowledge in the field of both cloud computing and emergency management by providing a comprehensive framework to reveal an in-depth understanding of multi-dimensional elements that influence the emergency professionals' perceptions of cloud-based technology deployment in natural emergencies. The framework can be used as practical guidelines for similar emergency services organisations to enhance organisational and individual readiness in cloud-based technology utilisation to carry out more effective emergency management performance.

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CHAPTER ONE - INTRODUCTION

1.1 Background

The approach to emergency management in New Zealand has changed significantly from an inflexible response-oriented model to a coordinated and all-hazard emergency management system (Saunders, Grace, Beban, & Johnston, 2015). However, emergency management organisations in New Zealand are still under significant pressure due to ever-increasing demands for services, limited resources and a possible growth of hazards such as earthquakes and floods (Bhandari, Owen, and Brooks, 2014; Ministry of Civil Defence and Emergency Management [MCDEM], 2018a). Recent years have seen multiple natural disasters hit New Zealand: the 2017 severe flooding in North Island, 2016 Kaikoura earthquake, 2010 and 2011 Christchurch earthquakes, 2010 Canterbury earthquake, as well as 2013 severe flooding in the South Island (MCDEM, 2018b). Therefore, it is important to consider New Zealand as an example to investigate the current status of the emergency management system in emergency services organisations.

The frequency and impact of natural emergencies have led many to question whether technology might have a greater role to play in the management of natural emergencies. The unpredictable nature of such emergencies can have adverse impacts in terms of physical damage to properties, casualties, and spread of diseases. This unpredictability means it is challenging for emergency managers to make and communicate appropriate emergency management decisions even with current technologies. The use of information and communication technologies (ICT) have been identified as one of the key success factors in improving emergency management processes (Hampton et al., 2017; Liu et al., 2016; Vogt, Hertweck, & Hales, 2011). Fundamentally, information technologies can be used to facilitate the dissemination of warnings (Toya & Skidmore, 2015; ur Rahman et al., 2016), integrate information about required supplies (Li et al., 2014; Li et al., 2017), coordinate emergency relief work between different parties (Hu & Kapucu, 2014; Kabra & Ramesh, 2015), motivate responses from both institutions and the public (De Stefani, 2017; Wehn & Evers, 2015), as well as evaluate the damages caused by the emergencies (Kamal, 2015; Kryvasheyeu et al., 2016). Hence, the emergence of new information technologies can provide opportunities for managing emergencies, thus being helpful for managers in minimising the emergency management risks (FathiZahraei et al., 2015). Cloud computing is one of the most advanced innovative technologies that has the potential to change the way in which the organisations operate (Al-Hujran et al., 2018; Li et al., 2014; Parsons et al., 2015). Hence, this thesis explores the role that the emerging technology, cloud computing, could play in enhancing emergency management processes.

The benefits of using cloud computing have been widely discussed in the current literature. First, cloud computing is argued to offer the organisations significant savings in IT related costs due to the reduced investment in IT infrastructure and avoidance of the risk of IT obsolescence (Jones et al., 2017; Rajaraman, 2014; Sommer, 2013). As for the emergency services organisations, it is beneficial in reducing the burden of maintaining IT infrastructure while focusing more on the emergency related issues (Gaire et al., 2018).

Cloud computing enables ubiquitous access and scalability (Botta et al., 2014; Jo et al., 2015; Wu et al., 2015). This ubiquity is achieved through the continuously advanced mobile devices that support various types of cloud platforms, resulting in a more flexible way for retrieving data (Gaire et al., 2018; Gangwar et al., 2015). Further, it is argued that technologies that are capable of managing extensive data when managing emergencies are necessary; in other words, such technology needs to encompass the capability of retrieving rich information with good scalability (Horita et al., 2015; Li et al., 2014). Cloud computing is a scalable computing model, allowing businesses to easily upscale or downscale their information technology requirements according to their dynamic demand with the usage-based pricing model (Zlateva, Hirokawa, & Velev, 2013). In this way, the scalable feature of cloud computing allows emergency services organisations to utilise computing resources as required, especially when dealing with a huge amount of data from other agencies or authorities (Al-Dahash et al., 2017). Therefore, it is considered that clouding computing is especially appropriate for supporting emergencies as some of its intrinsic technological advantages are extremely flexible in terms of setting up, deployment and management of computing resources, as well as establishing almost everything (application, platform, infrastructure) as a service (Ma et al., 2014).

Cloud computing also allows redundancy to be distributed around the globe to ensure that even if a part of the world is impacted by any emergency, everything can be still maintained in order (Velev & Zlateva, 2012a; Zong et al., 2016). This is because cloud computing can automatically back up important data for organisations, which allows rapid recovery if data is lost during emergencies (Davidovic et al., 2015; Rajaraman, 2014). Cloud computing is, therefore, considered as an emerging technology that has the potential to provide an effective and efficient way of information sharing, data backup and recovery, and resource accessibility when dealing with emergency management (Li et al., 2013; Velev & Zlateva, 2012a). These advantages especially require attention from emergency services organisations because of the critical role they play in supporting community needs during emergencies (Sauer et al., 2009).

The potential of cloud computing in terms of supporting emergencies is discussed in the current literature (see Chapter Two). This thesis focuses on *natural emergencies (e.g., earthquakes, volcanic eruptions, tsunamis and so forth) that possess the characteristics of high unpredictability and have the potential for a large impact on physical damage of properties and infrastructures in addition to casualties*. It is necessary to take action in all stages of the emergency management life cycle (as shown in Figure 1-1), mitigation, preparedness, response and recovery.

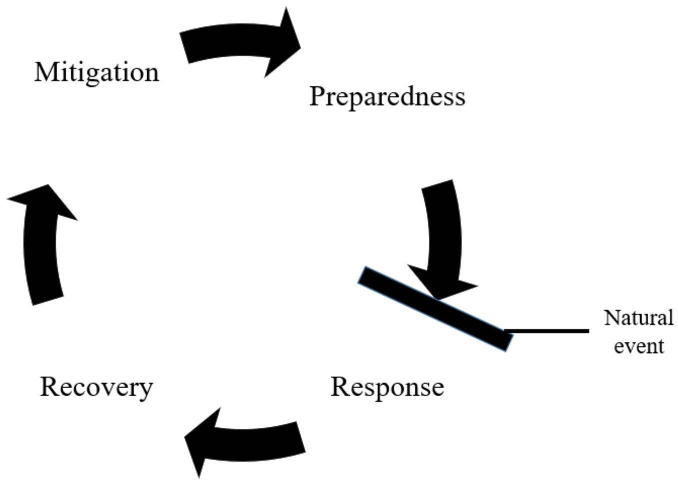


Figure 1-1 Emergency management life cycle (adapted from Haddow, Bullock, & Coppola, 2014)

This research focuses particularly on the impact of cloud-based technologies (C-BT) in the preparedness and response stage of the emergency management cycle. The primary reason for focusing on these two stages is that the real-time attribute of a technology is especially important in preparation for, and response to, unexpected natural emergencies which emphasises the technology's ability in gathering and disseminating reliable and large quantities of information as quickly as possible to help in decision-making.

The next section introduces the research purpose and objectives, which contribute to the theoretical and methodological development of the thesis.

1.2 Research Purpose and Objectives

The purpose of this research is to explore whether C-BTs could help emergency service organisations in New Zealand improve their emergency management capabilities, especially in the preparedness and response stages of the emergency management life cycle. Based on the research purpose, this thesis intends to fulfil two research objectives:

1. *To discover how cloud-based technologies could assist emergency service agencies to prepare for and respond to natural emergencies*;
2. *To investigate the perceptions of the emergency professionals on the usage of cloud-based technologies in the preparedness and response stages of natural emergencies in New Zealand.*

1.3 Significance of the Research

Despite the recognition of the significance of ICT in emergency management (FathiZajraei et al., 2015; Reddick, 2011; Vogt, Hertweck, & Hales, 2011), little research has identified the role that cloud computing plays in the key stages of emergency management. Moreover, C-BTs have had a disruptive effect on business more broadly (Kushida, Murray, & Zysman, 2015; Liu, Chan, Yang, Niu, 2018). Understanding the utilisation patterns of C-BTs can assist emergency organisations to better realise the potential of C-BTs to enhance the performance of emergency management. While the vast majority of the prior literature in this area explores the technical designs of cloud-based emergency response systems (e.g., Ekwe, 2012; Emmanuel, 2012; Li et al., 2013; Li et al., 2014), the real usage effectiveness in emergency services organisations is yet to be examined. Hence, the role that cloud computing plays in emergency management has not yet been fully identified. Especially, there is a lack of research investigating from the organisational perspective to understand the perceptions of the C-BT deployment in emergency service organisations.

Even though increasing attention has been paid to cloud computing adoption in various contexts, it is argued that empirical research on cloud computing adoption is still far from sufficient (Al-Hujran et al., 2018; Senarathna et al., 2018). There has been a call for more studies on investigating organisations' adoption or implementation of cloud computing in different contexts (Gangwar et al., 2015; Senyo et al., 2016). Hence, the investigation of the C-BT usage perceptions in the emergency management sector is necessary since there is a lack of existing theory explaining the possible association between C-BT deployment and emergency management.

On the other hand, it is argued that much of the previous research focuses on the response stage of the emergency management cycle; however, the other stage, especially the preparedness stage, might be equally important and worthy of examination (Hampton et al., 2017; Houston et al., 2015). Considerable previous study regarding cloud-based systems design focuses on the response stage. Consequently, there is limited understanding of the role that cloud-based systems could play in the preparedness stage of emergency management.

There has been a call to employ a qualitative case study approach in investigating cloud computing usage in various contexts (Gangwar et al., 2015). Previous research is dominated by quantitative studies when exploring organisational adoption of cloud computing (e.g., Alismaili et al., 2016a; Yang et al., 2015; Senarathna et al., 2018). Hence, limited research has attempted to employ a qualitative approach in investigating cloud computing deployment in organisations.

This research is thus important in that the critical role cloud computing could play in emergency management in New Zealand is an area that is poorly understood. This thesis seeks to address the research question:

1. *How can cloud-based technologies benefit emergency services organisations in the preparedness and the response stages of natural emergencies?*

This preliminary research question will be addressed by way of a comprehensive (secondary research) review of relevant literature around the likely cloud computing deployment within the emergency management sector. With the aid of these initial findings, and utilising primary research approaches, the following question will be addressed:

2. *What are the perceptions of emergency professionals on the usage of cloud-based technologies in the preparedness and response stages of natural emergencies in New Zealand?*

This research contributes to the small but growing literature that focuses on technology usage in emergency management (Hu & Kapucu, 2014; Kapucu, Garayev, & Wang, 2013; Rahm & Reddick, 2013). This research is different from these existing studies which are characterised by the quantitative survey method. This research is qualitative in nature, paying attention to the gain of in-depth understanding of perceived opportunities for C-BT deployment in emergency services organisations. Further, this thesis has a specific focus on the recent technology, cloud computing, which has rarely been examined in the previous research. It also contributes to emergency management literature that gives minimal considerations to the preparedness stage. It focuses on C-BT utilisation in both preparedness and response stages of natural emergencies. At a theoretical level, it draws on the theoretical lens from the Diffusion of Innovation theory (Rogers, 2003) to establish the initial conceptual idea to help understand and analyse the factors influencing the C-BT deployment in natural emergencies. The final theoretical model derived from the investigation goes beyond the initial conceptual idea. It contributes to the literature that considers technology usage in emergency management and provides theoretical and empirical insights into future research examining the adoption of cloud computing in the context of emergency management.

From a practical perspective, the results are intended to serve as a knowledge base for the emergency sectors to develop a more effective and efficient emergency planning framework. Further, the research can help emergency management professionals in New Zealand and other countries that are faced with frequent natural disasters to gain a better understanding of the potential usage of cloud-based technology in emergency management.

1.4 Overview of the Research Methodology

The research follows the tradition of the interpretivist research paradigm. The review of the literature was conducted to gain a preliminary understanding of the research questions. Subsequently, cloud storage, social media and cloud-based geographic information systems are identified as the most discussed C-BTs that could facilitate emergency preparedness and response in the previous literature. A conceptual idea depicting how C-BTs could benefit the emergency services organisations in the preparedness and response stages was proposed. Through the theoretical lens of Diffusion of Innovation theory, factors influencing the perceived C-BT deployment in the emergency services organisations were conceptualised deductively from the cloud computing adoption literature that examines the key technology innovation attributes through Diffusion of Innovation theory.

Research concerning cloud-based systems in the field of emergency management context is evolving and little is known about the perceived C-BT usage in managing natural emergencies. Therefore, interpretive qualitative research is considered appropriate to explore the C-BT usage in enhancing emergency management capabilities through the understanding of how the users perceive and evaluate the cloud-based system and what meanings the system has for them in the context of emergency management. A multiple case study approach was employed. This involved six emergency services organisations in New Zealand. Because limited research has been conducted regarding cloud computing usage in emergency services organisations, there is a lack of existing theory explaining the possible association between C-BT deployment and emergency management. The main purpose of this study is to gain an in-depth understanding of the phenomenon of C-BT deployment in the emergency management settings. Thus, the multiple case study was considered proper in this study.

Multiple data collection methods were used in this research. Semi-structured interviews were the primary data collection method employed: focus groups and exercise observations were also used. Data gathered was analysed through an adaptation of grounded theory data analysis technique, namely open coding, axial coding and selective coding, as proposed by Strauss and Corbin (1998). The adoption of grounded theory analysis led to the identification of concepts, categories and core categories emerging from the data. This is an exploratory study so that utilisation of grounded theory allows for the generation of theory. Findings from this qualitative research provide an in-depth understanding of the phenomenon regarding C-BT utilisation in the context of emergency services organisations. Consequently, a theoretical model is proposed to show the linkage between the multidimensional elements and C-BT deployment in natural emergencies.

1.5 Thesis Outline

The thesis is divided into eight chapters. This chapter introduces the research, including the background and significance of the research, and a brief overview of the research methodology. Chapter Two presents a comprehensive review of several streams of literature: emergency management, cloud computing, and C-BT's potential usage in the key stages of emergency management. Through reviewing cloud computing adoption research through the theoretical lens of Diffusion of Innovation theory, the initial conceptual idea of the study is formed. Chapter Three presents the research gap identified in the literature. This contributes to the formulation of the research questions. Chapter Four presents the research design which forms the basis for conducting this research. This includes the discussion of the research paradigm that the research fits within. Then, the chapter presents the justifications for the research design and data collection methods. Finally, it outlines the ethical considerations that guided the research.

The next three chapters present the findings and discussions of the study. Chapter Five presents the within-case descriptions of six cases. A descriptive summary for each case with three themes arising from the data is presented. Chapter Six presents the cross-case findings of this research. The findings presented are derived from the interviews, focus groups, and observation notes. All data were coded through grounded theory approach so that the concepts and categories that emerged are also presented. As the purpose of this research is to build theory, a final model was developed to show the elements that influence the emergency professionals' perceptions of C-BT deployment in natural emergencies. Chapter Seven discusses the multidimensional elements that influence the perceived value of C-BT deployment in natural emergencies. A second review of the literature was undertaken based on the inductive findings that emerged, which resulted in the formulation of the propositions. The final chapter presents the conclusion of the study, the theoretical and practical implications, and the limitations and future research opportunities.

CHAPTER TWO - LITERATURE REVIEW

This chapter presents a review of the extant literature. It begins with the description of the domain of emergency management including the concepts of emergency and emergency management. After discussing some commonly used information technologies in emergency management, the chapter proceeds with the introduction of cloud computing, definitions, and categories of cloud computing. Next, it examines the advantages and disadvantages of cloud computing in organisations. This is followed by an introduction of some well-known cloud-based technologies in emergency management. A discussion of how cloud-based technologies can be employed in the preparedness and response stages of emergency management is then provided. Finally, drawing on the theoretical lens of Diffusion of Innovation theory, a conceptual idea is proposed to understand the factors that influence the deployment of cloud-based technologies in emergency management.

2.1 Emergency, Disaster, and Crisis

The terms ‘emergency,’ ‘disaster’ and ‘crisis’ are sometimes used interchangeably by both academics and industry practitioners. However, they are different, albeit related, concepts. The author supports Boin and Hart’s (2010) view and contends that there are subtle differences between the three terms. However, the attention of this thesis is not on seeking differences between them, but to provide clarity relating to their usage throughout the thesis. Thus, the differences are only briefly explained.

An emergency is a situation that is unforeseen and narrow in scope but needs immediate attention (Boin & McConnell, 2007; Kapucu, Garayev, & Wang, 2013; Subramaniam, Ali, & Shamsudin, 2010). Another view stated by Lindell, Prater, and Perry (2006) places emergency into two somewhat different but closely associated categories of events: frequently experienced, and imminent. They argue that the frequently experienced events are relatively well understood and can be controlled with local resources, thus involving minor consequences. However, in the second type of emergency, the imminent characteristic of the event will lead to severe consequences and therefore requires urgent attention to minimising their impacts (Lindell et al., 2006). According to the World Health Organisation (WHO, 2002), an emergency is defined as a situation in which normal procedures are interrupted, and necessary measures are taken to avoid an emergency. Examples of emergencies include a power outage, a car accident, a chemical spill or a small radiation leakage (Boin & McConnell, 2007; Lighthouse Readiness Group, [LRG] 2012). In Boin and McConnell's (2007) view, emergencies would have no extensive consequences and can usually be terminated rapidly. However, emergencies can turn into disasters if they are left without attention and action, even though they are usually small in scale (WHO, 2002).

A disaster is similar to an emergency, although one difference is that the scope may be larger (LRG, 2012). The term disaster is retained for the actual disruptiveness of events that exceed the ability of the affected society to cope with, yielding widespread casualties and damage (Lindell et al., 2006; Shaluf, 2007). Thus, unlike frequently experienced emergencies, such as car accidents, house fires, or broken gas pipelines that have relatively minor impacts, disasters produce severe consequences for the community (Lindell et al., 2006). The US Federal Emergency Management Agency's (FEMA) focus of definition of a major disaster is on any catastrophic natural emergencies that have caused damage of huge severity and magnitude which lead to a call for assistance (Reidenberg, Gellman, Debelak, Elewa, & Liu, 2013). The WHO's (2002) definition of a disaster is "an occurrence disrupting the normal conditions of existence and causing a level of suffering that exceeds the capacity of adjustment of the affected community" (p.3). Yet, there is not a universally accepted definition of disaster (Reidenberg et al., 2013; Shaluf & Said, 2003). The reason is that the definition of disaster depends on how different disciplines use this term (Shaluf & Said, 2003). However, the commonality of those definitions reflects that in a disaster, constant coordination efforts among different agencies are required to respond to the disasters. Disasters can be categorised into three types: natural disaster (e.g., earthquakes, tsunamis, floods), natural hazards that would not have happened if certain human actions had not taken place (e.g., deforestation resulting in landslide when having heavy rainfalls), and disasters directly caused by human actions (e.g., industrial events) (Reidenberg et al., 2013).

Crises have different magnitudes and traits and are characterised as man-made events "result[ing] from the economic and political issues as well as from disasters" (Shaluf & Said, 2003, p.26). Much of the literature defines crises within the organisational context (Shaluf & Said, 2003; Duncan, Yeager, Rucks, & Ginter, 2011; Pearson & Sommer, 2011), that is, crises are events, tendencies or abnormal situations that will bring high risks to a business and therefore threaten the organisation's viability. Therefore, a crisis "entails a threat to the core values of a system or the functioning of life-sustaining systems, which must be urgently dealt with under conditions of deep uncertainty" (Boin & McConnell, 2007, p, 51). Crises are also described as occurrences of low-probability and high-impact that affect people within (e.g., employees, employers) and beyond (e.g., customers) the organisations, or local communities (Pearson & Sommer, 2011). Crises can be categorised as a community crisis (e.g., natural crisis, industrial crisis, economic and financial crisis) and non-community crisis (e.g., transportation accidents) (Shaluf & Said, 2003). This thesis treats the term crisis as different from an emergency and a disaster, as being a particular event that occurs within the organisational contexts. The term emergency is used throughout the thesis, which carries the connotation of disaster.

This thesis focuses on natural emergencies that possess the characteristics of high unpredictability which disrupts the status quo of society, resulting in large scale impacts of physical damage and casualties.

2.2 Emergency Management

2.2.1 Definition

As a result of the interchangeable usage of the terms emergency and disaster, the phrases disaster management and emergency management are often used synonymously. Table 2-1 presents various definitions used by scholars in terms of emergency management, disaster management, and crisis management. There is little evidence showing the difference between the expression of disaster management and emergency management. Crisis management is often used to describe an occurrence in the organisational context. Pearson and Clair (1998) define organisational crisis management as a "systematic attempt by organisational members with external stakeholders to avert crises or to effectively manage those that do occur" (p. 61). According to Nouali et al. (2009), disaster management is the discipline of strategy development for diminishing the impact of disasters and for providing assistance to the affected population. The term ‘emergency management’ is preferred throughout the thesis.

Table 2-1 Definitions of emergency management, disaster management, and crisis management

Items	Author(s)	Definitions	Focus			
			Process of the four stages	**Cooper-ative process**	**Broad term**	**Organisational perspective**
Emergency management	FEMA (2007)	Emergency management is the managerial function charged with creating the framework within which communities reduce vulnerability to hazards and cope with disasters.			✓	
	Buck, Cavett, Harris, & Yuan (2013)	Emergency management could be conceptualised as a process that consists of four **interrelated functional areas: prevention, preparedness, response and mitigation**, which correspond to the disaster-life cycle.	✓			
	Reddick (2011)	Emergency management involves four functions: **mitigation, preparedness, response and recovery**.	✓			
	Way & Yuan (2014)	Emergency management is defined as the process of developing and implementing policies and activities that are concerned with mitigation, preparedness, response, and recovery from disaster events affecting society.	✓			
	Aedo, Díaz, Carroll, Convertino, & Rosson (2010)	Emergency management is a cooperative process that requires the active and coordinated participation of different kinds of agents, including governmental and non-governmental agencies and corps, communities, volunteers, and citizens.		✓		
	Haddow et al. (2014)	Emergency management is a discipline that deals with risk and risk avoidance.			✓	
Disaster management	Nouali et al. (2009)	Disaster management is the discipline of strategy development for diminishing the impact of disasters and providing assistance to the affected population.			✓	
	Rao, Eisenberg & Schmitt (2007)	Disaster management is the practice across all phases of **mitigation, preparedness, response and recovery**.	✓			
	Dorasamy, Raman & Kaliannan (2013)	Disaster management involves activities such as **mitigation, risk reduction, prevention, preparedness, response and recovery**.	✓			
	Tan (2013)	Disaster management may be viewed as a process by which individuals, groups, and communities manage or ameliorate the impact of emergencies, disasters, and other hazards.			✓	
Crisis management	Pearson & Clair (1998)	**Organisational crisis management** is a systematic attempt by organisational members with external stakeholders to avert crises or to effectively manage those that do occur.				✓

Seeger, Sellnow, & Ulmer (2003)	**Organisational crisis** is an unusual event of overwhelmingly negative significance that carries a high level of risk, harm and opportunity for further loss.	✓

Scholars define emergency management in different ways. For example, emergency management has been defined as the action of applying science, technology, planning and management to cope with extreme events (Westbrook, Karlgaard, White, & Knapic, 2012). FEMA (2007) defines emergency management as the managerial function that is associated with generating the framework within which communities diminish the vulnerability of hazards and cope with disasters.

This thesis defines emergency management as the action of utilising technology, planning, and management to reduce vulnerability for large-scale, threatening, and unpredictable natural emergencies.

2.2.2 Emergency Management Cycle

Even though there are subtle differences between emergency and disaster, disaster management and emergency management in the literature share the common theme of using an emergency management continuum/cycle, which implies different actions are required in different phases. Although disaster management cycles only appeared in physical format in the 1970s, it is found that the origins of the disaster management cycle can be traced back to early 1930s (Coetzee & Van Niekerk, 2012; Neal, 1997). Some earlier influential research shows that disaster phase in a linear way. For example, the idea of the Disaster Life Cycle was first introduced by Carr (1932), considering a four-stage sequence pattern of an event (Neal, 1997; Smet, Leysen, & Lagadec, 2011). Carr (1932) distinguished four phases: 1) A preliminary stage during which the forces that are to cause the ultimate collapse are getting under way (e.g. the detection of a hurricane above the ocean, approaching the coastline); 2) a dislocation and disorganisation phase referring to the injuries, deaths and losses due to the collapse of the cultural protections; 3) a readjustment and reorganisation phase, reflecting the community’s attempt to respond to the situation; and 4) a confusion-delay phase, reflecting the term until the emergency plans begin to operate. Another study by Stoddard (1986, as cited in Coetzee & Van Niekerk, 2012; Neal, 1997) identified three overarching phases: pre-emergency, emergency and post-emergency phases.

Powell (1954) makes another attempt to classify periods of disaster, involving eight stages. Table 2-2 presents different terms for phases in the emergency management cycle.

Table 2-2 Different terms for phases in emergency management cycle

Author(s)	Number of phases	Phases							
		Early research with linear phases							
Carr (1932)	4	Preliminary or prodromal period	Dislocation & disorganisation	Readjustment & reorganisation	Confusion-delay				
Powell (1954)	8	Pre-disaster conditions	Warning	Threat	Impact	Inventory	Rescue	Remedy	Recovery
Stoddard (1986)	3	Pre-emergency	Emergency	Post-emergency					
		Emergency management phases in a cyclical way							
Johnson (2000)	5	Mitigation	Planning	Preparedness	Response	Recovery			
Olson (2000)	5	Mitigation		Pre-impact	Impact/Response	Recovery	Reconstruction		
WHO (2002)	5	Mitigation/ Prevention		Preparedness	Reponses/Relief	Rehabilitation	Reconstruction		
Cutter (2003)	6			Preparedness	Rescue and Relief	Recovery	Reconstruction		
McLoughlin (1985)	4	Mitigation		Preparedness	Response	Recovery			
Lindell et al. (2006)	4	Mitigation		Preparedness	Response	Recovery			
Reddick (2011)	4	Mitigation		Preparedness	Response	Recovery			
Smet et al. (2011)	4	Mitigation		Preparedness	Response	Recovery			
Kapucu & Ozerdem (2013)	4	Mitigation		Preparedness	Response	Recovery			
Haddow et al. (2014)	4	Mitigation		Preparedness	Response	Recovery			

In the early 1970s, a shift in philosophy occurred, and the concept of comprehensive emergency management began to emerge. The relationship between the four phases was cyclical rather than linear and all activities lead individually and cumulatively back to an ameliorated mitigation stage (Smet et al., 2011). One representative emergency management life cycle is that of WHO (2002) which starts from mitigation/prevention and preparedness, moving to response/relief, rehabilitation to reconstruction. This thesis adopts a more simplified emergency management life cycle (see Figure 2-1) than most of the literature utilises, which involves four phases: mitigation, preparedness, response and recovery (Reddick, 2011; Buck, et al., 2013; Haddow, Bullock, & Coppola, 2014). Since the conception of four phases has been adopted by FEMA for a long time, it has been broadly accepted and regarded as a suitable model for understanding the activities of emergency management (Lindell et al., 2006).

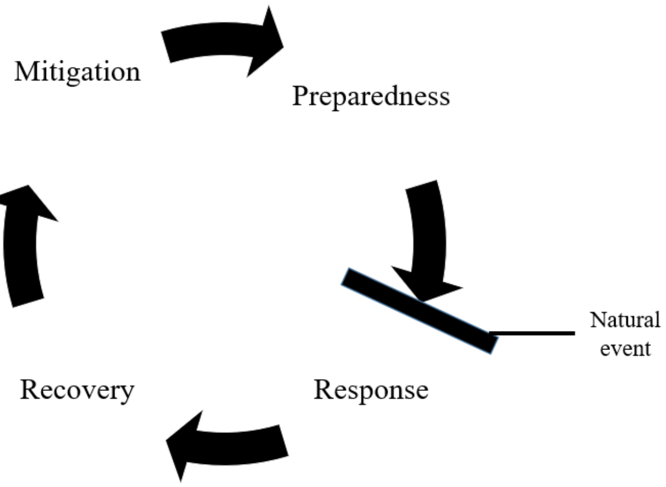


Figure 2-1 Emergency management life cycle (adapted from Haddow et al.,2014)

2.2.3 Mitigation

Emergencies must be managed for the purpose of eliminating, controlling or minimising the causes and potential effects of emergencies (Nikolic, Savic, & Stankovic, 2007). Mitigation is the sustained action to reduce loss of life and property from the hazards (Haddow et al., 2014). Typically, it is implemented before the disasters occur, in addition to the preparedness and response stages or during the period of recovery in which a disaster may be anticipated to recur. According to Lindell (2013), hazard mitigation is a more passive process that can be described as pre-impact actions to protect against casualties and damage in the case of the impact of the occurrence of hazard; this is opposite to the active emergency response to minimise casualties and damage caused. However, Schneider (2011), and Kapucu and Ozerdem (2013) argue that disaster mitigation should be viewed as a proactive step and taken into account long before an emergency takes place in order to eliminate or reduce the likelihood of the occurrence of an emergency or disaster. Mitigation is considered as being a local function and believed to be most successful when being conducted at the community level (Highfield, Brody, & Blessing, 2014; Schneider, 2011). Even though the importance of mitigation action is recognised, unfortunately, the implementation processes are often weighed down due to the political issues, financial constraints, bureaucracy, and the voices of participant resistance (Berke, Smith, & Lyles, 2012; Kapucu & Ozerdem, 2013).

There are various types of hazard mitigation actions that can be executed at the community level, among which the land use and building construction practices are regularly dealt with (Lindell et al., 2006).

Land use practices aim to reduce the vulnerability of hazards through keeping away from construction zones that are easily influenced by hazard impact, while building construction practices strengthen the individual structures in order to make them less vulnerable to natural hazards (e.g., usage of reinforced concrete in constructing apartment buildings) (Godschalk & Brower, 1985; Lindell et al., 2006). Therefore, the mitigation planning process offers an opportunity to help people to reduce vulnerability and develop resiliency via identifying needs and building the capability before hazards occur (Berke Cooper, Salvesen, Spurlock, & Rausch, 2010). The federal government, for example, under the Disaster Mitigation Act of 2000, commands all communities to enact mitigation plans as part of the local government's increasing attention to preparing a series of disaster plans (Berke et al., 2010). Schwab and Topping (2010) argue that there should be a strong linkage between local hazard mitigation plans and other mitigation activities of the community, in particular, the land-use planning. They found, however, that many US localities produce independent plans that fail in connecting local mitigation plans to the existing comprehensive plan as well as identifying future land-use, even though those are required by FEMA.

There are several benefits of hazard mitigation actions. In addition to the main benefit of preventing loss, other benefits include improved decision-making at each level before and after disasters happen, early establishment of partnership, better allocation of resources, increasing opportunities for external funding and acceleration of the communities' return to normality after disasters (Frazier et al., 2013; Schwab & Topping, 2010). These benefits again reflect that community resilience can be best realised when mitigation strategies are integrated with land use and comprehensive planning (Srivastava & Laurian, 2006). Whitehead and Rose (2009) also claim the benefits of natural hazard mitigation from an ecological perspective. For example, improved wildlife habitat and increased water quality can result from the relocation of structures in a floodplain (Whitehead & Rose, 2009).

2.2.4 Preparedness

Preparedness can best be defined as the readiness to respond to a disaster (Haddow et al., 2014). Whilst mitigation actions are important, they cannot prevent emergencies from happening. Therefore, preparedness actions are required to provide insurance against emergencies (Kapucu & Ozerdem, 2013). Emergency preparedness practices are also pre-impact actions but contribute to the active responses at the time of hazard impact in order to enable the proactive involvement of social units (Lindell, 2013; Singh et al., 2011). In concept, the preparation for responding to emergencies can be been viewed as a cycle with key elements of information sharing and communication (Jaeger et al., 2007) or a cycle involving planning, assessment, and evaluation (Haddow et al., 2014). In the opinion of Berke et al. (2010), there are several benefits of pre-disaster planning. For example, it makes contributions to the establishment of local commitment among different stakeholders, such as government agencies, non-profit organisations, and the general public, to bring forward the equity goals in disaster planning, expansion of choices for generating strategies towards reduction of social vulnerability, as well as educating residents and officials about the opportunities and rationales for change.

Activities that are essential in the preparedness stage include designing a plan or procedure, training, disaster drills and exercises in the emergency organisations in order to save lives and reduce damage when emergencies take place (Lindell et al., 2006; Subramaniam et al., 2010). These activities ensure that emergency responders can provide the best possible response in a timely and effective manner to the threat of imminent impact, but also act as guidance for the process of emergency recovery (Subramaniam et al., 2010). Lindell et al. (2006) argue that time is critical and limited during disasters and therefore it is significant to realise that it takes more time for responders to implement response actions than pre-planned actions. Also, sometimes the improvisations can produce unexpected obstacles or duplications among emergency organisations, which can make them lose the best time point for implementing response actions (Lindell et al., 2006). It is also important to note that to enhance organisational effectiveness in dealing with emergencies requires engagement and coordination among emergency organisations and communities in emergency preparedness (Lindell et al., 2006; Kapucu, 2008; Kapucu & Ozerdem, 2013). This is because sometimes organisations might have enough time to respond but not adequate time to propose an immediate coordinated response plan. The active participation in building consensus in pre-disaster planning processes has a strong impact on strengthening the organisational relationships, leading to effective response operations and coordination (Kapucu, 2008). As a result, preparedness plays an important role in establishing organisational readiness to reduce the detrimental impact of these events through active responses to keep individuals' health and safety from harm and the wholeness and functioning of physical structures (Adedeji, Odufuwa, & Adebayo, 2012; Tan, 2013).

2.2.5 Response

Response is the activities undertaken immediately to provide assistance in the aftermath of a disaster (Haddow et al., 2014). The response practices represent the climactic point of the efforts made in mitigation and preparation phases, simultaneously demonstrating their strengths and weakness (Kapucu & Ozerdem, 2013). During emergencies, communities and emergency response organisations must carry out multiple functions, such as emergency assessment (e.g., damage and needs assessment), hazard operations (e.g., coordination and mobilization of rescue), determining the priority of response, population protection, evacuation planning, detection of situation as well as providing timely information to public and organisations (Lindell et al., 2006; Mehrotra, Qiu, Cao, & Tate, 2013). The continuous assessment of the damages and organisation of coming and converging equipment and supplies are important responsibilities of relevant personnel in managing the emergency in order to promptly provide those affected areas with their greatest needs (Subramaniam et al., 2010). The response phase continues until the situation becomes stable, which means that the de-escalation of the risk of loss of life and property occurs (Subramaniam et al., 2010).

Emergency response usually encompasses cooperation among a wide range of community agencies. Preliminary response might be from a single agency (e.g. police, fire, search and rescue teams), but when the emergency event escalates, other services will be requested to provide help (Bhandari, Owen, & Brooks, 2014). Non-government organisations, such as the Red Cross, provide functioning rescue and relief (e.g., the supply of fresh water and food) and civil defence, police, and other institutions might also deal with different types of emergencies with their emergency plans (Tan, 2013). The government agencies, especially, perform functions to complete tasks that go beyond the capabilities of any household and organisation (Lindell et al., 2006). To provide assistance to households or businesses, it is important to have sufficient resources because insufficient resources will result in ineffectiveness of emergency response (Huang, Wang, & Lin, 2011). Physical resources (e.g., assets, equipment, facilities) are the most obvious and most often addressed; however, the human resources (e.g., training, competence, knowledge of employees, ability of managers) and organisational resources (e.g., planning procedures, organisational control, organisational culture, organisational learning atmosphere) are sometimes ignored (Huang et al., 2011). It is, therefore, critical to ensure the sufficiency of resources for emergency response which is associated with organisational effectiveness.

2.2.6 Recovery

Recovery encompasses decisions and actions in terms of rebuilding homes, reconstructing infrastructure and reinstating business, which brings the community back to normality with the long-term goal of lessening the future vulnerability (Haddow et al., 2014). In other words, it is different from the response phase that is full of the sense of uncertainty and urgency and needs to be thought about in terms of rebuilding, restoring, and returning the community to its normal structures (Lindell et al., 2006; Tan, 2013). Disaster recovery is a collaborative journey and effective social recovery needs both government and nongovernmental organisations (NGOs) working closely with the community (Tan, 2013). Consistent with the view above, Marshall and Schrank (2014) argue that it is a complex and long-lasting partnership between different parties, such as individuals, businesses, and public institutions, that actively make efforts in the recovery processes. Therefore, it requires trust, communication, and coordination for the partnerships to be effective. Meanwhile, it is better to propose a disaster recovery plan which can provide guidance in decision-making focused on short-term restoration of basic public services and long-term recovery of the physical infrastructure used by the community. Short-term activities attempt to return vital human systems to minimal operating standards and usually encompass approximately a two-week period (Berke et al., 2010; Kapucu & Ozerdem, 2013). Table 2-3 summarises activities within the four emergency management phases.

Table 2-3 Activities within the four emergency management phases

Stages	Activities
Mitigation	Land use practice to prevent the occupation of high hazard areas
	Imposing building codes
	Improved facility design
	Well thought-out hazard control (dams, levees, etc.)
	Risk analysis to measure the potential for extreme hazards
	Insurance to reduce the financial impact of disasters
Preparedness	Development of emergency management plans
	Warning procedures
	Education and training
	Budgeting for and acquisition of vehicles and equipment
	Construction of an emergency operations centre
	Development of communications systems
Response	Damage and needs assessment
	Evacuation of threatened populations
	Opening of shelters and provision of mass care
	Search and rescue
	Emergency infrastructure protection and recovery of lifeline services

Recovery	Clean-up and decontamination of stricken sites Reconstruction and restoration (e.g. rebuilding of roads and bridges and key facilities) Full restoration of lifeline services Financial assistance to individuals and governments Legal assistance to afflicted persons

Source: Lindell et al. (2006); Smet et al. (2011)

In short, hazard mitigation and emergency preparedness practices strive to reduce a disaster's physical impacts and social impacts in an indirect manner, whereas response and recovery practices attempt to reduce impacts more directly (Lindell, 2013). While each phase is unique in the emergency management, they often overlap in their execution (Godschalk & Brower, 1985; Smet et al., 2011; Subramaniam et al., 2010).

2.3 Information Communication Technologies in Emergency Management

Information communication technologies play an important role in emergency management. This is because technology has an impact on maintaining a sustainable network through smooth communication, better network decision-making, information sharing, and network information storage (Kapucu, Berman, & Wang, 2008). Therefore, information sharing and communication are critical parts in an emergency because inadequate communication or misinformation will impede the coordination among different emergency services providers. As a result, there is not the capability for them to reduce the casualties and provide an ongoing response (Chan, Killeen, Griswold, & Lenert, 2004).

Numerous important technologies are widely used in emergency management. Some universally utilised technologies outlined in the literature are the Internet, wireless technology, geographic information systems (GIS), direct and remote sensing, emergency management decision support systems, hazard analysis, and modelling and warning systems (Jaeger et al., 2007; Reddick, 2011). Among those technologies, Internet, GIS and GPS are widely used in emergency management to facilitate decision-making, smooth information sharing, improve communication quality, involve citizens and communities' engagement and make collaborative efforts (Hu & Kapucu, 2014). Table 2-4 presents various widely accepted non-cloud-based technologies used in emergency management.

Table 2-4 Various widely accepted non-cloud-based technologies in emergency management

Technologies	Functions	Authors	Emergency types
Internet	Information sharing Real-time communication	Gruntfest & Weber (1998) Kapucu (2006) Laituri & Kodrich (2008)	No specific type Terrorist attacks Natural disaster
Incident management systems	Providing rules and practices to guide the actions of the various organisations responding to disaster (command, operations, planning, logistics and administration)	Keim (2002) Kohn et al. (2010) Papagiotas (2012) Loop (2013)	Public health emergency Public health emergency Public health emergency Banking
GIS	Informing decision-making Facilitating information sharing Enhancing the quality of communication Receiving satellite information Producing accurate location information about the affected areas	Alparslan et al. (2008) Johnson (2000) Kapucu (2006) Prizzia (2009) Singh (2014)	Natural disaster No specific type No specific type Natural disaster Natural disaster
Wireless technologies	Transmission and reception of information Communication with first responder remotely Collection of digital data	Reddick (2011) Smith & Simpson (2009) Qiantori et al. (2012)	No specific type No specific type Natural disaster
Decision support systems	Supporting emergency manager in planning and training for responding to emergencies Recording, choosing and classifying information about community population or weather data Facilitating evacuations	Reddick (2011) Levy et al. (2007) Tinguaro Rodríguez, Vitoriano, & Montero (2010)	No specific type Natural disaster Natural disaster
Remote sensing	Providing data for weather predictions and natural or man-made disasters detection	Ehrlich et al. (2009) Rao et al. (2007) Tanzi & Lefeuvre (2010) Jha, Levy, & Gao (2008)	Natural disaster No specific type No specific type Oil spill emergency

2.3.1 Internet

The Internet is an important component of information sharing during emergencies. The Internet, which became popular in the mid-1990s, has changed the information flow in emergency management from top-down to two-way communication (Gruntfest & Weber, 1998). The public and first responders can get useful information about emergencies and quickly communicate and share resources (Reddick 2011). According to Kapucu (2006), the Internet often offers a more reliable way of communication, as was demonstrated in the terrorist attacks on the World Trade Centre where many people relied on email to contact friends and relatives. During a large-scale emergency, dependence on traditional methods of communications, such as radios, televisions, and landlines, often make it difficult for emergency management responders to make decisions as these tools become overloaded and are not able to provide real-time information (Singh et al., 2011). Therefore, the Internet serves as a critical communication tool, providing real-time communication.

In addition to quick communication, local community websites are potentially powerful tools to increase citizens' knowledge about environmental risks and hazard preparedness (Basolo, Steinberg, & Gant, 2006**;** Troy et al., 2008). Social media are now considered convenient and efficient ways to improve disaster response. Present social media platforms such as Facebook or Twitter have been used to support bottom-up participation by citizens in emergency management (Hughes & Palen 2009; Hu & Kapucu, 2014). Using these platforms, the local officials and the general public can share real-time emergency information rapidly and simultaneously rather than sharing information on a need-to-know basis.

2.3.2 Incident Management Systems

There are various approaches to, and different names for, incident management systems (IMS), but all have in common the idea of coordinating necessary actions to manage emergencies. It was called incident command systems (ICS) by law enforcement agencies or IMS by fire services (Perry, 2003). ICS was initially generated for forest firefighting in which the resources usually come from different locations, making coordination most necessary (Buck, Trainor, & Aguirre, 2006; Perry, 2003). IMS is now widely used in the American, Canadian, British and Australian fire services (Perry, 2003; Loop, 2013). ICS defines five major roles: command, operations, planning, logistics and administration (FEMA 2014; Jiang et al., 2004; Loop, 2013). The system provides guidance for the actions among various organisations responding to emergencies, and creates the procedures of coordination necessary among them (Buck et al., 2006). ICS provides a flexible structure for assembling resources and directing emergency response units that is adjustable to all types of hazards (Lindell, Perry, & Prater, 2005). Thus, the primary advantage of an ICS is that it provides a standardised procedure for multiple organisations working together, which avoids time delays with regard to developing a mutually agreed procedure (Lindell et al., 2005; Loop, 2013).

2.3.3 Geographic Information Systems

There have been a number of overviews in the field of geospatial technologies and their use in emergency management (e.g., Cova, 1999; Cutter et al., 2007; Waugh, 1995). GIS enable organisations to obtain satellite information and yield accurate location information regarding the affected areas, which can suggest further connection with other information (e.g. socioeconomic, demographic, and needs assessment) (Prizzia, 2009; Reddick, 2011). GIS is a powerful tool in terms of mapping and analysing, thus supporting spatial decision-making in emergency management (Cova, 1999; Kapucu, 2006; Tinguaro et al., 2010). For example, GIS can be used during evacuation procedures by emergency organisations to locate the people of the community and save their lives (Hu & Kapucu, 2014). Another example includes real-time fire mapping through (GPS) within a helicopter to help develop strategies of fire suppression, or mapping and assessing damage data via GIS in the aftermath of a quake (Prizzia, 2009). Kapucu (2006) notes that, in New York's 911 event, GIS proved to be an irreplaceable ability in providing useful pictures and information to rescue crews and officials to make critical decisions. In Singh's (2014) study, GIS shows its capability in assessing flood hazard in Gorakhpur, India to facilitate local resilience planning. Therefore, with the ability of gathering, manipulating, and displaying geographic information quickly, GIS plays a critical role in emergency management.

2.3.4 Wireless Technologies

Wireless technology allows emergency responders to respond to incidents rapidly with updated information (Reddick, 2011). It can be utilised to conduct simple tasks such as communication with key responders distantly, as well as more complicated tasks in terms of digital data collection (Reddick, 2011). Wireless communication technology has become critical in emergency communications due to its low cost and portability that allows getting rid of the fixed landline transmission and reception of information (Smith & Simpson, 2009). A simple example of wireless networking includes the use of mobile phones for voice and text communication (Gross et al., 2014). Wireless communications have considerably enhanced the quality of information that can be transmitted to and from an incident command system (Smith & Simpson, 2009). Mapping and spatial data can be relayed from the scene to personnel at almost any location via wireless networks to laptop computers or mobile phones (Smith & Simpson, 2009)

2.3.5 Decision Support Systems

An emergency decision support system is a critical tool that enables officials to enhance their emergency response capabilities in terms of an early warning contingency plan, coordination of emergency response activities, and resource management (Shan et al., 2012). The emergency management information system (EMIS) is an example of a decision support system (Kwan & Lee, 2005). Through using the system, emergency planners are able to "display and analyse the spatial relationships among possible event locations, shelters and other emergency management facilities and resources, transportation routes, and population at risk" (Kwan & Lee, 2005, p. 95). Computer Aided Management of Emergency Operations (CAMEO) is an example of a frequently used emergency decision support system for planners and responders in a chemical emergency (Reddick, 2011). Emergency management decision support systems also allow emergency organisations to record, choose and classify information about community population or weather data (Reddick, 2011). According to Kwan and Lee (2005), the decision support system can also integrate activities in all phases of emergency management, which includes planning and training in the preparedness stage, or coordinating evacuation and rescue during the response phase.

2.3.6 Remote Sensing

Remote sensing utilises image sensors over an area of interest, "collecting optical and radar-based imagery and transforming it into spatial information", which can be helpful in gaining an understanding of disaster conditions (Reddick, 2011, p.48). Therefore, remote sensing is valuable in monitoring hazard and assessing damages (Reddick, 2011). It is argued that, whenever possible, images from remote sensing satellites are the greatest sources of information in emergency management (Tanzi & Lefeuvre, 2010). Networks of sensors are used in many ways, for example, yielding data for weather prediction and earthquake detection in order to mitigate and prepare for many natural disasters (Rao et al., 2007). For example, Doppler radar is used to identify and track hurricanes, tornadoes, and other weather phenomena (Rao et al., 2007). Another example is the networks of earth and structure motion detectors which produce information regarding the severity and nature of earthquakes (Rao et al., 2007). According to Reddick (2011), remote sensing and other technologies are not mutually exclusive, meaning sensors actually can be combined with other technology, such as combining remote sensing with GIS.

This section has introduced some universally used technologies in emergency management, which either support information sharing, communication or aid in collecting, recording and analysing data as summarised in Table 4-4. However, all these functions cannot work without a technology that owns great computing power to deal with extensive information in large-scale emergencies.

The next section introduces the emerging technology, cloud computing, which owns the features of scalability and flexibility in dealing with the large amount of information gathered and used in emergency management.

2.4 Cloud Computing

It is argued that cloud computing is one of the most important technological developments in the last decade (Garg, Versteeg, & Buyya, 2013; Wang, Rashid, & Chuang, 2011). It has been considered as an economic commodity that many businesses and individual customers are able to reach and afford (Wang et al., 2011). Cloud computing is appealing to enterprise owners since it allows the users to eliminate upfront infrastructure provisioning and enables businesses to start from small-scale and increase resource utilisation only when there is a demand (Marston et al., 2011). Because of this rapid development, more industries are motivated to utilise various cloud services (Arean, 2013).

2.4.1 Definition and Characteristics of Cloud Computing

Definition

The cloud is often used as a metaphor for the Internet (Aleem & Sprott, 2013; Thomas, 2011). Actually, it is the technological advancement based on several existing technologies such as grid computing, utility computing and virtualisation (e.g., Ekwe, 2012; Thomas, 2011; Wang et al., 2010). Cloud computing is an attractive computational model that hosts and delivers services over the Internet (Armbrust, 2010; Bowers, 2011). Although many definitions of cloud computing have been proposed, the newest and widely accepted definition provided by the National Institute of Standards and Technology (NIST) presents a comprehensive view of cloud computing. They define cloud computing as “a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly supplied and released with minimal management effort or services provider interaction” (Mell & Grance, 2011, p. 2).

Despite the topic of cloud computing having recently drawn great attention from both academic and industry practitioners, there is still a lack of a universal definition (Aleem & Sprott, 2013; Ekwe, 2012; Voas & Zhang, 2009). Wang et al. (2010) offer three good reasons that contribute to the lack of a commonly accepted definition of cloud computing. First, researchers and engineers from different backgrounds have different point of views on cloud computing. Second, technologies, such as Web 2.0 and Service oriented-Computing that are the enablers of cloud computing, are still evolving and progressing. Third, cloud computing is still not deployed on a large scale, which also makes it difficult to reach a united justification of the concept. Table 2-5 presents various definitions of cloud computing. Most of the definitions cover just two aspects of cloud computing (e.g., Armbrust et al., 2010; Buyya et al., 2009; Marston et al., 2011). This thesis adopts Mell and Grance’s (2011) definition, which is consistent with the view of a number of scholars by covering all the necessary aspects of cloud computing (e.g., Aleem & Sprott, 2013; Dillon, Wu, & Chang, 2010; Ekwe, 2012; Grobauer, Walloschek, & Siemen, 2011; Wang et al., 2012; Zhang, Cheng, & Boutaba, 2010).

Table 2-5 Definitions of cloud computing

Author	Definitions	Characteristics included					
		On-demand self-service	Ubiquitous access	Resource pooling/ Multi-tenancy	Scalability & elasticity	Cost-effectiveness	QoS[1]
Mell & Grance (2011)	A model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly supplied and released with minimal management effort or services provider interaction.	✓	✓	✓	✓	✓	
Buyya et al. (2009)	A cloud is a type of parallel and distributed system consisting of a collection of interconnected and virtualised computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements established through negotiation between the service provider and consumers.			✓			✓
Armbrust et al. (2010)	Cloud computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the data centres that provide those services.		✓	✓			
Wang et al. (2010)	A computing Cloud is a set of network-enabled services, providing scalable, QoS guaranteed, normally personalised, inexpensive computing infrastructure on demand, which could be accessed in a simple and pervasive way.	✓			✓	✓	✓
Rajaraman (2014)	We define cloud computing as a method of availing computing resources from a provider, on demand, by a customer using a computer connected to a network (usually the Internet).	✓					
Marston et al. (2011)	It is an information technology service model where computing services (both hardware and software) are delivered on-demand to customers over a network in a self-service fashion, independent of device and location.	✓	✓				

[1] QoS means Quality of Service, which represents the extent to which the performance, reliability, and availability could be provided by an application and a platform or infrastructure hosting it. QoS plays a fundamental role in not only enabling providers to deliver the advertised quality characteristics to cloud users, but also in helping cloud providers work out the desirable trade-offs between QoS levels and operational costs (Patel, Patel & Patel, 2015).

Characteristics

Many (e.g., Dillon et al., 2010; Grobauer et al., 2011; Rajaraman, 2014) claim that Mell and Grance's (2011) definition clearly demonstrates five common characteristics of a cloud computing model. There are also various ways of summarising the key characteristics of cloud computing. Table 2-6 illustrates various terms that are used to describe the characteristics of cloud computing.

Table 2-6 Various terms for cloud computing characteristics

Authors	Characteristics				
	1	2	3	4	5
Mell & Grance (2011)	On-demand self-service	Broad network access	Resource pooling	Rapid elasticity	Measured service
Dillon et al. (2010)	On-demand self-service	Broad network access	Resource pooling	Rapid elasticity	Measured service
Rajaraman (2014)	On-demand self-service	Ubiquitous access	Resource pooling	Elasticity	Adaptive system
Jula, Sundararajan, & Othman (2014)	On-demand self-service	Broad network access	Resource pooling	Rapid elasticity	Measured service
Zhang et al. (2010)	Dynamic resource provisioning & Self-organizing	Geo-distribution & ubiquitous network access	Shared resource pooling		Utility-based pricing
Ekwe (2012)	Self-provisioning			Massive scalability & Elasticity	Pay-as-you-go
Naghavi (2012)		Location independence		Agility and scalability	

However, most of the literature depicts the five major characteristics of cloud computing: on-demand self-service provisioning; broad network access; resource pooling; rapid elasticity; and measured service.

1) On-demand self-service provisioning

A consumer who has an instantaneous need can avail any contracted computing resources, such as processing ability, network storage, software use, in a convenient self-service fashion from the service provider without depending on human interactions. Later on, users can also customise and personalise within the computing environment, for instance, software installation or network configuration (Wang et al., 2010).

2) Broad network access

As referred to earlier, all the cloud computing services are delivered through the Internet. Thus, users can access the computing resources with heterogeneous devices, such as mobile phones, tablets or laptops. Additionally, the cloud consists of data centres placed at different locations around the world which helps to achieve high network performance (Zhang et al., 2010). According to Yang and Huang (2014), it is complex to operate data synchronisation among heterogeneous devices, thus making it difficult to protect or maintain the copy of latest information and data among different devices. This particular feature of cloud computing helps to ease the difficulties in data synchronisation among different devices as the data are synchronised in various data centres in an automatic manner.

3) Resource pooling

The computing resources of a provider are pooled to offer the contracted service. Therefore, in contrast to traditional computing, which typically offers dedicated resource and storage to serve a single user, cloud computing supports services for multiple users (i.e., multi-tenancy model) on the same central hardware and software infrastructure. The motivation for setting up the multi-tenancy model is to achieve economy of scale (Dillon et al., 2010). However, since the accumulated resources may be geographically distributed across different geographical locations in multiple data centres, users generally do not have control or knowledge of where the resources are located.

4) Rapid elasticity

Computing resources can be scaled up and down rapidly and elastically by customers. In other words, the dynamic nature of cloud computing facilitates consumers to manage their resources in a most effective way by giving them the option of increasing or decreasing their resources on demand (Ekwe, 2012). In addition, from the consumer perspective, the resource provisioning appears to be unlimited, which ensures acceptable performance even at peak periods (Aleem & Sprott, 2013; Armbrust et al., 2010).

5) Measured service

Cloud computing systems work in an adaptive way which is able to balance loads on web servers in an automatic manner (Rajaraman, 2014). Resource usage is constantly monitored and reported to consumers. As a result, transparency in bills is provided to the users due to the pay-as-you-go business model (Rajaraman, 2014; Shiraz et al., 2013). Thus, the users only need to pay for the amount of the resource and time they have used. Therefore, in the cloud computing mode, users can conveniently access computing resources through paying corresponding fees to the service providers (Subramanian & Reddy, 2014). In short, this delivery model provides the advantage of extending IT's capabilities for accessing web-based applications in real time while reducing the cost and footprint of the internal IT infrastructure (Bowers, 2011).

2.4.2 Service Delivery Models

Extant research commonly suggests that cloud computing is composed of three service delivery models (e.g., Mell & Grance, 2011; Serrano, Gallardo, & Hernantes, 2015; Velev & Zlateva, 2012a; Wang, et al., 2011). The three service models are Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) (Aleem & Sprott, 2013; Emmanuel, 2012; Mell & Grance, 2011; Rajaraman, 2014; Wang et al., 2011). These service delivery models constitute the fundamentals of the cloud and they display certain characteristics that have been described in the previous section.

Cloud services began with the service of e-mails and then increased in scope to involve a number of other computing capabilities as services (e.g., computing power and storage), which is now called everything as a service (Li & Wei, 2014; Yang & Huang, 2014). In recent years, there is a trend towards classifying some other fine-grained cloud service models. For example, Data storage as a Service (DaaS) provides virtualised storage service on demand, which is considered a special type of IaaS (Dillon et al., 2010; Naghavi, 2012; Wang et al., 2012). The Amazon Simple Storage Service (S3) is an example of DaaS that provides a web services interface that allows the users to store and retrieve any data at any time and place through the web (Wang et al., 2012). Other classifications of services models with specific purposes include Information as a Service, Process as a

Service, Integration as a Service, Security as a Service, Testing as a Service and so forth (Naghavi, 2012; Catinean & Cândea, 2013). Nevertheless, SaaS, PaaS, and IaaS still remain the three major types of service delivery models that are discussed in the literature. Table 2-7 lists the major types of cloud computing services with examples.

Table 2-7 Major types of cloud computing services

Type	Examples
SaaS	Google: Email, Office Salesforce.com: Sales application NetSuit: Customer relationship management
PaaS	Google App Engine: Infrastructure and web applications Salesforce.com: Sales platform Microsoft Azure: Application development platform
IaaS	Amazon EC2, S3: Computing and storage Google Compute Engine: Infrastructure hosting GoGrid: Infrastructure hosting Rackspace: Storage, server, and website hosting

Software as a Service (SaaS)

The early implementations of Software as a Service (SaaS) began in the mid-1990s whereby some companies were able to provide email services online (Catinean & Candea, 2013). Prior to the availability of web-based email, having a mail server and specific applications was the exclusive way to achieve this type of communication (Catinean & Candea, 2013).

In the case of SaaS, (e.g., Google Apps, Microsoft Office 365 and Salesforce.com), the applications and software are created and hosted by the cloud service provider (Emmanuel, 2012; Wang et al., 2012). In other words, cloud computing provides the consumers with the capability of using the provider's applications on a cloud infrastructure (Carstensen, Morgenthal & Golden, 2012). The applications are attainable from a variety of users' devices through a certain interface, such as a web browser. Therefore, it is best to consider the SaaS service model as an application that is delivered through the Internet (Carstensen et al., 2012; Wu, Garg, & Buyya, 2012).

As a result, SaaS enables users to use applications to meet their specific needs but without the control over the operating systems, hardware, or network of the cloud infrastructure on which the applications are running (Mell & Grance, 2011; Wang et al., 2012). Thus, it is solely the cloud service provider's responsibility to manage any update or change in the application (Wang et al., 2011). This means that the service providers keep control of all aspects of application delivery such as availability, performance, and security (Carstensen et al., 2012).

Another critical aspect of SaaS is the support of multiple tenants (mentioned earlier when introducing the characteristics of cloud computing). For the purpose of achieving economies of scale, the application service in SaaS model must be multi-tenant, which enables the service provider to provide a single application instance which serves multiple users (Espadas et al., 2013; Gupta & Varshapriya, 2014). In the situation of a multi-tenant service model, many different users are provided with concurrent services of one or more hosted application instances on the basis of the shared hardware and software infrastructure (Dinh, Lee, Niyato, & Wang, 2013; Gupta & Varshapriya, 2014). Many different organisations share a single application with even their competitors, which raises the important issue of application security; however, this issue can be addressed in the SaaS environment as one user cannot access another user's data (Carstensen et al., 2012; Espadas et al., 2013).

Normally, the SaaS model is standardised, but it might be possible to provide users with limited application configuration settings (Aleem & Sprott, 2013; Mell & Grance, 2011). Some third party software applications that are available on the cloud allow users to manage customer relations as well as conduct word processing and spreadsheets (Rajaraman, 2014).

Due to the traits discussed above, SaaS provides many benefits that are different from traditional on-premise applications. It allows customers to access applications over the Internet without software related cost and effort, such as software licensing and upgrades (Boillat & Legner, 2013; Wu et al., 2012). The avoidance of a licensing fee enables the users to make payments that are based on, commonly, a monthly subscription. Such a way of payments more closely links the actual usage to the financial investment related to the application use, thus obtaining more value from the application (Carstensen et al., 2012; Gupta & Varshapriya, 2014). Further, without the requirement of installation, fast application deployment can be realised due to the immediate availability of the SaaS application. Therefore, it is claimed that SaaS has become the most broadly accepted form of cloud service models (Aleem & Sprott, 2013; Gupta & Varshapriya, 2014).

Platform as a Service (PaaS)

The platform as a service (PaaS) is an abstraction layer between software applications and infrastructure services (Dillon et al., 2010; Rajaraman, 2014). In PaaS (e.g., Google App Engine, Windows Azure, Heroku), users who are considered to be more like application developers can create an application through using programming language and developmental tools provided by the cloud service provider over the Internet (Emmanuel, 2012; Wang et al., 2012). Application developers can develop and run their software solutions on a cloud platform without the cost and complexity of buying and managing the underlying hardware and software layers (Pandey & Varshapriya, 2014; Patidar, Rane, & Jain, 2012). Therefore, the difference between SaaS and PaaS lies in SaaS only providing completed cloud applications for users whereas PaaS hosts finalised and in-progress cloud applications on a development platform (Dillon et al., 2010). In the program development environment, it enables users to manage the newly developed applications through customisation and test with control over the hosted application but without control of the physical cloud infrastructure in terms of operating systems, network, servers, or storage (Mell & Grance, 2011; Wang et al., 2012).

The reason that PaaS is understood to be significant is related to the cloud computing characteristic of rapid elasticity, Mell and Grance (2011) describe that in some cases it happens automatically. However, Carstensen et al. (2012) argue that "the so-called autoscaling does not occur automagically" (p.33). This means that in Infrastructure as a Service environment, it is necessary for the application developer to design and program the applications, and simultaneously ensure the required amount of computing resources. This issue can be solved in a PaaS environment whereby the total infrastructure capability is offered by service providers so that the developers are able to focus on designing the application itself (Carstensen et al., 2012). With some PaaS offerings, such as Windows Azure, the underlying computer and storage resources scale automatically to match application demand, which enables the cloud user to avoid allocating resources manually. Therefore, PaaS allows for the elimination of the requirement to install and run the application on the cloud user's computers, which simplifies maintenance and support.

Infrastructure as a Service (IaaS)

Infrastructure as a Service (IaaS) is the most basic cloud-service model, which is at the lowest level of abstraction. IaaS (e.g., Google Compute Engine, Amazon Elastic Computing Cloud, Joyent) serves as a virtual machine for users to have greater access to computing resources involving hardware, storage, servers, networking component and other fundamental computing resources (Mell & Grance, 2011; Wang et al., 2012). Therefore, it is best to consider IaaS as services that provide the capabilities of using virtualised infrastructure (Carstensen et al., 2012; Patidar et al., 2012).

The fundamental software that enables the creation of virtualisation is called hypervisor (Rajaraman, 2014). Pools of hypervisors support and operate large numbers of virtual machines and enable users to scale services up and down according to their various needs (Pandey & Varshapriya, 2014). IaaS-cloud providers supply these resources on demand from their large pools installed in data centres (Pandey & Varshapriya, 2014; Rajaraman, 2014). Customers are allowed to deploy and execute proprietary systems and application software. An extensive use of virtualisation is executed in IaaS cloud in order to meet customers' increasing or diminishing resource demand through integrating or decomposing physical resources (Dillon et al., 2010). Therefore, from the providers' perspective, virtualisation provides better resource utilisation, and from the users' perspective, the performance of the virtualised servers becomes closer to that of the native computation due to the advancements in software and hardware (González-Martínez et al., 2015).

Similarly to SaaS and PaaS, in IaaS environments, the user does not own the computing assets, for example, the physical server or network switches, but solely uses the computing capacity provided by the service providers (Carstensen et al., 2012; Rajaraman, 2014). Hence, the cloud service provider is only responsible for ensuring the appropriate capacity of the hardware components (Rajaraman, 2014). Generally, the users can deploy and run any applications without the management or control over the infrastructure (Li et al., 2013). IaaS service enables users to work with a personalised network structure based on a pay-as-you-go basis (Carstensen et al., 2012; Emmanuel, 2012). This reflects the significant benefit of IaaS which is getting rid of the previous essentiality of owning computing infrastructures to perform computing processes, so avoiding uneconomic ownership of computing resources (Carstensen et al., 2012). The earliest IaaS provider is Amazon EC2, and other providers include Rackspace or IBM SmartCoud+ (Rajaraman, 2014). The possession of a virtualised system enables all these IaaS providers to provide virtualised computational or storage hardware through which the users can deploy their own applications (Rajaraman, 2014). Figure 2-2 presents the major types of cloud computing service models.

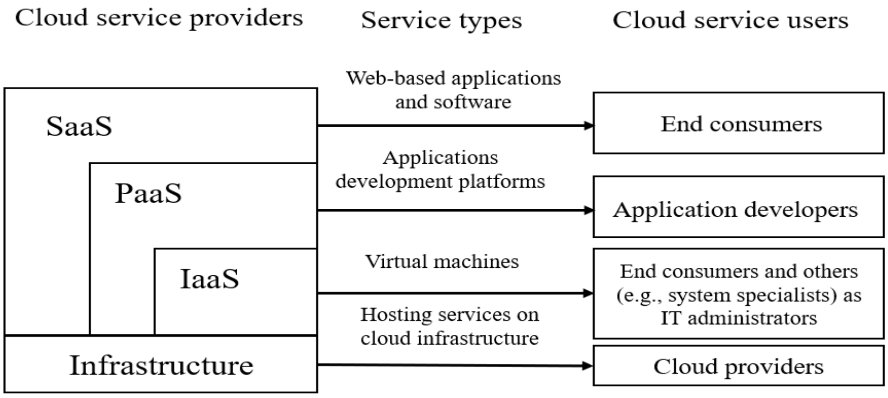


Figure 2-2 Cloud computing models (adapted from Kagadis et al., 2013)

In short, IaaS is an essential component (see Figure 2-3) that acts as a basis for all cloud services to work (Zhang et al., 2010). Generally, the higher the level of support available from a cloud provider, the more narrow the scope and control the cloud consumer has over the system (Jansen & Grance, 2011). All three service delivery models represent advanced business models that are designed for end users in terms of increasing user capacity and saving cost (Ekwe, 2012). The next section discusses the deployment models of cloud computing.

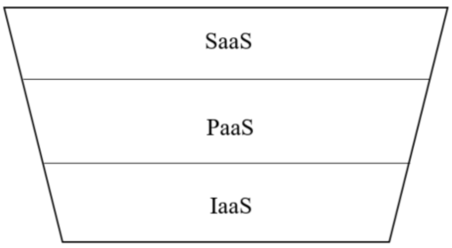


Figure 2-3 Depiction of cloud computing layers

2.4.3 Deployment Models

The deployment of cloud computing can be different according to specific requirements (Ogigau-Neamtiu, 2012). In this section, four cloud computing deployment models are identified, and each deployment model has distinct characteristics that support users' different needs. Cloud computing can be deployed in four ways: 1) public cloud, 2) private cloud, 3) community cloud, or 4) the hybrid cloud (Mell & Grance, 2011; Ekwe, 2012; Velev & Zlateva, 2012a). Deployment models broadly characterise the management and disposition of computational resources for the delivery of services to consumers (Janson & Grance, 2011). Figure 2-4 presents the four deployment models of cloud computing.

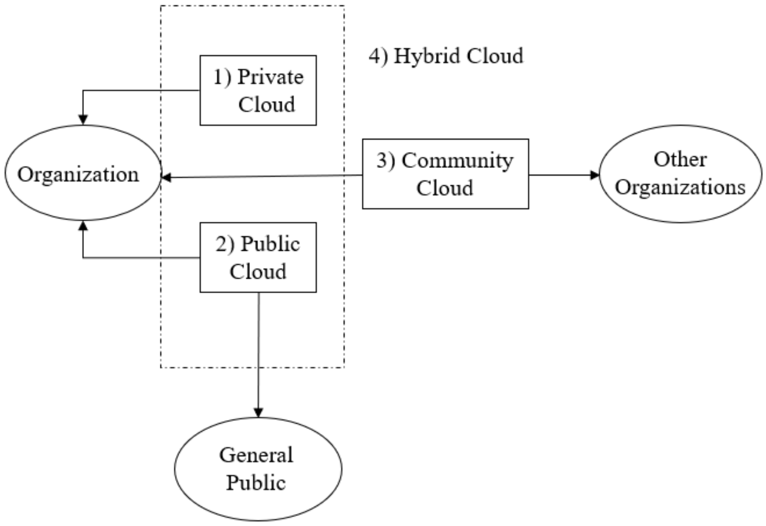


Figure 2-4 Deployment models of cloud computing (adapted from Kuo, 2011)

Public Cloud

The public cloud is the most common type and is obtainable through open access (Goyal, 2014; Carlin & Curran, 2011; Yang & Huang, 2014). The public cloud is the infrastructure made available to the general public from a third-party cloud service provider such as Google, Amazon, and Microsoft (Janson & Grance, 2011; Wang et al., 2012; Yang & Huang, 2014). In other words, it is typically located at the provider's site and controlled by the provider so that numerous users, either individual consumers or organisations, share the infrastructure at the same time (Carlin & Curran, 2011; Rajaraman, 2014). The public cloud platform is usually large scale and composed of data centres in different locations to offer various cloud computing services (i.e., SaaS, PaaS, and IaaS) (Sun et al., 2011). According to the definition of the public cloud, it is external to the user organisations. Thus, the customers are without control over how the resources are managed or available. It is opposite to the instance in which the application can be managed and controlled by an organisation itself, which is presented later on and known as the private cloud.

Extant literature categorises the public cloud from the perspective of cost. According to Jansen and Grance's (2011) categorisation, the public cloud has three classes, which are services that are provided to customers at no cost, at a low cost, and fee-based. Similarly, Rajaraman (2014) classifies the public cloud as free type services, for example, the free google email, office software and storage space, as well as services based on the pay-per-use basis such as the Amazon EC2 service (Rajaraman, 2014). Fundamentally, the capital investment is made by the public cloud provider whereas organisations themselves invest in the infrastructure in the private cloud (Adekunle et al, 2012). Therefore, from the providers' perspective, the public cloud enables the providers to offer competitive and quality services at a low cost (Carroll, Van Der Merwe, & Kotzeet, 2011; Yoo, 2011). From the consumers' perspective, the public cloud allows the consumers to deploy the services with little capital expenditure requirement compared to the capital investment that is normally required in other deployment options (Ogigau-Neamtiu, 2012; Sun et al., 2011). It is argued that smaller companies can derive the biggest advantages from this type of deployment model. This is because they have limited information technology resources or personnel resources such as information technology administrators and people who are responsible for the system security (Jansen & Grance, 2011). Through using the public cloud, the smaller organisations are able to achieve the economies of scale that are obtainable by the larger organisations with sizable data centres (Jansen & Grance, 2011; Sun et al., 2011).

A public cloud does not necessarily mean that the users' data is publically visible or not secure (Carstensen et al., 2012; Wang et al., 2012). In the public cloud service, the security of users' data is also provided as cloud service vendors offer a security mechanism for the users (Wang et al., 2012).

Private Cloud

As referred to earlier, the private cloud, also known as the internal cloud, is designed exclusively for a single organisation (Catinean & Cândea, 2013; Davidovic et al., 2015; Zhang et al., 2010). Thus, the cloud is typically operated and managed by an IT department within an organisation (Yoo, 2011; Wang et al., 2012) or may be managed by a third party organisation (Carroll, et al., 2011; Grossman, 2009). In this mode, users will have more confidence and control over the services (Carlin & Curran, 2011). This leads to the assertion that private clouds are appealing to organisations that require more control over their data, and additional IT infrastructure investment is not an issue as they have to buy the infrastructure to run the cloud and also have to manage the cloud themselves (Carlin & Curran, 2011; Aleem & Sprott, 2013). Hence, this type of cloud computing is generally used by large companies, and allows their corporate network and data centre administrators to effectively become in-house service providers catering for customers within the corporation (Adekunle et al., 2012; Ogigau-Neamtiu, 2012; Srinivasan, 2013).

The reason for many companies to implement private clouds at their own premises is that they are sceptical about data security in the public cloud (Wang et al., 2011). For some organisations (e.g., a private health research lab or government entities), the sensitivity of certain data information is the major issue that makes them reluctant to utilise the public cloud where they do not have complete control over the data process (Aleem & Sprott, 2013; Jansen & Grance, 2011). In the private cloud service, there is no limitation of network bandwidth or security exposures as in the public cloud (Wang et al., 2012). Therefore, it is regarded as offering the highest degree of control in terms of performance, reliability and security. The private cloud is considered as offering similar economic and operational advantages as the public clouds while allowing companies or organisations to retain absolute control over their IT resources (Purcell, 2014; Yang & Huang, 2014). However, criticism of the private cloud also exists; it is argued as being similar to traditional privately owned servers which do not offer the benefits of the elimination of up-front commitment (Zhang et al., 2010) because a private cloud requires capital expenditure, operational expenditure and a highly skilled IT team (Carroll, et al., 2011).

Community Cloud

In the community cloud, the infrastructure is shared by several organisations and provides assistance to a specific community that has shared matters of interest (e.g., mission, security, requirements, policy, and compliance considerations) (Mell & Grance, 2011; Carstensen et al., 2012; Srinivasan, 2013). The community cloud represents a "vertical market in which the organisations stand to benefit by having a dedicated server that addresses the specialised needs of that sector" (Srinivasan, 2013, p.50). It can be managed internally or by a third party and hosted within the organisation or externally (Carstensen et al., 2012; Ogigau-Neamtiu, 2012). Community cloud enables several organisations that have common bonds to share the cloud infrastructure (Adekunle et al., 2012; Goyal, 2014). For example, Google's GovCloud enables different city agencies in the US to manage and store data application together (Wang et al., 2011). Another example could be that a number of universities would like to interconnect their computing infrastructure to share resources with the established community (Rajaraman, 2014). The infrastructure of a community cloud may be owned and managed by organisations themselves or may be outsourced (Rajaraman, 2014; Wang et al., 2012)

Hybrid Cloud

The hybrid cloud consists of any combination of public, private or community cloud to serve a particular purpose, which maintains entities with own distinctions and make them bound together by standardised or individually owned technology that enables data and application portability (Aleem & Sprott, 2013; Catinean, & Cândea, 2013; Srinivasan, 2013; Wang et al., 2012). Based on this idea, Yoo (2011) argues that the focus of the hybrid cloud is "primarily on proprietary data centres, but rel[ies] on public cloud resources to provide the computing and storage needed to protect against unexpected or infrequent increases in demand for computing resources" (p. 409). Through utilising hybrid cloud architecture, individual or organisation consumers are able to avoid entire dependence on third-party services but use the combination of local immediate and the public services (Ogigau-Neamtiu, 2012). It is claimed that hybrid clouds offer more flexibility than either public or private clouds (Ogigau-Neamtiu, 2012; Zhang et al., 2010). Specifically, they provide tighter control and security over application data compared to public clouds, while still facilitating on-demand service expansion and contraction (Zhang et al., 2010)

It is argued that firms are more likely to utilise the hybrid form of services since a company could select the public cloud to conduct less critical activities, but keep more critical data within its own business data centre (Adekunle et al., 2012; Carlin & Curran, 2011; Géczy, Izumi, & Hasida, 2012; Low, Chen & Wu, 2011). Aligned with this idea, a common combination of a hybrid cloud is the utilisation of both private and public clouds, which allows the organisations to benefit from both deployment models. For example, an organisation could hold sensitive information on their private cloud and use the public cloud for handling large traffic movement and demanding situations (Carlin & Curran, 2011). Another example of a hybrid setup could be that organisations may consider running non-critical applications in a public cloud while keeping business critical services in their private cloud to maintain some relative control (Aleem & Sprott, 2013). Since the cloud models continue to evolve, such ways of combining both different types of cloud services will increasingly become a popular choice for organisations (Adekunle et al., 2012; Goyal, 2014; Srinivasan, 2013).

2.4.4 Benefits and Challenges of Cloud-based Technology in Organisations

The adoption of cloud computing has been growing rapidly in recent years. According to a report by Rightscale (2018), 81 percent of enterprises already have utilised two or more cloud computing services, which refers to a multi-cloud strategy. While cloud computing provides a series of advantages to businesses, it also comes with some potential drawbacks. The following sections discuss the benefits and challenges that organisations need to consider when wanting to adopt cloud computing.

Benefits of Cloud-based Technologies

Cloud computing brings several significant benefits compared with other powerful models that companies need to purchase and operate themselves (Grossman, 2009). First, cloud computing is argued to provide compelling savings in IT related costs (Armbrust et al., 2010; Carroll et al., 2011; Sommer, 2013; Zhang et al., 2010). Cloud-based technologies could significantly reduce the cost for firms planning to invest in hardware and software for the use of some large computing power applications (Adekunle et al., 2012; Marston et al., 2011). According to Carroll et al. (2011), SaaS is most often implemented to provide business software functionality at a low cost while allowing the consumers to obtain the same benefits of commercially licensed, internally operated software without the complexity of installation, management, support licensing and high initial costs. Thus, cloud computing enables companies to reduce some capital expenses while avoiding the risk of obsolescence of IT infrastructures (Rajaraman, 2014).

Additionally, applications are provided through cloud service providers' infrastructure, and organisations only pay based on their actual usage of the services (Armbrust et al., 2010), which helps companies to reduce their cost on those underutilised resources. This "pay-as-you-go" pricing model is particularly advantageous to start-up firms that have limited budget for setting up and maintaining their in-house IT infrastructure (Aleem & Sprott, 2013; Armbrust et al., 2010). As noted by Catinean and Cândea (2013), public cloud services are more attractive to small- and medium-sized organisations, particularly for newly established businesses, since organisations can gain the most viable solution in terms of increasing computing power at a cost advantage for growth. As a result, cloud computing can help smaller businesses to become more competitive. This is because it is more affordable for them to rent IT services compared to making heavy investments in those IT infrastructures, thus allowing them to focus more on their core competencies (Adekunle et al., 2012; Thomas, 2011). Therefore, for small- to medium-sized organisations, cloud computing will continue to be an attractive and cost-effective option as they are able to reduce the total cost of technology ownership (Aleem & Sprott, 2013).

In addition, cloud computing customers can benefit from the economies of scale because providers tend to use data centres on a large-scale that operates at a much higher level of efficiency, and to use the multi-tenant architecture to share resources among many different customers (Ekwe, 2012; Grossman, 2009; Zissis & Lekkas, 2012). This multi-tenancy model allows those providers to pass on savings to their customers. For this reason, organisations can benefit from the cloud-based services with a lower unit cost than that of hosting infrastructure directly by themselves (Grossman, 2009). Therefore, cost efficiency is considered as the main driver for adopting cloud computing in organisations (Carroll et al., 2011).

Further, cloud-based technologies enable ubiquitous access due to the characteristics of broad network access (Adekunle et al., 2012; Hoy, 2012; Zhang et al., 2010). Since most of the applications and information are Internet-based, cloud computing eliminates the device and location dependence, and facilitates users to access data and files from anywhere at any time (Marston et al., 2011). Organisations thus have easy access to their information and applications regardless of their physical locations (Adekunle et al., 2012).

Scalability is achieved by cloud computing whereby businesses could easily upscale or downscale their information technology requirements according to their dynamic demand with the usage-based pricing model (Adekunle et al., 2012; Carroll et al., 2011; Sommer, 2013; Thomas, 2011; Zissis & Lekkas, 2012). Scalability/ flexibility is one of the most important features that drive the use of cloud computing (Wang et al., 2010). The cloud services and platforms offered by the services providers could be scaled across various concerns, such as geographical locations, hardware performance, software configurations so that the computing platforms can be flexible and adapt to the various requirements of a potentially large number of users (Wang et al., 2010). Therefore, the highly scalable nature of cloud computing makes businesses more adaptive to their unpredictable client needs.

The quicker and more efficient solution for disaster recovery and business continuity is another key benefit of cloud-based technologies (Aleem & Sprott, 2013; Adekunle et al., 2012; Rajaraman, 2014). According to Adekunle et al. (2012), recent research indicates that about 90 percent of organisations do not adequately plan for disaster recovery or business continuity, which makes them vulnerable to any probable disruptions. Therefore, it is crucial to keep important data backed up offsite to eliminate the risk of data loss due to the disaster (Dillon et al., 2010). Cloud infrastructure can be used by organisations to automatically back up their important data, allowing rapid recovery if data is lost (Rajaraman, 2014). The virtualised application platform removes the enterprises’ dependency on hardware, enhancing the application availability and enabling business continuity during disasters (Wood et al., 2010). The on-demand and utility pricing nature of cloud resources dramatically reduces the cost according to different amount of resources required before, during, and after a disaster (Wood et al., 2010).

Challenges of Cloud-based Technologies

Although cloud computing has the huge potential of achieving economies of scale and other benefits that could attract a wide range of users, there are still several concerns and unpredictabilities (Thomas, 2011). Despite many organisations outsource tasks, such as payroll, or use the external cloud, such as email services, to keep sensitive information, the perceived security issues, such as data loss, phishing, and malicious attacks, are one of the biggest concerns for organisations (Aleem & Sprott, 2013; Armbrust et al., 2010; Dillon et al., 2010;). According to Carroll et al. (2011), data security risks account for the largest barrier for cloud computing. Once data is conveyed through a public communication system and data is kept in a shared disk system, there is a risk of communication being eavesdropped or the data being stolen (Rajaraman, 2014). Since the data security in the cloud is primarily managed by service providers, the issue of a lack of control over the system, application and data has been found to be one of the greatest concerns for firms planning to move into the cloud (Piechotta et al., 2013; Zissis & Lekkas, 2012). Another security issue involves a lack of confidentiality and privacy. Data confidentiality in the cloud is associated with user authentication (Zissis & Lekkas, 2012). The more the users can gain access to the services hosted on the public network, the higher probabilities for them to increase their exposure (Carroll et al., 2011). Therefore, users will be under threats that are made by malicious cloud providers or customers. As a result, leaked confidential data could appear due to a lack of security access rights across multiple locations (Carroll et al., 2011). Therefore, the security issue would reduce companies' desire for using cloud computing.

The reliability issue is another concern of enterprise. The enterprise applications are now so essential that cloud service providers are required to deliver reliable services to support 24/7 operations (Buyya et al., 2009; Rajaraman, 2014). This requirement is especially high for some enterprises that have their core business functions operating in the cloud (Dillon et al., 2010). It is important that the primary and backup sites are distributed in various geographical locations so as to ensure that a single disaster will not impact both sites. However, one prior study also finds customers, who are distant from cloud providers, may encounter latency, particularly if the Internet is heavily loaded (Leavitt, 2009). Further, uninterrupted communication is a critical factor that supports the working of the cloud service (Rajaraman, 2014). For example, a power outage will lead to the absence of a network connection, which can seriously restrict the end user's ability to carry out productive work (Rajaraman, 2014; Yoo, 2011). A real service outage, such as the service failure of Sale.com and Amazon's S3 (Simple Storage Service) and EC2 (Elastic Compute Cloud) in 2008, has shown a considerable amount of sales opportunity missed by cloud users (Leavitt, 2009). Thus, the concerns about unreliable services delivered by service providers could be another barrier for enterprises.

Cloud consumers also suffer from the incompatibility issue of cloud services (Hofmann & Woods, 2010; Leavitt, 2009; Rajaraman, 2014). Since there are no standards for files in cloud-computing to be consistent among different providers, the data format in one cloud system may differ from one another (Armbrust et al., 2010). As a result, the data exported from one vendor may not be recognised by another vendor's cloud system (Armbrust et al., 2010). Thus, if an organisation is not satisfied with one cloud service provider or the vendor stops the business, it is difficult and expensive for it to move from one service provider to another since the moving process entails reformatting its data and applications (Armbrust et al., 2010; Leavitt, 2009). This prohibits users from choosing alternative vendors/offerings that can help them to make the best use of the resources at different levels within an organisation (Dillon et al., 2010). Even though cloud computing has its own disadvantages, it is argued that whatever happens or may have happened, those concerns should not shade the benefits (Thomas, 2011).

2.4.5 Cloud Service Implementations

Motivated by the benefits of cloud services in terms of cost-efficiency, automation, scalability, and flexibility, an increasing number of organisations are moving from traditional physical IT systems to cloud computing (Yang & Huang, 2014). Cloud services are increasingly offered by commercial IT enterprises (Armbrust et al., 2010; Demydov et al., 2015; Naghavi, 2012). Some well-known examples of cloud service implementations are presented in the following section.

As mentioned earlier, one significant feature of cloud computing is that the data and application employed by cloud applications are situated in a data centre instead of in the end user's machine. Therefore, in terms of SaaS, it can deliver different business applications such as email services, customer relationship management (CRM), or enterprise resource planning (ERP). The cloud-based email service is one typical example of cloud computing usage in organisations. Specifically, the person who wants to access email via a web-based email service does not need to establish a local email program (Yoo, 2011). Google is such an example that provides various cloud services which satisfy different needs. It provides end users with its premier SaaS named Google Apps which includes tools for communication (e.g., Gmail, Google Talk, and Google Calendar) as well as tools for office productivity (e.g., Google Docs: word documents, spreadsheets, and slides) (Marston et al., 2011; Sultan, 2011).

The emergence of the cloud-based delivery model of ERP system has taken place, coming after the success of cloud computing (Boillat & Legner, 2013; Chen, Liang, & Hsu, 2015). These ERP solutions are marketed to offer similar functionality as their on-premise counterparts, but the infrastructure (software, computational power, hardware etc.) is provided on-demand by the vendors in a pay-per-use model (Ogunrinde & Jusoh, 2014). The cloud-based ERP services are available from NetSuite, Microsoft, Oracle, and SAP which are major players in the cloud services market (Chen et al., 2015). Among these companies, NetSuite is a fast-growing cloud provider and declares itself to be the leading company in cloud enterprise systems (Boillat & Legner, 2013). In a similar fashion, cloud-based CRM services are available from Salesforce.com, Sage and NetSuite (Choudhary & Vithayathil, 2013). Salesforce is the first well-known company that has specialised in CRM solutions and serves from small to large companies (Marston et al., 2011).

PaaS allows automatic and seamless application scaling without the need for intervention from the client or the application (Teixeira et al., 2014). Microsoft, as one of the major players, is investing heavily in this new computing service delivery model with Azure to provide a cloud platform to the users (Yoo, 2011;

Sultan, 2011). Windows Azure provides developers with on-demand computing resources to host, scale, and manage cloud applications (Carutasu et al., 2016; Sultan, 2011). Another example is the Google App Engine which implements the PaaS model of computational clouds which provides an application development and deployment platform in Google's data centres (Shiraz et al., 2013).

With regard to IaaS, it can provide users with cloud services such as storage, and website hosting. As one of the leading IaaS providers, Amazon offers virtualised resources and services in cloud data centres (Catinean & Cândea, 2013; Shiraz et al., 2013). Amazon's Elastic Compute Cloud (EC2) offers a variety of services that represents a virtual computing environment, allowing users to utilise web service interfaces to initiate applications within the customised application environments (Sultan, 2011). Another cloud service of Amazon's is known as S3 (Simple Storage Service), which enable users to store and retrieve any data at any time and place with a simple interface (Choudhary & Vithayathil, 2013; Sultan, 2011). Amazon Simple Queue Service (SQS) provides a highly scalable and reliable hosted queue for storing messages as they are transmitted between computers (Amazon, 2015). The service can facilitate developers to transfer data between distributed application components that execute different tasks without requiring each component to be always available (Sultan, 2011). Rackspace Cloud is one of Amazon's competitors in the area of commercial cloud hosting. Rackspace provides services embracing cloud servers, cloud storage, and cloud-based website hosting. Their cloud servers are provided with different sizes regarding the random-access memory and disk space and are supported by various operating systems (Krishnappa et al., 2013).

2.5 Cloud-based Technologies in Emergency Management

Even though cloud computing has its advantages and disadvantages, it has great potential in dealing with emergency management. No matter what natural or man-made emergency happens, there is always an urgent need for better preparation to respond to disasters in order to maintain the continuance of the organisation (Velev & Zlateva, 2012a). Therefore, a sound and comprehensive infrastructure is critical to the success of effective and efficient emergency management. Cloud computing is a technology that could contribute to organisations' preparedness for, response to, and recovery from, the disaster (Velev & Zlateva, 2012a). Table 2-8 outlines some example usage of cloud-based technologies in emergency management.

Table 2-8 Usage examples of cloud-based technologies in emergency management

Cloud-based Technology	Example Usage	Service & Deployment Models
Web-based communication tools (e.g. Email, online chatting)	**Fukushima Earthquake, tsunami, and nuclear disaster**: browser-based communication tool applied to facilitate sharing daily rescue activities and schedules among Japan Medical Association Teams (Nagata et al., 2013) **New York and New Jersey storm**: 33% of residents in the affected area used email to reach out to those around them (NORC, 2013)	SaaS public cloud
Social Cloud (web-based social media platform, such as Facebook, Twitter, YouTube, etc.)	**Van earthquake in Turkey**: Facebook page set up and used as a message platform for sharing information about victims' rescue, collection and distribution of aid, creation of disaster awareness, etc. (Yildiz & Demirhan, 2012) **Japan earthquake, tsunami and ensuing radiological emergency**: residents tweeted about the warning and details prior to disasters (Tucker, 2011) **New Jersey storm**: 31% used Facebook and 7% used Twitter to communicate during the storm (NORC, 2013) **Saint Clair flood**: officials used social media to organise volunteers to clean up sandbags used to prevent flooding (Tucker, 2011) **New York storm**: the New York Office of Emergency Management updated evacuation orders about the storm hourly on their Twitter account (Cohen, 2013)	SaaS public cloud
Cloud Storage	**Japan Tsunami**: hospitals saved thousands of clinical records stored in cloud networks, which would never have been restored if stored in local hard drive (Nagata et al., 2013) **New York Hurricane Sandy**: a backup data centre store in Washington D.C. used by Huffington Post (new website company) to ensure normal operation for the incoming Election Day (Vance et al., 2012) **Christchurch earthquake**: Hewlett-Packard storage technology used by local businesses, which helped avoid the business downtime and recovered critical business information after the earthquake (South, 2012)	IaaS public cloud

Emergency Notification Systems based on cloud computing platform (e.g. AtHoc IWSAlerts, Redflag)	**Washington D.C Navy Yard Shooting attack**: Athoc's emergency system used to alert Navy personnel, keeping them informed with situational information outside while being safely sheltered-in-place (Freenewspos, 2013) **Dallas Thanksgiving Day event**: Redflag was used as part of emergency action plan to deliver crisis communications in seconds and keep guests informed of any hazard during crisis (Redflag, 2013)	SaaS public cloud
Cloud Geographic Information System	**Canterbury earthquake**: internal and secure external web-based GIS served as the primary tool to share the information of areas of damage and emergency call outs, post-earthquake satellite and aerial photos, etc. (Eagle Technology Group, 2011). **Japan nuclear radiation disaster**: external web-based GIS called *geocommons* provided the up-to-date information on radiation level in each damaged nuclear reactor site (Pfau, 2013).	IaaS private/ public cloud

Since the scope of cloud computing usage has developed tremendously during the past two decades, considerable research has been motivated in the field of emergency management (Gelenbe & Bi, 2014). For example, Qiu et al. (2014) propose a cloud-based emergency management system that is able to analyse mass data and enable faster evacuation and better resource allocation. In their study, Klauck and Kirsche (2013) introduce a system that is a combination of portable hand-held devices and autonomous sensors with the cloud services to aid post-disaster management. Through combining those technologies, the system is able to provide more flexible communication (e.g., data exchange and interconnection) between different involved emergency management parties and allow a third party (e.g., volunteers) to access to the data. Gelenbe and Bi (2014) show the architecture of cloud-enabled navigation system, which aims to provide evacuees with suitable routes in a real-time manner. In general, all of these studies focus on the system design from the technological perspective, which is conceptual and has not yet been commonly used in emergency situations. Nevertheless, there are still some relatively well-known cloud-based technologies that can be utilised in emergency management and they are introduced in the following section.

2.5.1 Social Cloud

Social media is a typical example of SaaS of cloud computing. According to Thomas (2011) and Wang et al. (2010), Web 2.0 is one of the important technologies that enable cloud applications. Social media is one significant Web 2.0 application (Thomas, 2011). Some typical examples of social media are wikis, Google Docs, Facebook, Twitter, Flickr, and YouTube. Social media works through Internet-based applications that enable people to exchange open online information via conversations or interactions (White et al., 2009; Yates & Paquette, 2011). This reflects a feature of cloud computing; it is not necessary for emergency services organisations to install any software locally while sharing and communicating critical emergency information with the general public.

As a mass notification system, social media has great capabilities for emergency response. For example, during 2008 Hurricane Gustav, a Community Emergency Response Team (CERT) used Facebook to send mass e-mail notifications to team members to share information and organise volunteers when its call notification system failed to work (Lindsay, 2011). The American Red Cross and the Federal Emergency Management Agency (FEMA) now uses YouTube, Twitter, and Facebook frequently to share information with the public on how to be prepared and stay safe (American Red Cross, 2014; Belblidia, 2010) and the Centres for Disease Control establish linkage with Twitter, Facebook, MySpace, and DailyStrength (Centres for Disease Control, 2014).

Cloud services also can be accessed ubiquitously in real time. Social media is, therefore, emerging as an important technology for emergency response because of its real-time attribute. The real-time attribute of the technology is significant during emergencies since it can enable people who are geographically dispersed to get information quickly. Additionally, the real-time attribute of social media is useful in requesting for assistance during emergencies. There is an increasing trend of using social media for communication by communities in the disaster affected areas, which includes identifying and matching the requests for help in resources from potential victims during an emergency (Purohit et al., 2013). Addressing the requests for assistance during emergencies could considerably speed up the emergency relief efforts (Purohit et al., 2013). One survey found that people would turn to social media to ask for help when they could not reach the emergency call 911 (Tobias, 2011). It is also found that Twitter was extremely useful during the 2011 Japanese earthquake and tsunami in which individuals who had Twitter accounts tweeted for assistance when they were not able to use a phone (Lindsay, 2011).

It is also argued that electricity, that is required to support the power of the equipment, may be interrupted during or after an earthquake, flood, or explosion (White et al., 2009; Goodchild & Glennon, 2010). Nevertheless, people, who are not in the affected area, could still use the functions of the social network to disperse or get emergency information (White et al., 2009). Also, due to the significant extent of mobile usage on the social media platform, such as Twitter, the pace of disseminating information increases exponentially (Crowe, 2011). Therefore, social media plays a critical role in responding to emergencies.

2.5.2 Cloud-based Geographic Information Systems

GIS is considered to be an important instrument that can be particularly employed in a natural disaster that impacts humans (Bhat et al., 2011). There is no doubt that the emergence of cloud computing technology will lead to new opportunities for GIS. Cloud-based GIS has been suggested as an ideal approach to improve conventional GIS applications so as to provide services to users across the globe (Bhat et al., 2011). The process of analysing a large amount of spatial data is complex and computationally intensive (Aly & Labib, 2013). As a result, one weakness of the traditional GIS is that it possesses relatively weak computing power to process large-scale spatial data. Thus, emergency management confronts a difficulty in terms of analysing and managing emergency data (Mahmoud, Hegazy, & El-Dien, 2013). It is also costly and time-consuming for the user to purchase and customise the professional software as well as upgrade or maintain the application (Aly & Labib, 2013; Ye, Brown, & Harding, 2014). Therefore, it is necessary to establish a highly efficient, fast and responsive system to provide emergency service agencies with effective spatial information services.

According to Laituri and Kodrich (2008), the use of cloud-based GIS in the Indian Ocean tsunami and Hurricane Katrina reveals an important advancement, which helps to quickly provide remotely sensed images before and after the events. A well-known example of cloud-based GIS is Google Maps, which combine "satellite imagery with maps and geospatial data providing local information using the open Application Programming Interfaces (APIs)" (Laituri & Kodrich, 2008, p. 3042). Another real example of GIS in the cloud is ESRI's ArcGIS Server announced at by ESRI in 2010. It is also an example of IaaS model of cloud computing and public cloud in light of a deployment model provided by Amazon (Aly & Labib, 2013; Mahmoud et al., 2013). It was utilised to respond to the 2010 catastrophic flooding in Queensland, Australia, which was applied for providing information that met the needs of responders and the public (Mann, 2011).

To cope with the disadvantages of the conventional GIS, cloud-based GIS is argued as having advanced capabilities of collecting, processing, analysing and publishing geospatial data (Aly & Labib, 2013). Another benefit for emergency service organisations in using cloud GIS is the reduction of cost. Cloud-based GIS eliminates the need for on-premise installation while preserving the basic capabilities of access to geo-information (Bhat et al., 2011). The GIS users are easily able to access these services at low costs since the users need only to rent all computation resources (Aly & Labib, 2013; Bhat et al., 2011). In terms of elasticity, the cloud GIS enables users to increase or decrease the capacity as they want (Bhat et al., 2011; Mahmoud et al., 2013). The pay-per-use attribute of cloud GIS enables consumers to pay for the amount they only use in terms of the computing power, bandwidth or storage (Bhat et al., 2011). The following section reviews how cloud computing as a new computing model can be applied in various stages of emergency management.

2.5.3 Cloud-based Technologies in the Preparedness Stage

The stage of preparedness focuses mainly on information storage and retrieval (Haddow et al., 2014). It is argued that data availability, backups and redundancy are important components during the process of choosing the emergency management software (Velev & Zlateva, 2012a; Li et al., 2013). Therefore, cloud computing, as advanced technology, provides high availability of data that allows users to retrieve information rapidly from the cloud and terminal (Li et al., 2013). In cloud computing mode, the data are frequently backed up in separated locations (Velev & Zlateva, 2012a). This is particularly important in the situation of natural disasters where there is a high possibility of losing access to computers and data centre. Some disasters, such as fires, floods and earthquakes, take place in different regional areas whereas hurricanes can have an effect along the entire coast lines (Velev & Zlateva, 2012a). According to Sakurai and Kokuryo (2013), the Great East Japan earthquake in 2011 resulted in the loss of important data in terms of birth and resident records. This motivates the municipal government to take cloud computing technologies into consideration because cloud computing enables the data and applications to be stored in the network rather than the local servers. Thus, it is significant to ensure that backup sites are geographically located so that a regional disaster will not impact other back up sites that are not influenced by the disaster. Cloud computing provides the advantage of creating copies of data and keeping them in multiple locations even if the disasters happen unpredictably (Velv & Zlateva, 2012a; Li et al., 2013). Cloud storage service also has a very important function in improving the readiness for disasters in health related emergency service organisations. It can provide hospitals with a user-friendly, fast and extensible storage services of emergency data (Li et al., 2013). For example, the picture archiving and communication system (PACS) is now an essential equipment system for digital storage, transmission and retrieval of radiology images (Patel, 2012). Through any web-connected computers, tablets, and smartphones from anywhere and at any time, the medical practitioner can gain access to the cloud picture archiving and communication system (PACS) server to access the stored images and reports if a disaster happens (Patel, 2012). Therefore, the cloud storage provides the way for protecting digital files that enhance the readiness as the emergencies unfold.

Before emergencies happen, the necessary planning and analysis serve as the foundation of emergency operations. Cloud-GIS can provide better support for computing requirements in terms of the access to large-scale data for analysis. The cloud-GIS can provide large data sets of geospatial and mapping information to help researchers to conduct natural hazard analysis, for example, earthquake (Hofer, 2015) and tsunami (Theilen-Willige & Wenzel, 2012) research, analysis of hazardous exposure due to natural disasters in high-risk location (Wang & Kanter, 2014), and data classification of flood depth measurement (Liu et al., 2015). Therefore, cloud computing can be leveraged to conduct effective analysis on a vast amount of geospatial data which requires complex procedures and multiple tools, and to minimise the data processing time (Li et al., 2015). As a result, this type of knowledge can be delivered to emergency planners in a timely manner. The cloud-GIS can also be utilised to conduct a vulnerability assessment. A web-based GIS vulnerability assessment tool has been designed by the University of South Carolina in the US, which enables the users to spend less time in producing maps, analysing patterns, and preparing response strategies for their communities (University of South Carolina, 2016). Through the integration of social and natural hazard data, the application helps to identify the areas with greatest needs so that planners can allocate resources to those areas with higher vulnerability before events happen (Radke, Johnson, & Baranyi, 2013). Aligned with this idea, Theilen-Willige and Wenzel (2012) argue that it is fundamental to make an assessment of disaster prone areas in order to enhance risk preparedness, thus diminishing the negative impacts imposed by future events.

In the preparedness stage, social media also plays a critical role. Social networking sites can be used to share information to enhance the readiness of the public such as helping individuals, communities and agencies to share emergency plans and establish emergency networks (Merchant, Elmer, & Lurie, 2011). This is because people need advice and information, not only in the wake of a disaster but also for ensuring in advance that they are prepared (Velev & Zlateva, 2012b). According to Merchant et al. (2011), information about emergency room and clinic waiting times can be available prior to the disasters through hospital tweets (Merchant et al., 2011). Keeping an eye on such important information via the same social channels during a real disaster may assist responders to quickly verify whether there are overloaded facilities and which hospital can provide needed medical care (Merchant et al., 2011; Li et al., 2013). Therefore, these tools are really helpful in terms of improving preparedness through providing the public with their day-to-day and real-time information about how the community's health care system is operating (Merchant et al., 2011). Additionally, social media is helpful to make early warnings in natural emergencies. For instance, through content analysis, Chatfield and Brajawidagda (2013) find that Twitter was a useful complement to an established disaster information management system in the Indonesian Tsunami during the period of 2010-2012. This helps the public to develop an accurate understanding of their vulnerability before the disaster comes. Based on a naturally made experiment of extreme natural emergencies, Tyshchuk et al. (2012) discovered that Twitter enables the actors, the affected general public and the local media, to obtain, understand and make confirmations of emergency information as well as help to distribute information to other affected people. While different forms of social media have been widely adopted publicly, organisations are only recently becoming aware of their potential use in emergency management, especially in the preparedness stage (Chatfield & Brajawidagda, 2013; Yates & Paquette, 2011).

2.5.4 Cloud-based Technologies in the Response Stage

During emergency situations, it is critical that necessary information can be communicated to the right person in a timely manner (Carminati et al., 2011). A great deal of communication is required among different organisations in order to cooperatively counteract the disturbance in response to the disasters (Seyedin & Jamali, 2011). However, organisations are often unsuccessful in carrying out effective communication with each other, even in developed countries (Seyedin & Jamali, 2011). Therefore, the availability of an infrastructure that supports information sharing and communication is one vital and strategic component for realising efficiency and effectiveness in emergency management (Velev & Zlateva, 2012b; Carminati et al., 2011). For example, when a disaster occurs, telephone lines in disaster areas are overloaded with calls; however, detailed and real-time disaster information can be conveyed to government agencies by using cloud computing applications such as email services (Ardagh et al., 2012; Ambrust, et al., 2010). Even though the network may experience, usually temporary, interruption, the cloud applications can help organisations to maintain the business operation until the outage disappears (Armbrust et al., 2010).

The cloud storage continuously plays an important role in the response stage. Inoguchi et al. (2012) find that the Cloud-based Spatial Data Infrastructure was effectively used in storing and sharing maps and layers among central and local emergency authorities during the 2011 Great East Japan Earthquake. Important data can also be stored in Word and Excel documents online and shared when needed among multiple partners (Leidig & Teeuw, 2015; Ma et al., 2015). Since backup sites are geographically located, a regional disaster will not impact other backup sites that are not influenced by the disaster (Velev & Zlateva, 2012a).

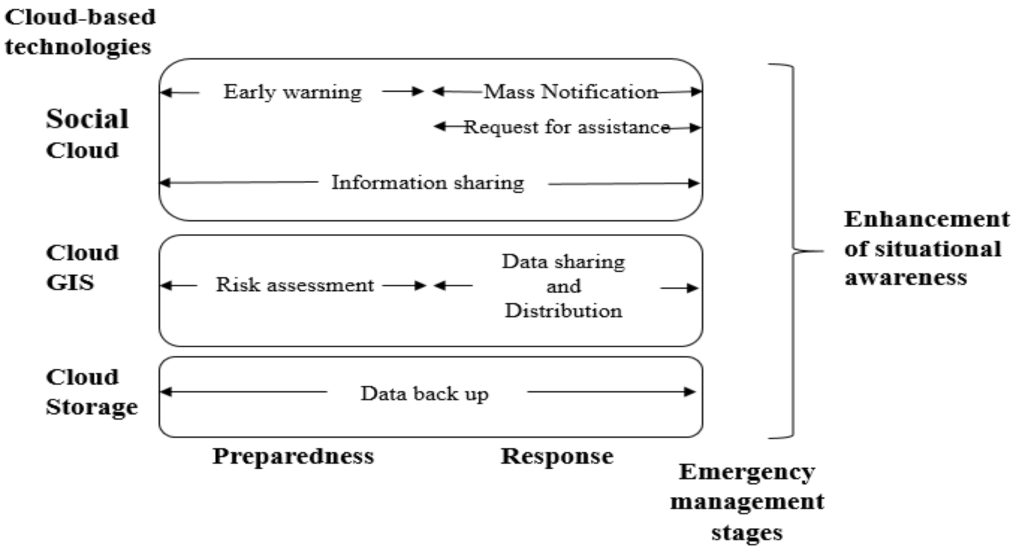
Therefore, cloud computing provides the advantage of creating copies of data and keeping them in synchronisation in multiple locations as the events evolve (Velev & Zlateva, 2012a; Li et al., 2013).

It is argued that in the response stage, one of the biggest challenges is the design of an effective GIS data management system which supports collaboration among different emergency partners in terms of sharing of relevant data (Radke et al., 2013; Sakuraba et al., 2013). The reason is that during an emergency, gaining access to up-to-date, reliable and relevant information from multiple partners is critical to first responders' actions in saving lives and ensuring the security of areas affected by major disaster events. However, multiple partners use multiple systems and technologies that do not support the exchange of essential information in the same data formats (Department of Homeland and Security, 2014). To solve this problem, a web-based platform, virtual USA, has been initiated by the US Department of Homeland Security in partnership with local agencies, which is designed to share GIS data in response to national extreme events across all state agencies (Radke et al., 2013). This system has been tested in terms of its inter-operability in a national level earthquake exercise in 2011 where it shows that all partners can interoperate successfully and share geospatial data in this system. In this way, the situational awareness level can be enhanced due to the real-time information integration during the events.

There is an increasing trend for using volunteered geographic information (VGI) in emergencies (Cinnamon & Schuurman, 2013). Some well-known examples include OpenStreetMap, Ushahidi, and RinkWatch, which function as a platform that encourages anyone in the public or non-official agencies to share relevant event information on the website through usable ways such as Short Message Service (SMS), e-mail or Facebook Twitter (Fast & Rinner, 2014; Roche et al., 2013). These tools are considered a novel source of geographic information that can be used by emergency organisations as complementary data in supporting decision-making (Fast & Rinner, 2014; Radke et al., 2013). For example, the Brisbane City Council established a crowd-sourced map on the Ushahidi platform through making a call for volunteers to help in responding to severe flooding from December 2010 to January 2011 (Awange & Kiema, 2013). Another example includes an online map-based application established by Hamilton County, Tennessee, in east central United States, which allows residents to report storm damage to their properties that creates an awareness of the overall situation of communities when events occur due to citizens' greater contribution to the geographic information (Radke et al., 2013). Therefore, these applications have become necessary tools for emergency management due to their capability to broadcast the near real-time situations on the ground (Cinnamon & Schuurman, 2013; Fast & Rinner, 2014; Roche et al., 2013).

With the growing usage of social networking and micro-blogging, such as Facebook or Twitter that are examples of SaaS, the general public actually has a high level of enthusiasm to publish emergency information (e.g., texts and photos) and has become part of a large response network (Kongthon et al., 2014; Li et al., 2013; Parsons et al., 2015). Through content analysis, Kongthon et al. (2014) find that Twitter was a particularly useful tool to obtain and disseminate "up-to-the-minute" information, including announcements of the flood situation, announcements of support, and request for assistance, by citizens in the worst 2011 Thailand flooding (p.10). Similarly, Parsons et al. (2015) through content analysis, find that Twitter was effectively used to create the situational awareness such as identifying the evacuation routes, a useful feature for the response phase. Additionally, social media deployed the use of SaaS model has the potential to augment public health communication (Merchant et al., 2011; Thackeray et al., 2012). It is common to see some disease spread when a natural disaster happens. Therefore, social media can be used to "inform, educate, and empower people about health issues and to enhance the speed at which communication is sent and received during public health emergencies or outbreaks" (Thackeray et al., 2012, p. 237). For example, web-based message boards produced by the American Red Cross have been used to share and receive information about suspected disaster casualties during recent emergencies (Merchant et al., 2011). This illustrates how social media provides a platform with push and pull strategy that offers opportunities for engaging both emergency organisations and citizens during emergencies.

Cloud computing is an advanced technology that can better facilitate the emergency service organisations in backing up important data and disaster planning in the preparedness stage as well as sharing stored data as required during events. Due to the real-time attribute of cloud computing, the flexible usage of social cloud and cloud GIS are particularly valuable in the preparedness and response stages. Hence, all the activities in the preparedness and response stages contribute to the understanding of the current situation, thus enhancing situational awareness and enabling the emergency management personnel to make decisions effectively. Based on the discussion of the possible applications of C-BT in the preparedness and response stages, a conceptual idea (Figure 2-5) is proposed to depict how situational awareness can be enhanced through various types of cloud-based technologies in these stages of the emergency management life cycle. This is a visual guide of this study in terms of understanding how C-BT could facilitate emergency services organisations to deal with natural emergencies in the two key stages with different focuses and providing the context for data collection.



(Note: The arrows define the different roles of the three types of C-BTs in a specified stage of the emergency management life cycle

Figure 2-5 Cloud-based technologies usage in preparedness and response stages of the emergency management life cycle

2.6 Theoretical Framework - The Diffusion of Innovation Theory

The previous sections have discussed the cloud computing characteristics and some well-known types of C-BTs that have been used in emergencies. Nevertheless, it is also significant to gain theoretical support at the organisational level, so it is necessary to examine how the organisations are adapting to the technology innovation in the environment of the business context (Haider & Pishdad, 2013). This research has a strong focus on social perspectives in which it investigates the emergency professions' perceptions regarding cloud-based systems usage in an emergency management context. Therefore, it is necessary to understand the factors that influence the emergency professionals' perceptions regarding the successful deployment of cloud-based technologies in emergency services organisations. Hence, Diffusion of Innovation (DOI) theory, as one of the most influential theoretical frameworks in examining the organisations' innovation adoption (Alhammadi & Eardley 2015; Lynn et al 2018; Oliveira et al., 2014), is drawn on and discussed in this section.

Rogers' (2003) Diffusion of Innovation (DOI) theory is a basic theory used to explain the diffusion process of a new technology. The theory explains how innovations are communicated through certain channels over time within a particular social system (Rogers, 2003). It describes the patterns of adoption, explains the mechanism of diffusion, and assists in predicting whether and how a new invention will be successful. This theory has been successfully used in many fields: agriculture (e.g., Aubert, Schroeder, & Grimaudo, 2012; Marra, Pannell, & Ghadim, 2003; Padel, 2001); public health (e.g., Dingfelder & Mandell, 2011; Nicol et al., 2014; Sanson-Fisher, 2004); and marketing (e.g., Scharl, Dickinger, & Murphy, 2005). Other fields include communication, criminal justice, and social work (Dingfelder et al., 2011).

In information system research, the diffusion of innovation theory was originally used to help explain individual consumer's innovation adoption behaviour (e.g., Chen, 2013; Dash & Tech, 2014; Emani et al., 2012), but recently it has been applied to research that investigates the innovation adoption inclination and decisions in organisations. For example, studies examining innovative technology adoption in organisations through DOI include user satisfaction of Enterprise Resource Planning (ERP) system (Hsu, Lai, & Weng, 2008), implementation success of ERP system (Bradford & Florin, 2003; Poba-Nzaou, Raymond, & Fabi, 2008), broadband adoption in small- and medium-sized enterprises (Oni & Papazafeiropoulou, 2014), and factors influencing e-learning system (Lee, Hsieh, & Hsu, 2011). The innovation in this research is identified as the cloud-based systems that would be utilised in the emergency management context.

An innovation is considered as “an idea, practice, or object that is perceived as new by an individual or other unit of adoption” (Rogers, 2003, p.12). Even though the definition of innovation is provided in a relatively simple way, the paradigm of DOI expansively involves theories that are both applicable to the adopter of an innovation and the attributes of the innovation (Wu et al., 2013). According to DOI theory, individuals vary in terms of their timing of adopting an innovative technology. Rogers (2003) classified individuals into five categories in their particular social system: innovators, early adopters, early majority, late majority and laggards, from the earliest to the latest adopters. Each category of adopters has different characteristics. However, this research does not aim to investigate the characteristics of a certain target population in terms of the adoption of an innovation since the research aims to discover the perceptions of the current usage of an innovation in organisations. Rogers’ (2003) innovation attributes are relevant to this research in understanding the emergency professionals’ perceptions of C-BT usage in the emergency services organisations since the attributes are perceived by the users of the C-BTs in emergency services organisations.

According to Rogers (2003), five perceived attributes of the innovation help explain the rate of adoption: 1) Relative advantage, 2) Compatibility, 3) Complexity, 4) Trialability, and 5) Observability. Previous empirical studies have acknowledged that these attributes are insightful in examining the organisations’ adoption of technology innovations (Luo et al., 2018; Senyo, Effah, & Addae, 2016; Wang et al., 2017). Table 2-9 presents previous studies that investigate the innovation attributes that influence the adoption of cloud computing.

Table 2-9 Innovation attributes influencing cloud computing adoption in prior research

Author	Research Method	Innovation Attributes	Context
Alharbi, Atkins, & Stanier (2016)	Survey	Relative advantage is more significant than compatibility in cloud computing adoption. Complexity is excluded after the reliability test.	Healthcare sector in Saudi Arabia
Al-Hujran et al. (2018)	Interview	Security, privacy, trust, compatibility and integration requirements influence cloud computing adoption	Developing country Jordan

Ali, Soar, Yong & McClymont (2015)	Interviews	Main factors identified as having significant role in influencing adoption of cloud services: relative advantage, compatibility, cost, technology readiness, competitive pressure	Municipal government in Australia
AlIsmaili, Li, He, Shen. (2016)	Interview	Critical factors affecting adoptions: security concerns, cost savings, and privacy due to geo-restrictions. Insignificant factors are complexity and competitive pressure	SMEs in Australia
Chong & Olesen (2017)	Meta-analysis approach	Relative advantage, compatibility, and complexity are all significant, along with other important attributes including technological readiness, IT infrastructure, perceived direct benefits, perceived indirect benefits, and perceived risks.	No specific industry: Eco-effectiveness Green IT adoption
Friedrich-Baasner, Fischer, & Winkelmann. (2018)	Interview	Influencing factors on adoption: security, handling of data, trust, privacy and security	SMEs in Germany
Gangwar et al. (2015)	Survey	Relative advantage positively influences perceived ease of use and perceived usefulness. Compatibility enhances perceived usefulness and perceived ease of use. Complexity has a negative impact on perceived usefulness and perceived ease of use.	Manufacturing, IT and finance sectors in India
Gutierrez et al. 2015	Survey	Relative advantage and compatibility were not supported to be major drivers of cloud computing adoption. Complexity was found to be a barrier to cloud adoption.	No specific industry: UK end-user organisations
Lian et al. (2014)	Survey	Relative advantage is perceived as insignificant. Data security and costs are perceived as the two most dominant factors, along with the complexity. Compatibility is not perceived as important for non-adopters.	Hospital industry in developing countries
Lynn et al. (2018)	Survey	Only organisational and human factors are significant, none of the attributes influence the adoption.	No specific industry: High performance computing
Oliveira et al. (2014)	Online questionnaire	Relative advantage and technology readiness are significant. Complexity and compatibility are not statistically significant.	Manufacturing & services sectors
Senarathna et al. (2018)	Online survey	Relative advantage, quality of service, and awareness of cloud are significant.	SMEs in Australia
Senyo, Effah, & Addae, (2016)	Survey	Relative advantage was found to be significant. Compatibility was insignificant.	No specific industry: Organisations in Ghana
Tashkandi & Al-Jabri, (2015)	Survey	Relative advantage, complexity and data concern were the most significant factors. Compatibility has not significant effect on cloud computing adoption.	Education

Wilson et al. (2015)	Survey	Compatibility and complexity are significant. No evidence shows relative advantage influence the adoption.	SMEs in India
Yang et al. (2015)	Survey	Compatibility is more important than relative advantage and simplicity.	SaaS adoption in Chinese SMEs
Yigitbasioglu (2015)	Interview	Adoption is subject to government promotion, industrial trend, IT cost management and improvement in IT agility, and internally depending on usability and institutionalised beliefs of firm executives	Medium to large accounting & information technology firms in Australia

Relative advantage refers to the degree to which an innovation is better if replacing the existing idea (Rogers, 2003). In other words, relative advantage is useful in examining whether the adoption of C-BTs can increase the relative operational advantages (Lian et al., 2014). It is claimed that cloud computing has the relative advantage over other technologies, especially in terms of the operational costs due to the lower cost of maintaining infrastructure, pay-per-use pricing mechanism and multi-tenancy architecture (Zhang et al., 2010; Sommer, 2013; Gangwa et al., 2015). Through utilising cloud computing, users in the organisations could gain the advantages of utilisation of shared resources and adjustment of the usage level and fees according to their needs (Anshari, Alas, & Guan et al., 2016; Botta et al., 2016). Hence, emergency professionals would be able to concentrate more on the emergency issues than the provision of IT resources. The flexibility is also an important advantage that the users can obtain from cloud computing due to its ubiquitous accessibility and mobility (Alismaili et al., 2016a; Gangwar et al., 2015; Gutierre et al., 2015). Emergency professionals can access the cloud-based systems with any smart devices as long as the Internet connection is available when managing emergencies.

Compatibility is associated with the degree to which an innovation is aligned with the social values, past experience and needs of potential users (Rogers, 2003). That is, it is more likely for the organisation to be more willing to take the advantages of cloud computing when the cloud-based platforms are aligned with their working practices, thus reducing the uncertainty of the technology usage (Gangwa et al., 2015; Lynn et al., 2018; Yang et al., 2015). It is argued that organisations might have unique systems for supporting their business performance so that it is critical for the organisations to consider the compatibility between the internal system and external cloud computing platform when migrating the internal systems (Gangwa et al., 2015; Lian et al., 2014). Similarly, emergency service organisations may also have their specialised internal systems. There is more likelihood for the emergency service organisations to move to external cloud when it is compatible with their internal systems.

Complexity is the degree to which an innovation is perceived to be difficult to understand and use (Rogers, 2003). It is argued that if the innovative technology is not easy to use, it will negatively impact the adoption of cloud computing (Gangwa et al., 2015). Consistent with this view, it is further argued that regardless of their size, there is a high possibility of causing problems for organisations when they perceive having more difficulties in utilising cloud-based systems than the existing systems or more complexity in integrating the cloud-based systems with the existing processes (Gutierrez et al., 2015; Luo et al., 2018). As a result, the users in the organisations would have more fear and lower confidence in accepting complicated systems (Gutierrez et al., 2015; Hassan et al., 2017). Therefore, the complexity of cloud-based systems might hinder the emergency professionals' C-BT deployment when managing emergencies.

Trialability is the degree to which an innovation is easy to experiment with, while *observability* represents the degree to which the benefits of an innovation are visible to a potential adopter (Rogers, 2003). It is acknowledged that these two attributes are not widely examined in technology innovation research (Hassan et al., 2017; Oliveira et al., 2014). Until recently, they have been incorporated into the studies of cloud computing adoption (Luo et al., 2018; Sabi et al., 2017; Sabi, Uzoka, & Mlay, 2018), but no evidence has shown the existence of the correlations between either trialability or observability and intention to use cloud computing. Therefore, the two attributes, trialability and observability, are not useful in understanding technology innovation adoption in the context of cloud computing.

Therefore, relative advantage, compatibility, and complexity are relevant to this research in understanding the reasons for emergency service organisations' C-BT deployment in natural emergencies. Even though all five attributes are argued to have an effect on the adoption of innovation, not each of these attributes can be applied to every situation (Hazen et al., 2012; Rogers, 2003; Wu et al., 2013). Therefore, it is necessary to choose the attributes that are important in the specific situation (Rogers, 2003). Among the five attributes, previous research argues that the relative advantage, compatibility and complexity are the main attributes that are frequently used in predicting the adoption of information technology innovation (Low et al., 2011; Nuseibeh, 2011; Hassan et al., 2017). They are also most relevant to the characteristics of cloud-based technologies. As noted earlier, cloud computing has a relative advantage over traditional IT solutions in terms of less investment in IT infrastructures. Further, the services are scalable while the end users and the organisations' existing information systems remain unchanged, which suggests that the cloud services will be compatible with the existing systems (Wu et al., 2013). In terms of complexity, cloud computing is relatively new to organisations with its disadvantages such as security issues. Complexity thus can act as an obstacle to the deployment of cloud-based technologies. According to the characteristics of cloud-based technologies, these three attributes are most pertinent to this research. Figure 2-6 presents the proposed conceptual idea regarding the factors that influence the emergency professionals' perceptions regarding C-BT deployment in emergency management.

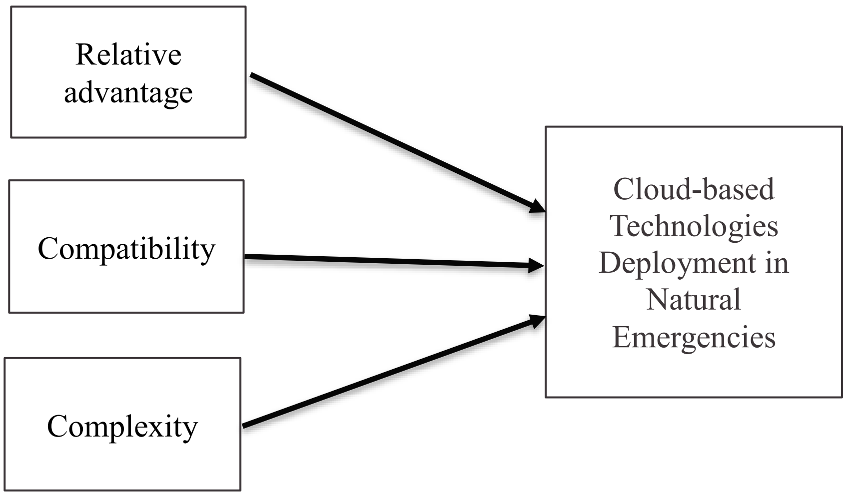


Figure 2-6 Factors influencing the emergency professionals' perceptions of cloud-based technology deployment in emergency services organisations through DOI

2.7 Chapter Summary

This chapter has presented the extant literature concerning information technologies in emergency management. The emerging technology, cloud computing, offers great potential in dealing with emergencies. Thus, how C-BTs can be applied in various stages of emergency management was discussed. Through the theoretical lens of Diffusion of Innovation (DOI) theory, a conceptual idea is proposed to understand the factors influencing emergency professionals' perceptions regarding C-BT deployment in emergency management. The next section presents the research gap and questions.

CHAPTER THREE - RESEARCH GAP AND QUESTIONS

Chapter Two reviewed the prior literature associated with the information systems in emergency management and the utilisation of C-BTs in two key stages of the emergency management life-cycle. Diffusion of Innovation, as the theoretical lens, was reviewed with empirical applications of the theory in examining the cloud computing adoption in different contexts. There is a lack of research investigating the cloud computing deployment in key stages of emergency management. This chapter discusses the gap identified to guide the research in this thesis.

The previous literature clearly shows that cloud computing offers strong potential to satisfy the emergency services organisations' needs in managing natural emergencies due to its characteristics of achieving economy of scale, ubiquity of access, scalability, and data backup and recovery. Therefore, it is able to facilitate emergency agencies to enhance preparedness for and response to the disasters by providing extensible data storage and data backup as well as enabling effective communication and information sharing. Recent research has shown an increasing interest in investigating cloud-based systems for managing natural emergencies (Bitam, Mellouk, & Zeadally, 2015; Chang, 2015; Hijji et al., 2013; Maléřová et al., 2014; Murase, Tanaka, & Naito, 2018; Palmier et al., 2016; Varatharajan, Manogaran, & Priyan, 2018); however, the vast majority of the research focuses on the conceptual architectural design of the system while the usage effectiveness in real emergencies has not been examined. Therefore, even though the previous research acknowledges that cloud computing significantly influences the computing world, the role that cloud computing plays in emergency management has not yet been explored fully by the existing sources (Yusoff, Abdullah, & Din, 2015). Thus, there has been a call for studies that examine the real usage of C-BTs in emergency services organisations (Jennings, Arlikatti & Andrew, 2015; Kuhnert et al., 2015).

A growing number of studies investigating the potential of cloud-based systems in emergency management have drawn attention to the utilisation of social media (e.g., Facebook, Twitter, YouTube etc.), which is a well-known public cloud. However, most of them explore social media from the perspective of user behaviour (e.g., Hughes & Palen, 2009; Sakaki, Okazaki, & Matsuo, 2010; Wong, Palaniappan & Hong, 2017). Other streams of studies focus on designing the architecture and measuring the performance of social media in enhancing situational awareness (e.g., Brynielsson, Johansson, & Lindquist, 2013; Yin et al., 2012; Halse et al., 2018), conducting post-disaster assessment (e.g., Graham et al., 2015; Guan & Chen, 2014), or considering the ethical and legal issues of social media usage in natural disasters (Rizza & Pereira, 2014; Batard et al., 2018). Therefore, research that investigates from an organisational perspective in terms of how C-BT is perceived valuable when deployed in emergency service organisations is scarce.

Although increasing attention has been paid to cloud computing adoption in various contexts, such as education (Tashkandi & Al-Jabri, 2015; Arpaci, 2017), healthcare (Lian et al ., 2014; Alharbi, Atkins, & Stanier, 2016), manufacturing and services (Gangwar et al., 2015; Oliveira et al., 2014), or developing countries (Al-Hujran et al., 2018; Senyo et al., 2016), empirical research on cloud computing adoption is still far from sufficient (Al-Hujran et al., 2018; Senarathna et al., 2018). On the other hand, there are an increasing number of studies focusing on the adoption of cloud computing in SMEs in different countries, such as Australia (Senarathna et al., 2018), Ireland (Doherty, Carcary, & Conway, 2015), China (Yang et al., 2015), and India (Shetty & Kumar, 2015; Wilson et al., 2015). Nevertheless, there is a lack of research conducted in the context of the emergency management sector even though the importance of technologies in emergency management has been acknowledged (Prasanna & Huggins, 2016). Previous research shows inconsistent results in terms of cloud computing adoption in different contexts so that results from one context may not be applicable to another. It is argued that there is a lack of a dominant model for discovering the adoption of cloud computing (Lynn et al., 2018). There has been a call for more studies on investigating the organisations' adoption or implementation of cloud computing in different contexts (Gangwar et al., 2015; Senyo et al., 2016). Hence, the investigation of the C-BTs usage perceptions in the emergency management sector is necessary since there is a lack of existing theory explaining the possible association between C-BTs deployment and emergency management.

Despite much of the previous research regarding the architecture design of cloud-based emergency management systems focusing on the response stage, which seems to be the most attractive stage (e.g., Aazam & Huh, 2015; Leidig & Teeuw, 2015; Li et al., 2013), it is argued that other phases of the emergency management lifecycle, especially the preparedness stage, might be similarly important (Hampton et al., 2017; Houston et al., 2015; Janssen et al., 2010). As discussed earlier, very limited research has been conducted to discover the perceived opportunity for C-BT deployment in emergency services organisations. There is even a lack of research investigating the C-BT usage in the preparedness stage in emergency services organisations. Among various cloud-based systems, attention has been paid mainly to the integration of social media usage in terms of early warnings for emergency situations (Finch et al., 2016; Simon, Goldberg, & Adini, 2015; Wendling, Radisch, & Jacobzone, 2013).

Most previous studies are quantitative in nature when investigating the organisations' adoption of cloud computing (e.g., Alismaili et al., 2016b; Oliveira et al., 2014; Prasanna & Huggins, 2016; Senyo et al., 2016; Senarathna et al., 2018; Tashkandi & Al-Jabri, 2015; Yang et al., 2015) while limited qualitative research has been conducted (e.g., Al-Hujran et al., 2018; Friedrich-Baasner et al., 2018). This is summarised in Table 2-9 in Chapter Two. There is a lack of qualitative research in exploring C-BT deployment in the context of emergency management as most of the empirical studies undertaken have utilised survey and testing the hypotheses established. There has been a call for employing a case study approach in investigating cloud computing usage in various contexts (Gangwar et al., 2015).

Thus, little is known in the field of emergency management about how C-BTs aid in the preparedness and response stages. As the result of the identified gap, this research addresses the following research questions:

1. *How could cloud-based technologies benefit emergency services organisations in the preparedness and response stages of natural emergencies?*
2. *What are the perceptions of emergency professionals on the usage of cloud-based technologies in the preparedness and response stages of natural emergencies in New Zealand?*

The next chapter presents the research design which was utilised to address the research questions.

CHAPTER FOUR - METHODOLOGY

This chapter presents the research design which forms the basis for conducting this research. This begins with a discussion of the research paradigm that the research fits within. Philosophical assumptions underpinning this qualitative research are then presented, followed by the justification for the research method. After the data collection methods and procedures are described, the limitations of the data collection methods are addressed. The chapter then discusses the data analysis strategy in terms of the multiple case analysis strategy and the process of utilising grounded theory in analysing the data. Finally, it outlines how issues of ethics and trustworthiness underlying this qualitative research are addressed.

4.1 Theoretical Foundations and Research Paradigms

The philosophical ideas of the researcher play an important role in influencing the practice of research, which needs to be identified, even though they exist covertly in the research (Creswell, 2009). These philosophical ideas are paradigms or worldviews that refer to a set of beliefs guiding the actions (Creswell, 2009; Lincoln & Guba, 2000). Through this set of propositions that give the explanations of how the world is understood, the researchers are able to perceive and know the complex real world in terms of its importance, legitimacy and rationale (Guba & Lincoln, 1994; Patton, 1990; Sarantakos, 2013). As such, a valid research, whether quantitative or qualitative, relies on the underlying assumptions that guide the appropriate research methods, which are important to know (Mayers, 1997).

The philosophical assumptions underlying the social research are guided by three fundamental factors: *ontology, epistemology and methodology* (Guba & Lincoln, 1994; Sarantakos, 2013). According to Sarantakos (2013), these three elements are put in a hierarchical order whereby the ontology sets up the building blocks for establishing the logic of epistemology, epistemology shapes the nature of the methodology, and methodology specifies the appropriate research design of the research methods and instruments. Figure 4-1 illustrates this.

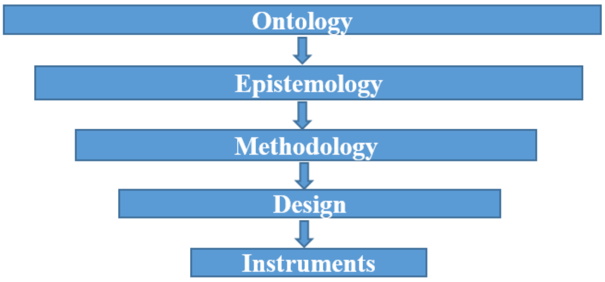


Figure 4-1 The foundations of social research

Source: Sarantakos (2013)

4.1.1 Ontology

Ontology is concerned with the nature of reality (Bryman & Bell, 2011; Sarantakos, 2013). The central question is whether social reality can be regarded as objective, existing external to the social actors, or something that can be produced from social actors' perceptions and actions (Bryman & Bell, 2011). Thus, the ontological questions ask "What is the form and nature of reality and therefore, what is there that can be known about it?" (Guba & Lincoln, 1994, p. 108). There are two common perspectives of ontology in social research: *objectivist and constructionist* (Bryman & Bell, 2011; Sarantakos, 2013). The objectivist ontological position assumes that the existence of universals is objective or absolute so that social phenomena are not reached or influenced by the social actor, which are external facts (Bryman & Bell, 2011; Burrell & Morgan, 1979; Sarantakos, 2013). Thereby, the reality exists independent of social actors' consciousness and experience. On the other hand, the constructionist ontology postulates that the objective reality does not exist whereby the meanings of social phenomena come out of social actors' interaction with the world instead of existing in a fixed way (Bryman & Bell, 2011; Gray, 2014; Sarantakos, 2013). Therefore, the truth and reality are dependent on social actors and the meanings are created through the social interaction in different ways.

4.1.2 Epistemology

Epistemology is associated with the nature of knowledge, thus informing researchers how to obtain knowledge in the social world (Myers, 1997; Sarantakos, 2013). The centrality of the epistemological issue is whether the social world can be studied in such a way that the same principles or procedures can be applied in the same and tangible way or whether it needs to be studied through personal experience (Bryman & Bell, 2011). The epistemological questions ask "What is the nature of the relationship between the knower or would-be knower and what can be known?" (Guba & Lincoln, 1994, p. 108). There are two main epistemological positions in social research: *positivism* (functionalism or empiricism), and *interpretivism* (symbolic interactionism or phenomenology). The positivist epistemology recommends that methods of natural sciences are applied to studying social reality, thus perceiving the reality as objective and putting emphasis on the observation and measurement of social phenomena (Bryman & Bell, 2011; Sarantakos, 2013). In contrast, the interpretivist position holds the view that it is necessary to respect the differences between social actors and the objects of the natural science; as a result, grasping the subjective meaning of social actors is necessary (Bryman & Bell, 2011). Epistemology offers a philosophical basis for determining the legitimacy and adequacy of certain types of knowledge (Gray, 2014). Consistent with this view, Easterby-Smith et al. (2002) argue that it is important to have epistemological stances for two reasons. First, it is helpful to illuminate the issues of research design as to where and what kind of evidence needs to be gathered, and in what way it is interpreted. (Easterby-Smith et al., 2002). Second, having an epistemological stance helps the researcher to identify the type of design that fits the research objectives (Easterby-Smith et al., 2002).

4.1.3 Methodology

Methodology relates to the nature of research design and methods (Bryman & Bell, 2011; Sarantakos, 2013). The methodological question asks "How can the inquirer (would be knower) go about finding out whatever he or she believes can be known?" (Guba & Lincoln, 1994, p. 108). It is aligned with the answers given to the questions of ontology and epistemology; thus, not any selected methodology is appropriate. There are two main types of methodology: *quantitative* and *qualitative* (Bryman & Bell, 2011; Guba & Lincoln, 1994; Sarantakos, 2013). The quantitative methodology takes scientific methods with an accurate, objective and neutral position (Bryman & Bell, 2011; Sarantakos, 2013). Differently, qualitative methodology emphasises that the social reality is perceived in a subjective way and employs an inquiry derived from real life and nature; thus, it centres on openness, reflexivity, detailed analysis and flexibility (Patton, 1990; Sarantakos, 2013). These two methodologies are further discussed in Section 4.2.

In short, the ontology incorporates the understanding of what reality is while epistemology attempts to make sense of the meaning of the knowledge (Gray, 2014). Paradigms are constructed based on the principle with the same nature in terms of ontology, epistemology and methodology, which prescribe the way research is conducted (Sarantakos, 2013). As mentioned earlier, a paradigm represents a researcher’s worldview which is the way that a researcher views knowledge and reality (Creswell, 2009; Guba & Lincoln, 1994). Much of the previous work has been conducted to classify paradigms in different but overlapping ways. For example, Burrell and Morgan (1979) suggest four paradigms: functionalist, interpretivist, radical humanist, and radical structuralist, and each of these paradigms identifies a unique social-scientific reality. Orlikowski and Baroudi (1991), supporting Chua (1986), suggest the classification of the research epistemology as positivist, interpretive and critical. Creswell (2009) classifies four paradigms: postpositivism, constructivism, advocacy/participatory, and pragmatism. With the availability of different theoretical perspectives, positivism and interpretivism are the most influential epistemological paradigms in social science (Gray, 2014). These are discussed below.

4.1.4 Positivist Paradigm

Positivism was the predominant epistemological paradigm in social science from the 1930s to the 1960s (Gray, 2014). The positivist paradigm holds a view of objectivist ontology and empiricist epistemology, which provides the direction of quantitative research strategies, and thus suggested fixed designs and quantitative methods (Sarantakos, 2013). In other words, positivist studies postulate the existence of a fixed relationship among variables of certain phenomena, which are normally examined through structured instruments (Orlikowski & Baroudi, 1991). Knowledge is gained through gathering the facts that provide the foundations for the regulations; therefore, the purpose of the positivist study is to generate hypotheses that can be tested (Bryman & Bell, 2011). Thus, the central argument of this paradigm is that the social world exists externally to the researcher. The positivist studies are looking for evidence. Further, there is the existence of post-positivism that is recognised as the criticism of positivism which challenges the conventional beliefs of the absolute truth of knowledge (Guba & Lincoln, 1994; Phillips & Burbules, 2000). Therefore, the knowledge gained through the post-positivist stance is on the basis of carefully observing and measuring the objective reality (Creswell, 2009).

4.1.5 Interpretivist Paradigm

Interpretivism, on the other hand, is a key anti-positivist point of view, "which looks for culturally derived and historically situated interpretations of the social life world" (Gray, 2014, p.21). Interpretivism is built on the basis of constructionist ontology, guiding the strategies of qualitative methodology and endorses flexible designs and qualitative methods (Sarantakos, 2013). Interpretivism asserts different types of methods are required due to the dissimilar nature of natural reality and social reality (Gray, 2014). Therefore, interpretivists assume that the social reality is accessed only through social constructions such as language and shared meanings, which is therefore not independent of social actors (Creswell, 2014; Muijs, 2010). Thus, this approach is concerned with understanding the nature of the social world at a level of subjective experience (Burrell & Morgan, 1979). There is an absence of predefined dependent and independent variables in the interpretivist approach, as it centres mainly on the complexity of human sense-making as circumstances appear (Myers, 1997).

4.2 Quantitative and Qualitative Research Methodology

In information systems (IS) research, the strategies that have been employed by researchers can be generally categorised into two types: quantitative and qualitative (Venkatesh, Brown & Bala, 2013). The fundamental difference between quantitative and qualitative research is the underlying worldviews and philosophies that have been discussed in Section 4.1. In other words, the decision of which approach should be used in a study is determined by the philosophical assumptions the researcher brings to the study.

The *quantitative researcher* normally asks, "How many instances of a certain kind are there here?" (Erickson, 2013, p. 89). Quantitative research is a research strategy that focuses on the testing of existing theories through the examination of the relationship among variables (Creswell, 2014). These variables can be measured through a typical instrument so that the data gathered can be analysed using a statistical procedure (Bryman & Bell, 2011; Creswell, 2014). The final findings in quantitative research are then generalised to a wider range of population (Morgan, 2014). Further, in quantitative research, the theory and concepts are tested in research (Bryman & Bell, 2011). Overall, the quantitative study emphasises quantitative data and positivist philosophy (Myers, 1997). Positivists generally assume that the social world exists in a comparatively concrete and empirical way so that the existence of social phenomena and their meaning is independent of social actors (Burrell & Morgan, 1979) and can be described by measurable properties (Myers, 1997). The positivist approach attempts to test theory to increase the understanding of phenomena in a predictive way (Myers, 1997). Consistent with the view above, Orlikowski and Baroudi (1991) categorise IS research as positivist if there was "an evidence of formal propositions, quantifiable measures of variables, hypothesis testing, and the drawing of inferences about a phenomenon from the sample to a stated population" (p.5). As a result, quantitative research employs empirical methods, pursues objectivity and value neutrality and asks for clarity in design and procedure (Sarantakos, 2013).

In contrast, the *qualitative researcher* seeks the answer of the question in terms of "What are the kinds of things, material and symbolic, to which people in this setting orient as they conduct everyday life?" (Erickson, 2013, p. 89) Therefore, qualitative research aims to seek to uncover and describe in a narrative way in the light of the action of a particular type of people and the meaning of the actions to them (Erickson, 2013). Thus, it is designed to help researchers understand the social and cultural phenomenon (Myers, 1997; Bryman & Bell, 2011). It is an approach for understanding the meaning and the context of the phenomena investigated, as well as the specific events and processes that constitute these phenomena over the course of time in the natural settings (Maxwell, 2005). Therefore, the qualitative research focuses on the contextual understanding of behaviour, values, and beliefs in the context studied (Bryman & Bell, 2011). In qualitative research, the researcher maintains a focus on acquiring the meaning of a problem or issue studied from the participant's point of view (Bryman & Bell, 2011; Creswell, 2014). Through learning the meaning of the phenomenon, the researcher can establish a set of themes. Thus, in qualitative research, the theory and concepts are emergent from data that have been collected by the researcher (Bryman & Bell, 2011). Therefore, qualitative research places emphasis on words and interpretivist philosophy (Myers, 1997). Table 4-1 contrasts quantitative and qualitative research.

Table 4-1 Differences between qualitative and quantitative research

Research elements	Qualitative	Quantitative
Setting	Natural	Laboratory/ Experiment
Data collected	Words	Numbers
Theory	Emergent from data	Testing hypothesis
Researcher: relation to research subject	Involved	Distant
Researcher: point of view	Participant	Observer
Use of results	Contextual understanding	Generalisation

Source: Bryman & Bell, (2011)

4.2.1 Rationales for Interpretivism and Qualitative Research

Based on the premise of the difference between qualitative and quantitative research, this research follows a *qualitative approach*, which fits within the *interpretivist paradigm*. The reasons for adopting an interpretive paradigm are discussed below and outlined in Table 4-2.

Table 4-2 Reasons for conducting qualitative research

Dimension	Qualitative	Quantitative	Current Study
Epistemological orientation	Interpretivism	Natural science model, in particular positivism	The researcher is not independent of any social actor
Ontological orientation	Constructivism: social phenomena and their meanings are constantly created by social actors	Objectivism: the world exists and is knowable as it really is	Beliefs in that the phenomenon of C-BTs usage in emergency service organisations and the meaning to the users is constructed by the perceptions and actions of people in those organisations.
Principle orientation to the role of	Inductive; generation	Deductive; testing of	Generating theories in the area of technology usage in

theory in relation to research	of theory	theory	emergency management

Source: Adapted from Bryman & Bell, (2011); Cohen, Manion, & Morrison, (2013)

First, the researcher emphasises the *epistemological view of an interpretivist* approach, which aims to interpret the subjective meaning of the social actors through language, symbols or text, as opposed to positivism that aims to seek the patterns and causal relationships between some variables by generating hypotheses and testing them. This research is proposed to explore the C-BT usage in enhancing emergency management capabilities through the understanding of how the users perceive and evaluate the cloud-based system and what meanings the system has for them in emergency management. Hence, the interpretive research is especially helpful in understanding "human thought and action in social and organisational contexts and has the potential to produce deep insights into information systems phenomena including the management of information systems" (Klein & Myers, 1999, p. 67). Therefore, the interpretivist approach provides the researcher with the opportunities to enhance the understanding of the importance of social and organisational issues in relation to the adaptation and adoption of the information systems in organisations or communities (Kaplan & Maxwell, 2005).

Second, the researcher holds the *ontological position of constructivism* which asserts that the social phenomena and their meanings are not pre-given but are constantly created by social actors (Bryman & Bell, 2011). The quantitative approach holds an antithetical position of objectivism which means that the researcher believes that the social phenomena have already existed out there which is independent of any social actor and regardless of how the researcher perceives them. In this study, the researcher believes that the phenomenon of C-BT usage in emergency service organisations and the meaning to the users does not objectively exist there, but is constructed by the perceptions and actions of people in those organisations. This is because the C-BT implementation experience is considered as being context-dependent so that such experience might be different according to an individual's distinctive interpretations and experiences. Therefore, constructivism rejects the view of objectivism and holds the view that truth and meaning do not exist in the external world, but are created through the participants' interactions with the world (Gray, 2014). Consistent with this view, it is argued that the usual ontological stance for an interpretive IS researcher is particularly with regard to the human interpretations and meanings associated with computer systems (Walsham, 1995).

As a result, an *inductive approach* is employed in the qualitative study (Bryman & Bell, 2011). Inductive approaches "primarily use detailed readings of raw data to derive concepts, themes, or a model through interpretations made from the raw data by an evaluator or researcher" (Thomas, 2006, p. 238). With an inductive stance, the theory is the outcome of research. In other words, the process of induction involves drawing generalizable inferences out of observations (Bryman & Bell, 2011). This study attempts to generate theories through building up patterns, categories and themes from the collected data, thus helping to improve knowledge advancement in the area of technology usage in emergency management. These reasons lead to the decision that the qualitative research method is most appropriate for this study.

The qualitative research methodology selected guides the decisions for employing the strategies of qualitative methods. The following section continues with the discussion of the research design which is important to address the research questions in discovering the influence of C-BTs in emergency management.

4.3 Qualitative Research Design

Qualitative research and quantitative research are conducted in different ways. However, both require researchers to carry out the research that follows a fundamental process, namely the research design, leading the researcher from the beginning until the end of the investigation. According to Creswell (2009), "research designs are plans and the procedures for research that span the decisions from broad assumptions to detailed methods of data collection and analysis" (p. 3). In this comprehensive plan, decisions are required to be made according to the worldviews and assumption that the researcher holds, and the specific nature of the research problems (Creswell, 2009; Gray, 2014). Since qualitative researchers make interpretations of what they have observed, heard, and understood due to the interpretive inquiry (Creswell, 2009; Sarantakos, 2013), the main qualitative research strategies include *narrative research, phenomenology, ethnography,* *action research, grounded theory, case study* (Bryman & Bell, 2011; Creswell, 2014; Gray, 2014).

Narrative research centres on the studies of individual's life and stories that are told chronologically, and finally views from both participants and researchers are combined to become a collaborative narrative (Creswell, 2009). Phenomenology, as a philosophy and a methodology, explores the intrinsic nature of human experiences relating to a phenomenon to see how people make sense with their everyday life in the world. Ethnography is viewed as a process of in-depth study of the culture within a group of people in a natural setting (Bryman & Bell, 2011; Creswell, 2009). Action research is an approach whereby the researcher and a client work collaboratively on a real problem within the client's organisation and develop a solution based on the problem. Grounded theory is a strategy that produces a theory that is grounded in the views from the participants. The final decision of choosing the type of research design depends on the research purpose. The current research was conducted on the basis of case study design since the main purpose is to gain an in-depth understanding of the phenomenon. Case study helps the researcher to achieve this through developing an in-depth analysis of a case.

4.3.1 Case Study Research

Various qualitative research designs are outlined in the previous section and the case study research is considered as most appropriate for this research as explained below. The reasons for conducting multiple case study are also discussed. Hence, the case study is chosen is considered as a valid research strategy within the IS research community (Klein & Myers, 1999). According to Walsham (1995), the in-depth case study is often the medium for conducting interpretive exploration requiring the researcher to visit a field site in a frequent and extensive manner over a period of time. The classification of various types of cases is discussed in the literature. For example, Stake (2005) claims that the case selection depends on the intent, including the intrinsic, instrumental or collective (multiple) case study. On the other hand, Creswell (2007) views the case study as a research methodology whereby a bounded system (i.e., a case), or multiple bounded systems (i.e., cases), are investigated by the researcher over time, which is similar to Benbasat, Goldstein, and Mead’s (1987) categorisation.

Rationale for Case Study Design

The case study method is appropriate for this research for a number of reasons. First, it is an appropriate way to investigate an area in which few prior studies have been conducted (Benbasat et al., 1987). Since cloud computing is an emerging technology, limited research has been conducted regarding its use in emergency services organisations. Therefore, it is believed that the case research strategy is suitable for capturing the knowledge of practitioners and creating theories through induction (Benbasat et al., 1987). Second, the case method enables the researcher to address the "how" and "why" questions, that is, to understand the nature and complexity of the processes taking place (Benbasat et al., 1987; Gray, 2014; Yin, 2014). This research not only proposes to identify what C-BTs could be used by emergency service organisations but also seeks to understand how people in these organisations perceive and make sense of what they do and why they think in that way. Third, the case study is useful when the phenomenon of interest needs to be conducted in a natural setting (Gray, 2014; Yin, 2009). This study aims to investigate the phenomenon of C-BT usage in real emergency organisations, which does not seek to manipulate relevant behaviours in a laboratory. Further, the case study is preferred when the purpose is to examine contemporary events (Benbasat et al., 1987; Gray, 2014; Yin, 2014). This study investigates the contemporary usage of C-BT in emergency services organisations.

The *multiple case study* approach is employed in this study. This approach allows the researcher to compare and contrast the findings obtained from each of the cases (Bryman & Bell, 2011; Yin, 2014). Yin (2003) argues that the multiple case study method enables the researcher to analyse the data within each situation and across situations simultaneously. This is the main difference between a single case study and a multiple case study: the differences and the similarities among the cases can be identified through studies of multiple cases (Stake, 1995; Yin, 2003). The multiple study method enables researchers to see what is distinctive and what is common among different cases and therefore “promotes the theoretical reflection on the findings” (Bryman & Bell, 2011, p. 63). This study aims to build a theory that is grounded in the data (Benbasat et al., 1987). The study is considered to be more robust when utilizing multiple cases, producing a more convincing theory (Eisenhardt & Graebner, 2007; Yin, 2003).

Unit of Analysis

In case study research, it is important for the researcher to decide the most appropriate unit of analysis for the study before searching for the sites (Benbasat et al., 1987; Yin, 2003). This is because a unit of analysis helps the researcher to clarify the phenomena studied and the research problem under investigation, as well as which data is to be collected and analysed (Collis & Hussey, 2003**).** Thus, a single unit of analysis can be an individual, a group of people, an organisation, an event, or even a process (Benbasat et al., 1987; Collis & Hussey, 2003). In determining the unit of analysis, the researcher should examine the research questions to be addressed since the research question provides an indication of an appropriate unit of analysis (Benbasat et al., 1987; Yin, 2003).

The focus of this study is on the perceived value of C-BT usage in different emergency management organisations through understanding emergency management professionals' perceptions regarding C-BT usage in natural emergencies. Therefore, the unit of analysis is the emergency service organisation. Through analysing the perceived value of C-BT in different emergency service organisations when dealing with natural emergencies, it can make a contribution to a better understanding and acceptance of IT opportunities in emergency service organisations.

Case Selection

The *criteria* for selecting the cases are discussed in this section. It is argued that the case selection needs to be considered according to the nature of the topic (Benbasat et al., 1987). The focus of this study is the important role that C-BTs play in dealing with natural emergencies in New Zealand. Thus, the selection of cases was made purposively by targeting organisations within the emergency service sector in New Zealand. Further, emergency in this research is characterised as natural emergencies with high unpredictability, resulting in large impacts on physical damage and casualties. Therefore, the chosen organisations are considered to be equipped with information technologies to cope with large-scale and unexpected situations. It is advocated that the characteristics of the organisations be considered when conducting research of phenomena on an organisational level (Benbasat et al.1987). Therefore, the researcher searched for possible organisations. A total of 31 organisations were found and classified as government, not-for-profit, and research organisations, in the emergency service sector in New Zealand. Since the research focuses on C-BT usage both in the preparedness and response stage, the selected organisations need to be involved in both of these two stages in natural emergencies. As a result, organisations which do not engage in these stages were not taken into consideration. For example, the organisations that only focus on the mitigation stage and volunteer organisations that only focus on the recovery stage were not considered.

The organisations selected were contacted in various ways: a posted letter, email, and phone call. The researcher tried to contact as many organisations as possible during the process of contact. Although it is difficult to set an ideal number of cases, it is suggested that between four and ten cases generally works well (Eisenhardt, 1989), as with fewer than four cases, it is difficult to generate theory "with much complexity and the empirical underpinning is likely to be unconvincing unless there are several sub-cases within them" (Gray, 2014, p. 271). With more than ten cases the volume of data can quickly become overwhelming. According to Creswell (2007), it is also necessary to approach accessible cases. As a result, the multiple case study included six key emergency services organisations, which are either government or not-for-profit organisations, in New Zealand emergency service sector. To preserve the anonymity of these organisations, they are known by pseudonyms in this research as CNS, PNS, FNS, JNS, HNS and RNS.

4.4 Data Collection Method: Interviews, Focus Groups and Observations

Qualitative methods can be categorised into three types of data collection: in-depth, open-ended interviews; observations; and written documents (Patten, 1990). Various methods can be adopted: observations, interviews, focus groups, and document perusal. While researchers can use any method to answer different research questions, they cannot choose the methods randomly (Hartas, 2010). There is no perfect research method because all methods have weaknesses. The choice of research methods is guided by the aim of answering the research question and the feasibility of accessing the resources and participants (Hartas, 2010; Walter, 2013). For conducting a case study, Yin (2003) suggests six commonly used sources of evidence in conducting case studies are documentation, archival records, interview, direct observation, participant-observation, and physical artefacts. Documentation was considered by the researcher. However, this is not desirable for this research for several reasons. It is argued by Bailey (2008) and Yin (2003) that many documents initially are not written for research purposes, but with particular purposes for the particular audience. Thus, the different goals and purposes for which the documents are created can make researchers biased in different ways (Bailey, 2008). The selection of the documents can be biased if the particular collection of the documents is incomplete (Bailey, 2008; Creswell, 2014; Yin, 2003), and the access to the documents may be obstructed (Yin, 2003). It is also argued that case study emphasises collecting up-to-date information (Gray, 2014). Since the research investigates the current C-BT deployment in emergency services organisations, more up-to-date information can be gained through data collection methods such as interviews, focus groups and observations.

Yin (2003) also highlights that no single source is completely superior to every other source. A good case study will require using many sources since they are highly complementary (Yin, 2003). Triangulation, the use of multiple sources of evidence in order to corroborate the same fact or phenomenon, is important in the case study (Yin, 2009; Bryman & Bell, 2011). Therefore, data collection in this research used multiple sources. Interviews were the main method supported by observations and focus groups. Each of these data collection methods is delineated below. The advantages and disadvantages of the data collection methods are outlined in Table 4- 3 and discussed in the following sections.

Table 4-3 Advantages and disadvantages of data collection methods

Methods	Advantages	Disadvantages
Interview	•Flexibility •Nonverbal behaviour •Control over environment	•Social desirability issue •Costly & time-consuming •Interview bias
Focus Group	•Flexibility •Stimulation of new ideas	•Less control over processes •Lack of privacy •Bias •Difficulty of transcribing, coding & analysing •Difficulty of organising
Observation	•Non-verbal behaviour •First-hand experience •Discovery of unusual aspects	•Intrusive feelings •Difficulties of gaining entry •Time-consuming

4.4.1 Interview

Interviewing is the *primary data* collection method for this study. The interview is the most important data source in case studies, as it enables researchers to access the interpretations and views that participants have with regard to the actions and events which are taking place (Walsham, 1995). It also allows researchers to "step back and examine the interpretations of their fellow participants in some detail" (Walsham, 1995, p.78). According to Arksey and Knight (1999) and Patton (2002), interviewing enables the researcher to capture the multiple perspectives of the participants in terms of their experiences, perceptions, and stories that one cannot understand directly through observing. In other words, the researcher focuses more on what the participants think than what they do. Through interview, the researcher will be able to better understand the perceptions of the participants in terms of the related issues of the C-BT usage in emergency services organisations. Therefore, the interview is the main data collection method in this research.

The *semi-structured interview* was chosen in this research. There are three major types of interviews: structured, semi-structured and unstructured (Hartas, 2010; Bryman & Bell, 2011). In a structured interview, the interviewers are supposed to ask pre-defined questions sequentially, following what is prepared on the agenda (Bryman & Bell, 2011). When using structured interviews, the researcher is not able to get rich and detailed answers from the participants, which is not in line with what the qualitative study pursues. Thus, the structured interview is frequently used in the quantitative study. In unstructured interviews, the researcher uses a very brief guide, which are often informal questions that cover a certain range of topics (Bryman & Bell, 2011).

Different from structured or unstructured interviews, in the semi-structured interview, the interviewer has questions in a general form and may not have to follow the schedule as listed (Bryman & Bell, 2011). It is typically associated with qualitative research, as it is more flexible and can involve further probing questions in response to respondents' replies (Hartas, 2010; Bryman & Bell, 2011). The researcher can also repeat questions when the respondents indicate any misunderstanding during the interview (Bailey, 2008). As a result, the face-to-face semi-structured interviews were conducted. Unlike the telephone interview, the face-to-face interview allows the researcher simultaneously to observe the non-verbal cues while listening to the participants (Hofisi, Hofisi, & Mago, 2014). With the in-person interview, the researcher is more able to control the scene, such as protecting the participants' privacy and making sure there is no noise, which cannot be achieved in telephone interviews or mailed questionnaires (Bailey, 2008).

4.4.2 Focus Group

The *focus group* is one of the multiple sources that is employed in this study. Focus groups have been used as a common tool in market research and are increasingly deployed in social science research (Bryman & Bell, 2011; Carey & Asbury, 2012; Gray, 2014; Hennink, 2014) which is usually associated with the qualitative design. It is a form of interview that is conducted with groups of participants with the goal of drawing out information regarding the participants' views (Gray, 2014; Hartas, 2010). Specifically, focus groups are designed to take the advantage of the interaction among the group members, thus enhancing the "collection of deep, strongly held beliefs and perspectives" (Carey & Asbury, 2012, p.17). Therefore, it is conducted in a very different way from an in-depth interview; it emphasises the collective environment for interactions between group participants to generate data (Ritchie, Lewis, Nicholls, & Ormston, 2014). There are several reasons for conducting focus groups in this research. First, it is argued that a focus group is particularly useful when new topics are explored and complex issues are examined (Carey & Asbury, 2012). Since this research aims to investigate the C-BT usage perceptions within the emergency management sector in both preparedness and response stages, which has been rarely examined by previous research, it is a relatively new topic in the emergency management area. Therefore, the explanation of the C-BT usage perception informing the action is needed since there is a lack of instruments on hand to study the question (Carey & Asbury, 2012).

In addition, the purpose of the focus group is to make participants interact and discuss with each other within the group (Gray, 2014). In other words, the researcher will be interested in how people respond to others' views and establish a view through the interactions within the group (Bryman & Bell, 2011). As a result, one significant advantage of the focus group is that it allows diverse point of views to emerge and the stimulation of new perspectives to take place (Gray, 2014). The group dynamics could stimulate participants to think deeply about the topics (Hartas, 2010). This is also the reason why focus groups can be used to overcome the limitation of traditional one-to-one interviews in which the participant can be restrained in responses or easily led by the interviewer, thus responding in a particular way (Hennink, 2014; Ritchie et al., 2014). Therefore, focus groups act as a non-directive interview method whereby the interviewer plays a minimal role and pursues the group dynamics in information gathering (Hennink, 2014; Rabiee, 2004). Thus, the selective use of focus groups was proposed to gather various views within groups of people in different emergency service organisations regarding the usage perception of C-BT in natural emergencies. The recruitment process followed the approved ethical application where the informed consent was collected before conducting the focus group and reinforced during the beginning of the group discussion.

Group Size and Composition

It is necessary to decide on the right number of participants for a focus group in order to generate a discussion with enough people while not having too many people who might feel that they are forced out of the discussion (Morgan & Scannell, 1998). Krueger and Casey (2015) suggest that it is ideal to have 10 to 12 people for market research but five to eight people for non-commercial topics. In this research, each focus group consisted of an average of four people, and the duration was between 45 and 60 minutes. Even though it is argued that a small group, less than six people, may limit the diversity of experience shared (Hennink, 2014), it is reasonable to include four people in each group for several reasons. The size of the focus group is determined by the research purpose. It is asserted that it is usually best to organise smaller groups, which also can be called mini-focus groups, with four to six people when the research aims to understand people's experiences (Krueger & Casey, 2015). In this research, the aim was to gain an in-depth understanding of the participants' perceptions of utilising C-BTs in natural emergencies, which requires them to describe their experiences intensively. Therefore, a mini-focus group with four to five people is preferable so that the researcher can gain more in-depth insights into the perceived C-BT usage in natural emergencies. Further, it is argued that when the topic is complex, which in this case is the perceptions of C-BTs utilisation in emergency management, the smaller groups are recommended (Krueger & Casey, 2015; Morgan & Scannell, 1998). Sometimes, a smaller group might be the only choice due to the recruitment restrictions, such as the lack of eligible participants, or the difficulties in organising people to attend at a certain time (Morgan & Scannell, 1998). In this research, the researcher encountered both of these problems. First, only people who have a certain level of knowledge of, or require to use, C-BTs in emergencies were selected. Second, due to busy shifts among employees in emergency services organisations and the characteristic of their jobs that requires them to conduct services outside of the organisations, it is less straightforward to organise groups with more than six people. Therefore, a group of four people is acceptable.

The *group composition* influences the focus group discussion greatly, thereby requiring to be considered carefully (Hennink, 2014). Hennink suggested two characteristics of a focus group to produce a more positive environment: the participants are a homogenous group, and they are acquainted with each other. Members of focus groups are more willing to share their opinions and experience with people who are considered similar to them, such as their status and knowledge. Therefore, homogeneity can contribute to better quality data because it helps to create an environment for open, productive discussion (Hennink, 2014). The level of acquaintance between participants can also influence group participation. The advantage of recruiting a group of acquaintances is that less time is needed to build group rapport because participants are already familiar with one another. As a result, other members will be more willing to complement the points that other members have raised, enhancing the information accuracy and depth (Hennink, 2014). Due to the busy workload of employees in emergency service organisations, it was not possible to satisfy both aspects at the same time. For example, some focus group included more participants at the management level than at the operational level within the group (see attached list of focus group constitution in Appendix D). Nevertheless, the researcher tried to organise participants who held similar positions within the same organisations as much as possible. The second aspect was met as all participants within the group were acquainted with each other, being from the same organisation. They were professionals (such as system usage advisors, emergency planning advisors, response team members) from an emergency management background in each organisation.

4.4.3 Observation

Non-participant observation is employed in this research. According to Patton (1990), there are limitations to what people say as the major source of qualitative data that is gained through an interview, written documents or survey responses. Therefore, observations are a good way for researchers to fully understand the complexities of many situations (Patton, 1990). The observation method has been a profound method in ethnography since ethnography studies require the researcher to understand the cultural norms of communities or groups through immersing themselves in the settings (Ritchie et al., 2014). In addition to the use of observation in ethnography, it can be used as a non-central method in other sociological studies. There are two main forms of observation: participant and non-participant (Bailey, 2008; Flick, 2014). Participant observation is primarily associated with qualitative research in which the observer immerses himself or herself in a social setting in order to observe the behaviour of that group or community (Bryman & Bell, 2011). In non-participant observation, the observer observes others but without interaction and participation in the social settings (Bryman & Bell, 2011). Participant observation is applied more frequently in ethnographies while this research conducts the case study that does not require the researcher to immerse herself deeply in the context. Therefore, the non-participant observation method was chosen.

The non-participant observations of emergency exercises were conducted with several different emergency services organisations. Through observations, the researcher was able to gain an insight into the use and application of C-BT in emergency management in the near real-life situations. As a result, the researcher could understand how and why people perceive C-BTs as being useful in their organisations. This is aligned with the argument that observation can help researchers to gather first-hand data on behaviours or processes, and uncover issues and problems which might not yet be known or realised by participants themselves (Lofland & Lofland, 1995; Creswell, 2009). Also, observation enables the researcher to gain an insight into the phenomenon of interest that exceeds what is conveyed in verbal communications (Ritchie et al., 2014). As a result, observations help researchers to understand what might be missed when using other forms of data collection methods (Ritchie et al., 2014). As such, the researcher was able to understand the phenomenon of C-BT usage perception in natural emergencies with a more concrete sense rather than relying only on what was told by the participants.

During the observation, notes were made according to some guiding questions considered beforehand, such as What kind of C-BTs are used during the drill? and Do all technologies function well? This was guided by Creswell (2007) in which two columns with the labels of Descriptive Notes and Reflective Notes were established in the notebook. This approach is similar to Ritchie et al.'s (2014) guideline whereby the detailed descriptions, analytical notes and subjective reflections were the key elements for the filed notes. The researcher wrote down anything that was not clear during the drills or meetings and asked the relevant person later on. Notes of the observations were collated immediately after the exercise finished. It is claimed that making fieldnotes is a common method in observations, but the analysis based on the available data will be constrained by what was taken down (Ritchie et al., 2014). However, observation in this multi-method research is not the primary data source. Observations are used to understand the physical context of cloud-based system usage during emergencies in emergency services organisations, thus gaining some sense of how something described in the interviews was performed in practice, and to verify what was said in interviews (Ritchie et al., 2014). Hence, the disadvantage of relying solely on fieldnotes can be minimised.

4.4.4 Procedures for data collection

Interview procedure

Based on the list of potential organisations to be interviewed, the researcher started with composing an official invitation letter to the first organisation on the list, one which plays a leading role in natural emergencies in New Zealand. Fortunately, the researcher received the reply with approval within several days and then arranged the meeting for the interview immediately. The rest of the participants in various organisations were contacted through emails or phone calls. A relationship was established either through various participants' introduction of the researcher to the participants with the same position in other organisations or by researcher herself checking available contact details online. The research, a multiple case study, consists of six cases: four government organisations and two not-for-profit organisations in the New Zealand emergency service sector.

The opportunities for conducting focus groups and exercise observations were also sought at the end of each interview. The arrangements of focus groups and observations were able to be made after interviews. The data collection, involving the interviews, focus groups and observations, occurred from 2 September 2015 to 31 August 2016. It took time to wait for the participants' reply after invitations as the job characteristics of managing emergencies meant they were often quite busy with meetings and business trips around New Zealand and overseas. There was a period of idle time where no exercises or participants were available to be observed or interviewed during Christmas and New Year. Nevertheless, the first four interviews in four different organisations before Christmas established a basis for the following data collection activities. The data collection started again in March 2016 and finished in August 2016.

Interviews were conducted within selected organisations in person and digitally recorded. Both government and not-for-profit emergency services organisations were visited. Open-ended questions were asked during each interview. The general aspects of the questions for the semi-structured interviews include 'What are the primary cloud-based systems that are currently used in your organisation?'

and ‘How are these technologies helpful in enhancing emergency management capabilities?’ (see Appendix A for interview questions). Probing questions were asked for further explanation and clarification through asking, ‘Can you explain further about…?’ or ‘Do you mean that…?’ This was employed when respondents provided answers that are incomplete (Sarantakos, 2013)

The participants were professionals working at both managerial and operational levels in the emergency service organisation. The selected participants were all senior employees in organisations within the New Zealand emergency management sector. The senior managers and operational staff are most likely to have knowledge and opinions around the use of C-BT in emergency situations, so were the most appropriate persons to be interviewed. The length of each interview was between 45 minutes and two hours. All participants were informed that the interviews would be recorded and were provided with the information sheet and consent form (see Appendix C) before each interview started. All data collection was undertaken only after final ethical approval was obtained.

In total, *29 semi-structured interviews* were conducted (See Appendix D for the list of participants). It is argued that it is challenging to make the decisions on the number of participants since there is no fixed guideline for predetermining the exact number of interviews to be conducted in a qualitative study (Beitin, 2012; Marshall et al., 2013). For example, Morse (2015) suggests 30-60 participants for semi-structured interviews while Creswell (2007) endorses, for case studies, four or five cases with three to five participants for each case. However, there is a lack of explanation for the rationale of such recommendations when those qualitative methodologists provide numbers for the sample size (Marshall et al., 2013). Therefore, the number of interviews in this research was not pre-determined, instead, it was based on the concept of theoretical saturation where the researcher finds that no new or relevant data appear to constitute a category during the ongoing process of sampling (Bryman & Bell, 2011). The termination of the data collection also relates to the consideration of time constraints and the availability of participants. Therefore, the final number of the interviews is believed to meet the purpose of this qualitative study in identifying the perceived value of C-BTs in the emergency management field.

Focus Group Procedure

It is suggested that there is a higher possibility for people to agree to participate in the focus group if they are invited by someone they know (Krueger & Casey, 2015). Krueger and Casey further claim that it is more effective to ask the person who is at a high level within the organisation to make the initial contact since the weight and the status of the position convey the importance of the study. Therefore, the researcher asked the interviewees who were at a higher management level to help her to approach the potential participants for the focus groups and sent follow-up invitations to the potential participants of each organisation. According to Gray (2014), one of the aims of qualitative research is to "achieve a degree of data saturation, a point where the last focus group does not provide or promise new knowledge" (p.485). Hence, it is suggested that three or four focus groups are necessary for the research design (Gray, 2014). *Three focus groups* (See Appendix D for the list of focus group members) were conducted respectively in three organisations since busy workloads did not allow for undertaking focus groups in the other three organisations. All of the focus groups sessions were digitally recorded and notes were also made. A focus group can be used either before, after or in combination with an interview (Ritchie et al., 2014). In this research, focus groups were conducted after the in-depth interview, because it can help the researcher to gain a good understanding of the policies and process of a particular emergency service organisation before a focus group is conducted, which is more complex than interviews with individuals. Under the guidance of a facilitator/moderator who runs the focus group, participants are motivated to discuss "their opinions, reactions and feelings about a product, service, type situation or concept" (Collis & Hussey, 2003, p.166).

The researcher herself acted as the moderator and no assistant was recruited since it is time-consuming to find an appropriate person and conduct training even though it placed the burden on researcher herself in terms of taking down notes while facilitating the session. It is advocated that it is necessary to prepare a discussion guide which lists the topics and actual questions that the moderator will ask during the group discussion (Hennink, 2014). The main purpose of the guide is to remind the moderator of the questions to be covered to meet the objectives and what to do next during the sessions. All focus groups follow a guide which was developed beforehand (see Appendix A for focus group questions). Table 4-4 shows the main stages that the focus groups followed.

Table 4-4 Stages of focus groups

	Stages	Things to do
1.	Scene-setting & ground rules	Informing participants about the research topic: seeking their perceptions regarding the C-BTs
2.	Individual introduction	Everyone was asked to introduce themselves in terms of their position and how long have been with the position.
3.	Opening topic	A general and neutral opening was made by asking about the types of natural disaster which have been encountered to familiarise participants with the context.
4.	Discussion	The main body of the focus group, with key issued discussed: usage of C-BTs in preparedness and response stage.
5.	Ending discussion	Signal was provided in advance that the discussion was coming to an end. General final points were provided before ending the discussion, letting them know what will happen next and thanking them for their contribution.

Source: Adapted from Ritchie et al., (2014)

Observation procedure

The observation procedure followed several steps. First, the researcher checked the appropriate upcoming exercises through all emergency service organisations' official websites as well as directly asking the emergency professionals who were interviewed. Once the exercise was identified, the researcher contacted the relevant personnel through email to check the possibility of participating in the exercise as an observer. After the consent of the participation was gained, the researcher started to get familiar with the scenario, participation organisations, objectives and major players. Finally, the researcher made arrangements to get to the field to observe the exercises. The observations made are summarised in the following sections.

In total, *five observations* (See Appendix D for the list of observations) were conducted: simulated scenarios of two major earthquakes, one tsunami, one hazard substance explosion and one geothermal eruption. Table 4-5 presents a summary of observed emergency exercises. Four of the observed exercises were classified as functional and one of training was mainly a table-top discussion with some computer simulation. Among all of the exercises, there were two multi-agency exercises led by CNS, two led by FNS, and one led by RNS. The details and duration of each exercise observation varied (see Appendix B for separate descriptions). Discussions of the observation results are included in Chapter Five, where both within-case and cross-case analysis integrated the phenomena observed in those exercises with interviews and focus group results where necessary.

Table 4-5 Summary of observations in emergency services organisations

Exercise	Simulated Event	Exercise Type	Aim	Agencies Observed
Earthquake	Magnitude 7.0 earthquake in one region	Functional	To practice the coordination and implementation of a multi-agency response in a significant earthquake scenario	CNS as the leading agency with other supportive agencies FNS, PNS, HNS, JNS
Hazard substance explosion	General Hazard substances explosion	Table-top & computer simulation	To understand and reinforce the importance of situational awareness and dynamic risk assessment on the fire ground	FNS
Earthquake	Magnitude 7.2 earthquake in one district	Functional	To practise the collection of information on rapid disaster risk assessments right after the earthquake occurs and analysis by the control centre to prioritise the resources in the best possible way	FNS
Tsunami	A regional source tsunami affecting the entire New Zealand coastline	Functional	To test New Zealand's arrangements for preparing for, responding to, and recovering from a national tsunami impact	CNS as the leading agency with other supportive agencies FNS, PNS, HNS, JNS
Geothermal Eruption	A geothermal eruption due to increasing lake temperature: land tremors in one district	Functional	To cement the skills taught and test teams responding to relevant support service scenarios in natural emergencies	RNS

4.5 Treating Limitations of Data Collection Methods

All research methods have limitations so that the interview, focus group and observation have no exception. Although interviews offer many advantages such as flexibility, observation of non-verbal behaviour and control over the environment (Bailey, 2008; Creswell, 2014), there are also disadvantages. For example, threats to the trustworthiness of the interview data can emerge because of a social desirability issue (Bryman & Bell, 2011; Hartas, 2010). That is, participants are generally more likely to respond in a way that they think would be more acceptable so that they might not provide accurate or honest answers to the questions (Hartas, 2010). This is avoided by assuring the anonymity of the participants and careful word choice of the questions. The participants were told that the identities of all the participants and organisations will not be identifiable in the thesis. Second, even though the interviewer makes sure that the instructions and questions of the interview have been introduced to the responders, there are still possibilities for both parties to have misunderstandings (Bailey, 2008). This issue may challenge the researcher to legitimately make interpretations of the responses (Bailey, 2008; Hartas, 2010). This was counteracted by providing detailed information as much as the researcher could to avoid misunderstandings. For example, some of the participants were confused about the notion of cloud computing. The researcher realised this immediately during the interview and made a further explanation to the participants. Interviews can be both costly and time-consuming due to the time spent for doing transcription and the problem that the respondents are geographically dispersed and the need for follow up interviews (Miller & Brewer, 2003). Although it was time-consuming to do interviews geographically, engaging with the participants' practical working environment enhanced the researcher's understanding of the statements made by the participants. For example, when referring to some technical word of a particular C-BT name, the researcher might not be able to understand the meaning immediately. However, during the interview, the researcher was shown around to see the real technology on-site and how it worked to advance her understanding of such usage in the emergency management context.

Despite the advantages, the focus group has a number of disadvantages. For example, there is a lack of privacy in this type of interview so that the participants may be afraid of giving a response to sensitive questions (Bailey, 2008). This is avoided by focusing on asking relevant questions in terms of C-BT usage rather than private questions which were not the focus of the research. The focus group questions were also reviewed by the supervisor panel to ensure their relevance. Moreover, the facilitator may not be able to have as much control over the processes and consequences as in an individual interview (Gray, 2014). Thus, the imbalance of providing opinions among different participants will occur and conflicts may appear that are difficult to manage (Gray, 2014). This is so when there are more than six members in the focus group discussion. However, there were fewer than five participants in each group and no conflicts took place. Further, it is argued that a focus group can be especially effective when dealing with issues of power or culture as well as when the aim is to discover the extent of consensus on certain subjects (Gray, 2014). However, this research does not seek to explore any issue associated with power or culture. Additionally, it is difficult to organise the focus groups because the researcher not only needs to ensure all the people agree to participate in the study but is also required to persuade them to appear at a specific time (Bryman & Bell, 2011). This was the challenge that the researcher encountered in this study. Therefore, it was not viable to conduct a focus group in each of the six case organisations. Also, the recording of interviews where a large number of people are talking (sometimes simultaneously) poses a major challenge for transcription and data analysis where it is considered important to attribute particular comments to individuals (Hartas, 2010). This was handled before each focus group started. The researcher reminded the focus group members to respect others through avoiding interruption as much as they could.

In terms of observation, there are some drawbacks to this method. For example, participants may consider it intrusive and, therefore, might feel more nervous and stressed than they usually are. This is because people might adjust their behaviours when they know they are being observed (Bryman & Bell, 2011). This was avoided by keeping a certain distance when the researcher was observing and taking notes. Also, the researcher did not ask the participants any questions during the exercises in order to observe their authentic behaviour. The researcher needs to invest heavily in time effort and obtain sound skills and resources of the observation so that the same subject can be observed for several times to ensure reliability (Muijs, 2010). Although the researcher was new in conducting observations, Creswell's (2007) guideline was followed as referred to in Section 4.4.3. Further, since this research aims to discover the C-BT usage in the emergency situations, many emergency service organisations (e.g., government agency) may not want to disclose such an important process to a third party. It would establish difficulties for the researcher to gain approval to observe such sites. This happened during the application process because the agency thought that many observers would interrupt their operation during the exercises given that it had already invited internal observers to observe the exercise. The next section presents the data analysis strategy for analysing the data collected in this research.

4.6 Data Analysis Strategy

Qualitative data analysis is a process of preparing and organising the data which involves text data, such as transcripts, or imagery data, such as photos, and then reducing the data through coding whereby data can be transformed into a more condensed form and finally building a theory based on the codes identified (Creswell, 2007; Hennink, Hutter, & Bailey, 2011). Preparing research data is considered a very important research activity (Hennink et al., 2011). In this research, it involves producing the verbatim transcripts of the interviews and focus group discussions, as well as observation notes. A verbatim transcript plays an essential role in grounded theory analysis (Hennink et al., 2011). The verbatim transcript was utilised as the data analysis strategy in this research and is discussed in Section 4.6.2. This is because the verbatim transcript helps to capture the meaning of the words and phrases that are expressed by the participants themselves, thus reflecting the emphasis and emotions of the participants relating to the issues explored (Hennink et al., 2011).

The analysis of data was conducted continuously throughout the process of data collection whereby the researcher immersed herself in the details of the field notes and transcriptions that were produced simultaneously with memo writing in the form of phrases, ideas and key concepts that the researcher developed. Improvements can be made through comparing the initial thoughts with the new data as it emerges (Collis & Hussey, 2003; Creswell, 2007). Simultaneously with the process, the coding of the data was conducted, which is the process of data reduction whereby the raw data is assigned with codes through grouping and clustering. The transcripts were revisited back and forth multiple times in order to ensure the researcher did not rely on the pre-existing codes that guide the coding process (Creswell, 2007). Then the analysis moved from classification of similar codes to a more abstract level of categorisation, which adopted Strauss and Corbin's (1998) approach of grounded theory analysis which is discussed later in Section 4.6.2. Therefore, qualitative data analysis is an ongoing process which starts as soon as the data collection begins, which is different from quantitative study whereby data analysis is conducted when the data collection is completed (Gordon, 2006). While the data was analysed through grounded theory technique, it is necessary to consider how to analyse cases since this research employed a multiple case design. The following section discusses the approach for case analysis.

4.6.1 Case Analysis Strategy: Within-case and Cross-case

It is argued that analysing data is critical to theory building from case studies while published studies rarely provide large space for the discussion of analysis (Eisenhardt, 1989). Nevertheless, some of the scholars (e.g., Creswell, 2007; Eisenhardt, 1989) identify two key features of analysis for multiple case studies: within-case and cross-case analysis. The two approaches are employed in this study and are shown in Figure 4-2.

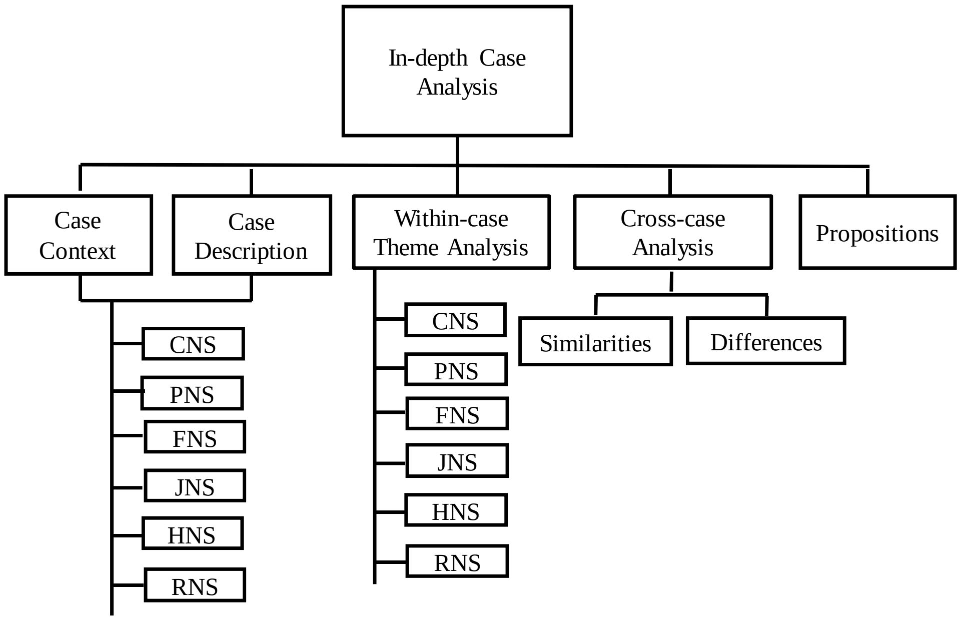


Figure 4-2 Coding approach for multiple case study

Source: Adapted from Creswell (2007)

It is argued that within-case analysis is one key step for conducting data analysis in case study research (Creswell, 2007; Eisenhardt, 1989; Yin, 2003). The within-case study normally encompasses detailed write-ups for each case, which are crucial to facilitate researchers in gaining insights into the phenomena with a large quantity of data (Eisenhardt, 1989). Even though there is a lack of common guidelines for such analysis, Creswell (2007) recommends that a researcher can typically provide a detailed description of each case through themes within the case when multiple case study is chosen. Following this strategy, a descriptive summary for each case was produced (see Section 5.2) in which the discussion is based on three main themes arising from the data: emergency management working procedures, C-BT usage purposes in emergency management, and current C-BT usage level in natural emergencies. Quotes from the participants are included to support the discussion. Therefore, the within-case analysis enables researchers to see the unique patterns emerge from each case rather than realise generalisation of patterns across cases directly (Eisenhardt, 1989).

Combined with the within-case analysis is cross-case synthesis (Creswell, 2007; Eisenhardt, 1989; Yin, 2003). Such analysis is most suitable for multiple case studies that consist of more than two cases (Yin, 2003): six cases are involved in this research. Yin argues that cross-case analysis supports a more robust result of findings than that of a single case. Aligned with this view, Eisenhardt (1989) claims that the cross-case analysis can help to avoid the researcher reaching a conclusion too early or even a wrong conclusion due to biases when processing information. Through cross-case analysis, the findings across a series of individual cases can be aggregated to explain the emergency management professionals' perceptions of C-BT usage in the context of natural emergencies. In order to realise the synthesis across different cases, Eisenhardt (1989) suggests using categories or dimensions, then, through comparison and contrast, the similarities and difference among cases can be discovered. The grounded theory analysis based on Strauss and Corbin (1998) discussed in the next section was employed to identify the categories of the data in this research.

4.6.2 Grounded Theory Analysis

Analysing qualitative data is important as the researcher needs to understand how to make sense of text so that answers can be formed to the research questions (Creswell, 2012). The grounded theory analysis was employed to analyse the data gathered from the interviews, focus groups and exercise observations in this research. The process of analysing qualitative data needs to be rigorous and logical so that small parts of the disaggregated data can be connected into new concepts (Gray, 2014). Grounded theory is a method that provides the researchers with rigorous procedures to examine, polish, and establish the ideas and sense of feeling about the data (Charmaz, 1995; Urquhart & Fernandez, 2013).

Grounded theory was originally developed by two sociologists, Barney Glaser and Anselm Strauss (Glaser & Strauss, 1967), and was adopted extensively in sociology, nursing research, evaluation research and organisational studies (Charmaz, 1995; Gray, 2014). It is a valuable methodology which allows for the generation of a theory that is grounded in the data and therefore establishes the building blocks for generalizable empirical research (Strauss & Corbin, 1998; Zarif, 2012). Aligned with this view, Charmaz (1995) acknowledges the logical and consistent data collection and analysis procedures that the grounded theory process entails to develop theory. However, the two originators' continuous independent promotion of this method resulted in different techniques for analysing data, recognised as Straussian and Glaserian approaches (Strauss &

Corbin, 1998; Urquhart & Fernandez, 2013; Zarif, 2012). The Straussian technique, in Strauss and Corbin's (1998) book, proposed a procedure that breaks the coding process into three coding stages: open coding, axial coding and selective coding. All three stages make contributions to the final generation of theory relating to categories. This procedure was criticised for its inflexibility and rigidity - one important debate over 'emergence and forcing'- whereby the single coding paradigm constituted the forcing conceptualisation of the data (Seidel & Urquhart, 2013; Urquhart & Fernandez, 2013).

From Glaser's (1987, 1992) perspective, the identification, development and relationship of the concepts need to be conducted through constant comparison. The Glaserian approach emphasises the emergence of data and theory through the analysis of basic social processes. In other words, data gathered should not be forced and analysed through preconceptions (Charmaz, 2000). Glaser believes that a pure grounded theory process pays less emphasis on the coding procedure and therefore entails researchers' engagement with the research subject without preconceptions, enabling the data to emerge inductively (Dillon & Taylor, 2015). Therefore, the Straussian approach represents a more prescriptive method while the Glaserian approach emphasises the flexibility (Urquhart & Fernandez, 2013).

Even though there are criticisms of the Strauss and Corbin approach, it is still argued to be the most influential version of grounded theory method that serves as a powerful statement of the method and has instructed graduate students throughout the world (Bryant & Charmaz, 2010; Charmaz, 2006). Charmaz (1995) asserts that grounded theory methods enable both novices and experienced researchers to conduct qualitative research in an efficient and effective manner since the method assists in the structure and organisation of gathering and analysing the data. Urquhart and Fernandez (2013) argue that "one needs to be aware of the intellectual history of grounded theory method, as opposed to worried by that history" (p.227). This researcher follows Strauss and Corbin's (1998) approach, which is suitable for a novice qualitative researcher to use as a guide.

Rationales for Grounded Theory Method

Grounded theory is a systematic and qualitative procedure employed to generate a theory that “explains a process, an action, or an interaction about a substantive topic" (Creswell, 2012, p. 423). The procedure is to systematically identify categories from collected data and connect these categories to form a theory that explains the process (Creswell, 2012; Bryman & Bell, 2011). It is argued that grounded theory is useful when the researcher wants to generate a theory where existing theories are not able to address the problem or the participants that the researcher plan to study (Creswell, 2012). This study aims to investigate the usage of emerging C-BTs and their effectiveness in emergency services organisations where little is known from previous studies. This is consistent with Orlikowski’s (1993) views about the three characteristics of grounded theory which are “inductive, contextual and processual” (p. 4). Therefore, such technique allows for theory development that is grounded in the data from people’s experience pertaining to the organisational context. Hence, the approach fits with the interpretivist orientation of this research. Since a theory is grounded in the data, it can offer a better explanation than a theory that is directly borrowed from previous research (Creswell, 2012). Thus, through coding and categorising the data that is closely related to the phenomenon, the resulting theory or framework can better fit the situation and works in practice (Gilliland, 2003; Creswell, 2012).

Further, this research relies mainly on the in-depth qualitative interviewing which is argued to match grounded theory methods particularly well because both are emergent methods (Charmaz, 2008). Additionally, grounded theory method is especially suitable to answer questions that focus on understanding how individuals experience the process and identifying the steps in the process (Creswell, 2007). This research aims to know the individual emergency professional’s perception regarding the technology usage process in their organisations. Therefore, it is suitable to use the grounded theory method in this research.

However, it is argued that there are challenges to the grounded theory approach. According to Creswell (2007), the investigator needs to set aside, as much as possible, theoretical ideas and notions so that the analytic, substantive theory can emerge. Strauss and Corbin (1998) warned that researchers should not immerse themselves too deeply in the literature as this will impede and constrain researchers' creativeness. Thus, such a challenge is related to the question of whether the grounded theory method is treated as a technique for analysing data or as a research philosophy in its own right (Urquhart, 2000). As was argued by Urquhart (2000), the grounded theory technique that has been used in IS research is not inclined to be a pure grounded theory study but a primary technique for analysing data. Therefore, this research adopts the Straussian approach mainly as a technique to analyse the data in the multiple case study rather than a methodology for a pure grounded theory study. This is considered a suitable and helpful guide for a novice qualitative researcher in data analysis. The following section illustrates how the analysis is conducted through grounded theory.

Grounded Theory Analysis

As was mentioned, the procedure of grounded theory for analysis consists of open, axial, and selective coding. These three stages are then pulled together into a framework, a conditional matrix, which involves conditions, actions, and consequences that are interrelated with the related phenomenon (Gray, 2014; Strauss & Corbin, 1998). An overview of each coding stage conducted in this research is presented below.

Open coding

Open coding is the first stage of coding in grounded theory. It is the process of examining, naming, and categorising the phenomena in the raw data (Strauss & Corbin, 1998). Simply put, it is the step of constructing categories of the data. Categories are concepts that represent the phenomena obtained from the data. The phenomenon is a unit of information that entails events, happenings and instances that are defined as being significant to the respondents, leading to the identification of key categories (Sarantakos, 2013). In the open coding stage, the researcher undertakes an examination of the text from transcripts, fieldnotes, or documents to discover prominent categories that are supported by the text (Creswell, 2007). In this research, the sources of text were transcripts and observation notes made immediately after the exercise observations.

The researcher firstly breaks down the data and labels individual elements, which makes it easier for the researcher to recognise and manage the data (Collis &

Hussey, 2003). This is the process of labelling. There are several different strategies of conducting open coding: line-by-line analysis, analysing a whole sentence or paragraph, or comparing a whole document with another (Neuman, 2012; Strauss & Corbin, 1998). Even though the line-by-line strategy seems to be time-consuming, it is particularly important at the beginning of the study since it provides the researcher with the means to generate categories quickly (Strauss & Corbin, 1998). In this research, data from interview and focus group transcripts, as well as observation notes were classified in the form of incidents through line-by-line examination of phrases and sentences. The process was conducted in NVivo where hundreds of nodes were created and merged during the process. This is because the researcher read and re-read the transcripts and observation data in order to modify the concepts to ensure their fit to the data. Hence, similar incidents were given with the same conceptual labels. Following this procedure, 58 conceptual labels were generated in Excel with corresponding names. An example of the coding process including open coding, axial coding and selective coding stages is presented in Appendix E.

During the process of open coding, it is important to remember making comparisons and asking questions, which both assist researchers to assign categories to specific phenomena (Gray, 2014). Therefore, these two techniques were performed in the open coding stage of this research. Constant comparison is conducted in a way that researcher continuously compares the categories and codes emerging from new transcripts with existing categories and codes so that thoughts about the properties and dimensions of concepts and categories can be stimulated (Glaser & Strauss, 1967). This is an on-going process until the researcher thinks the saturation is reached, which means that repeated rather than new codes or categories emerge from the data when coding more transcripts.

The concepts that fit in the same phenomenon were grouped together to establish the categories, which is known as the process of categorising. The categories were then assigned more abstract conceptual names. The researcher made constant reinterpretation and refinement to these categories. Such process allows for the codes to be verified and saturated (Sarantakos, 2013). A total of 13 categories were generated: the process of giving names to the categories follow the suggestion of Strauss and Corbin (1998).

According to Strauss and Corbin (1998), there are three ways to assign names to categories: according to the researcher's interpretation, with regard to the concepts appearing in the literature, or referring to the words of respondents themselves (in-vivo codes). Even though the naming process may be subjectively chosen by the researcher, it is decided on the basis of the context in which the incident takes place as suggested by Strauss and Corbin (1998). In current research, the categories were named in all of these three ways. As suggested by Collis and Hussey (2003), the researcher avoided using terms such as technical labels or jargon as these can give rise to interpretation problems for readers who are unfamiliar with the field.

Once a category is identified, it needs to be assigned properties, representing the dimensions of a property along a continuum (Strauss & Corbin, 1998). It is important to develop properties and dimensions which establish a strong basis to facilitate the process of making relationships between categories and subcategories, as well as the major categories in a later stage (Gray, 2014). Therefore, the categories were assigned with properties and then were dimensionalised along a continuum. For example, the 'usage frequency' category was dimensionalised into familiarity, current C-BT usage level, and usage instances. These dimensions were further assigned along a continuum of very familiar; less familiar, non-extensive usage; frequent usage; and many-limited. Comparing properties of the instances enables the researcher to place the instance into a more abstract level of classification (Strauss & Corbin, 1998).

Axial coding

Following the open coding process whereby the disaggregated data are categorised, axial coding is the process in which the researcher relates the categories to their subcategories along the lines of their properties and dimensions (Strauss & Corbin, 1998). The subcategories stand for details of the categories that have more explanatory power on the concepts in terms of when, where, why and how a phenomenon happens and with what consequences (Strauss & Corbin, 1998). Therefore, it is a more advanced level of coding. This process involves specifying a category in terms of the conditions that induce to cause it to happen, the context in which it happens, the actions and interactions that come from it as well as the consequences (Gray, 2014). Strauss and Corbin (1998) called this the paradigm that helps to systematically integrate the data. Therefore, in axial coding, the researcher is constantly thinking of the causes and consequences, conditions and interactions, strategies and processes that stimulate considerations of the linkages among the concepts (Neuman, 2012).

Generally, this stage focuses on the reinforcement of the connections between categories. In the current research, it was conducted through renaming or reclassifying the categories that had been identified during the open coding stage. This means the axial coding was conducted simultaneously with open coding in this research. As stated by Strauss and Corbin (1998), open coding and axial coding are not performed sequentially which is because “one does not stop coding for properties and dimensions while one is developing relationships between concepts” (p. 136). Therefore, axial coding in this research involves the integrating and establishing the linkage or relationship among the categories presented in Appendix E. This provides the representation of the phenomenon of interest, which are the multi-dimensional factors that influence the emergency professionals’ perceptions of C-BT usage in natural emergencies, in a holistic way.

Selective coding

Selective coding is the final coding stage. This is a process of choosing core categories from the data for the purpose of building theory (Gray, 2014). There are not many differences between selective coding and axial coding. The only difference is that selective coding produces a much higher level of abstraction (Strauss & Corbin, 1998). During axial coding, a set of phenomena or categories are derived through coding and are assigned with their properties and dimensions. As a result, categories are developed in a systematic way and related to the phenomena (Strauss & Corbin, 1998). In the selective coding stage, core categories are sought after to form a story - the central phenomena of the study (Gray, 2014). The criteria for choosing the core categories involve the centrality enabling all major categories to relate to, frequent appearance in the data, presentation of logical and consistent explanation to its related categories, level of abstraction leading to the development of theory, as well as the ability to explain variations in the data (Strauss & Corbin, 1998). Thus, it is the process to help the researcher realise integration and refinement of the categories and reach the final theory.

One technique that suggested by Strauss and Corbin (1998) to assist with identifying the central category is writing the storyline, which simply means providing a few descriptive sentences. Appendix E presents the process of how selective coding evolved through story descriptions related to the research question. This process cannot be done without the pre-identified core categories in the axial coding stage and can then be further strengthened in the selective coding stage. The final core categories of factors influencing emergency professionals' deployment of C-BT in natural emergencies were produced and are presented in Appendix F.

Through employing grounded theory analysis, the identification of concepts, categories and core categories contribute to the understanding of multi-dimensional factors that influence the emergency management professionals' perceptions of C-BT deployment in natural emergencies. Based on the three coding stages, the coding results served as the basis for conducting cross-case analysis, and developing propositions for understanding the phenomenon of the emergency professionals' perceptions of C-BT usage in emergency services organisations in natural emergencies, leading to the final theoretical framework development.

4.6.3 Usage of Software for Analysis

Qualitative research software has become increasingly diverse and functional, which can help the researcher to code and categorise large amounts of texts from open-ended interviews or documents (Yin, 2009). The software NVivo 10 was utilised to import transcriptions and observation data for generating nodes for identified incidents. Yin (2009) noted that if the researcher creates and defines a set of nodes in NVivo, it can provide the assistance to locate the words, phrases, or sentences that match the nodes that have been created, or count the occurrence or frequency of the words or phrases. Therefore, the key to understanding the value of the software is to treat it as the assistant tool.

In this research, NVivo was mainly used for storing transcriptions and observation notes, also identifying incidents and merging similar incidents during the open coding stage. The identification of incidents in NVivo utilised the one strategy as suggested by Yin (2009) and Lincoln and Guba (1985) where some nodes were established based on the words that frequently occurred through running the function of word frequency query. For example, the software showed that the word 'access' appeared more than 400 times from all transcriptions. Thus, the term 'accessibility' can be identified as one node that reflects one of the characteristics that C-BTs have. Further, for a better visual comparison of those conceptual labels among different cases, the researcher exported all the labels into an Excel spreadsheet and set up the spreadsheets case by case.

According to Bazeley and Jackson (2013), it is important to select the document that the researcher considers as typical and representative or particularly interesting and rich when starting coding in NVivo. The reason is that it significantly influences the categories the researcher determines to create (Bazeley & Jackson, 2013). The transcript of CNS was chosen for coding first because CNS plays a leading role in natural emergencies and the results show that it indeed utilised more C-BTs than other organisations do. It was chosen for coding first due to its richness for generating the categories. The ongoing categorisation was based on the generation of the CNS categories.

4.7 Ethics Consideration

It is also necessary to consider ethical issues when conducting any research that is associated with human participants. Creswell (2009) provides a guideline that facilitates the researcher to identify possible ethical issues that may arise across all stages of the research. This is aligned with the ethical issues discussed by Ritchie et al. (2014) which mainly involve issues of gaining ethical approval prior to conducting the study, informed consent, disclosure of the purpose of the study, and deception avoidance when beginning the study and data collection, as well as respecting the privacy and anonymity during data analysis and reporting.

According to Creswell (2009), the first step before starting the research is to submit a proposal for ethical approval to the appropriate professional association. This was conducted through submitting an ethical application to the ethics committee of the University of Waikato in the very beginning of this research. After gaining ethical approval, the researcher was able to continue the data collection. Before data collection, it is also necessary to gain informed consent from the participants; a key principle of social research whereby participants are provided with adequate information regarding the research so that they can be able to make a decision of whether or not they will participate in the research (Creswell, 2009; Ritchie et al., 2014). In the current research, the participants were provided with full information in terms of research purposes and procedures through emails prior to the interviews. They were also informed about their rights to refuse to answer any question if they do not want to do so or to opt out at any time before a specified date. These steps are taken to ensure that the participation is on a voluntary basis and enable the participants to make a decision about participation without any type of pressure (Ritchie et al., 2014). All the relevant information is included in the attached participant information sheet in Appendix C.

Before starting interviews, all participants were asked whether they had read the participant information sheet again in order to ensure they know the research purpose and their rights clearly. After that, all participants were required to sign the consent form (see Appendix C). All participants are knowledgeable professionals in emergency service organisations so that they all understand the aims of the study and rights they have and were happy to do what has specified in the participant information sheet and consent form. Further, participants were informed that they would be kept anonymous when reporting the findings which means they would not be identifiable throughout the research. Similarly, the confidentiality of participants is protected through non-disclosure of any audio records or transcripts to a third party except the researcher's supervisors.

4.8 Quality in Qualitative Research

It is important to evaluate the quality of the research once the researcher has applied the method and conducted analysis in order to ensure the rigour in the results (Bryman & Bell, 2011; Collis & Hussey, 2003; Sarantakos, 2013). Unlike the assessment of quality in quantitative research, Lincoln and Guba (1985) suggested that 'trustworthiness' can be used as the alternative criterion for evaluating how good a qualitative study is. The reason is that qualitative researchers endeavour to gain an understanding of the phenomena through spending a considerable amount of time in the field with social subjects so research is conducted in the natural settings which are not controllable so that qualitative researchers do not emphasise the terms of generalisability, objectivity, external and internal validity or reliability that are the focus of quantitative research (Bryman & Bell, 2011; Creswell, 2007). A number of researchers proposed various assessing criteria for evaluating the quality of the qualitative research. For example, Patton (1999) suggest three criteria for judging qualitative research, involving rigorous techniques and methods, the credibility of the researcher and the researcher's belief in the naturalistic inquiry of qualitative research. Lincoln and Guba (1985) suggest the criteria of credibility, transferability, dependability, and confirmability. Nevertheless, Lincoln and Guba's (1985) four criteria are suggested by many scholars (e.g., Bryman & Bell, 2011; Collis & Hussey, 2003) as a useful guide for assessing the quality of qualitative research. Thus, the validity of this research is assessed based on these criteria.

Credibility is mainly concerned with whether or not the research was conducted in a good practice so that the subject of enquiry was identified and described in a correct way (Collis & Hussey, 2003). Several strategies are suggested by scholars to strengthen the credibility of the qualitative research, such as prolonged engagement in the field with the subjects, data richness, triangulation of data sources, or peer scrutiny of the research project.

The long-term immersion in the field for the data collection was employed in this research as the researcher immersed herself in numerous interviews within six case organisations as well as several exercise observations. Most of the observations lasted for a whole day and one earthquake exercise took two days. Because of this, the data gathered was not only rich in the amount but was more "direct and less dependent on inference" (Maxwell, 2008, p. 244). The intensive involvement and interviews allow for the data richness in the current research as the data were detailed enough to provide a full picture of the phenomena being studied (Maxwell, 2008). For example, the interviews and focus groups were transcribed verbatim in this research so that the findings were not reflected merely in the notes that the researcher felt were significant but also in the detailed observation notes.

Another commonly used strategy is triangulation which entails the use of multiple different sources of data collection method in the social study of the phenomena (Bryman & Bell, 2011; Creswell, 2007). This research utilised multiple sources of data: interviews, focus groups, and exercise observations, which Patton (1999) termed 'triangulation of sources'. Evidence from different sources allows for corroboration of the findings whereby it reduces the risk of biases due to relying on a particular method while enhances the consistency of information (Creswell, 2007; Maxwell, 2008; Patton, 1999).

Peer assessment of the research is considered important because it allows the researcher to refine their research design and methods, and reinforce their arguments (Shenton, 2004). In the current research, the research design and methods were guided by the supervisory panel. The researcher also presented some of the findings of the research in one doctoral students conference during the process of the study and took the suggestions from the peers and academics to refine the explanation of the theoretical model.

Other aspects that could enhance the credibility of this qualitative research were considered by the researcher. The interview questions were reviewed by the supervisory panel in order to improve the clarity and relevance of the questions in understanding C-BT usage perception in the emergency management context. The interviews included participants from both managerial and operational staff in each organisation. This allowed the researcher to compare different perspectives of informants from multiple points of view, which also enables triangulation (Patton, 1999). In terms of researcher's experience, although the researcher could be considered novice in qualitative research, the research design process and findings reporting were monitored and scrutinised by supervisors who are experienced in conducting information system research through grounded theory analysis. The researcher was guided to approach potential participants and required to re-visit the data multiple times to enhance the consistency of the concepts and categories that have been created during the process of analysis.

Transferability is similar to external validity in quantitative research which is concerned with the degree to which the findings of the research can be applied to another situation, thus allowing for generalisation (Collies & Hussey, 2003;

Merriam, 1998). Nevertheless, qualitative findings are yielded based on purposive sampling to understand the particular phenomena within the unique context of a relatively small number of subjects in depth instead of breadth rather than generalising the truth to the many (Bryman & Bell, 2011; Merriam, 1998). Therefore, it is suggested to reframe the term generalisation to transferability, in a sense of qualitative inquiry (Merriam, 1998), which is concerned with whether the findings are applicable to another situation with sufficient similarity to allow for the naturalistic generalisation. The tactic of providing thick description is emphasised where sufficient description of the research settings is provided to enable to readers to make decisions of whether findings can be transferred (Croswell, 2007; Merriam, 1998). In the current research, a detailed description of the settings of each individual case was provided in the within-case analysis section in terms of the organisational characteristics and working procedures. This will help readers to determine the extent to which their situations closely match with the current research, thus transferring the findings due to the shared characteristics (Creswell, 2007).

Dependability parallels reliability which is concerned with the degree to which the findings of the research can be repeated in quantitative research (Bryman & Bell, 2011). However, it is not what qualitative research pursues since the assumption of single reality existence and generalisation of the same results of future studies does not fit with the purpose of naturalistic research. Therefore, dependability in qualitative research stands for the consistency of results gained from the data (Lincoln & Guba, 1985; Merriam, 1998). This can be achieved by ensuring that the research processes are rigorous and well-documented throughout the process of the research (Bryman & Bell, 2011; Collies & Hussey, 2003). In the current research, the research design and its implementation were detailed in Section 4.3, Section 4.4 and Section 4.5. In addition, the dependability can be enhanced through keeping a chain of evidence as suggested by Yin (2009). This is conducted through maintaining all types of data gathered in terms of interview and focus group records, transcriptions, coding and analysis records in NVivo, as well as the field notes, to provide a sufficient chain of evidence. This enhances the possibility for future research to replicate the research procedure. Further, the role that triangulation plays in this research needs to be emphasised again, as multiple data sources have enhanced the consistency of the results obtained from the data. This is what Lincoln and Guba (1985) emphasise, that the close relationship between credibility and dependability where the triangulation improves the credibility of the research which will also enhance the dependability of the research.

Confirmability is concerned with whether the researcher has acted with honesty when conducting the research (Bryman & Bell, 2011). Several aspects of this research show the impartiality of the researcher. As referred earlier, triangulation is achieved through employing multiple sources of data: interviews, focus groups and exercise observations. Therefore, the triangulation of sources could improve the confirmability of this research and bias could be reduced by not focusing on a single method to gather the data. Further, the verbatim quotes were included both in the within-case and cross-case analysis to present the findings emerged from the cases, which enhances the authenticity of the findings. Collis and Hussey (2003) confirm that the insertion of quotes from the participants is essential in qualitative research, as they allow for authenticity and vibrancy through sharing what the researcher is analysing. The ethics application was approved before data collection, and the participants were recruited on a voluntary basis and informed that they have the right to withdraw from the study from any time which ensures a genuine willingness to take part in the research interviews and focus groups.

The four important aspects, credibility, transferability, dependability, and confirmability, have been considered in completing the current research. It is believed that these components are important in enhancing the validity of the research process and findings stemming from the current research.

4.9 Chapter Summary

This chapter has presented the discussion of the research paradigm and underlying assumptions of social research. This is followed by rationales for selecting interpretivism of qualitative research through comparing the quantitative and qualitative research design. The chapter then discussed the qualitative multiple case study, followed by the delineation of data collection methods of interviews, focus groups and observations. The remainder of the chapter includes the explanation of the data analysis procedure and the treatment of the limitations of the data collection methods. Finally, it provided the description of the issues of ethics and quality in qualitative research. The understanding of the research design and the implementation of the data collection and analysis helps to form the constitution of the findings and discussions, which are presented in the next chapter.

CHAPTER FIVE – WITHIN-CASE DESCRIPTION

5.1 Introduction

As discussed in Chapter Four, the case analysis strategy for multiple case study involves within-case and cross-case analysis. Although the focus of this research is on the cross-case comparison, the within-case analysis cannot be overlooked. The reason is that the within-case analysis facilitates the researcher to become familiar with the emerging patterns in each distinctive case, which is helpful to realise generalisation of patterns across cases (Creswell, 2007; Eisenhardt, 1989). The within-case analysis was conducted through a detailed description of each case. Following this technique, a descriptive summary for each case and themes within the case was prepared. There are three main themes arising from the data: emergency management working, C-BT usage purposes in emergency management, and current C-BT usage level in natural emergencies.

5.2 Within-case Descriptions of Each Emergency Service Organisation

Before proceeding to present the within-case analysis, the relationship among those six case organisations and a brief procedure of managing natural emergencies are described which is helpful to understand the role of each case as they are interrelated during large-scale natural emergencies where a multi-agency action is to be taken.

To protect the confidentiality of the identity of the participants and organisations, the participating organisations' names are presented in pseudonym as CNS, FNS, PNS, JNS, HNS and RNS. Further, some names of the C-BTs are also presented in pseudonym (see Table 5-1, Table 5-2, Table 5-3, Table 5-4 and Table 5-5) if they are characterised as particular internal cloud-based systems, which are utilised as important cloud-based systems, within the organisations other than those well-known examples of third-party SaaS applications, such as Google Drive, Microsoft 365, or Facebook. The internal cloud means the cloud is privately owned but is either hosted by the organisations themselves or by a third-party company while the external cloud refers to the cloud that is external to the organisational and fully hosted by a third party. The section starts with the brief introduction of the interrelationship among organisations studied in this research to understand the role of each case organisation.

CNS plays the leading role in natural emergencies in terms of coordinating resources required among the other five different organisations. The other five organisations play a supportive role in providing the resources required to minimise the impact of natural emergencies.

FNS, PNS and JNS undertake different responsibilities. FNS ensures people's safety and PNS maintains the social order while JNS is a charitable organisation providing an extensive range of health-related services to the communities. However, the three agencies operate through sharing the same communication centres which are spread at three different locations in New Zealand. Through the dispatch order from the communication centres, the three agencies can exchange information regarding the situation and make decisions to allocate the frontline personnel nearest to the scene in an immediate manner. This course of action enhances the process of providing the needs of people who need help in emergencies in an effective way.

HNS undertakes the main role of planning for health and disability services in order to minimise potential human infectious diseases and pandemics in the aftermath of natural emergencies. RNS, an auxiliary to the local authorities, is also a charitable organisation providing welfare services during the natural emergencies. The voluntary relief teams are deployed when it is required for outreach tasks, such as rescuing people and delivering water.

The six cases are described in the following sections

5.3 Case 1 C-BT Deployment in Natural Emergencies in CNS

5.3.1 CNS Background

CNS is a leading agency for supporting communities to manage natural emergencies, geological events such as earthquakes, and tsunami, and weather events such as coastal hazards, floods, and severe storms, in the New Zealand emergency management sector. The organisation constitutes more than ten different local groups in different areas in New Zealand. Each local group consists of a different number of local authority units. Each local authority unit visited is made up of fewer than eight employees. CNS provides leadership in mitigating risks in, getting prepared for, responding to, and recovering from, natural emergencies. It aims to deliver the right tools, knowledge and skills to people who are at the local level in managing natural emergencies. Therefore, it plays a leading role in managing natural emergencies among the other five case organisations.

The CNS headquarters and three units from different groups of CNS were visited. Five participants were in the interview sessions from both managerial and operational level: one national manager, two group managers, one system training coordinator and one emergency planning coordinator. One focus group was conducted at the headquarters, consisting of four members who are either emergency management advisors or capability development advisors. Two multi-agency exercise observations were conducted: an earthquake exercise at the regional level and a tsunami exercise at the national level. All the participants have the experience of utilising C-BTs in the preparedness and response stages of natural emergencies. Participants at the managerial level have had extensive working experience in the emergency sector for at least ten years.

Due to the standalone characteristics of each CNS group, the C-BT usage strategy in CNS had not been consistent throughout New Zealand. From both managerial and operational participants' point of view, there was a need for a more uniform usage. This is now detailed in the following sections through describing the workings, C-BT usage purposes, and frequency of C-BT usage by CNS in managing natural emergencies.

5.3.2 CNS Emergency Management Working

Preparedness Working

CNS plays a critical role in providing guidance and coordinating other emergency service organisations in New Zealand. CNS' approach to managing natural emergencies started with recognising the range of disasters that New Zealand commonly faces and the vulnerability that the communities and infrastructures face. It was predominantly conducted through careful and thorough planning in the preparedness stage. CNS mainly focused on preparing working procedures and plans. Making detailed emergency plans thus was a particularly important role for CNS to be prepared for natural emergencies and constituted a large part of its business-as-usualworking. As noted:

> So business-as-usualwhat we're doing is developing policies, procedures, and plans. (ID2)

The planning also involved meetings and discussions with other advisory groups from different sectors such as welfare, lifeline, or non-government organisations. The reason was that those authorities undertook different responsibilities with varying additional resources and capability. Through relationship establishment, CNS was able to complement its current planning of managing natural emergencies, such as knowing how to cope with vulnerabilities of infrastructure or meet the welfare needs of the communities. Another aspect of CNS' preparedness activity was to coordinate with other agencies on system development projects. It was considered helpful to enhance the organisation's preparedness through gaining better systems for assessing the impacts that the potential natural emergencies might cause or acquiring comprehensive mapping information via the collaborative GIS project. As commented:

> There is another piece of software that we have to deliver but we didn't touch on, that is impact assessment. After an earthquake or something has happened, we send teams to those impacted areas to do impact assessment and come back with information, and that helps us to set the priority where do we need to start probably with the big issues…we work with FNS so we can also use it within to check on other impacts. (ID1)

CNS also placed emphasis on providing emergency management course training and emergency management system usage training to all levels of emergency employees in the preparedness stage. CNS tried to make efforts in helping staff to achieve a higher level of proficiency in using key C-BTs in the long run, which was considered critical to realising better operations in the response stage. For instance, every year CNS arranged several natural emergency exercises at different levels: local, regional or national.

Response Working

Compared with the preparedness stage, the response stage required CNS' immediate reaction to be to go through activation procedures. Setting up priorities of the resource allocation was a particularly important step for CNS to start coping with natural emergencies. The level of activation, which could be local, regional or national, depended on the scale of the natural emergencies, and required resources and capabilities. As commented:

> If it involves multiple areas, then the group will activate because I have to decide sometimes the priorities over resources or if it's just a region-wide event. (ID2)

Additionally, sharing information among various agencies was another important aspect during the response stage. Since situations might change quickly, it was necessary to share key situational information among various agencies in the response stage. The most critical documents that CNS needed to disseminate were the situation reports and action plans. As noted:

> In the response stage, the main thing that we need to send or people need to know is action plans so this is for our partner agencies. Action plan is about what we intend to do…We do situational reports which are what we have done and a little bit about what we going to do shortly. (ID5)

5.3.3 CNS Cloud-based Technologies Usage Purpose in Emergency Management

The main C-BTs in CNS used both internal and external clouds as shown in Table 5-1. As for the internal clouds, CNS hosted these by itself while the external cloud usage was mainly SaaS. However, different groups had different strategies and focuses on C-BT usage due to the standalone characteristic of each group. Therefore, the usage was based on different needs and capacity that each group had. For instance, external cloud storage might be preferred by one group rather than another due to limited IT resources availability. Further, on a large-scale natural emergency, most of the activated groups used CNS' E System in the response stage. In terms of the usage purposes of C-BTs in natural emergencies, there were varying needs in different stages of emergencies.

Table 5-1 Summary of C-BT usage type in CNS

C-BT Usage Type	Case 1 CNS	
Internally-owned Cloud	1.	Core response system denoted as "CNS E System"
	2.	Official Website
	3.	Learning management system
	4.	Cloud-based text messaging
	5.	Web-based GIS mapping
	6.	Alerting system
	7.	Email
External Cloud	1.	Social media platforms, such as Facebook or Twitter

	2.	External storage such as Dropbox
	3.	Third party GIS platforms, such as ArcGIS, Google Maps, or Bing Map
	4.	Gmail

Cloud-based Technologies Usage Purposes in the Preparedness Stage

In the preparedness stage, several functions of C-BT were applied. First, data storage was mostly mentioned by all participants, which was considered the basic need that C-BT could provide. CNS' E system was utilised to store standard operating procedures, evacuation plans, minutes and agendas from meetings, and contact lists. However, due to the different system choices, some groups might prefer an external cloud for storing plans. As commented:

> We do when plans are completed. We saved them in our Dropbox now. (ID 5)

In terms of the communication, two forms took place through C-BTs: the internal communication within CNS, and the external communication with other agencies or the public. The email system was mentioned as being frequently used by CNS to communicate within the organisation and among different agencies. For example, messages of multi-agency course training were shared through email internally. Official website and social media platforms were utilised to educate and alert the public regarding natural emergencies. CNS was quite proactive in engaging the public when dealing with natural emergencies. As the focus group commented:

> The Facebook went really well since people were asking questions and you can respond usually when you see it. (FG1)

In addition to informing the public, CNS also utilised the internal alerting system, which monitored different types of natural disasters for multi-zones 24/7, to alert various agencies and local authorities. It was considered useful in terms of disseminating information to local CNS groups and other agencies if they had registered on the system. Then those local authorities would use their own system to push out information to their community.

Another purpose for CNS to use C-BTs in the preparedness stage was employee training. The training included the online emergency management course learning, which aimed to reinforce the understanding of their roles and responsibilities. The

CNS' E System was also utilised to produce situation reports and action reports in the multi-agency natural emergency exercises.

Cloud-based Technologies usage Purposes in the Response Stage

In the response stage, storage continuously played an important role in storing important documents and information, such as messages and photos, in various forms. Cloud storage was the main useful function mentioned by all CNS' participants. It was also observed in the two multi-agency exercises led by CNS in which the CNS' E system was mainly used to store the key documents, such as situation reports and action reports.

In terms of communication and information sharing, email was CNS' first choice. Information sharing with other agencies through Gmail was observed in both multi-agency exercises even though face-to-face communications also took place frequently. In addition to the communication with different supportive agencies, CNS also shared key emergency information with the public community not only through its official website but also via social media platforms, Facebook and Twitter. CNS considered social media as an efficient way to disseminate disaster-related information to the public through social media platforms. As stated:

> Well, a lot of people in the [Location] earthquake were getting messages out through Facebook rather than you know being able to ring people or text. (FG1)

Additionally, CNS considered the GIS mapping system particularly important in identifying vulnerabilities of the lifeline infrastructure due to the devastating impacts that might be caused by large-scale natural emergencies. Having useful map layers of lifeline locations was considered critical to the success of disseminating correct and updated information, such as road closures, or power outages in some affected areas with priority. However, CNS currently lacked important map layers so that it only recently started gaining and integrating more value-added map layers to their own mapping system, helping to identify the priority of information flow.

5.3.4 CNS Current Cloud-based Technologies Usage Level in Natural Emergencies

CNS' C-BT usage differed among various local groups due to the different IT deployment strategies. Therefore, each group had different choices in C-BT. As a result, there was a lack of a consistent usage level on CNS' E system because it had not been the preferred system utilised in the emergency by all CNS groups. This was largely due to the standalone characteristic of the local groups so that the headquarters could not force each group to use CNS' E System. This was the obstacle to gaining better lessons learned from other user groups. However, the commonality among the local groups was that all of them utilised social media platforms extensively both in the preparedness and response stages. As commented:

> Every local authority is a total, independent, standalone entity, so we can only advise them but we can't direct them. It is a problem. Therefore, when we do actually offer a system like EMIS it has to be attractive to them for them to take it out. (ID1)

On the other hand, a cloud GIS system, such as ArcGIS, was quite new to CNS. It had recently started to utilise it in one recent multi-agency tsunami exercise. It was observed that ArcGIS Mapping was set up on the scene, but it was not used very frequently. Therefore, CNS still required to put an effort into discovering how to best utilise GIS system in emergencies.

Additionally, there was more C-BT usage in the response stage than in the preparedness stage due to the lesser need for C-BTs in the preparedness stage. Even though the purposes for C-BT usage in the preparedness included storing plans and conducting training exercises, the C-BT usage on training was seen as far from enough. In addition, the lack of C-BT usage in the response stage of natural emergencies was also due to the limited existence of useful C-BTs. Although CNS had established a core system, CNS' E System, for deployment during the response stage, it had not utilised the system to its full potential. CNS' E system had been utilised in a few small emergencies, but there was a lack of experience of using it in response to large-scale emergencies. Also, the CNS' E System was not considered a one-size-fits-all system by the participants. Therefore, different CNS groups also utilised external C-BTs, such as Microsoft office 365, Gmail, or Dropbox.

5.3.5 Summary

CNS focused on making plans and conducting necessary training in the preparedness stage, which was critical to the success of managing natural emergencies once they took place. In the response stage, CNS centred on setting priorities during the activation of the procedures and disseminating response-related information on time to other supportive agencies during the operations.

As a leading agency in New Zealand emergency service sector, CNS had made great efforts to align the C-BT deployment with its needs in the preparedness and response stage, including the data storage, communication internally and externally, and training. Even though CNS established its core emergency management system, there was a lack of usage experience at the moment. With its special organisational structure, the standalone local groups, it was difficult for CNS to realise C-BT usage consistency. CNS also attempted to involve more C-BTs, such as the GIS system, to enhance their performance, but it still took time for CNS to adapt to this.

To conclude, CNS was moving towards more frequent usage of C-BT in both preparedness and response stages. This required CNS to make continuous improvements and identify the value of C-BTs that could be added to their working procedures.

5.4 Case 2 C-BT Deployment in Natural Emergencies in FNS

5.4.1 FNS Background

FNS is one of the key agencies that make up the New Zealand's emergency service sector. Although the main role of FNS is to ensure the safety of people's lives and property in non-natural emergencies, such as hazardous substance explosions and rescuing trapped people, it also provides services to minimise the consequences of natural emergencies when it is requested for assistance. It plays an important but supportive role in cooperation with other agencies when dealing with natural emergencies. FNS aims to improve the readiness for, and response to, any emergencies through enhancing their coordination within the organisation and with other emergency services. It is a large organisation with more than 15,000 employees and more than 600 local branches throughout New Zealand. FNS also deploys three special domestic search and rescue teams, made up of 230 members from local branches around New Zealand, and one international team, consisting of 76 people for overseas deployment. When the international team is deployed, FNS has to keep the capacity for domestic utilisation.

The FNS headquarter and three different branches of FNS were visited. Seven participants were in the interview sessions from both managerial and operational levels: one national ICT manager, four area managers and two senior officers. One focus group was organised, consisting of three members: two area managers and a volunteer training officer. Two exercises led by FNS were observed: one hazardous substance explosion and one earthquake exercise. The non-natural emergency exercise provided the opportunity to the researcher to see whether there was any C-BT usage difference in the different types of emergency. Participants at the managerial level have substantial working experience in the emergency service sector varying from 10 to 20 years.

Different from CNS, FNS is an organisation unified throughout New Zealand so that the C-BT usage level is consistent within FNS. However, participants from both managerial and operational levels considered that the C-BT usage experience was far from enough when dealing with emergencies, especially at the frontline. Consequently, they were aiming to move towards using more C-BTs in managing emergencies. The following sections present the important aspects of FNS' emergency management working, C-BT usage purposes and level of C-BT usage in supporting the management of natural emergencies.

5.4.2 FNS Emergency Management Working

Preparedness Working

Since FNS played a supportive role in natural emergencies, it had to follow CNS' guidance during natural emergencies. Even though FNS did not focus on making plans related to natural emergencies, as a large frontline agency, it still had to be prepared through planning aspects that were related to the frontline saving responsibilities in natural emergencies. FNS had only generic plans for natural emergencies, and was proposed to maintain its own business in the natural emergencies. The aspects of the plans were associated with the resources needed (e.g., the location of pumps and number of large vehicles required), building information, and evacuation plans for reacting to the risks that might happen. As explained:

> If it is a large natural disaster, such as an earthquake, there isn't lots of information for FNS to the management of it. But there is some generic information on earthquake and flooding because a lot of those jobs where you turn up to, you have to make a dynamic risk assessment of the

> situation and start creating some strategies and tactics around the type of incident you've got. (ID17)

FNS emphasised the pre-planning of getting site information, which was about creating a site plan through gaining key information of specific sites physically and complementing site information in the system for future use. This required a large amount of time and effort but provided a strong basis for responding to the upcoming emergencies due to the enhanced familiarity with a particular site. As a result, it helped to generate more effective performance in the response stage immediately. Similar to CNS, FNS also established relationships among different agencies and authorities, which were considered critical to the success of responding to the emergencies in the response stage. As stated:

> So in the preparation phase, it's often about developing relationships with other stakeholders. So like we would have a relationship with [PNS]; we would have the relationship with local authorities. (ID15)

Additionally, training also played an important role in FNS in the preparedness stage. This was because training could reinforce employees' understanding of operating procedures, which helped to enhance their reaction to the upcoming emergency more effectively. There were three types of training. The first type was the incident management course training at the management level, which was more of a table-top discussion to strengthen the emergency professionals' understanding of the actions among different agencies to be taken during the emergencies. Secondly, since the main responsibility of FNS was to save and rescue people during emergencies, it was necessary to conduct some physical training. The physical training has penetrated into their business-as-usualpreparedness activity.

The third type of training was about system usage. Although system usage training was considered quite an essential part of the training process, the level of training in FNS was far from sufficient. It was mentioned by most of the participants that they undertook a self-learning process most of the time so that they were not able to get a very consistent and systematic training in a clear way. Hence, the participants thought that the system itself was quite useful, but the training was provided less frequently, and the session was too short. This would impede the comprehensive understanding of the system usage, such as in terms of searching for useful information in the system, which was not beneficial to the system usage in the response stage. It was identified by one of the participants:

> We got a whole new mapping system which is very good. I did the training, but it is always too short. (ID 6)

Response Working

In the response stage, FNS relied on receiving dispatch orders from the communication centres to take actions. FNS mainly communicated with the communication centres to enhance its operational efficiency. The communication centres allocated the resources in different FNS branches to save people and property within different zones in an efficient manner. Having multiple communication centres thus greatly helped FNS to handle peak demand rather than relying on a single communication centre.

When it turns from the preparedness to the response stage, the first critical task for FNS was to identify the situation of the emergency, especially knowing the places that people were living. Hence, the next phase of allocating resources such as people, vehicles and tools could be made. Setting the priority of tasks was important for FNS to make decisions because there would be too many tasks on hand when the emergency happened. As explained:

> Say for instance, people living in a dangerous building with fire and they won't get out; so it's my responsibility and I will make the safety officer go down to the road right now. It's a priority and sees what you can do to make it a safer place and tell the local authority…… We have to prioritise what tasks we do with those resources. (ID13)

5.4.3 FNS C-BT Usage Purposes in Emergency Management

Both internal and external cloud storage was used by FNS (see Table 5-2). The external cloud usage deployed SaaS as the service model. The FNS' S System was an internal cloud-based system which was utilised as a business-as-usualtool in the preparedness stage. It was used, on one hand, for managers to manage the business planning, risk assessment reports, building information, rostering and task allocation. On the other hand, it was used by the crew to input incident reports. The FNS' F System served as a web-based library for staff to draw down information such as the plans, training content, and alerting information regarding the incident on the ground.

Table 5-2 Summary of C-BT usage type in FNS

C-BT Usage Type	Case 2 FNS
Internally-owned Cloud	1. Internal management system denoted as "FNS S System" 2. Internal enterprise system denoted as "FNS F System" 3. Mapping system
External Cloud	1. Social media platform, Facebook and Twitter 2. Third party GIS platform, such as Google Maps, or ArcGIS 3. Web-based Information collector 4. Shared usage of CNS's E system only in multi-agency event

Cloud-based Technologies usage Purposes in the Preparedness Stage

The functions of C-BT that FNS applied in the preparedness stage involved mainly storage, training, internal alerts, and information sharing. Data storage was considered the most useful function by most of the participants in terms of storing plans and procedures. For example, the incident action plan application was specifically mentioned by the participants as a useful tool. The reason was that it provided the necessary strategies and techniques for staff to follow when dealing with emergencies, such as evacuating many people from a dangerous building. Another useful aspect of this tool was that it could be used to plan not only for non-natural emergencies but also for large-scale and complex natural emergencies. With this tool, the participants thought it was helpful to enhance their speed of gaining useful information to perform quickly. As explained:

> It covers all plans. We will use it to plan for any major event… Managing a big event or complex events. (ID14).

Training was another important aspect for FNS to utilise C-BT in the preparedness stage. In addition to the necessary physical training, FNS undertook cloud-based system usage training for the staff, involving training on the usage of the mapping system, FNS' S System, as well as training on the large mobile vehicles equipped with the same technology onsite. The external cloud was also utilised by the staff in the training sessions. For example, the Google Maps was used as a supportive source of mapping information. This would enhance employees' skills in discovering the complementary source of information if there was not enough knowledge at hand. As claimed:

> We use Google Maps which is linked to our electronic incident action plan program in our large vehicles……a lot of maps in Google……we copy and paste and add all the maps to the systems on the vehicles so that we can use them for the incident. (ID18)

Alerting was a third important purpose that FNS used C-BT in the preparedness stage. There were two ways of alerting in FNS, which were considered by the participants. Internally, staff within the organisation received alerts through FNS' F System and externally, FNS alert the public via the official website. In terms of communication, FNS' C-BT usage mainly involved information sharing internally within the organisation through FNS' F System. For example, managers in different areas engaged in a blog discussion of specific projects to share knowledge to enhance their performance in managing emergencies. There was a lack of evidence showing that FNS put sustained efforts in public engagement through social media platforms since it was not currently the main business focus. The internal communication was also conducted through an email system which was used as more of a business-as-usualsystem for submitting filled templates with completed jobs or receiving changes or updates of systems. Therefore, it is a normal channel that FNS uses within the organisation.

Cloud-based Technologies Usage Purposes in the Response Stage

In the response stage, FNS had not relied on C-BTs much yet. This was due to the heavy role that it played at the frontline in terms of physically saving lives and property. Therefore, frontline people in FNS mainly utilised the traditional technologies, such as telecommunication network, text messaging, the paging network, which were perceived as being more reliable.

Although FNS had not utilised C-BT in the response stage extensively, the participants acknowledged the potential that C-BT could deliver. For instance, the participants thought that C-BTs were promising in helping FNS enhance resource management (e.g., personnel, locations for tasks, number of trucks required and task allocation), allowing more effective allocation to achieve the outcome for a specific event.

In addition, FNS' current mobility lay in its mobile large vehicles which were equipped with the same C-BTs on site. However, it was rarely used other than in large and complex emergencies. Further, during large-scale natural emergencies, a multi-agency operation was carried out in an emergency operation centre led by CNS. FNS' liaisons would use CNS' E system in the operation centre to collect and feed necessary information into the system. However, there was still space for improvements in such a system since there was a lack of a big picture of the situation so that limited aspects of the information could be gained through this platform by each agency. As stated:

> Yes, they give us the logon we can only come to pick up the layer so that we cannot always see the whole picture. We only see what they want to tell us and vice versa what we feed the information back to them. (ID13)

5.4.4 FNS Current Cloud-based Technologies Usage Level in Natural Emergency

FNS' usage level of C-BTs in natural emergencies was far from enough. Although participants could foresee the benefits that C-BTs had in terms of gaining information quickly and speeding up the information flow, there was a lack of existing useful technologies, especially at the frontline, to help achieve that. The strong willingness of having and using useful C-BTs was expressed by most of the participants. As commented:

> It would be nice to have technology that we can look at where the hydrant is, or where the river is, or the rainfall is, and all that live data that's collected, say, during a storm. (ID18)

Nonetheless, certain types of C-BTs were used frequently by FNS, including the internal mapping system which was used predominantly in the organisation for locating the position of the required resources and buildings. In terms of social media usage, there was a lack of usage at the local branches and only one national page of Facebook was established by FNS. Consequently, if something happens at a local level, the staff at local branches are not able to gain useful information or deliver information related to the emergency to the public appropriately. However, many participants acknowledged the importance and usefulness of social media. Hence, it would be the next biggest step in the IT aspect for FNS to achieve better situational awareness.

There was also a lack of C-BT usage for the frontline crew whereby they could only rely on the radio network for communication with the communication centre and use the hard copy of plans to get information, such as water mains, the potential risk of the locations, and so forth. Therefore, FNS had started to change, and each truck would be equipped with mobile tablets with applications. In this way, the frontline crew could get information in a faster and more effective way than waiting for information from communication centres. As expressed:

> We're very sure that we're overdue for a tablet device that's going to be on our large vehicle and it's a mobile-based tablet and that interacts directly with our communication centre’s system so that we can populate data on the way to the incident and also with the management of incident and reporting functions. (ID18)

The lack of C-BT usage was also observed in the hazardous substance explosion exercise. Although it was not a natural emergency exercise, it confirmed the viewpoint of participants from both managerial and operational levels that certain C-BTs would only be used in large-scale or complex emergencies. Therefore, no evidence of C-BT was noticed during the exercise. The utilisation of technology mainly includes a desktop Excel spreadsheet for taking down the tasks being allocated to the frontline members, radio networks for communications, and simulation game consoles for simulating the hazardous situation. The exercise observation also corroborates that the frontline crew communicated mainly through radio networks rather than C-BTs with people at the backend. This reflects that FNS’ current ICT strategy for frontline communication was deficient.

As a final point, FNS had delivered some cloud-based solutions, such as a web-based disaster information collector and ArcGIS, for its urban search and rescue teams. These tools could be utilised both domestically and overseas, they could enable the rescue team to receive the most updated field information without relying on other agencies’ information. However, these technologies were currently being used on trial and had only been used very few times within New Zealand. FNS still required extensive usage experience to gain some experience.

5.4.5 Summary

In FNS, the main preparedness activities were pre-planning, physical training, course training, and system usage training, though on an infrequent basis. As a frontline agency, its strongest emphasis was on having adequate information about the event site beforehand. In the response stage, it mainly relied on information conveyed through communication centres for dispatching resources to the frontline crew.

As one of the important supportive agencies, FNS focused more on saving lives and property at the frontline. Therefore, the C-BT usage was limited at the moment. It mainly utilised its internal system for planning, training, and reporting. No C-BT usage occurred at the frontline. However, the change was in progress since FNS started rolling out mobile devices that could facilitate the cloud applications usage at the frontline. The social media usage was deficient, especially at the local level where it was not able to take advantage of the platforms in knowing public issues and the situation of the emergencies. This would be the next step they started to investigate.

To conclude, the C-BT usage in FNS was far less in the response stage than in the preparedness stage. However, it was working towards identifying how to match the appropriate cloud-based tool to the response activities.

5.5 Case 3 C-BT Deployment in Natural Emergencies in PNS

5.5.1 PNS Background

PNS is also one of the key agencies that support New Zealand's emergency service in the sector. The main function of PNS is to maintain the safety of people within the community through preventing the occurrence of crime, crashes or anti-terrorism emergencies. However, PNS also engages with natural emergencies when there is a need for PNS to liaise with other agencies to use its resources effectively in maintaining social order, protecting life, and assisting in search and rescue. Thus, it plays a significant, but supportive role, in coordinating with other agencies in natural emergencies. Therefore, PNS delivers its service in a cooperative environment with a wide range of local authorities. PNS is divided into more than ten different branches throughout New Zealand with more than 14,000 employees.

The PNS headquarters and two different branches of PNS' were visited. Six participants were in the interview sessions from both managerial and operational levels: two district managers, one system strategic advisor, and three senior persons responsible for emergency response. The multi-agency exercises that were observed in CNS also included PNS' involvement. Most of the interviewed participants had substantial working experience in the emergency service sector, which varied from ten to 20 years, except for the system strategic advisor who had worked in PNS for two years. Most of the findings represent the views of those more experienced participants.

Similarly to FNS, PNS is a unified organisation throughout New Zealand which makes sure the C-BT usage is consistent within the organisation. However, the usage of C-BT was also found to be limited within PNS when dealing with natural emergencies. This is discussed in the following section.

5.5.2 PNS Emergency Management Working

Preparedness Working

Due to the supportive role of PNS in natural emergencies, PNS focused more on the planning for non-natural emergencies in terms of required resources. However, there were generic plans for natural emergencies, which was the standard operating procedures for managing earthquakes, flooding, tsunamis and so forth.

Training was another important aspect of the preparedness stage. Similar to FNS, people at management level in PNS also attended table-top discussions at regular intervals with various agencies. Such discussion provided opportunities for establishing relationships and a better understanding of each other's working procedures and priorities, which was considered helpful in the real practice of response operation. The second type of training was the physical training due to working at the frontline for preserving lives and property. PNS had the capability in search and rescue so that regular physical training was conducted. Training on system usage was also conducted in PNS. However, most of the participants considered that there was a lack of systematic training on system usage since they relied on self-learning. As suggested:

> Probably more training is needed for us to be able to use [PNS' R System] and everybody is trained to a reasonable standard. Some are really good at using it, but some are not, so that I think there should be a standard training of that. (ID11)

Response Working

Since PNS played a supportive role in natural emergencies, it mainly followed the instructions of CNS. Therefore, PNS primarily coordinated with CNS in terms of allocating personnel and resources in conducting investigations, or relocation of people. The communication centre played a critical role in the response stage for PNS. Since PNS operated within the communication centre together with FNS, the working procedure was similar to FNS where the frontline staff were required to wait for information from the communication centre regarding the location of the emergencies and resource needed. A participant described this situation:

> We have standard operating procedures which are used basically by communication centres to make sure that all of the things that need to be considered …… which gives the response details of who to call out so that we can determine what the priority tasks are. (ID11)

It was quite busy for PNS to respond to the emergencies for the first couple of hours due to the large volume of calls from the communication centres which required PNS to make quick decisions to allocate appropriate resources to the solve the problem at the scene. Hence, setting priorities was considered critical during the response stage to ensure effective allocation of resources.

5.5.3 PNS Cloud-based Technologies Usage Purpose in Emergency Management

Both internal and external cloud systems were used by PNS (see Table 5-3). Similar to FNS and CNS, internal clouds were hosted by PNS itself. In terms of external clouds, PNS also deployed SaaS. PNS' R System was a platform to support command and control operations within the organisation throughout New Zealand. It provided a common operating picture for PNS to enhance situational awareness and facilitate planning and collaboration. PNS aimed to use PNS' R system to deal with all types of emergencies.

Table 5-3 Summary of C-BT usage type in PNS

C-BT Usage Type		Case 3 PNS
Internally-owned Cloud	1.	Internal emergency management system denoted as "PNS's R system"
	2.	Internal enterprise system
	3.	Mapping software
	4.	Email
External Cloud	1.	Social media platforms such as Facebook and Twitter
	2.	Third party GIS platforms, such as Google Maps, or ArcGIS
	3	Shared usage of CNS's E system only in the multi-agency event

Cloud-based Technologies Usage Purposes in the Preparedness Stage

PNS' preparedness activities mainly involved making plans, such as a district action plan, and a standard operating procedure for emergencies. Therefore, data storage was the useful function of C-BT most referred to by most of the participants. Also, the multiple sites for storage were considered to ensure that they had redundancies in case any one of the sites did not work. External mapping systems, such as Google Maps or Esri, were a complement to PNS' current mapping system. This was because PNS required adequate location information to respond to the emergencies during the response stage. It seemed that the external mapping system was used on a frequent basis, which enhanced the staff's familiarity with discovering other sources of location information when responding to the emergencies. A participant described this:

> We use Esri for our mapping system and they collect information from that. We also use google maps. We use Google Maps on a daily basis. We have our own GIS but we use google maps. (ID6)

In terms of internal information sharing, it was conducted either through email or PNS' R System. Email was used frequently to share the updated plans. The PNS' R System seemed to be very useful in the preparedness stage to share large volume of information for sharing lessons learned from previous logs. As a result, it enhances transparency among all branches of PNS around New Zealand.

Cloud-based Technologies Usage Purposes in the Response Stage

PNS utilised limited C-BTs in the response stage at the frontline when dealing with natural emergencies, which was similar to FNS. Therefore, it relied on information from the communication centres through traditional technologies, such as phones or radio networks. C-BTs had not been applied in communicating with the frontline crew yet. As commented:

> Probably email is the most useful system at the moment. (ID8)

One useful cloud-based application in PNS was to confirm people's identity and the characteristics of the place where they were located during emergencies. Since PNS' role was to maintain social order and avoid crime, such an application was helpful to determine whether a person or a house was risky for them to approach, if any related issues happened during the natural emergency. Information sharing with and gaining updated information from external agencies were critical in the response stage. Email was also used during the response stage in terms of updating situation reports or acquiring information from other agencies to take further action.

Social media platforms such as Facebook or Twitter had been utilised to gain knowledge about the situations from the public. However, PNS had made little effort in communicating with the public through social media platforms even though PNS had realised the benefits of using such platforms. Currently, a platform such as Facebook or Twitter was only utilised at the national level, but not at the local level. So local branches were not able to share information with the community. As explained:

> In terms of social media, CNS does the social media sort of releases more than we do, and social media is not our focus at the time. (ID11)

During the response stage, effective resource allocation was critical to the success of frontline saving tasks. PNS' R system was considered to have the potential to help with the management of resource allocation. Even though it had only been used in exercises rather than in a real natural emergency, the effectiveness was foreseen by the participants. One participant noted:

> [PNS' R System] has not really been used in the real event. I can just think of a couple of mass rescue exercises. With [PNS' R System], it helps with agencies that we don't really have a lot to do with the work while we are in the space like rescue coordination centre. So it helps with keeping coordinated and understanding where all the resources are - those sorts of things. (ID11)

Similarly to FNS, PNS is also required to utilise CNS' E System to share the PNS side of information on the system with other agencies in a multi-agency emergency. However, it was also perceived by PNS participants that it was not efficient and effective in using such a system due to the lack of sharing the common operating picture of the situation.

5.5.4 PNS Current Cloud-based Technologies Usage Level in Natural Emergency

PNS used various tools such as email, mapping system, PNS' R System in managing emergencies. Among these tools, PNS' R System was the basic and relatively new platform for PNS to utilise since the last big Christchurch earthquake. Therefore, PNS' C-BT usage in large-scale natural emergencies was still rare. The usage of C-BTs in dealing with non-natural emergencies occurred more often in PNS in its main responsibility of maintaining social order. For example, PNS utilised one typical web-based social media monitoring tool to oversee the potential risk of terrorism or protests events. As a result, there was a lack of C-BTs that were used to deal specifically with natural emergencies. Another reason for lacking C-BT usage experience in natural emergencies was the limited number of large-scale natural emergencies that PNS had encountered in the last couple of years.

Additionally, PNS' C-BT usage at the frontline was minimal as the communication was mainly conducted through phones or radios. The reason was that frontline persons were busy with the tasks at hand rather than spending time on typing information and transferring it back to the control centre. Further, due to a high possibility of losing connection with cloud services during large-scale natural emergencies, the frontline crew relied more on the hardcopy of procedures. As explained:

> It doesn't have to be on the phone, but it could be on this, but I'm anticipating in a severe emergency, you won't have access to any of this and you're going to be relying on traditional written instructions on pieces of paper and running the operation. (ID10)

In addition, several things caused the PNS' deficient usage of social media. First, PNS had not discovered a better way to manage information from social media platforms. Also, social media platforms were considered less competitive when the mainstream media such as TV, news websites involved in the news release. Thus currently, PNS has not placed much emphasis on using social media source.

5.5.5 Summary

In the preparedness stage, PNS focused on planning and training. Nevertheless, the plans were more generic for natural emergencies than other non-natural emergencies. The physical training and the table-top discussion were considered more effective than the system usage training. In the response stage, PNS relied on their communication with the communication centres and focused on setting priorities for effective resource allocation.

As another important supportive agency in facilitating the operation of saving life or property, PNS played a critical role at the frontline. However, minimal C-BT usage took place there. C-BTs were used more frequently in the preparedness stage, such as for planning, storing, and internal information sharing, than in the response stage. Transparency and efficiency were achieved through information sharing on the PNS' R system. C-BT deployment in terms of communication and information sharing with external agencies was limited to email. The social media usage was deficient and no local pages were established for sharing information with the community.

To conclude, PNS was working towards using C-BT increasingly when dealing with emergencies. This required PNS to make improvements in providing staff with more systematic training on system usage and identifying how to use the advantages of social media platforms when managing emergencies. The efficiency that C-BT could deliver in delivering a better performance could be achieved in both preparedness and response stages.

5.6 Case 4 C-BT Deployment in Natural Emergencies in HNS

5.6.1 HNS Background

HNS' responsibility is to undertake the planning necessary to provide health and disability services in health-related emergencies. However, infectious diseases can also occur in the aftermath of natural emergencies. HNS plays a critical role in facilitating the leading agency to deal with health-related emergencies during natural emergencies, minimising the effects of infectious diseases or pandemics. HNS constitutes around 20 local groups which are responsible for providing health and disability services in the respective regions in New Zealand. It is a large organisation with more than 20,000 employees. HNS provides funding to and monitors the planning of all branches.

The HNS' headquarters and branches in three different regions were visited. Five interviews were conducted with participants from both managerial and operational levels: two emergency management planners, one emergency management system advisor, and two emergency managers. Participants at the managerial level had the working experience around ten years.

All branches of HNS had freedom in terms of ICT usage: each branch had its own IT model. The existence of a core response system in HNS provides a good platform for staff to share information across the country. However, from both managerial and operational participants' view, the usage of core C-BT in the response stage was infrequent. It is now discussed in the following section.

5.6.2 HNS Emergency Management Working

Preparedness Working

HNS focused on preparing health plans for health-related emergencies. However, these plans were required during natural emergencies when diseases and pandemics occurred. Similarly to other supportive agencies, HNS prepared generic response plans for natural emergencies. The purpose of making the plans was to provide guidance to a large number of branches, ensuring that the local plans were aligned with the national plan. The planning also involved an evacuation plan which was considered important by the participants. For example, HNS focused on looking after elderly people during natural emergencies so that an evacuation plan for old people with diseases or disabilities would be taken into consideration as a priority. As noted:

> We should take special care of elderly people in the community such as during the process of evacuation. (ID26)

The risk assessment was also considered important by the participants in the planning stage. This was helpful in analysing the consequences, such as damages to health facilities and physical injury or death in the community, arising from the emergencies. Many participants expressed the view that the plan could be better carried out based on the threats that had been identified from the risk assessment. Additionally, HNS took an active approach to updating the plan at regular intervals, every three years. This helped to ensure that the plan could be adaptable to any new situation that had not been considered in the plan, so that the organisation would have the capability of providing health-related services in an effective and flexible manner. Moreover, HNS' planning took surge capacity into account in the preparedness stage, which was about keeping the continuity of providing care to existing patients, managing the increased demand for health services, and provisioning the surge capacity during the emergencies. It was because the situation always changed faster than it had been pre-planned.

Training also played a critical role in the preparedness stage in HNS. The training was mainly the table-top discussion, scenario simulation, emergency management courses, and system usage practices. The table-top discussion and emergency management courses were conducted most frequently among all of those types of training, helping to reinforce the understanding of roles and responsibilities. Some participants considered that the emergency training under the same structure was important, and led to a more effective performance during the response stage since staff at different branches had the same level of understanding and was ready to assist other branches immediately. Some branches of HNS also involved other agencies during exercises, which provided good opportunities to enhance mutual understanding of the operation in the response. The learning from the exercises could complement the existing plans. The system usage training of HNS' H system was provided to all branches. However, the frequency of the training on using the system varied among branches, such as monthly, every six weeks, or one to two years. Thus, HNS had not set up a systematic structure for the training on using the core system. As described:

> It's probably every one to two years. So the regional emergency management advisor comes in and runs through the system. So we've got IT training rooms over [Location]. We can sort of fit 14 people to work around computers at that the time. So we'll run multiple sessions and sort of talk them through the system and show them how to enter the situation report or annual plan. (ID27)

Response Working

During the response stage, HNS main action was to activate the health-related plans. The operations were conducted through coordinating incident management teams in the HNS' emergency operation centre if it was a relatively large-scale emergency. Keeping the continuity of providing resources to meet the health needs of the community and considering the needs of vulnerable and hard-to-reach communities were important aspects in the response stage in HNS. For example, it was a requirement to create an incident action plan during the response stage to deal with certain situations, such as the entry of a large number of patients.

During the large-scale multi-agency natural emergency, it was important to gain necessary information, such as road closure, or the number of deaths and injuries, from key partner agencies, as this was critical to HNS' operation in satisfying the health-related needs. The information was communicated through the appointed liaison of HNS' in CNS' emergency operation centre. In this way, important information that was critical to HNS' decision-making of resource allocation could be sent back to HNS. As noted:

> If it was a health event alone, I would be potentially the emergency operation centre manager and liaison to the emergency services, but if it was a natural emergency led by [CNS], I would be the liaison person in [CNS] feeding information back to the incident management team. (ID25)

5.6.3 HNS Cloud-based Technologies Usage Purpose in Emergency Management

HNS deployed both internal cloud and external cloud systems (see Table 5-4). The external cloud usage was mainly SaaS. The HNS' H System was owned by HNS, but the system was hosted by a third-party company. Even though it was a relatively new C-BT that HNS was utilising, it was the core infrastructure that HNS relied on, especially in the response stage.

Table 5-4 Summary of C-BT usage type in HNS

C-BT Usage Type	Case 4 HNS
Internally-owned Cloud	1. Internal emergency management system denoted as " HNS H System"
	2. Official website
	3. Email
External Cloud	1. Social media platforms such as Facebook and Twitter
	2. Volunteer management system
	3. Shared usage of CNS's E system only in the multi-agency event

Cloud-based Technologies Usage Purposes in the Preparedness Stage

One of the most important usage purposes of C-BT was the storage function that helped HNS store readiness documents, involving plans, templates, and contact lists. All emergency management related documents were stored on its internal storage service. Some generic plans which could be disclosed to the public were stored on the official website. It was considered by the participant that storing plans on HNS' H System enhanced the capability in documents sharing among different regions. Thus, some valuable learning in terms of resources planning could be gained by reading other regions' plans. One participant elaborated on this view:

> You are just tapping what would need to be shared. It's good to… in the preparedness stage… to share plans because the plans are different within different regions. So in the preparedness stage, it's good to look at people's resources and we learn from other people's resources management. So sharing documents, it's really good. (ID26)

C-BT was utilised for internal communication within HNS. For example, email was used frequently for disseminating training exercise messages to all staff so that they could receive the alerts of the upcoming exercises. Additionally, the internal alerting system was utilised in the preparedness stage when necessary. It was a separated email function that was monitored 24/7 by a duty manager so that an alerting email could be sent to related responsible groups when there was an emergency. In addition to the group email alerting, HNS' H System was embedded with the alerting function to spread alert information to the corresponding incident management team, so the incident team members could immediately know about the alerts. A participant described this system:

> There's an alerting capability in [HNS' H System]. Potentially it has … It's a hugely important piece of the young tool because as a responder if I was sitting there in the emergency operation centre, I can have a pre-programmed message which goes out to my response team listed on their phones. (ID24)

Cloud-based Technologies usage Purposes in the Response Stage

During the response stage, one of the critical roles that C-BT played in HNS was to manage the information that was related to the decision-making of allocating resources. For instance, HNS' H System provided a platform for managing real-time information, such as how many patients are required to be handled by a certain number of wards. It also helped in tracking the sources of the information as to who has sent the information. Therefore, HNS' H System was considered useful by most of the participants in generating situation reports, and tasking different branches when necessary during the response stage. C-BT was also utilised by HNS in requesting staff for assistance. For example, such requests took place during one of the large earthquakes where extra nursing staff were required to help on-site. Through the group email function, it was efficient to know each branch's current status and whether they had the spare capacity to assist in the event.

Similarly to other supportive agencies, HNS also engaged in multi-agency operations in CNS' emergency operation centre when it was required. Thus, HNS delegated the liaison to sit in the emergency operation centre to use CNS' E System while using their own HNS' H System.

In terms of communication with the public during the response stage, social media played an important role in HNS to disseminate important information to the community. It was specifically monitored and used by HNS' communication teams to communicate with the public. It was also helpful for incident management teams to gain real-time information to address the problem on hand, as well as deliver the necessary information to the incident management team to accelerate the process for decision-making of resource allocation. One participant described part of this process:

> We use open-source social media monitoring tools and that's rather fast intelligence that helps in the awareness of what's going on in Twitter or Facebook, then allowing our public information management team to tailor some of those messages and address them or pass it onto operations to validate and follow up whether or not it's essentially an issue. (ID23)

5.6.4 HNS Current Cloud-based Technologies Usage Level in Natural Emergencies

HNS used several C-BTs. The internal cloud system was used mainly when dealing with health-related needs in natural emergencies while the external cloud complemented the usage purposes that the internal cloud was not able to satisfy. Among these C-BTs, email seemed to be utilised as the primary tool for sharing plans and disseminating messages internally in the preparedness stage. On the other hand, HNS' H System was the main system in the response stage for managing and sharing information internally.

In terms of cloud storage, HNS preferred to use internal storage rather than an external service. This was due to the lack of trust of holding large amount of information on the external cloud. A participant explained this decision:

> We do not use Microsoft 365. They are all on the servers. There are millions of documents held on our servers and we all have our own space. We are worried about losing it, but we have all those backups on the server every day. (ID25)

Additionally, HNS' H System had not been used to an adequate level, although it had been used in certain events such as readiness work for a virus disease, or response to a man-made poisoning event. Although the system had been established for many years, the usage frequency was relatively low because it was a relatively new system so that staff had not adapted to its usage in response to the emergencies. Despite the storage function that could be easily mastered to store plans in the preparedness stage, staff required more chances to practise how to use other useful functions of the system for the operations in the response stage. HNS' H System was more likely to be utilised in large-scale emergencies. Thus, staff were not able to take full advantages of the system. As commented:

> We haven't had any major event yet in using [HNS's System]. (ID26)

Despite the different IT models being used among various branches, all branches of HNS devoted to the HNS' H System usage in the response stage, which was different from CNS. It ensured consistent operations during the response stage and enhanced the transparency of information delivery throughout all branches in New Zealand. Additionally, HNS was leveraging the capability of social media platforms. Also, it would be the C-BT usage strategy that HNS followed in the long run in the response stage of emergencies.

As a final point, there was no evidence of the use of the cloud-based mapping system when dealing with emergencies. This was because HNS had not discovered an appropriate way of leveraging such capability even though they had adequate resources to invest in exploiting the mapping capability. Gaining useful layers from other agencies, such as lifeline agencies, was considered beneficial to HNS' improvement on GIS utilisation.

5.6.5 Summary

In HNS, health planning played the main role in the preparedness stage where all branches' plans were under the guidance and aligned with the requirements of the national guidelines. Training activities were helpful to enhance the preparedness level so that staff could operate smoothly during the response stage. System usage training was not carried out on a frequent basis. During the response stage, HNS strived to keep the continuity of health service to meet the needs of the community.

HNS' current C-BT usage was also limited as email was the primary tool for plan sharing and communication in the preparedness stage. Also, HNS relied on HNS' H System for operation during the response stage. However, in HNS, it was far from enough to exploit the key system to its full potential due to the lack of usage experience in large-scale emergencies and frequent training on system usage. Social media played a long-term critical role in informing the public during the response stage.

To conclude, HNS was satisfied with its current C-BT usage. Nevertheless, more frequent system usage training was required so that the operation can be better carried out during the response stage.

5.7 Case 5 C-BT Deployment in Natural Emergencies in JNS

5.7.1 JNS Background

JNS is a charitable organisation that provides essential healthcare services to communities when responding to injuries during emergencies. Working as a welfare agency, it plays a significant and supportive role in large-scale natural emergencies in responding to injuries, transporting and treating patients, and distributing first-aid kits to households. JNS also works closely with other organisations in the health-related area due to the similarity of providing an extensive range of services and products. JNS is a large organisation of around 10,000 employees among which a large portion of employees are volunteers due to having a volunteer ethos.

JNS is divided into three regions: northern region, central region and South Island region. The headquarters in the northern region and one branch in the central region were visited. Four interviews were conducted with participants from both managerial and operational levels: three managers responsible for response and operation, and one clinical support officer. One focus group was conducted with three emergency planning advisors and two emergency planning managers. Most of the participants had around ten years' working experience.

From both managerial and operational participants' point of view, the C-BT usage in JNS was relatively low. Nevertheless, JNS owns the core cloud-based systems for resource dispatching. The emergency management working, C-BT usage purposes and current C-BT usage level are now presented.

5.7.2 JNS Emergency Management Working

Preparedness Working

Similarly to other agencies, JNS focused on planning in the preparedness stage. Although JNS played a supportive role in natural emergencies, it relied on the working policies and procedures in terms of transferring patients for treatment in major incidents during natural emergencies. The plans helped to ensure that the resources could be allocated appropriately to transfer patients to a safer place for treatment. From both managerial and operational staff's point of view, the plans provide a good guideline for them to learn about the actions to be taken during the response stage.

In JNS, establishing the relationship among various agencies was also important in the preparedness stage, as this helped to enhance the understanding of each other's operation during the response stage. For example, some of the plans also involved advice from other health-related agencies, which showed the efforts that had been made in relationship establishment during the preparedness stage. Relationship establishment also was exhibited in the regular meetings between JNS and FNS for a better cooperation at the scene of the emergencies:

> …or at the scene making sure that we need to get together and put our minds together, work together on this and do the right thing. We have improved to make sure sort of senior people in PNS, ambulance and FNS now meet each regularly rather than establishing that relationship once it happens. With that relationship already exists, which is better. (ID20)

Training also played an important role in JNS. There were several types of training: table-top discussions, medical technique training, simulation exercises, education of emergency policy and procedure, and tablet practice. Training courses were consistently provided to all JNS branches in New Zealand. Therefore, the consistency of staff knowledge understanding regarding mass casualty incident was achieved through the uniformity of the training courses. The simulation exercise, a special type of table-top exercise conducted through using figurant cards, had become more regular in JNS than it used to be. Such exercise helped staff to experience the process of allocating resources to handle patients during large-scale events that they were not regularly faced with. Medical technique training was provided regularly. This meant that the life-saving skills were maintained at a certain level in terms of dealing with the patients during the response stage, which was considered as necessary training in JNS. In terms of system usage training, there was a lack of training in using JNS' H System which consisted of many separate websites. Even though the website itself was considered easy to understand, it was confusing for staff to use many websites at the same time without systematic training, which was not beneficial to performing efficiently. JNS increased the training for using a patient report application installed on the tablet, which was considered crucial to the smooth operation of transferring patients from one place to another during the response stage. A participant explained that:

> We did a lot of work around introducing a [application name] tablets. So we did a whole lot of work around that in terms of teaching people how to use it and practice jobs. (ID20)

Additionally, JNS put emphasis on ensuring a common understanding of the policies and procedures in dealing with emergencies. For example, internal staff, such as the management team, were communicated with regularly to ensure a consistent level of understanding of the plans. External volunteers were also organised to learn the policies and procedures in dealing with emergencies on a regular interval. As noted:

> Regularly interacting with usually management teams to make sure they understand the plans so that they can apply them. (ID19)

Response Working

During the response stage, immediate initiation of the action for the operation was critical to respond to the emergencies once the emergencies were activated. A teleconference was normally set up immediately to discuss the steps to follow in responding to the emergencies. The communication between JNS and its communication centres played a significant role during the response stage, especially in facilitating JNS to receive important information regarding resource allocation. It helped JNS to ensure that the operation would not influence the business-as-usualperformance. This ensured JNS made careful decisions on resource allocation during the response stage. As explained:

> During the response, information regarding resource allocation and resource deployment is important. In a disaster or mass casualty incident, we still have to provide patient transporting service to the rest of the country. (ID22)

JNS was also involved in the coordination with other agencies during the response stage of large-scale natural emergencies. For example, as a frontline agency, JNS worked together with PNS and FNS at the scene during the response stage through face-to-face communication. The coordination at the scene was considered particularly important to be carried out in the early stage when responding to the emergencies. Despite the action on the scene, information sharing behind the scene was conducted through appointing liaisons in an emergency operation centre during large-scale natural emergencies. This meant important information, such as road closure, or the capacity of the receiving centre for patients, from other agencies, could be conveyed to JNS to better facilitate its resource allocation decisions. A participant explained that:

> On a national basis, we provide national liaison officers to the national crisis management centre in [location] so that information regarding the whole picture can be sent back to JNS through the liaisons. (ID19)

5.7.3 JNS Cloud-based Technologies Usage Purpose in Emergency Management

Both internal cloud and external cloud usage took place in JNS (see Table 5-5). However, JNS focused on using its internal system, JNS' H System, which was a business-as-usualsystem, but was also used to some extent in the preparedness stage. JNS' V System and T System were mainly used in the response stage for better resource allocation.

Table 5-5 Summary of C-BT usage type in JNS

C-BT Usage Type	Case 5 JNS
Internally-owned Cloud	1. Internal enterprise system denoted as "JNS H System" 2. Resource allocation in emergencies denoted as "JNS' V System" and "JNS' T System" 3. Email
External Cloud	1. Social media platform such as Facebook 2. Third party GIS platform, such as Google Maps 3. Shared usage of CNS's E system only in the multi-agency event

Cloud-based Technologies Usage Purposes in the Preparedness Stage

In terms of cloud storage, JNS did store key policy and procedural knowledge on JNS' H System for employees to learn in the preparedness stage. However, some of the emergency plans or procedures were stored electronically on their mobile devices allocated by the organisation or in the form of hard copy. This was due to JNS' characteristics of conducting urgent frontline life-saving jobs during the response stage whereby the operation was carried out off-site so that cloud storage might not be able to assist crews without a stable Internet connection. Thus, utilising mobile devices or hard copy of documents were the first choice for the frontline operation presently. As commented:

> All of the branches of [JNS] maybe the same for everyone. They have a hard copy of emergency plans and also on in the laptop or iPad stuff. So generally people will store it themselves and access, if they can get on the network and have a hard copy. (ID20)

JNS' H System was also utilised for the self-learning of the procedures and policies, which helped to reinforce the knowledge of procedures to be followed during the response stage. Hence, self-learning through the system was considered by the participants to be a necessary activity in the preparedness stage. With regard to staff management, JNS utilised an online rostering system for managers to check the number of staff who were getting ready for the shift, in case an emergency happened. It was considered a useful function by the participants since it helped JNS to manage staff more efficiently during the response stage. Additionally, social media was utilised in the preparedness stage but only for recruiting volunteers for help since the volunteer workforce constitutes a large portion of JNS. A participant described this function:

> Within [JNS' H System] we look at lots of things such as time sheets roster programming, 'find my shift'. So we know who is working and the schedule for that. (ID21)

Cloud-based Technologies usage Purposes in the Response Stage

In terms of information sharing and communication, email was used most frequently by JNS both internally and externally. Social media was also used for information sharing during the response stage in some branches of JNS. For example, the communication team in one branch utilised social media to gain information about the current situation and places that required help for saving people. Such source of information also facilitated the branch to allocate resources to the potential patients during the response stage. Social media was also considered helpful in checking whether there was any issue of resource allocation so that the performance can be improved. JNS utilised two separate systems, JNS' V System and JNS' T System, to facilitate the process of resource allocation of personnel and vehicles predominantly in the response stage. Through JNS' V System, up-to-date information regarding the situation of emergencies assisted to allocate the amount of resources required. JNS also utilised CNS' E System and HNS' H System in a multi-agency natural emergency. Using these systems, the JNS' appointed liaison could send information back to JNS.

5.7.4 JNS Current Cloud-based Technologies Usage Level in Natural Emergencies

JNS was another organisation that used limited C-BTs for managing natural emergencies. As a charitable organisation, no evidence has been found that a core system existed especially for dealing with natural emergencies. Rather, several separate cloud-based tools, such as JNS' T System and JNS's V System, had been used for assisting resource allocation in the response stage while JNS' H System had been utilised only in the preparedness stage for learning policy and procedures. Despite these tools, email was the most frequently used C-BT combined with other non-C-BT tools such as phone, text or paging system, for communicating with frontline crews. As commented:

> We haven't had that many. So just picking on it on a few. Definitely, your phone and it would be messaging service over probably anything else. Emails. I have my email on my phone and that's always coming up with updates and the [JNS' H System] that will be probably the last place and when you get to know a particularly important piece of information, you get an email notification first anywhere. (ID22)

Even though JNS was involved in the shared usage of other agencies' systems during the response stage, these systems were not used by JNS on a regular basis. Thus, JNS' people in the emergency operation centre were less likely to focus on the emergency management issue but on how to use the systems. Further, limited people in JNS had access to both CNS' E System and HNS' H System during the response stage. The reason was that it was still the early stage for the shared usage of systems during the response stage among different agencies in New Zealand. A participant noted that:

> We are just not familiar. It is hard to comment on which system is easy to use because I haven't used both of them quite often. (ID19)

Finally, very limited external cloud usage existed in JNS. In terms of social media usage, it was utilised differently in various regions of JNS. Not every branch had established a local page for deployment, and only one national page had been established, mainly for volunteer recruitment or fundraising. The usage of Google Maps was mentioned, but only in the focus group. None of the participants in the individual interview mentioned any usage of the external cloud for managing emergencies, except for the personal choice of storing non-confidential information. The reason for limited external cloud usage might be that the current C-BT in JNS had been used appropriately for allocating resources such as vehicles and personnel to help at the frontline. On the other hand, if there was a need for JNS to get other aspects of information, such as road closure or weather forecast, it would turn to the responsible agencies and ask for such types of information.

5.7.5 Summary

As another supportive agency to provide welfare services to the community, JNS strived to save the lives on the scene and transfer patients to the appropriate centre for treatment. Therefore, making plans in terms of mass casualties in large-scale emergencies was particularly important in the preparedness stage. The consistent policy and procedure learning, as well as the regular training exercises, provided a strong basis for JNS crews to achieve the more desired performance of life-saving at the frontline. During the response stage, JNS focused on the communication with the communication centre and collaboration with other agencies in large-scale emergencies while maintaining the capacity for the normal business.

C-BT usage was limited within JNS as a small number of C-BTs were used either in the preparedness or in the response stage. Although JNS used C-BTs for monitoring resource allocation, it relied more on traditional technologies, such as radio technology, to dispatch personnel to the scene. The mobility of information was gained through non-C-BT which had the risk of losing information, resulting in interruption of actions. Further, social media usage was not consistent throughout JNS, so that the potential of the platform has not yet been achieved.

To conclude, JNS' C-BT usage was in the early stage where C-BTs that could be used were limited. Therefore, sometimes it relied on additional information provided by other agencies during the response stage. It is believed that JNS will move towards using more C-BTs in emergencies once it has discovered the appropriate C-BTs to matches its performance needs in large-scale emergencies.

5.8 Case 6 C-BT Deployment in Natural Emergencies in RNS

5.8.1 RNS Background

RNS is part of the largest network in providing humanitarian services to the community, both locally in New Zealand and internationally. Such services involve, for example, providing first-aid courses and education, setting up refugee programmes, fundraising and serving the community with transport services. In addition to the main role of providing these services, RNS also plays a supportive and critical role in providing welfare services, such as establishing welfare centres and distributing relief items, to support community-based needs during natural emergencies. RNS is a large organisation with around 1,000 employees; half of the members are made up of volunteers scattered across 19 teams in different regions. Those teams will be deployed to deliver the welfare services to the affected community when necessary. RNS is a voluntary relief organisation which is auxiliary to the local authorities.

It is divided into North Island and South Island regions with one emergency officer in each looking after the same aspects of emergency management. The two disaster management officers were involved in the interview sessions. Both interviewees had around 10 years of working experience.

In the view of both managers, the C-BT usage in RNS was quite limited as there was a lack of a core system for managing natural emergencies when responding to them. The following section presents the working, C-BT usage purposes, and current C-BT usage level in RNS.

5.8.2 RNS Emergency Management Working

Preparedness Working

In the preparedness stage, RNS focused on planning. There were various types of procedure planning for RNS to prepare during this stage in order to perform effectively when responding to natural emergencies, such as the standard operating procedures, volunteer management, logistics procedure and so forth. Nevertheless, the emphasis was more on welfare perspectives, such as the number of shelters, physical needs of medicine, water supply, and sanitation. The plans ensured RNS' ability in providing essential services and to satisfy communities' welfare needs in a stable manner. Therefore, the planning activity was considered an important step and a core task in the preparedness stage. Currently, a review of the emergency management strategy was being undertaken, which indicates RNS' continuous efforts to support its service continuity. As explained:

> RNS is currently going through the review of that disaster risk management strategy. So there will be a lot more … information in the coming year and have a clear strategy around resilience, community resilience and what we're doing in that space. (ID28)

The plan also involved team exercise training where both North Island and South Island teams were trained together annually based on the plans. The annual training exercise was about conducting outreach tasks, such as search and rescue minorities, or delivering relief items of water and food, under a given situation. Team members were also required to have regular training modules, including first-aid training, provision of welfare, ground-based rescue and communications in responding to emergencies. Therefore, there were different modules for team members to take part in. The exercise in conjunction with other agencies provides a good opportunity for RNS to establish good relationships with various agencies such as PNS, CNS, JNS, and FNS. RNS acknowledged the importance of coordinating with other agencies during natural emergencies. As commented:

> Our normal preparedness or day-to-day work is around relationship management with territorial authorities. And it's specifically the regional groups of CNS and also the emergency services that we also have our relationships with. So we have MoU with JNS there and working relationships with police and also not much of fire but we do engage with fire from place to place. So it is our day-to-day business. (ID28)

Response Working

In the response stage, RNS activated the deployment of teams according to the severity of the emergency. Once the emergency was activated, it was followed by the management of the activities that were planned in the preparedness stage. For example, volunteer teams were deployed to carry out outreach tasks, such as delivering water and relief needs and working with CNS in terms of establishing welfare centres. Therefore, during the response stage, volunteer teams played a quite important role since they were the main source for assistance in the frontline service in RNS. The deployment of the voluntary teams had been organised in a very structured way during the response stage in RNS. Thus, the tasks could be allocated to the team members effectively. RNS considered first-aid rescue a critical part in the response stage of a natural emergency. As noted:

> In the disaster, people need to know first-aid. If someone's dying of a heart attack, you don't need an app for that, but the saving technique. (ID29)

Coordination with external agencies was also an important activity during the response stage. It involved sharing information with partner agencies in terms of reporting to the lead agency in terms of what RNS had done and what the next steps were. The liaison served as a bridge between RNS and other agencies in terms of sharing the information. Also, RNS facilitated key agencies in rescuing or evacuating people even though these might not be the main task of RNS. As long as it was within RNS' capacity, it would conduct these tasks together with other agencies. As commented:

> In the event of a widespread disaster, I can do stuff, but it could be that we are activated through local authority to support the FNS in the rescue or the PNS with a local evacuation. (ID28)

5.8.3 RNS Cloud-based Technologies Usage Purpose in Emergency Management

The combination of internal cloud and external cloud usage took place in RNS (see Table 5-6). In terms of internal cloud usage, even though RNS deployed a private cloud system, a large percentage of RNS' IT infrastructure had been moved to an external cloud service provider.

Table 5-6 Summary of C-BT usage type in RNS

C-BT Usage Type	Case 6 RNS
Internally-owned Cloud	1. Internal enterprise system denoted as "RNS R System" 2. Email
External Cloud	1. Social media platform such as Facebook 2. Third party GIS platform, such as Google Maps 3. Gmail 4. Google Docs 5. Shared usage of CNS's E system only in the multi-agency event

Cloud-based Technologies Usage Purposes in the Preparedness Stage

In the preparedness stage, the storage of plans was the main purpose of RNS' C-BT usage. For example, the RNS' R System was the primary source of tracking plans, procedures and training materials. Although it was not specifically designed for the purpose of emergency management, it was utilised as a place for storage plans. Further, a volunteer database was utilised, which was considered convenient for managers to manage volunteer member information, such as driver licenses, allergies, and passports, thus allocating tasks more effectively according to their characteristics. A participant noted that:

> During preparedness, we've got our volunteer database and we capture information like driver's licenses, passports, allergies, next-of-kin, their training requirements which is sort of stored online. (ID29)

Internal communication was another important aspect of C-BT utilisation in RNS. Email was used predominantly for conveying plans and messages within the organisation. Since the organisation's members were spread all around New Zealand, email primarily supported RNS' share of plans in a more efficient way.

In terms of the information sharing among team members, Google Docs was utilised to, for example, share training reports, for self-monitoring.

Additionally, C-BT was utilised for field training in RNS. As mentioned earlier, RNS put emphasis on several training modules where all of the training plans were stored in RNS' R System. This ensured that the training plans were trackable during the training session. A participant described their system:

> So we will set up our emergency operation centre to support the training…we use a Wi-Fi system and we will access to [RNS' R System] which is a cloud-based system for training plans. (ID28)

Cloud-based Technologies Usage Purposes in the Response Stage

In the response stage, RNS utilised C-BTs for sharing information internally and communicating with members in the field. Email was mainly used to communicate internally and externally. Nevertheless, the radio network was the first choice for communicating with teams during outreach tasks. Externally, email was utilised for information sharing with other agencies, such as status reports or key information that was helpful to other agencies' operations. As for communication with the public, social media platforms were found to be more likely to be utilised in the response stage for conveying important messages to the public. This was because RNS recognised the benefits of utilising social media platforms to deliver real-time information to the public. For example, it was useful to update the necessary information about welfare needs such as water and food distribution locations.

RNS also utilised external cloud mapping applications, such as Google Maps which was particularly useful during the response stage. The main reason was that RNS lacked its own web-based maps for pinpointing the locations for the tasks. As noted:

> We all use google maps since we don't have a GIS section of RNS… we can plot on the google map of where we've been and what we've done and what we need and coloured the information. (ID28)

5.8.4 RNS Current Cloud-based Technologies Usage Level in Natural Emergencies

The C-BT usage in RNS was most limited compared with the other five agencies. RNS relied mostly on email for information sharing and communication in both the preparedness and response stages. RNS' R system was used for the storage of plans so that procedures could be checked once the emergency was activated. However, RNS' R System, was also utilised primarily for carrying out business-as-usualfunctions, such as human resource and finance. Hence, it was not designed particularly for managing natural emergencies, though it had been used for storing emergency plans. Thus, RNS lacked a core system that specifically dealt with emergencies. RNS was now working towards this since it had realised the importance of establishing a more appropriate platform for responding to the emergencies during the response stage. As explained:

> So after the Christchurch earthquakes, we found that we need to have some emergency operation centre software that management type software like CNS' E System or whatever. At the moment, we're investigating several suppliers, but we haven't initially implemented anything yet. (ID29)

As a result, during the response stage, RNS heavily relied on desktop Microsoft productivity tools such as Excel spreadsheets or Word file processing in terms of managing team members' rostering and generating situation reports. No mention was made of generating documentation via cloud-based applications, such as Microsoft office 365 or cloud storage during the response stage. Thus, the usage of C-BT in the response stage was very limited. Further, there was a lack of C-BT usage for field communication. The communication with team members was conducted through email via their own mobile phones in the field. Another communication channel included hand-held radio which was used more frequently than email during the response stage. Regarding communication with the public, social media was found to be used rarely by RNS to educate or alert the public about the natural emergency in the preparedness stage. RNS utilised social media platform mainly for posting information about fundraising and refugee programmes when no emergencies were taking place.

On the other hand, RNS was just starting to use a free mobile application for the teams to carry out a needs assessment of the community during the response stage. It was considered helpful in monitoring the up-to-date progress of the team members in the field in completing their allocated tasks. The usage of the free application on the tablet also assisted in enhancing the speed of communication between the controller and the team members. A participant described this:

> We're just, in the next month, we're just providing a tablet to each of our 19 response teams. It helps us in terms of being able to communicate with the members in the field through sending emails or photos. (ID29)

RNS also took part in the multi-agency operation coordination during large-scale emergencies in which CNS' E System was utilised by RNS as well. Only an appointed liaison utilised CNS' E System and would send information back to RNS. Even though CNS' E System existed for a while, RNS was not yet a big player of the system, and such a system had not been fully implemented throughout New Zealand.

5.8.5 Summary

In RNS, preparedness activities predominantly included working on standard operating procedures and planning of training modules. Pre-planning of the operational procedures was crucial to guiding RNS' operation during the response stage. Since it is an organisation relying on deploying teams with volunteers, the effective volunteer management in the preparedness stage facilitated RNS' better response operation in the response stage. Training for volunteers also eased the way for them to deliver services to meet community needs during the response stage.

As one of the supportive agencies, RNS paid much attention to meeting the welfare needs of the community. However, there was a lack of a core emergency management system for RNS to utilise, especially in the response stage as email was the preferred technology among a limited number of applied C-BTs in RNS.

To conclude, the C-BT usage in RNS was the most limited of the six organisations. However, it was working towards establishing core infrastructure for emergency response and to embrace mobile application usage for conducting more efficient needs assessments. Therefore, there would be a huge space for RNS to involve more C-BT usage that could match their needs to perform in the response stage.

5.9 Chapter Summary

This chapter outlines the background and descriptions of findings derived from six cases. The descriptions of the findings were presented based on three themes: emergency management workings, C-BT usage purposes in emergency management, and current C-BT usage level in natural emergencies. All cases were described independently and quotes from the participants were included to support the findings. Findings indicate that the leading agency focused more on natural emergency planning and C-BT training than the supportive agencies. Nevertheless, all agencies placed emphasis on relationship establishment early in the preparedness stage. All agencies seemed to use both internal and external clouds, but the usage purposes varied according to the different focus of tasks in the preparedness and response stages. The C-BT usage level was also different among agencies. The leading agency made the most efforts in using C-BTs that were either owned by the organisation or externally hosted by a third-party while the supportive agencies relied mainly on internal cloud-based systems. The specific report for each case enabled the researcher to become more familiar with each case in terms of the C-BT usage practices among different emergency services agencies. This facilitated the cross-case comparisons. The next chapter provides the detailed analysis for cross-case comparisons.

CHAPTER SIX – CROSS-CASE FINDINGS

6.1 Introduction

This chapter presents the cross-case findings of this research. The results are supported by transcript quotations and observation notes. These sources are primarily the interview transcripts, but also include focus group transcripts and exercise observation notes. The chapter starts with the summary of grounded theory method of coding and analysis that contributes to the final theoretical framework formation. It then proceeds with the findings which emerged from the data. The cross-case findings are arranged by the elements of the framework derived from the grounded theory analysis.

6.2 Grounded Theory Results

The grounded theory results are presented in this section. As mentioned in Chapter Four, the grounded theory analysis follows the systematic process which consists of three steps: 1) open coding which constructs categories of the data; 2) axial coding which creates possible relationships among categories; 3) selective coding which involves integration and refinement of categories through forming a storyline.

During the open coding stage, the concentration was on identifying and labelling the incidents through line-by-line examination of phrases and sentences. As a result, *1393* incidents emerged from the data that delineate the factors influencing the emergency professionals' perceptions regarding C-BT usage in natural emergencies. Similar incidents were grouped together and resulted in *58* conceptual labels (see Table 6-1). In the axial coding stage, the researcher focused on finding the relationships among categories, which involved classifying the categories that had been identified in the open coding stage. Selective coding was used as the final stage to integrate and refine the categories. The technique of writing storylines was employed to facilitate the process of identifying the final six core categories (See Appendix F).

Table 6-1 Concepts which emerged from open coding with number of incidents in descending order

Concept Code	Concept Name	Number of Incidents
IP2	System advancement	90
OR2	Current usage level	84
CT15	System and infrastructure vulnerability	54
CT22	Private cloud or Internal cloud	52
CT4	Efficiency	51
CT18	Communication	46
CT23	Public cloud or External cloud	46
OR1	Familiarity	45
CT11	Complexity	44
CT17	Date storage	44
CO2	Obstacles to information sharing	39
OR13	Training frequency	38
CT10	Compatibility issue	38
ORD3	Communication redundancy	37
CT5	Mobility	36
OR3	Cloud movement readiness	35
CT13	Security concern	34
ORD1	Paper-based redundancy	30
OR9	Human resources	29
CT16	Unexpected situations	29
CO5	Shared capacity	24
CO3	Common platform	23
CT12	Cost	23
OR12	System advancement initiative	22
CT6	Redundancy	22
OR7	Access to IT expertise	21
CT1	Accessibility	21
ORD4	Connection redundancy	20
IR3	Confidence in C-BT usage	19
OR10	IT resources	17
CO1	Relationship establishment	17
OR14	Consistency of training	16
CT2	Consistency	16
OR11	Budget	15

CT3	Cost-effectiveness	15
CT19	Warning/Alerting	15
IR8	Cloud-based technology concept	14
CO4	System linkage	13
CT21	Training management	13
IR2	Reluctance to change	13
OR6	System promotion	11
IR5	Personal effort	11
IR7	Cloud-based technology awareness	11
CT20	Resource management	10
CT8	Stability	9
IR6	Trust	9
IR1	System attractiveness	8
OR4	Consistency of usage	7
OR8	C-BT hosting capacity	7
ORD2	Storage redundancy	7
OR5	Usage commitment	6
OR15	Training expertise	6
CT9	Transparency	6
CT14	Privacy concern	6
IP3	Uninterrupted connectivity	6
IP1	Cloud preference	5
IR4	Age	5
CT7	Situational awareness	3

The concepts above were further grouped into *13* categories as shown in Table 6-2

Table 6-2 Grouped categories

Category Code	Category Name	Concepts Included	Number of Incidents
A	Usage Frequency	OR1, OR2	129
B	Usage Preparedness	OR3, OR4, OR5, OR6	59
C	Capacity	OR7, OR8, OR9, OR10, OR11, OR12	111
D	Training	OR13, OR14, OR15	60
E	Inter-agency Coordination	CO1, CO2, CO3, CO4, CO5	116
F	Perceived Advantages	CT1, CT2, CT3, CT4, CT5, CT6, CT7, CT8, CT9	179

G	Perceived Disadvantages	CT10, CT11, CT12, CT13, CT14, CT15, CT16	228
H	Usefulness	CT17, CT18, CT19, CT20, CT21	128
I	Deployment Model Type	CT22, CT23	98
J	Enhancement Expectation	IP1, IP2, IP3	101
K	Human Factors	IR1, IR2, IR3, IR4, IR5, IR6	65
L	Knowledge	IR7, IR8	25
M	Offline Redundancy	ORD1, ORD2, ORD3, ORD4	94

The following sections now discuss the categories which emerged from the data as shown in Table 6-2.

6.3 Cross-case Findings: Influence of Dimensional Elements on C-BT Deployment in Natural Emergencies

Despite the homogeneity of emergency services organisations in the sector in New Zealand, the leading or supportive role that each organisation plays in natural emergencies and the nature of the organisation, government and non-government, distinguished the extent of C-BT utilisation in these six case organisations. CNS, as the leading government emergency service agency in natural emergencies, made a significant effort in establishing the key C-BT in facilitating the resource allocation and coordinating other emergency service organisations to respond to natural emergencies. Among the remaining five organisations, which play a supportive role, HNS was most proactive in utilising its key C-BT for managing health issues FNS, PNS, and JNS, as the frontline agencies, made less emphasis on C-BT utilisation even though two of them are government organisations. RNS had made the least effort in C-BT utilisation due to its volunteer-based nature as more actions were required on the ground by volunteers. Nevertheless, it had proposed to develop its own C-BT for emergency management.

Findings derived from the grounded theory analysis of cross-case analysis show that the emergency professionals' perceptions of C-BT usage in natural emergencies are influenced by multi-dimensional elements (see Figure 6-1). There were four dimensions of elements emerging from the data: *organisational factors, individual factors, technology characteristics* and *offline back-up*. The four dimensions were further broken down into six core categories: *organisational readiness, coordination, individual perception, individual readiness, C-BT characteristics,* and *non-C-BT redundancy.* The findings are arranged according to the six core categories. The next section discusses these concepts derived from the case studies. Section 6.3.1 and Section 6.3.2 discuss the organisational factors that influence C-BT deployment in natural emergencies. Section 6.3.3 illustrates how the research findings relate to technology-related factors. Section 6.3.4 and Section 6.3.5 elaborate on the findings on individual factors in influencing C-BT deployment in natural emergencies. Section 6.3.6 describes how offline back-up plays an important role in influencing C-BT deployment.

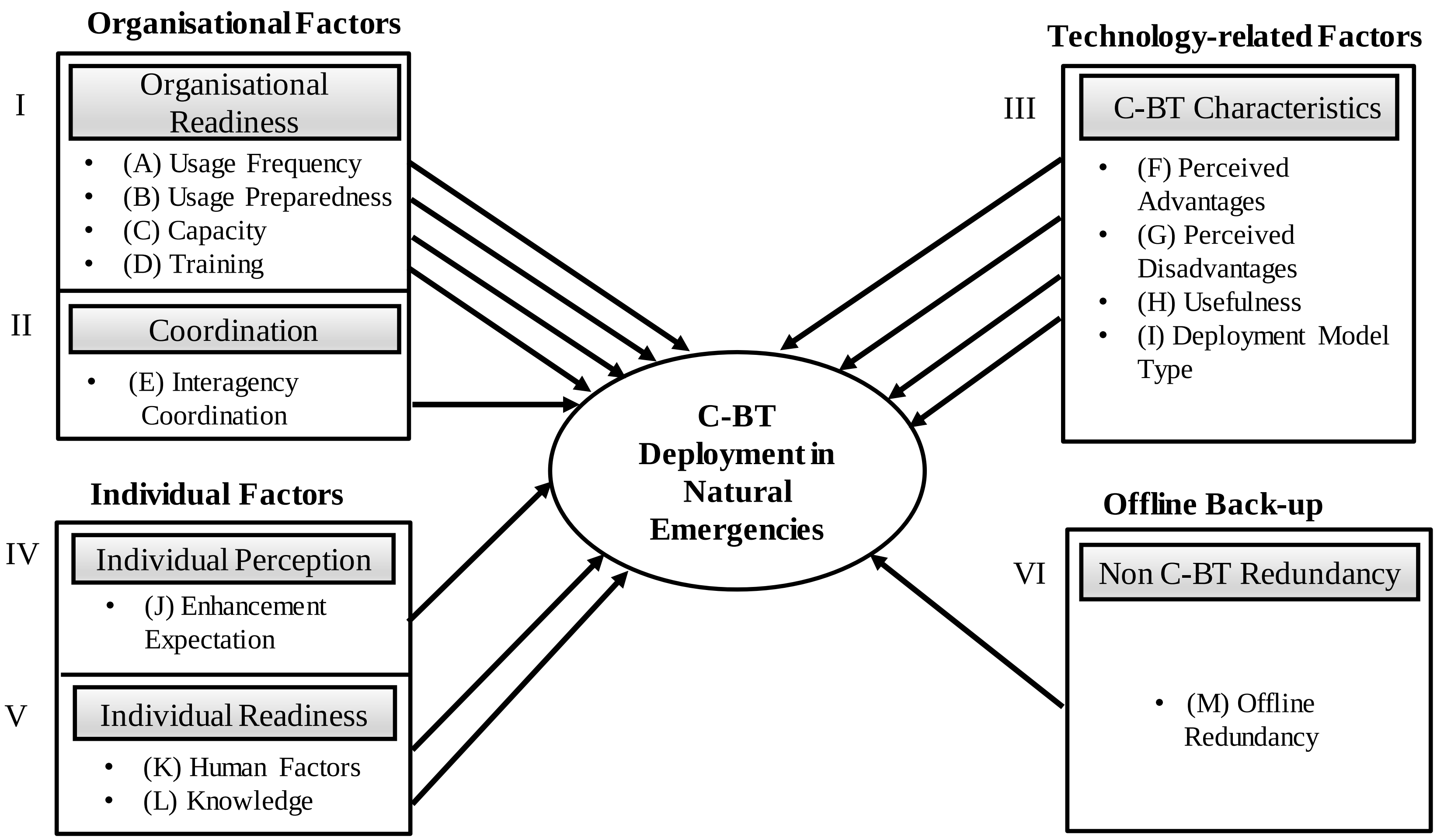


Figure 6-1 Dimensional elements influencing C-BT deployment in natural emergencies in New Zealand emergency services organisations

6.3.1 Organisational Readiness

The organisational factor plays an important role in influencing the emergency professionals' perceptions regarding C-BT usage in natural emergencies. It is associated with the organisational readiness in utilising C-BTs when dealing with natural emergencies. The organisational readiness can be further broken down into four lower level groups: usage frequency, usage preparedness, capacity, and training. From the interview and focus group transcripts and the observation notes, 359 incidents emerged, which formed the 15 concepts presented in Table 6-3.

Table 6-3 Open coding of organisational readiness concepts with number of incidents in a descending order

Concept Code	Concept Name	Source			Number of Incidents
		Interviews	Focus Groups	Observations	
OR2	Current usage level	27	3	3	84
OR1	Familiarity	20	2	4	45
OR13	Training frequency	24	1	3	38
OR3	Cloud movement readiness	19	2	0	35
OR9	Human resources	6	2	0	29
OR12	System advancement initiative	16	1	0	22
OR7	Access to IT expertise	20	0	0	21
OR10	IT resources	11	3	0	17
OR14	Consistency of training	11	1	0	16
OR11	Budget	19	1	0	15
OR6	System promotion	8	1	0	11
OR4	Consistency of usage	4	1	0	7
OR8	C-BT hosting capacity	2	3	0	7
OR5	Usage commitment	6	1	0	6
OR15	Training expertise	12	1	2	6

The concepts above were then further grouped into four categories as shown in Table 6-4.

Table 6-4 Category groupings of organisational readiness

Category Code	Category Name	Concepts Involved	Number of Incidents
A	Usage Frequency	OR1, OR2	129
B	Usage Preparedness	OR3, OR4, OR5, OR6	59
C	Capability	OR7, OR8, OR9, OR10, OR11, OR12	111
D	Training	OR13, OR14, OR15	60

These concepts are now discussed in the following sections.

Usage Frequency

Usage frequency refers to whether the emergency service organisations use C-BTs on a frequent basis for managing emergencies. It relates to the level of organisational readiness in terms of C-BT usage in natural emergencies**.** The results show that the familiarity with the system usage and current C-BT usage level constitute the two important aspects of usage frequency. Each of these is now discussed.

Familiarity

The familiarity with the system usage is associated with the extent to which the emergency professionals are skilful at using the C-BTs when dealing with natural emergencies. Familiarity with the system was considered important by most of the participants from all six organisations since it required emergency professionals to be already familiar enough with the system so as to be able to operate it immediately in the response stage.

Several issues are shown to be the reasons why emergency professionals' familiarity with some particular C-BTs was low within the organisations. First, certain key C-BTs, such as CNS' E System or HNS' H System utilised by different partner agencies during the response stage, were not used on a daily basis. As claimed by one HNS' senior emergency management advisor, enhancing the familiarity with the system was the prerequisite for achieving a higher level of proficiency regarding the key systems' usage. It shows that most of the emergency professionals were more familiar with frequently used cloud-based software applications, such as internal enterprise systems or external cloud applications (e.g., email, Dropbox, or Microsoft 365) than the key C-BTs for managing specific natural emergencies. As a result, it posed difficulties for emergency professionals to become familiar with the system instantly during the response stage of natural emergencies, as when large-scale natural emergencies take place, emergency professionals will have to deal with not only the procedures but also the information system for sharing information. If emergency professionals are rusty at using the cloud-based system, it will not be helpful for efficient information sharing, but become an obstacle to smooth operations, especially during the response stage. Therefore, the lack of familiarity with the key emergency management systems reflected the less frequent use of significant C-BTs in New Zealand emergency services organisations when dealing with natural emergencies. As stated by the participants:

> I couldn't think of anything that could make it easier for us at the moment than office 365 or other cloud-based systems. It is what we used on a day-to-day basis while [CNS' E System] has separate logins and people don't use it all the time. So they will forget the password and username because it is not used all the time. (ID3, CNS)

> You can have a system like [CNS' E System] that sort of thing, but it can be barely operated in everyday life and I would be too scared to do with it when I was managing a major emergency because I am just not familiar with it. (ID13, FNS)

Therefore, most of the participants expressed the opinion that it was necessary to use the key cloud-based systems on a regular basis or turn it into a business-as-usual tool. This would make it less likely to lead to inefficient operations during emergencies.

Unlike some types of well-known C-BTs such as email, social media platforms, or cloud storage, findings show that users of the key cloud-based systems (e.g., CNS' E System or HNS' H System) had problems remembering login details due to the less frequent use of such systems. It did not seem to be a difficult problem from the frequent user perspective. Nevertheless, it was a problem for most of the users who had not used the particular system on a frequent basis. The issue of unfamiliarity with the logins was considered frustrating by most of the participants who were at the managerial level. It was because that they could not force people in the organisation to use the system on a daily basis or remember the username and password. It will be a critical issue, more during the response stage than in the preparedness stage since there is lack of time for people to recall the login details while there is an urgent need for aggregating and sharing the critical information of the emergency situations. As reflected by the participants:

> We've had a lot of issues and this is the half the problem with some of the things that people do when they log on is really basically flawed. I wonder how they can withdraw money from ATM sometimes because it's not that difficult. (ID24, HNS)

> For things that we use on a day-to-day basis, it would not be a problem, but for things like [CNS' E System], it would. If you don't use it often, you have to remember how to use it. You will forget the login stuff. (ID3, CNS)

Although most of the participants from all six organisations recognised the need to solve the issue of infrequent usage of key C-BTs, CNS seemed to have more concerns about this issue. This was because CNS played a leading role in providing strategic advice and coordinating nationally in natural emergencies in which it was responsible for gathering, aggregating and disseminating critical situation information of the emergencies. In other words, CNS' E System was the main cloud-based system to be used by CNS itself and different agencies in a multi-agency event. Thus, a large number of emergency professionals were required to use CNS' E System during large-scale natural emergencies. The unfamiliarity of the system usage was a critical issue, especially for CNS. As confirmed by the focus group discussion from CNS:

> Some people have their training and they do not use the [CNS' E System] for three to six months a year and then they forgot about what they have been trained (FG 1).

The issue of familiarity with the system usage was also observed in the regional level earthquake exercise *(OB1)*. For example, in the regional level earthquake exercise, many people were not familiar with the functions of the CNS' E System where an on-site technician was frequently asked for help in terms of how to enter the right page through clicking the right icon in the system. Further, it was observed that critical information, such as the situation of the road closures, deaths, lifelines etc., gathered through the role play of the phone call injections or social media was either written down on paper, in a Word document or typed into Gmail and then conveyed to the correct person who needed such information. Therefore, it reflected that the cloud-based system, which though was considered as important, was not used to its full potential even at the scene of the exercise. It would not be ideal to have such disturbance if a real event takes place, as it could result in inefficient performance.

Conversely, RNS had less concern over being unfamiliar with system usage for several reasons. Despite its current movement to the external cloud provider in terms of a large percentage of IT infrastructure, RNS had not developed its own cloud-based system for the particular purpose of dealing with emergencies. Therefore, RNS had not really gained much experience of using C-BTs in natural emergencies. Further, RNS did not play a big part in using key C-BTs employed in multi-agency events due to that RNS' main responsibility being to conduct outreach tasks to support the communities; as a result, critical situational information was communicated mainly through email, phones or other traditional tools such as a paging system. Therefore, RNS currently did not have problems related to the key C-BT usage in the multi-agency event that other agencies did. On the other hand, even though the issue of different user interface could be a problem for the staff to use its current enterprise system, this did not seem to influence its usage. As mentioned by one emergency manager of RNS:

> There's an issue where we take our staff members into it. They are not used to it. The look of that. This issue can be easily fixed if there is a consistent look. It could be problematic if not using it on a daily basis and then going to use it; it's a different look upon email accounts, but they tell me that's an easy fix. (ID28, RNS)

Current Usage Level

The current usage level refers to the extent to which the emergency services organisations have utilised C-BTs extensively in natural emergencies. The level of C-BTs usage in large-scale natural emergencies was relatively low in all of the case organisations. First, many participants in the interview asserted that even though current key C-BTs were powerful tools, they had not been fully exploited and utilised in large-scale natural emergencies. For example, certain functions were only used by some local groups of the organisation, or the promised functions, such as sending out alerting messages to key agencies, were not realised yet within the system. As the following extracts reflect:

> We are the only group using the welfare module even in the last flooding event which has done a lot of work in [CNS' E System]. (ID5, CNS)

> [HNS' H System] was meant to be a lot better that probably offers more functionality, but I think a lot of the stuff that we were promised has still

> not realised. So we don't use it often and that's one of the liabilities I guess. (ID27, HNS)

What those emergency professionals could do was to keep an eye on what the cloud-based system could provide to them so that they could apply certain functions appropriately when dealing with natural emergencies. Findings show that some organisations, especially CNS and HNS in this research, were more likely to have the problem of not having fully exploited the key cloud-based systems due to similar organisational characteristics. Both organisations are large and have many standalone groups around New Zealand. Therefore, this posed difficulties to the organisations in terms of keeping consistent usage of C-BTs in natural emergencies. This resulted in certain functions of the key C-BTs perhaps not being utilised by some groups of the organisation so that the cloud-based system could not be used to its full potential.

Second, the low level of usage was also reflected in the insufficient exposure to the key C-BTs that were used in natural emergencies. It was mentioned by some participants that people in emergency services organisations had different levels of exposure to the key cloud-based systems. For example, the system trainers or advisors were those who had the most opportunities to use the key C-BTs in the organisation since they were either responsible for teaching people how to use the system or providing recommendations on the inadequacy of the systems for further improvements. On the other hand, the volunteers employed by the emergency services organisations, especially at the local level, had the least chances to use the system. Also, the large organisations, such as CNS and HNS with many standalone groups around New Zealand, were more likely to encounter the problem of not having adequate chances to use such systems since the local groups could make their own decisions on choosing systems for managing emergencies. Nevertheless, emergency professionals can only become skilful in using the key cloud-based systems when they have more chances to gain usage experience of the systems. Such experience can be built up through using the systems more frequently in exercises or smaller natural emergencies which though might not require using the systems. Thus, the emergency professionals would less be afraid of the issue of being unfamiliar with the system in larger events due to the accumulated usage experience gained through small events. The following statements represent the perceived lack of sufficient usage exposure to key C-BTs even in small-scale events:

> To my understanding, all our group are using it, but the word ‘using’ needs to be defined. To be honest, [Region Name] maybe the region that uses it most often. I have used it in three small storm events but it has only been me and another person rather than the whole centre. (ID5, CNS)
>
> Ideally, one system that could manage them only when you use the smaller events to get good at managing whether it’s the bigger event. You ideally direct people to use it a lot would be an advantage…. [HNS’ H System] would be used to deal with any event in the near future…but I don’t think we do that well and I think we can improve on doing that more often. (ID25, HNS)

The lack of the familiarity with the usage of the key C-BT, CNS’ E System, was also observed in the regional earthquake exercise 2015 *(OB1)* than that in the national tsunami exercise 2016 *(OB4)*. Although people in the tsunami exercise operated the system more smoothly than those in the earthquake exercise, which might be due to different training frequency between local level and national level, people in both exercises more or less had some problems with logins and lacked familiarity with the functions.

In addition, most of the participants commented that there was a lack of key C-BTs usage experience in large-scale natural emergencies in New Zealand emergency services organisations. This was because the idea of cloud usage was not popular prior to the major Christchurch earthquake in 2011. Also, there had not been many major natural emergencies after the 2011 event. Therefore, most of the emergency professionals did not really have many chances to use the key C-BTs yet besides some frequently used cloud-based applications such as email, or cloud storage. By the time the data collection was completed, none of the participants could recall a large-scale natural emergency that they had engaged in except for some small-scale events such as a tornado, flooding, or non-natural emergencies such as counter-terrorism, pandemics, and hazardous chemical explosion. As verified by the focus group discussion from the leading agency CNS:

> In the last couple of years, we have not really been through much. (FG1)

On the other hand, most of the participants thought that the lack of key C-BT usage experience in large-scale natural emergencies would be a weakness when dealing with real large natural emergencies. This especially happened to other supportive agencies that also needed to use the key C-BT in multi-agency events since they had even fewer opportunities to be trained on using such a system on a regular basis. They also had to master how to use their own organisational cloud-based applications. Many participants expressed the view that to cope with this problem, supporting agencies required more opportunities to be trained on using the system in simulated large-scale natural emergencies exercises. Only in this way would they be able to operate the key C-BTs appropriately through practising and testing the systems at regular intervals. Currently, it was far from enough for the emergency professionals to operate the system straight away in the emergency operation centre if a real event took place. Thus, there was still a long way before a smooth operation of the systems could be achieved. As asserted by the participants:

> We don't use [CNS' E System] on a daily basis and we don't even have tested it [sic]…They might test that at the management level but all about that is the login (ID8, PNS)

> I mean it's still not really been tested enough …… it still needs to be. It can be better, but I still think there is a long way towards managing it. (ID24, HNS)

Additionally, the usage of C-BTs in the preparedness stage was less than that in the response stage. In other words, most of the participants rarely mentioned the C-BT usage in the preparedness stage except for the cloud storage, either external or internal, which had been used by all six organisations. CNS, as the leading agency, had the responsibility of alerting external agencies as well as the public. Thus, it owned an internal cloud-based alerting system and utilised different social media platforms so that various agencies and the public could be warned about the upcoming natural emergencies. Further, many participants, either in the interviews or focus groups, confirmed that C-BTs were not used extensively in terms of planning and training, which are key activities in the preparedness stage. The most frequent use of C-BTs for planning activities was the internal storage for storing plans. For example:

> In terms of planning, we do not typically use the cloud-based technology to do that sort of stuff……we want to be able to use that technology a lot more efficiently than we currently do. (ID6, PNS)

> That's the only way we use Dropbox, for preparedness only, as we can store them there so we can use it for a response. Because we don't need

> to use any cloud-based for our preparedness stuff at the moment. We are looking at more of those though. (ID5, CNS)

In terms of training in the preparedness stage, C-BT usage for training was seldom heard of from most of the participants. The main reason was the type of training exercises conducted by the organisations. The results show that emergency management courses, in the form of table-top discussions, were frequently conducted in all six emergency services organisations. Nevertheless, among all six organisations, CNS was the only organisation that initiated the use of C-BT to provide systematic emergency management online course training and key cloud-based system usage training during simulated natural emergency exercises. CNS strived to provide different types of training through C-BTs although this had not yet been extensively conducted. In the interview, several CNS' participants referred to the internal cloud-based learning system, but none of them thought it was used frequently. The non-extensive usage of C-BT for training in the preparedness stage was confirmed by CNS' focus group discussion:

> We would like to use more C-BT, but it is not used a lot in the sector yet. That's something we're introducing them to people and to give people the opportunity just to train and prepare beforehand anytime anywhere…… A lot of training that is done on cloud-based would be using [CNS' E System] because a lot of people need to be trained. (FG 1)

Findings also reveal that none of the participants referred to any form of C-BT usage in practical exercises, such as physical training, medical techniques training, or simulation exercises using figurant cards. Therefore, apart from the limited C-BT usage in training in CNS, the current usage of C-BT in training activities in the preparedness stage in the other five organisations was none-existed.

On the other hand, it was found that C-BTs were used more frequently in the response stage than that in the preparedness stage. This happened especially in the other five key agencies, except for RNS due to having the least experience of using C-BTs during emergencies. These organisations either own specific internal cloud-based systems or utilise external cloud-based applications, such as social media platforms, or Google Maps, etc., during the response stage. For example, CNS' E System was used particularly for tasking, reporting, and generating situation reports during response stage even though it could be used as an internal cloud storage system for storing files in the preparedness stage. However, it was treated more as a response system. Another example was that social media platforms were utilised as two-way communication tools, either in terms of alerting the public about the upcoming natural emergencies or gaining information from the public regarding the situation of the emergency. Therefore, the C-BT usage purposes or types may vary among different organisations, but it seemed that the C-BTs were more likely to be used in the response stage. This is reflected in the statements:

> [CNS' E System] is very useful when in a response and social media is very useful in a response as well as. (FG1)
>
> Twitter feeds, public Twitter feeds or web mapping; they were faster. We found them faster to understand what the situation was on the ground than information coming through from emergency management systems. (FG2)

Another aspect of findings that reflects the current C-BT usage level is that most of the participants considered there was a lack of existing appropriate cloud-based systems for specifically managing natural emergencies. For example, CNS, as the leading agency in natural emergencies, used limited types of cloud-based systems for managing emergencies, which included the alerting system for sending alerting messages to various agencies around New Zealand in the preparedness stage and CNS' E System for aggregating information in the response stage. Further, all of the participants from one of the key supportive agencies, FNS, said that there was a lack of C-BT usage in the response stage since the frontline staff did not rely on cloud-based technologies for managing emergencies. Thus, the communication between the manager and the frontline crew was conducted through traditional ways, such as paging and texting systems. As stated:

> At the moment, I guess the core one is still the [CNS' E System] for lack of a better tool. (ID3, CNS)
>
> [The C-BT usage was] very minimal. Besides [CNS' E System], I don't really know. Not yet. (ID14, FNS)
>
> We receive information from our com centre mainly through our radio to us other than using any other technology such as phones or mappings. But some of our guys will use phones for Google maps to find the address. So it is very basic and limited. (FG2)

Most of the participants from PNS, FNS, JNS and RNS stated that different types of internal cloud-based systems were owned by the organisations, but most of the internal C-BTs were used mainly for achieving business-as-usual tasks, such as delivering rostering, financial or reporting functions, rather than that the systems were designed specifically for managing natural emergencies. Therefore, despite the usage of certain key C-BTs in multi-agency natural emergencies, there were no specific C-BTs for those supporting agencies to use in natural emergencies. For example:

> There hasn't been with any incident with these tools. They are sort of business-as-usual not sort of mass casualty jobs. (ID20, JNS)

Interestingly, findings reveal that none of the participants from HNS commented that there was a lack of existing C-BT for managing emergencies even though there was only one key internal cloud-based system, HNS' H System, for the organisation to utilise during emergencies. It did not mean that there was no problem with C-BT usage for HNS to manage emergencies at all at the time of the study. Most of the participants thought that it would be necessary to integrate the key C-BT into their business-as-usual application which would enhance their response capability. The main reason that HNS had limited choices of C-BTs for managing emergencies was their avoidance of pursuing leading-edge technology in which they did not have confidence. The following statement from HNS' system usage advisor reflected the organisation's attitude towards C-BT usage:

> The main tool would be email and [HNS' H System] but because we don't want to expand out too far. (ID23, HNS)

Among all six organisations, it was found that the frontline agencies, such as PNS, FNS and JNS, had the least usage of C-BT by staff at the frontline when dealing with natural emergencies. It was confirmed by most of the participants that the key to making appropriate decisions of resource allocation during the emergencies was to get information quickly from the scene. However, the vehicles used at the frontline currently had not been equipped with mobile or cloud-based technologies. For example, JNS vehicles were provided with a log book for mass casualty incidents for recording information manually. Another example was that FNS' trucks were filled with hardcopy manuals and paging systems for the frontline staff. Even though all of the FNS' participants referred to the large trucks as being equipped with computers and Internet access, quite often these vehicles were not used since they were only used in large-scale emergencies. Findings reveal that such a vehicle was only mentioned as being used in the Christchurch earthquake, which was not frequent. The lack of C-BT usage at the frontline meant that the frontline staff were not able to convey important real-time information back to the control centre through C-BTs except through phones or radios. However, there was no guarantee that the telecommunication infrastructure would not be destroyed at all times during large-scale natural emergencies. In the real-life situation, frontline officers from those three agencies, PNS, FNS and JNS, would have face-to-face communications at the scene and then send the information back to the control centre for further notice on the actions to be taken. Therefore, if frontline staff can be equipped with appropriate cloud-based systems to enhance its mobility of sharing information with people at the backend, it would produce better response performance. As one of the FNS search and rescue managers stated:

> We were not using any in the field to be fair and that is where we're going and that's with a project. My other job is around the foundations for mobility which is the purpose of services to put everything into the cloud and then make information more easily available to any stakeholder. (ID15, FNS)

Usage Preparedness

Usage preparedness of C-BT represents the extent to which the emergency service organisations are ready to use C-BT in natural emergencies. There are several important aspects that reflect the current status of New Zealand emergency services organisations' readiness in using C-BTs for managing emergencies: cloud movement readiness, consistency of usage, usage commitment, and system promotion. These are now discussed.

Cloud Movement Readiness

Cloud movement readiness is associated with whether the emergency services organisations are ready to use C-BTs extensively for managing emergencies. Findings indicate that the readiness of C-BT usage in emergency services organisations still requires great effort. Even though certain types of C-BTs, mainly private clouds, had been utilised by all organisations, all six organisations were not ready yet to move to cloud entirely in managing emergencies. One important reason was that most of the participants expressed that they were not sure to what extent the organisations wanted to move to the external cloud usage. Because of this, the emergency service organisations lacked clear strategic goals for moving to use cloud extensively for emergency management. Hence, there was a lack of a clear direction for local groups to move forward. For example, one senior CNS' group manager commented that clear strategies were required for clarifying the long-term usage of C-BTs. The following statements show that participants felt that they were not sure about the long-term strategic goals of moving to C-BT.

> Government is now starting to move away and is more open to the idea of external cloud by serving. I am not sure to what extent they're thinking of moving that up. (ID1, CNS)

> It is an investigation process at the moment about using cloud or not and it's a government area that's already up and running……We've no idea. It is the early days of investigation about cloud technology I think and in our [HNS' branch], I'm not sure and, have you heard from other branches about how much they are considering using it? (ID25, HNS)

In addition, most of the HNS' participants considered that it was a slow changing process to move onto extensive C-BT usage. For example, the slow changing process was confirmed by most of HNS' participants as being due to distinctive IT systems and strategies executed by each branch. Thus, it would take time for every branch to make the change. One participant noted:

> A lot of it has moved on and is changing because it's just a slow process because you can't take it and ask every [HNS' branch] to have done with that. (ID24, HNS)

On the other hand, most of the CNS' participants thought the government was starting to move towards C-BT usage. However, the current situation was not ideal for them to move forward faster since the current key C-BT was not developed well enough to meet the needs at the local group level. Due to the need for redeveloping the current software to fit the requirement at the local group level, CNS was not able to spend extra time and money on other C-BTs. Therefore, the immaturity of current software acted as an obstacle to realising further cloud movement.

In terms of technology usage trends, many participants from all six organisations acknowledged the increasing trend of moving to more C-BT usage in managing emergencies in the near future. Some of the organisations were interested in moving to the external cloud, but that could not be achieved quickly at the time. The insufficient level of usage was found to be a key reason that was identified by all of the participants in the interviews. For example, one senior HNS' emergency planner thought it was still early days for moving into C-BTs environment entirely. Even though the current HNS' H System had been established for a while, it was not used on a frequent basis. Similarly to HNS, CNS' participants also thought their current key C-BT was utilised at a low level. The following statement from JNS focus group discussion also reflected such a point of view:

> Right at the moment, it is relatively low usage but we are moving towards significant usage of cloud. (FG3)

It was also found that all six organisations had put different level of efforts into technology advancement. Readiness in terms of investing in specific emergency management systems is critical to the success of C-BT deployment. CNS and HNS represented the only two organisations, among all six organisations, that had established their own key C-BTs for managing emergencies specifically. Nonetheless, most of the participants from these two organisations thought that it would be a slow process to move towards using such cloud-based systems fully. On the other hand, the other four organisations had not established unique cloud-based emergency management systems yet. FNS had invested most, among the six organisations, in many C-BT projects related to emergency management. Due to the large organisational size, it took time to make progress on big IT projects, such as moving to Microsoft Azure and promoting tablets for frontline staff. A participant from its staff noted:

> We are moving to the Microsoft Azure, so that's a cloud-based system. The objective of the [FNS] in the next few years is to go away from enterprise protected internal network that requires logins to get in through the firewall which provides significant performance issues to push information out into the cloud which means once it is in the cloud it is available to whoever. (ID15, FNS)

Consistency of Usage

The consistency of usage refers to whether the usage of C-BTs was consistent at both central and local level. If the usage is not consistent throughout the whole organisation in New Zealand, it will be hard to manage the emergency professionals' usage performance and know the real effectiveness of the C-BTs across a large number of branches of the organisation. Organisations, such as CNS and HNS, had a similar problem due to their organisational policy whereby the local groups had different IT operations, which means the IT operation of local groups was not controlled and supported by the headquarters of the organisation. The central organisation only provided the local groups with access to the established key emergency management system. This created the difficulty in realising the consistency of C-BT usage. For example, CNS' local groups shared IT infrastructure with local authorities so that it followed the steps of the local authorities in terms of the cloud movement. Similarly, one HNS' emergency planner illustrated that the central organisation provided each HNS branch with the access to HNS' H System for storing key documents, but its usefulness depended on how frequently people uploaded information onto that system since the IT model in each branch were entirely different. Therefore, despite the trend of C-BT deployment starting to be popular at both central and local level, the consistency of usage was different between the two levels. As noted by two participants:

> We are [a] sort of semi-autonomous organisation. We were employed by [regional authority] which includes a number of small local authorities and we live here and we use their IT system. So the bigger organisation is moving towards cloud-based. (ID2, CNS)

> They're all different systems within [local branches of HNS]…. they have systems which are probably found to be more developed in some areas than that of others. So you have various mixtures of information. We are at the ministry cannot see those because they are owned by that branch. (ID24, HNS)

Another important aspect of the findings was that most of the participants from HNS and CNS asserted that even though the organisations had introduced the key C-BT to the local groups, the usage level was inconsistent between the central and local levels. In other words, the usage level of key C-BT was low at some local groups. As stated by the two participants:

> I would say here, in particular in [location] in this office, we would not be ready to use it and operate during an actual event, but then if I went to [location] or [location], [location] or [location]or [location] or some of the other areas they are really ready to go. (ID4, CNS)

> It's still early days for [HNS' H System] too. We've had it for a while for a long time but we're not all using it a lot. (ID25, HNS)

On the other hand, participants from FNS confirmed the benefits of using the internal system in a consistent way across the country. For example, through the consistent usage of the FNS' F System, it was able to keep the consistency of training management in terms of physical training. In this way, staff were able to maintain the training skills on a consistent level as well. Thus, the consistent level of readiness at both central and local levels would provide a strong basis for emergency professionals in C-BT deployment when dealing with natural emergencies.

Usage Commitment

Usage commitment relates to whether the emergency service organisations have a high commitment to the usage of C-BTs for managing natural emergencies. Whether the emergency services organisations can understand the effectiveness of C-BTs for managing emergencies depends on the level of commitment they have made. Most of the participants who referred to usage commitment were from CNS and HNS. It was because they were the only two organisations that had established and used the core C-BT currently while other agencies have not yet done so. Therefore, CNS and HNS were focusing more on increasing the usage commitment throughout the organisations because the usage commitment was not high in both of the organisations. For example, because the usage of CNS' E System was on a voluntary basis the usage commitment varied in different CNS groups. This led to difficulties in assessing the system effectiveness and usage performance. In other words, CNS, as the leading agency, was not able to gain a high usage commitment from local groups, which resulted in different levels of understanding and familiarity with the system. Therefore, it was not beneficial to the success of promoting the system that was particularly designed for managing natural emergencies. As expressed by the senior system trainer in CNS:

> Some of them just don't want to use it at this point in time. So we encourage them by putting stuff on [CNS' E System] that they are forced to register which is what some regions have decided to do that they have said in minutes. If you're not registered, you are not getting them in the other way so that at least forced them to basically register and it works. (ID4, CNS)

In terms of HNS, different branches owned different IT models so that each branch focused more on its own unique IT programmes than the key C-BT provided by the headquarters. Some participants confirmed that the key C-BT was more likely to be utilised in large-scale emergencies by local groups. Hence, the usage commitment was not maintained at a high level by the branches. Nevertheless, it requires emergency professionals to accumulate the usage experience to achieve a smoother operation during a real emergency. Therefore, the HNS headquarters had a certain level of expectation for each branch to increase the usage of the system. As expressed by the participant:

> So [HNS' H System] is supplied by the [HNS' Headquarters] and they built the system and own it and then there's an expectation for [HNS'

> Branches] to use it and personalise it and use it for the incidents. (ID27, HNS)

Most of the participants from all six organisations explained that when natural emergencies happen, they would firstly prefer face-to-face communication, which was the normal procedure for communication. This means that different agencies would have to sit down and talk about the planning and resources availability according to the current situation. Since the capabilities of each organisation were quite different, it was not possible to merely rely on cloud-based systems or other communication technologies to discuss important issues at the very beginning of the response stage. Therefore, the emergency service organisations were not ready yet to use cloud-based systems fully either in the emergency operation centre or at the frontline when dealing with emergencies. This was also observed in two multi-agency exercises *(OB1* and *OB4)* where a number of communications were still conducted through talking to other agencies rather than focusing on using systems. The following example shows how agencies coordinate at the frontline through face-to-face communication:

> If we have an earthquake, then it shakes the buildings down, the most important step is to look at it. We look at the information we got on the homes, the childcare in the hospitals and all that. We will go to meet with the other agencies and we do a planning and talk about them. (FG2)

System Promotion

System promotion stands for the extent to which the emergency service organisations have been ready to promote the current key cloud-based systems for managing emergencies. Promotion of the system indeed played a critical role in the emergency services organisations since each organisation owned a number of branches around New Zealand. If the current key systems are not promoted heavily, the local branch will not get prepared sufficiently and be determined to use the systems. Nevertheless, organisations were more willing to promote the system when it could have proven that such a system really added value to the emergency management operation. Some of the participants from organisations, (CNS, FNS, and HNS) said that they would prefer not to promote the system until they were quite sure about the effectiveness of the system. For example, one CNS' senior emergency planning coordinator asserted that OneNote was considered as a useful tool for conducting training Moodles but was only trialling it by himself at the moment since he would need to prove the benefits of the system and then persuade others to use it. The main reason was that emergency professionals needed to make careful decisions on system promotion because once they started to promote a system, they would promote it heavily. The following statement reflected the participant's concern over quick promotion of a new C-BT:

> It should add value to what they do. I shouldn't implement a new product or service or process if something does not have value because I have to fix that problem…… Until such time we feel comfortable, we are not even gonna show people about it. So we've tried [CNS' E System] in these small events and it didn't add value. (ID5, CNS)

FNS was similar to HNS in that it was not pursuing leading-edge technologies which were modern but immature. Thus, they would make decisions about investing in a new system carefully and evaluate its effectiveness before it was rolled out extensively. For example, FNS was currently investing in some mobile application projects and would need to test their effectiveness before tablets could be rolled out to all of the branches. It would waste huge amounts of money, if the testing was not done effectively. This was confirmed by FNS' focus group discussion:

> The reality here is… what happens is that because we are a national organisation, if something comes out to you, but you have to really evaluate that and work out what is going to cost and what the value is. (FG2)

Unlike FNS, even though JNS was also a frontline agency, it was not yet prepared to invest more in cloud-based systems for frontline usage. This was because it had already invested in non-cloud-based mobile applications and tablets for inputting details of injured people, which was under promotion. Therefore, there was not any particular C-BT for JNS to promote at the time. Nevertheless, the national emergency response manager commented that they would move to cloud-based mobile applications in the near future. On the other hand, RNS was not yet ready to promote any system even though a large percentage of its enterprise system for business-as-usual work had been moved to an external cloud platform. It strived to develop its own system for managing emergencies specifically.

Conversely, there was no evidence that PNS was promoting any particular system at the time, even though the key cloud-based system, PNS' R system, was referred to by most of the participants. PNS might not have to promote the system due to its characteristic of centralisation. As a centralised organisation, each branch was obliged to utilise the system. Since there were too many different systems within

PNS, as referred to by most of the participants, the current challenge was how to integrate information from different applications rather than system promotion. As one of the emergency managers stated:

> So once we get the right program it will be cloud-based. That will enable us to do what we would like to do. (ID28, RNS)

Some emergency service organisations had invested a great amount of money in establishing new systems, but it seemed that they were not quite ready to promote new systems heavily at the time since they would need to prove the real value the system had. Until then, they would not be able to promote the system heavily throughout the organisations.

Capacity

Capacity is associated with a variety of the organisational resources owned by the emergency service organisations which are critical to the successful deployment of C-BTs in managing emergencies: the access to IT expertise, C-BT hosting capacity, human resources, IT resources, budget, and system advancement initiative. The six types of the organisational resources constitute the integrated capacity that influences current emergency services organisations to utilise C-BTs when managing natural emergencies. They are discussed in the following sections.

Access to IT Expertise

Access to IT expertise refers to the extent to which the emergency service organisations own the capacity of expertise on-site for solving IT issues. Emergency professionals will have less concern about IT issues if they have an on-site person to ask for technical support. Not all six organisations had an IT unit within the organisation or the branches. Interestingly, CNS lacked IT capacity most among all six organisations since no specialised IT unit was established within the headquarters of the organisation. Nevertheless, it played the leading role in managing natural emergencies and required instant help from on-site IT experts to fix any problem of systems when necessary, especially during the response stage of natural emergencies. For example, one senior CNS group manager asserted that:

> If there is any problem, it has been done at the ministry level, especially for the government. They are not 24/7 on call. So if it happened at midnight, trying to get someone in the ministry to reset a password is not

> viable because no one is on call in the ministry for [CNS' E System]. (ID5, CNS)

Most of the CNS' participants would like to have on-site specialists to provide suggestions and help with IT issues. The reality was that the IT service at CNS headquarters was requested from external IT outlets while CNS' local groups relied on IT services from local authorities that also contributed services to CNS. For example, one senior CNS group manager expressed how urgently he required on-site experts to provide IT support:

> I am responsible for almost everything. This is the problem, but I am the only person who has the IT background in this building. (ID5, CNS)

The private cloud was mainly used by all six organisations, although certain types of external clouds, such as Gmail, Google Maps, or Microsoft office 365, etc., were used as well. Therefore, it would be better to have experts on-site to deal with problems of the internal systems. In terms of the other five organisations, most of the participants were less concerned about not having experts on-site. They had a similar strategy of providing basic IT support on internal systems where one centralised IT unit was established within each organisation's headquarters. Further, a specialised IT person was allocated either within the branch of the organisation or for the whole region. As one participant said:

> We have one person here who looks after IT here and then there is a team of IT specialists in [location] that makes sure things keep working. (ID9, PNS)

C-BT Hosting Capacity

Hosting capacity refers to the capacity that the emergency services organisations have to host internal cloud-based systems. As noted earlier, the main type of cloud-based system was private clouds with each organisation. Therefore, to meet the security needs, the organisations require sufficient capacity to host the internal cloud-based systems. Again, interestingly CNS, as the leading agency, had the most difficulties in maintaining private cloud-based services due to it being the only organisation among the six organisations that did not own a specialised IT unit. Hence, the key C-BT, CNS' E System, had to be maintained by the national manager himself. Whenever there was an issue with the system, the national manager requested IT support from external companies. However, it was stressful for only one person to maintain an important and complex system without instant on-site support. As the national manager stated:

> But that is an expensive system to maintain and it can break down. This brings my own knowledge of these things let me down. If we can outsource the service and make it or develop it more securely 24/7, it would be better. (ID1, CNS)

In terms of the other five organisations, no evidence was found that there was a lack of hosting capacity within the organisations since none of the participants referred to this issue. Even though the issue was only found in CNS, it was still important for emergency services organisations to consider having specialised IT expertise on-site which would be helpful to reduce emergency managers' burdens and concerns about maintaining IT infrastructure while focusing more on emergency management issues.

Human Resources

Human resources are associated with the capacity that the emergency service organisations possess to deliver operations related to C-BT usage when dealing with emergencies. The lack of human resources will also influence the successful C-BT deployment in natural emergencies. Many CNS' participants referred to the issue of staff shortage in monitoring social media platforms. CNS used social media most and considered social media platform as being an important channel either to educate the public how to better get prepared in different types of natural emergencies or to send warnings regarding the upcoming emergencies. Social media can also serve as a good channel to gain emergency-related information from the public. However, with the huge amount of information on Facebook and Twitter, it required more personnel to do the job. For example, there was a lack of personnel in keeping the social media pages new or humorous to engage the public. This was verified by the focus group discussion:

> I think resources are number one because if we go back to social media Facebook, we need the amount of people resources to monitor those dialogues. (FG1)

Conversely, none of the participants from the other five organisations mentioned the issue of lacking staff for managing social media platforms in emergencies. This was due to the extent to which the organisations put emphasis on social media usage. For example, PNS, HNS, and RNS used social media more often for business-as-usual purposes, such as preventing crime, alerting for pandemics, or fundraising. FNS had not invested much time and effort in social media, which was not its current focus. Nevertheless, if an emergency service organisation had established a mechanism for using social media in natural emergencies, it would have to allocate more people to monitor and analyse the information. As noted:

> All the agencies are trying to set up intelligence gathering systems around this which is labour-intensive. Obviously, we have the barriers to having the capacity to manage it. (FG3)

In addition, there was a lack of human resources for managing C-BTs or conducting administration work in some of the organisations. For example, one CNS group manager stated that the separate usage of different systems, the shared service from regional authority and their own usage of Dropbox for storing and sharing important documents in the group, placed some burden for him to manage its usage. Further, one RNS emergency manager also mentioned the lack of staff for conducting the administration work of the rostering for volunteers in their internal system. As said:

> At the moment, it is all done by an administrator somewhere. So that's quite a problem for us because it's a large spreadsheet which requires a lot of work and update. (ID28, RNS)

Therefore, if enough human resources were allocated to emergency managers, there would be fewer concerns for them to use C-BTs.

A deficiency in human resources for assisting daily jobs existed in most of the organisations. For example, each branch of CNS consisted of fewer than eight people as observed and reported by the participants. One of the visited branches had only two full-time and several part-time employees. The human resource capacity was varied among different branches of CNS. Nevertheless, one senior group manager explained why it was reasonable not hiring more full-time employees. It was out of their capacity to hire more when they were not sure about the exact time that the large-scale events would take place. Thus, when such scale of emergency really happened, they would call people for help from different groups, such as regional authorities, private industry or volunteers. For those frontline agencies, some of the participants asserted that there was a lack of people to take over tasks when necessary, such as chasing building information or dropping the jobs at hand in order to arrive at the scene immediately. As commented by the participants:

> We're doing our best, but there are thousands of the buildings out there, but there is only 35 to 36 staff here. So there is a lack of capacity and ability to do a thorough job. (ID16, FNS)
>
> Our response is only part of our normal day job. So there has been an issue of not having enough resources and people around to assist. If there is an incident, you are expected to drop everything and respond to the incident. Even if you are doing something else out of town, they still sort of expect you to come back to respond to the incident. (ID11, PNS)

Therefore, due to the tight human resources allocation, emergency service organisations would not be able to spare extra personnel to manage or monitor any other type of C-BTs that might be useful to gain or deliver important situation information about emergencies when necessary.

IT Resources

IT resources reflect the capacity that the emergency services organisations have to provide sufficient IT infrastructure for managing natural emergencies. The phenomenon of IT resources deficiency existed in all six organisations. It was interestingly found that CNS, as the leading agency, lacked the IT resources most since no IT unit was established within CNS and the IT service was requested from external IT stores. Using shared services was referred to by many participants from CNS who said that they needed the support from local authorities to provide IT infrastructure and they relied on them. Otherwise, they would need to identify suitable C-BTs, such as Dropbox, or Microsoft Office 365, that could be used in managing emergencies by themselves to satisfy the IT needs. This was because the local authorities might not have a contingency plan if unexpected situations occurred. Therefore, the group managers were required to make sure that they could find other options to keep business continuity. As noted by one participant:

> We don’t have a lot of resources and I try to dedicate my time to make this happen. So things like Dropbox, 365, iPad those for sharing things are doing by ourselves. So that is us fighting for what had happened. (ID5, CNS)

On the other hand, FNS shared IT resources with other agencies. For example, it shared IT services owned by PNS in the communication centre. Thus, it was not possible for FNS to operate autonomously in the communication centre when they needed whatever IT resources for the operation since the centre was owned by PNS. As stated by one participant:

> So we can't just put stuff there without [PNS'] permissions. (ID14, FNS)

One commonality of lacking IT resources among the six organisations was that the information regarding the new type of C-BT system that might be beneficial to emergency management process was gained through networks in the sector or external contractors regardless of whether there was an IT unit within the organisation or not. For example:

> We will be told about systems often by [HNS], but also by other agencies like [PNS], [FNS], and [CNS]. (ID19, JNS)

It was also found that internal IT units within all supportive agencies organisations merely had capacity in dealing with business-as-usual infrastructure while limited capacity was available to support C-BTs for managing specific emergencies. For example, RNS had not established any particular cloud-based platform yet for managing emergencies so that they were relying on some free open source cloud-based applications, such as Google Maps, and needs assessment applications. The following statement is an example from one PNS' participant that reflects the deficiency of IT resources:

> Not specifically for emergency management. We have a big ICT team. They focus on the moment is doing the Windows 8 rollout for us and replacing all of the hardware. A lot of those functions are gonna be outsourced as well. (ID6, PNS)

Budget

The budget reflects the extent to which the emergency services organisations have the capability to invest in C-BTs for managing emergencies. The emergency professionals were more than willing to make improvements on current C-BTs, but the budget constraints limited what they could do. Most of the participants from all six organisations would like to make improvements to their current systems. For example, CNS' E System required to be re-coded to enable the advanced function of sharing information through messaging directly within the system. Nevertheless, the current budget capacity did not allow them to do it immediately. Due to the standalone characteristics, the local CNS groups were not funded by CNS headquarters. Therefore, CNS' local groups were suffering from the issue of insufficient budget. As discussed earlier, the local groups were required to rely on the IT services of regional authorities. As one participant asserted:

> Yes, I mean I have budget but it depends on the cost. My problem is that everything that is 500 dollars needs a cheque from executive, but you can't do IT only with 500 bucks. (ID5, CNS)

Similarly, other agencies also had insufficient budget for upgrading current systems or enhancing mobility with tablets. Extra budget on purchasing or developing new C-BT was not available. As explained by participants:

> We have not been using C-BT so much, but I can see from there. Just right now we are not because it the just upgrades gonna cost some 50 million dollars for a big upgrade we were doing that. (ID14, FNS)
>
> Definitely! It is very tight so our budget hasn't increased for three years. (ID6, PNS)
> We want our own system and that system will talk to [CNS' E System], … it's just cost and contract to supply. (ID28, RNS)

System Advancement Initiative

System advancement initiative represents the extent to which the emergency services organisations have the capacity to improve system usage experience. All six organisations made efforts in system improvements but each to a different extent. For example, CNS and HNS, which had already established core C-BTs for managing emergencies, centred more on developing the new versions to improve the usage experience. As stated by one participant:

> [CNS' E System] is going to have a new version and currently is under development. (ID5, CNS)
>
> I think [HNS' H System] from a response point of view, it's very good…… I think there's space to improve what do from the GIS point of view. So we have started some work recently. (ID27, HNS)

Evidence of making efforts to improve the usage experience of systems was also found in the rest of the four organisations. It was conducted through searching for or establishing better systems, such as a system for matching people who were missing in emergencies, managing shifts of the volunteer staff automatically or an incident management system for managing specific emergencies. Among those four organisations, it was found that FNS, as one of the key frontline agencies, had put the most effort into enhancing its frontline mobility since many FNS' participants referred to the big mobility project. With advanced mobile technology, such as tablets, to access cloud-based applications, this project would enable FNS frontline staff to receive up-to-date and relevant information to support frontline jobs. It seemed that most of the FNS' participants were looking forward to realising agility at the frontline. One FNS' participant explained:

> The benefits from cloud technology make it possible……the project is actually all about giving information to the truck…… since the truck will have a black box that catches all the information and then the black box provides information to a number of tablets that are on the truck. (ID15, FNS)

This was verified by the focus group discussion:

> There is finally a full mobility project in [FNS] to take this and the whole part of information like he said, the buildings, the hazardous substances will be mobile on the trucks. We have tried to do that for years. (FG2)

Therefore, owning sufficient capacity in terms of IT resources, budget, human resources, and system enhancement is important to identify whether organisations are ready to provide support to emergency professionals, resulting in the successful deployment of C-BTs for managing emergencies.

Training

Training plays a significant role, especially in the preparedness stage which provides a strong basis for a smoother operation in the response stage. Training in emergency services organisations was categorised into two types: practical training, such as physical training, medical technique training, and scenario simulation exercises; and the key C-BT system usage training. The discussion in this section focuses on the second type of training since no evidence was found that C-BTs were utilised in the first type of training in all organisations studied. Based on the results, three aspects were found to be important to achieve effective training for the system usage, including training frequency, consistency of training, and on-site expertise support on system usage. They are discussed in sequence.

Training Frequency

Training frequency is the extent to which the emergency services organisations provide system usage training on a frequent basis to help staff to master the key C-BT usage. It is necessary to train emergency professionals to master the usage of key C-BTs so that they can operate the system smoothly during the response stage. Findings show that the training frequency of key C-BT usage varied among different organisations, but the commonality was that there was a lack of frequent system usage training.

For example, CNS’ E System was a relatively new system which had been updated twice since it was first established after the 2012 Christchurch earthquake. It means that there were certain advanced functions which required the emergency professionals to learn. Nevertheless, most of the participants asserted that they were not trained on a frequent basis. It was found that the frequency of the training on CNS’ E System was once a year, which was insufficient for emergency professionals to master the system adequately, leading to unfamiliarity with the system usage. This was also reflected in the observation of the regional earthquake exercise (*OB1*) in which many of the emergency professionals were not familiar with the user login process and certain functions of the system, such as how to input information in the corresponding places in the system.

Similarly, the systematic training of HNS’ H System was not provided on a frequent basis either, with the frequency of once every one or two years. It was observed in the regional earthquake exercise *(OB1)* that two HNS people were not able to log in and use the system for a whole morning. Even though they tried to call HNS technical support for help, it was not until the late afternoon that they were able to use the system. During the process, they could only gain part of the information from other agencies rather than sharing HNS’ side of information with other agencies for the whole morning. Thus, the system was not able to be utilised to its full potential by HNS people in the exercise. Therefore, sufficient training on the usage of key cloud-based systems for response operation plays a significant role in emergency services organisations. As noted by two participants:

> They're just not trained enough yet…So we cannot use it until people are trained. (ID4, CNS)
>
> It’s actually only training people to use it is an issue yet to be resolved. (ID24, HNS)

Despite these examples, findings reveal that the supportive agencies did not put much emphasis on the system training. The examples were referred to by some of the participants regarding the lack of sufficient training on system usage. For instance, one FNS’ area manager referred to the new mapping system training, but the duration of sessions was too short for him to master the usage. One senior area coordinator from FNS stated that due to frontline job characteristics of saving lives and properties, the focus would not be on technology usage so that they would ask people who have advanced capability and skills to use the technology at the scene on the large vehicles. Apart from that, participants from RNS also said that it was necessary to get staff trained on using its current system even though they had not developed any key cloud-based system for emergency management. Even though less focus on system training existed among supportive agencies, the importance of the system training was acknowledged by the participants whether the organisations had key C-BT already or not yet. The following statement shows that one JNS territory manager was not even certain about whether the system training existed or not,

> It's not easy, the website, because it is huge. Maybe they offer training for new people but I am not sure. (ID21, JNS)

Additionally, most of the participants from FNS, PNS, and JNS emphasised the self-learning of the system they currently owned. In other words, system usage training was not carried out systematically and regularly in the organisations. For example, PNS staff would receive an email with a pamphlet telling them how to use different applications or they could watch online videos to facilitate the self-learning. Therefore, participants asserted that it was particularly important to get some ICT training since the system had numerous functions and contents, which were not easy to master even though it was just a huge website hub. The following comments show how participants thought the system usage training was not sufficient:

> Not really for the training. There is some training...had a session that you can log on to a computer and go through a session so that is more on the computer which is through videos or stuff to read. (ID8, PNS)

> I would say so. We don't ever have any ICT training. The lack of IT training definitely. (ID22, JNS)

Consistency of Training

Consistency of training is the extent to which the emergency services organisations provide system usage training at a consistent level. It is necessary to make sure that the consistency of training is maintained at a certain level by the organisations so that the performance can be consistent. Findings reveal that there was a lack of consistent system training in CNS and HNS. This was because both organisations had a large number of standalone local groups, which made it quite difficult to carry out the consistent system usage training. As noted:

> What we have not done very well is training management across our whole country……they do different stuff. We haven't really ever seen how it is going to work. So this is just starting to happen with the tool we currently are using to do the integrated training. (FG1)

On the other hand, it was found that consistent system usage training was also perceived as being important by participants from organisations that had less focus on system training. For example, system usage training in supportive organisations, such as FNS, PNS, or JNS, was mainly conducted through self-learning via online materials. Therefore, training effectiveness would be different from person to person. As a result, it was even more difficult to maintain consistent system training performance in those organisations. Hence, some participants commented that staff were required to be trained to a reasonable standard.

The lack of standard training plans and goals was another reason for the organisations' inability to achieve a consistent level of system training. As mentioned earlier, the self-learning through online materials was the main way for some supportive organisations to conduct the system training. Thus, there were no clear goals for system training which was more likely to lead to inconsistent training performances. It was also found that the lack of a training plan resulted in different training performance in different local groups of HNS. As referred to by HNS participants, there was no standard plan for training on the HNS' H System so that each branch decided the level of training. Therefore, it was hard to make sure that staff in different branches would have the same level of training since the training efforts that each branch had made would be varied. As referred to by the participant,

> In terms of mastering the function in the system, it is very much up to their own in each branch. (ID23, HNS)

Organisations with the introduction of relatively new cloud-based systems were more likely to have an urgent need of establishing standard training plans for staff. Due to the new system usage, the organisations were not able to achieve a consistent level of training immediately. For example, CNS was not able to deliver a consistent system training as much as it could even as the leading agency in managing natural emergencies. The main difficulty lay in that they just started to train and establish the national training programme while there was a large number of the users at the that time. Therefore, it was difficult for CNS to maintain a high level of consistency of the system training. One participant noted:

> ……providing access to [CNS' E System] and training but on a product without a good implementation plan could be problematic. (ID5, CNS)

Training Expertise

Training expertise refers to whether the emergency services organisations have on-site training expertise to support the system usage. In addition to the training frequency and training consistency, the lack of on-site expertise to support the system usage was the third issue that would influence the system training effectiveness. For example, among the six organisations, CNS was found to be the only one that was equipped with three system usage trainers. This was observed in the regional earthquake exercise *(OB1)* where two of the system trainers were present on-site to provide technical support on using CNS' E System. Most of the people involved in the exercise relied on the help from the two trainers. Hence, there is a need for emergency service organisations to allocate at least one person on-site for facilitating the system training. Nevertheless, findings reveal that the phenomenon of not having on-site expertise to assist with system training was more likely to take place in organisations, such as FNS, PNS, and JNS, that relied on self-learning since no system usage training was provided in a formal way. For example, PNS and JNS, either place an assistant person in the organisation or in the region for answering technical questions while FNS and RNS merely had some basic support from a remote IT team from the headquarters. This was far from enough to enable staff to become familiar with and be skilful in the system usage formally on a regular basis. Several participants mentioned the issue of lacking formal system usage training:

> There's a lot of training left behind technology (ID14. FNS).
>
> No, not formal and definitely self-learning (ID22, JNS)
>
> No specific training. It's all remote support. (ID29, RNS)

To enable emergency professionals to use key C-BTs with a higher level of proficiency, it is necessary to provide system training formally on a frequent basis, establish clear training goals in the training plan, and allocate training expertise on-site. In this way, the emergency professionals will be more familiar with the system usage to facilitate the response operation in the response stage.

6.3.2. Coordination

Coordination is another important element under the category of the organisational factors. It plays a critical role, especially in large-scale natural emergencies. It is important not only within a single emergency service organisation but also across various emergency agencies during large-scale emergencies where multi-agency coordination will take place. Through better coordination among different agencies, critical information regarding emergency situations can be conveyed smoothly, resulting in better performance. A total of 116 incidents emerged from all three sources of data, which formed five concepts as shown in Table 6-5.

Table 6-5 Open coding of coordination concepts with number of incidents in descending order

Concept Code	Concept Name	Source			Number of Incidents
		Interviews	Focus Groups	Observations	
CO2	Obstacles to information sharing	19	2	0	39
CO5	Shared capacity	18	2	0	24
CO3	Common platform	15	2	2	23
CO1	Relationship establishment	13	1	1	17
CO4	System linkage	15	1	0	13

These concepts were then further grouped into one category as shown in Table 6-6.

Table 6-6 Category grouping of coordination

Category Code	Category Name	Concepts Involved	Number of Incidents
E	Interagency Coordination	CO1, CO2, CO3, CO4, CO5	116

It is discussed in the following section.

Inter-agency Coordination

Inter-agency coordination is especially important when major natural emergencies happen due to the different responsibilities that various agencies undertake such as search and rescue, first-aid, or humanitarian services, and resource supply. Important situational information needs to be shared in a timely manner to deal with the emergencies. Thus, using C-BTs in a cooperative way seems to be necessary to achieve this goal. Inter-agency coordination can be further broken down into several elements: relationship establishment, obstacles to information sharing, common platform, system linkage, and shared capacity.

Relationship Establishment

Relationship establishment is the extent to which the emergency services organisations build a close working relationship with key agencies and other involved stakeholders. The results reveal that making connections and maintaining relationships with other agencies are important in the preparedness stage, which provides advantages for emergency professionals to operate smoothly in the response stage. This is because they know who they need to ask for resources and help without hesitation. As stated by the participant:

> We have regular meetings with [FNS], [PNS] and we attend a local group of [CNS], which is important in the preparedness stages. (ID 21, JNS)

Participants from all six organisations acknowledged the importance of having a close relationship with the leading agency, CNS, in the preparedness stage. Several aspects that were associated with relationship establishment had been referred to by participants. These included the experience of engaging in either the local or the national exercises every year, taking part in the multi-agency courses for planning and response, attending inter-agency workshops for sharing ideas, experience and knowledge, and strengthening the links with CNS through liaisons. It reveals that most of the participants took the advantage of these opportunities to build their relationships with people from different key agencies. For example, both of the RNS' managers mentioned the importance of the relationship established during the preparedness stage, such as in the conjunction of exercises and day-to-day working relationship. In this way, various agencies could better understand how other agencies work. As commented:

> So we usually work in conjunction with a [local authority] emergency operations centre…… Our normal preparedness or day-to-day work is around relationship management with territorial authorities. It is specifically the regional [CNS' groups] and also the emergency services that we also have our relationships with. (ID 28, RNS)

The collaboration was observed in the geothermal exercise *(OB5)* where FNS and CNS members were engaging in the exercise to help RNS to satisfy the welfare needs of the community in terms of establishing a welfare centre and checking the needs for installing a smoke alarm.

Apart from the close connections with the leading agency, several participants from the frontline agencies also emphasised the importance of maintaining a close working relationship among the frontline agencies in the preparedness stage, rather than only in the response stage, since those agencies would have to coordinate at the scene immediately. Therefore, better coordination could be achieved through a close working relationship that had been established in the preparedness stage. One participant noted:

> We have improved to make sure sort of senior people in [PNS], [JNS], and [FNS] now meet each regularly rather than establishing that the relationship once it happens. With that relationship already exists which is better. (ID 20, JNS)

Although relationship establishment did not seem to directly influence C-BT usage in emergencies, having a close working relationship with key agencies would be helpful to enhance emergency professionals' positive perceptions regarding C-BT deployment in emergencies. This was because each agency would be more familiar with how other agencies work. The trust that had been built among agencies would enhance emergency professionals' confidence in managing emergencies through cloud-based systems, especially during the multi-agency emergencies. As stated by one participant:

> To be honest we have not run into any issue as far as we talk to people. We have invested in the infrastructure to allow us to keep talking to one another across [location]… relationship is the key and when you pick up the phone, you already know the person. (ID 3, CNS)

Due to the improved trust and familiarity, information could be shared more smoothly among different agencies when responding to an emergency. Therefore, early relationship establishment among different agencies would indirectly influence the successful C-BT deployment when dealing with emergencies.

Obstacles to Information Sharing

There were several obstacles to sharing information smoothly through C-BTs among various agencies. The usage of different systems in each organisation was the biggest issue for sharing information. Most of the participants thought that the different system usage made it difficult to coordinate among various agencies. Thus, each agency would be more likely to focus on their own operations rather than performing in a cooperative manner. Therefore, it would be better to have a central hub for all agencies to share information for further action plans during emergencies. Findings show that even though CNS was the leading agency for natural emergencies, it had the most difficulties in realising coordination with other agencies in terms of information sharing. This was due to its unique standalone characteristics of local groups where some groups refused to use the CNS' E System but used their own systems. One FNS search and rescue manager had concerns about the quality of the information shared between CNS and other agencies. As noted:

> Then they got sub-branches underneath, they don't even talk to each other and they disagree so that must affect the quality of information that goes into here. (ID14, FNS)

Another example was that even though the three frontline agencies, FNS, PNS, and JNS, shared the same communication centre to get a whole picture of the emergency information, such as where the emergency calls came from or the live movements of trucks, the process of information sharing was not conducted in an automatic way. Such information sharing was achieved through emailing the layer of emergency calls to each other. As discussed by the focus group:

> So it is not automating whereby we have to add our layer to the [PNS] and [JNS] layer. So it is pretty clunky. (FG2)

Privacy concerns for sharing information were mentioned by some of the participants. For example, certain information might contain sensitive facts, such as photos of people's house damage, or personal contacts, which posed difficulties for agencies to look at each other's cloud-based systems in multi-agency emergencies. Supportive agencies, such as PNS, FNS, and JNS, were less willing to share information that might cause privacy issues, while participants from CNS had more confidence in sharing information with private details due to trust in other agencies' ways of handling the information. Therefore, with the organisational boundaries, it would be difficult to share information through cloud-based platforms smoothly among various agencies. The following statement reflects a participant's view,

> I cannot have a [FNS' person] looking at all that information because there can be personal information in that database that we should not share. (ID19, JNS)

In addition, accessibility was another factor that influenced the inter-agency coordination in terms of C-BT usage. It refers to whether emergency agencies are allowed to access each other's key C-BT systems when necessary. Most of the participants regarded it as quite important and necessary to access other agencies or authorities' systems since they could collect and contribute critical information as needed. For example, it would be efficient for various agencies to read each other's plans in the preparedness stage so that they could receive updated plans for different types of emergencies quickly. As the participant stated:

> So I can get into [regional authority and CNS] their platform to read their plans. (ID8, PNS)

The accessibility to other agencies' systems was found to be one of the biggest obstacles to sharing necessary information in both preparedness and response stages. For example, not all of the agencies were able to access CNS' E System, even though CNS was able to allow other agencies to access their key cloud-based system during the emergency. Thus, each agency needed to wait for access approval to contribute critical emergency information to CNS, which was not an ideal way to enhance the efficiency of gaining information. Nevertheless, the original purpose of establishing CNS' E System was to enhance the speed of information sharing, which contained sites for other agencies to input information. As the participant asserted:

> In terms of the planning tool that [CNS] uses, the [CNS' E System] system, all of us such as [PNS], [JNS], [FNS] are supposed to have access to it so that we could log into it but it never happens. They promised us that if there is an event we could log straight and put out stuff but it never occurred. (ID14, FNS)

This was echoed in JNS focus group discussion:

> We have far fewer people [who] have access to that one than having access to [HNS' H System]. But we have key people who have that access. (FG3)

On the other hand, it shows that it was not possible to achieve mutual system accessibility between agencies due to policy restriction. Even though one agency could provide system access to another one, the information flow was still one-way rather than two-way. As the participant stated:

> They can't log into ours, but we can log into theirs because we can't share [the] whole [of the] information that we have. We can't share, which is why we can't give them access to our system. (ID6, PNS)

Conversely, it was found that RNS had less concern over the accessibility. This was because none of the participants mentioned the issues of accessibility to other agencies' system since RNS relied most on email to share information with other agencies and it was not a big player in other agencies' C-BTs at the moment. RNS' current focus was on establishing its own emergency system. Thus, it had fewer issues of accessibility to other agencies' system.

Additionally, the compatibility issue of information sharing was emphasised by many FNS' participants. As one of the key frontline agencies, FNS needed to get key information for their pre-planning before arriving at the scene. Therefore, it was particularly important to ensure that the information file gained was compatible with its system. Nevertheless, there were incompatibility issues when sharing files that included critical building and mapping information. For example, FNS required to integrate the mapping information gained from PNS before arriving at the scene, but the two types of files were not compatible. As the participants stated:

> It's the same based mapping system, but it's different. So we can't give them the [FNS] layer and put it over the mapping systems. (ID15, FNS)

> That is a trouble is that we can feed information to a lot of people and some of them can feed us back with relevant information but not compatible. (ID13, FNS)

Common Platform

Common platform refers to the extent to which various key agencies have the same platform to have a big picture of the emergency situations during multi-agency emergencies. Having a common platform is particularly important to enable different agencies to gain key information from other agencies so that further decisions can be made quickly. Even though some participants admitted the benefits of achieving a certain level of efficiency due to having access to CNS' E System, the efficiency of gaining information was far from enough. Therefore, having a common platform for sharing information completely on the same page was considered important by most of the participants.

As observed, even though CNS' E System had been offered to key supportive agencies during the multi-agency exercises *(OB1* and *OB4),* each agency still used their own unique cloud-based systems to deliver their responsibilities, such as tasking and allocating resources, when managing natural emergencies. As a result, each agency could only access a fraction of the whole picture rather than an overall view of the emergency situation through using CNS' E System. It was mentioned by most of the participants from supportive agencies. One participant noted:

> Yes, they give us the logon. W can only come to pick up the layer so that we cannot always see the whole picture. We only see what they want to tell us and vice versa, what we feed back to them. Although they have mapping systems, they don't have the information that we've got. (ID 13, FNS)

Most of the participants asserted that there was a lack of a common platform for all different agencies to share information simultaneously. One senior HNS' emergency management advisor thought that it would be better to merge their system with CNS' E System to enable all of them to have a clear picture of the situation. In this way, they would be able to keep a higher level of transparency of key emergency information during the response stage.

The inefficiency of the operations occurred due to the lack of a common operating system. For example, duplication of tasking messages was sent by various agencies because of not delivering tasks on the same platform, which resulted in confusion. Therefore, it would be better to have a shared site for all agencies to report and allocate tasks instead of operating in silos. The following statement showed how the participant felt the inefficiency when operating on different platforms:

> It is dangerous because you could task me to do something… but they could have already done from their end which means the [CNS]person could have tasked their person to ask the [PNS] officer in [location] and I could have tasked them as well… there could be confusion and we've always identified that. (ID 11, PNS)

In addition, the frontline agencies were more urgent in having a common cloud-based platform when operating cooperatively at the scene. With a common platform, it would be more efficient to share information, such as the number of deaths and injuries, and to allocate resources in a more effective way. Even though those agencies were moving towards having a common platform, it was hard to achieve currently due to the different policy within each organisation. As stated by the participant:

> We always need a common cloud that sits there… we can feed information into it because [FNS] and [PNS] is easy because we're actually the same. Our communication centre is the same. Again that's a policy thing because of the security they believe that the communications are far more secure than ours. (ID15, FNS)

Most of the participants thought there was a need to reach a conclusion and have an arrangement for a common platform among agencies. It would be beneficial to all agencies to carry out more efficient operations when dealing with emergencies.

System Linkage

System linkage is associated with whether different systems used by various emergency services agencies can be linked to enhance the information sharing ability in key stages of natural emergencies. As discussed earlier, there was a lack of a common platform for all key stakeholders to have a common operating picture. Most of the participants thought that different systems of various agencies should at least be able to link with each other to share information efficiently. Only systems at the communication centres shared by PNS, FNS, and JNS had the ability to transfer information flexibly to each other. On the other hand, most of the HNS' participants said that it would be simpler and more efficient to link the two similar systems between HNS and CNS for sharing information, such as situation reports, rather than transferring information back to HNS through email, which was frustrating. Therefore, the system linkage among agencies had not been achieved yet due to the barrier of bureaucracy and privacy concerns. As one participant noted:

> If for instance, [FNS] create something in SharePoint and we use SharePoint, we should be able to connect the two somehow and pull information from one to the other, but sometimes bureaucracy does not allow us to do this. For those who use different systems, they cannot coordinate with us. (ID4, CNS)

Another huge challenge that participants identified was that each agency operated quite differently so that it was difficult to link to other systems with a different focus. For example, even though the key cloud-based systems owned by HNS and CNS were similar platforms, it was not possible to link the two systems since HNS' system only dealt with health-related issues while CNS' system handled all related aspects of the information from different agencies. As one participant stated:

> So in terms of actual platforms, they're very similar… if the [CNS] people would use our system for their own purposes it wouldn't work for them because ours is a health-focused system. (ID 23, HNS)

Although RNS had not yet established their own emergency information system, both of the participants acknowledged the significance of linking systems to other agencies. In this way, the situation report could be shared easily with external agencies. Therefore, it was realised the systems connections among different agencies were considered important by most of the participants to improve the efficiency of information sharing.

Shared Capacity

Shared capacity is associated with the extent to which the emergency service organisations share the capability of C-BT usage with other agencies in key stages of natural emergencies. Although obstacles existed in terms of having a common platform and establishing linkage between systems among various agencies, there was a trend of moving towards sharing C-BT usage capacity among agencies. For example, the usage of CNS' E System was mentioned to be used most during large-scale natural emergency exercises in the preparedness stage, although it still had some limitations in terms of information sharing. As noted:

> So we will not use [CNS' E System] full-time and will also be using our [HNS' H System] solution, but we will as we refer to it or they refer to it and to access those systems as well. (ID 23, HNS)

Also, most of the participants mentioned that they shared CNS' capability of a national warning system during large-scale natural emergencies. Various agencies could help to spread the warning message and implement the pre-plans regarding their responsibilities. Additionally, some participants from CNS and FNS mentioned the inter-agency project coorperations which were in progress. For example, FNS had undertaken several multi-agency projects, such as the web-based public alerting solution, and the new generation of emergency call capability through using applications on a cell phone for the public to make phone calls to communication centres. Another example was the cooperation between CNS and transportation and lifeline agencies to establish an enhanced mapping system. Hence, the application could better suit the agencies' needs due to having the advanced mapping layers.

In addition, FNS had strong cloud-based mapping capabilities to share with other agencies. For example, half of the FNS participants mentioned that they shared mapping capabilities with CNS in the previous earthquakes since CNS did not have any application to use at that time. FNS also shared the usage of Esri's ArcGIS and disaster assessment solution with CNS when necessary. One JNS national manager mentioned that JNS would share FNS' technology on their large vehicle at the scene, which was flexible among those frontline agencies. The following statement shows how FNS support other agencies in a large earthquake:

> For example, in the [location] earthquakes, we supplied where all 111 calls are coming from and gave them to [CNS]. (ID 13, FNS)

On the other hand, due to a similar focus on health-related issues, HNS would use the alerting capability supported by JNS. As stated by the participant:

> [JNS] have an [alerting system] and the [HNS] will send the message to all those people. (ID 22, HNS)

Therefore, even though each agency has their own systems for managing emergencies, the collaboration through using the shared capacity of the cloud-based system among various agencies would enhance the flexibility of the operation at the emergency operation centre as well as the frontline.

6.3.3 Cloud-based Technology Characteristics

Technology-related characteristics play a second significant role in influencing the emergency professionals' perceptions of C-BT usage in emergencies. The perceived advantages, perceived disadvantages, usefulness, and deployment model type of C-BTs constituted the category of technology characteristics. The number of incidents emerged from all three sources of data was 633, which become the 23 concepts in this category in Table 6-7.

Table 6-7 Open coding of C-BT characteristics concepts with number of incidents in a descending order

Concept Code	Concept Name	Source			Number of Incidents
		Interviews	Focus Groups	Observations	
CT15	System and infrastructure vulnerability	18	3	2	54
CT22	Private cloud or Internal cloud	28	3	1	52
CT4	Efficiency	23	2	2	51
CT18	Communication	22	3	4	46
CT23	Public cloud or External cloud	23	3	3	46
CT11	Complexity	28	2	0	44
CT17	Date storage	24	1	2	44
CT10	Compatibility issue	27	2	0	38
CT5	Mobility	21	2	2	36
CT13	Security concern	28	2	0	34

CT16	Unexpected situations	21	2	2	29
CT12	Cost	18	1	0	23
CT6	Redundancy	16	2	1	22
CT1	Accessibility	27	2	0	21
CT2	Consistency	16	1	1	16
CT3	Cost-effectiveness	11	1	2	15
CT19	Warning/Alerting	15	2	1	15
CT21	Training management	8	1	0	13
CT20	Resource management	7	1	0	10
CT8	Stability	6	1	0	9
CT9	Transparency	14	0	0	6
CT14	Privacy concern	11	0	0	6
CT7	Situational awareness	4	0	0	3

The concepts above were then further grouped into four categories as shown in Table 6-8.

Table 6-8 Category groupings of C-BT characteristics

Category Code	Category Name	Concepts Involved	Number of Incidents
F	Perceived Advantage	CT1, CT2, CT3, CT4, CT5, CT6, CT7, CT8, CT9	179
G	Perceived Disadvantage	CT10, CT11, CT12, CT13, CT14, CT15, CT16	228
H	Usefulness	CT17, CT18, CT19, CT20, CT21	128
I	Deployment Model Type	CT22, CT23	98

They are discussed in sequence in the following section.

Perceived Advantages

Perceived advantages are associated with the perception of C-BT utilisation benefits that the individual emergency professional has in managing emergencies. These are important because the more benefits the emergency professionals have, the more likelihood that they will be more active in utilising C-BTs in managing emergencies. The elements that constitute the category of perceived advantages are now discussed.

Accessibility

Accessibility refers to the extent to which the emergency professionals consider the cloud-based systems easy to access. Even though there was a lack of C-BT usage experience in large-scale natural emergencies, most of the participants from all six organisations highlighted the ease of access to C-BTs in response to emergencies. That accessibility was considered as the most important advantage that influenced the emergency professionals' perceptions regarding C-BT usage in natural emergencies. Most of the participants had a strong sense of the benefit of the easy accessibility which enhanced their working flexibility since they could work anywhere without relying on the single desktop in managing emergencies. For example, most of the participants thought that it would be flexible and efficient to access important documents and more types of information at any time and any place. Nevertheless, participants from FNS and JNS particularly indicated the difficulty of access to C-BTs in remote areas during the frontline operations but did agree that it would be normally easy to access C-BTs in urban areas. One participant stated:

> Generally, I got good access but you couldn’t go too far in New Zealand in order not to lose connectivity. (ID20, JNS)

The ability to access key C-BTs was particularly important in the response stage of large-scale natural emergencies where unexpected situations, such as power outages, Internet connections lost, and other damaged infrastructures, would have a high possibility of occurring. With the ease of accessibility, CNS’ participants thought that it would be particularly helpful to enhance the flexibility of operations during multi-agency emergencies. It was because if the emergency operation centre collapsed, registered agencies with login details could access and feed information to CNS’ E System remotely. Similarly, one senior HNS system advisor explained that they were able to work cooperatively through HNS’ H System to deal with a live emergency while they were on vacation at different places. Therefore, the flexible access was considered valuable to support a virtual emergency operation centre. It means that the virtual team could still work together remotely as long as they had devices and Internet access even when the emergency operation centre was destroyed or they could not be present at the operation centre. This was discussed by the CNS focus group:

> ……and other benefits is about not having to be in a singular location to manage the event like if we really had to. So if we have a big event tomorrow and the [National Emergency Operation Centre] wasn't available, all of our staff can work from home or anywhere. (FG1)

Consistency

Consistency refers to the extent to which the emergency professionals perceive that they can achieve a consistent level of performance through C-BTs when managing emergencies. Most of the participants considered that keeping a consistent level of performance was the main thing, especially during the response stage. With synchronised updated data on a single document stored in the cloud-based system, emergency professionals could access consistent content, such as the situation reports, contact details, as well as templates and forms, during the response stage. Thus, staff at different regions could access the same content across the country on a single document instead of maintaining different versions of a certain type of document. For example, one senior FNS area manager emphasised the importance of having a common operating picture through maintaining the same information. This was because emergency professionals relied on consistent messages to make correct decisions and then turn them into actions. The following statement shows the importance of keeping consistent information perceived by the participant.

> What it does is that it gives consistency in terms of templates that you can fill out and post information. So the sitreps are the same, the template of incident plans are the same, template and the tasking and login information is in the same format and accesses the same way from everyone. (ID27, HNS)

This was corroborated by the focus group discussion from CNS:

> …you can have a single document that is accessed by all the different [city authorities or regional authorities]. (FG1)

This was also observed in the tsunami exercise *(OB4)* where situation reports were produced on CNS' E System for all CNS' branches and support agencies to share the information of the current situation. The single source of truth ultimately helped to enhance the accuracy of information flow across the country.

Most of the participants thought that better collaboration, either internally or externally, could be achieved through sharing information consistently on the same C-BT platform. This was because the consistent information was produced on the same platform for collaboration. For example, one senior FNS area coordinator argued that it was foreseeable that with the flexible accessibility of C-BT, they would be able to receive critical information on their mobile appliances at the frontline across the country due to the same technology equipment on all appliances. Other examples of internal collaboration included sharing documents, such as planning through Microsoft Office 365, or having conversations through an internal online blog. With a central platform, emergency professionals were able to work collaboratively on consistent platforms during the chaos. This was especially critical to emergency services organisations with many branches located at different geographical locations. It was also beneficial to emergency services organisations in which various systems were used by different branches. As stated by one participant:

> It's about bringing people into a collaborative workspace where they can access systems… our [branches] are running different IT systems. So they can't easily access … They are just standard IT systems so that [HNS' H System] can bring them together. (ID23, HNS)

Therefore, C-BT played an important role in helping emergency professionals to keep the consistency of operation when dealing with emergencies. Compared with the other five organisations, participants from RNS did not mention much about the consistency of performance. The reason was that the organisation had not yet had any experience of managing natural emergencies through specialised C-BTs and it had just started to establish its own emergency management platform.

Cost-effectiveness

Cost-saving was another factor influencing emergency professionals' C-BT usage perception when managing natural emergencies. It relates to whether the cost of C-BT investment is low or not. Organisations that used external cloud platforms, such as Dropbox, Microsoft office 365, Skype, etc. would have a stronger sense of cost saving. Most of the participants thought that they could spend less on keeping infrastructure and upgrade. For example, one senior CNS group coordinator noted that they only had to pay a small amount of money for a Microsoft Office 365 licence for the period they wanted to use the service, which was a cost-saving approach with its tight budget on IT investment. Thus, the pay-as-you-go pricing model of external cloud solutions worked well in organisations with the limited budget. Therefore, they did not have to invest much in the infrastructure and upgrade since the service provider would set up all the services. The following statement reflects how the participants perceived cost was saved by using external cloud services:

> Cost is a big factor. we are finding that as time moves on cost is reducing for cloud solutions and outsourced services. (ID12, FNS)

> Once it is web-based we can move to thin clients. There will be some savings for us both in hardware and technical support. (ID6, PNS)

As a result, emergency professionals were able to save maintenance costs on C-BTs. This was because all the maintenance would be looked after remotely by a third-party company, which means the organisations did not have to employ people to provide that support.

On the other hand, most of the participants thought the cost of storage would be reduced. This is particularly related to the multi-tenancy characteristic of cloud services. Therefore, the service provider has more capacity to offer storage services to the organisations than that the organisations establishing their own clouds for serving. As noted by one participant:

> For me, the advantage of owning systems is that they are leveraging a global user base and therefore cost can go down because I got significant savings. So I think it is cost effective; storage and access are cheaper. (ID 5, CNS)

In addition, the shared cost of purchasing Infrastructure as a Service among different emergency agencies was another approach for saving cost currently. It enabled emergency service organisations to enhance their capability to purchase more cloud-based services. For example:

> We are leveraging government shared services as well. All of movement procurement would purchase IaaS and we have a lot of cost reduction on shared services across government as well. So, a bit of power to buy those type of as a service capability. (ID12, FNS)

Interestingly, it was found that RNS was most in favour of external clouds at the moment due to the limited budget on IT investment as a volunteer organisation. Therefore, RNS relied more on open-source C-BTs such as Google Maps or needs assessment applications.

Efficiency

Efficiency refers to the extent to which the emergency professionals perceive C-BTs could enable them to perform in an efficient way when dealing with emergencies. Most of the participants perceived that one of the main benefits that C-BTs could deliver was enhanced efficiency. Many thought the C-BTs were helpful to gather and share immediate intelligence, which means information could be shared and updated faster both internally and externally. For example, social media was a great platform to get current information from the public, which could also add value to their internal performance. One senior CNS group manager described that it took two to three hours to produce situational reports without cloud-based systems in the past, which was quite inefficient since the data could easily become obsolete. It was also confirmed by all CNS participants that there were no cloud-based systems tracing back to 2011 during the Christchurch earthquake. Now with data synchronisation on a single platform, either the internally owned emergency management system or externally supported platforms, it was helpful to increase the operation efficiency through receiving and tracking integrated information rather than manually updating different aspects of the information separately. As explained:

> ……the concept of having cloud-based document storage proved itself in that event… We can just share any document through Dropbox link, and password… We couldn't do that before. (ID5, CNS)

There was an increasing use of mobile applications, which were either internally established applications or public applications. The functions of the applications included alerting the internal staff and the public, supporting evacuation routes or conducting impact assessments. For example, one senior CNS group manager illustrated that they were considering using an application for alerting the community, which was similar to Facebook pages, but it focused more on messaging within a certain community. People who might be affected in the area could be reached quickly as long as they used the application.

Additionally, many participants from the frontline agencies, FNS, PNS and JNS, considered that C-BT usage could enhance the efficiency of resource management. With cloud-based systems, resources, such as personnel and facilities, could be monitored and managed more effectively. For example, it was challenging for JNS in the past to manage shifts without web-based applications. With its newly established shift management application, it was able to coordinate and allocate tasks efficiently during emergencies. A similar thought was shared by one FNS area manager:

> So it's all about personnel and resource management….It's about knowing where everybody is at any one time… You use it as a planning tool that we never had any. Your span of control is only one to four so you can only manage four people effectively at an emergency event. This is a tool that helps you do that better. (ID14, FNS)

Efficient data management was found to be a third aspect that could be achieved through using C-BTs. Most of the participants thought that critical documents could be stored, updated and synchronised efficiently in the system especially during the response stage. For example, templates and contact lists were synchronised if any change were made on the documents. Through synchronisation, the large quantity of information could be managed more effectively. It was efficient to access the same updated documents for better operation. This was described by one participant:

> So these benefits are speed collaboration working on documents together……It is efficient since the documents are in the cloud, we can make changes into that document at the same time. (ID28, RNS)

Therefore, enhanced efficiency is quite important to increase individual manager's positive perception of C-BT usage.

Mobility

Mobility refers to the extent to which the emergency professionals perceive that the usage of C-BTs through portable devices make the job easier and more efficiently executed. Most of the participants referred to the potential usage of mobile devices as including tablets and smartphones. Almost every participant had a smartphone that was either owned privately or allocated by the organisations. However, due to the limitation of screen sizes and capabilities in supporting various functions, smartphones were mainly used to conduct easy jobs, such as making phone calls or checking emails. Tablets were perceived as being more attractive to be employed in emergencies.

However, none of the organisations had put tablets into extensive use in practice. As observed, tablets were utilised only in one geothermal exercise *(OB5)* led by RNS. Several organisations, CNS and FNS, had recently bought some tablets for facilitating the cloud-based applications usage while other organisations had not yet. Therefore, if there was a real large-scale emergency, the organisations would still use computers rather than mobile devices. Nevertheless, most of the participants could foresee the potential benefits of using mobile devices in supporting cloud-based applications in emergencies. Participants from FNS particularly reinforced the importance of deploying mobile devices at the frontline. This would significantly enhance the flexibility and efficiency of frontline operations in terms of downloading critical files faster, establishing requests and tracking allocated resources more easily. As commented:

> So you get called out that you can look at that one your mobile…… I can look at where the trucks are. (ID13, FNS)

Similarly, PNS and RNS used mobile applications for field operations. For example, RNS utilised mobile applications on tablets in the field to do needs assessments, which helped to enhance the efficiency of identifying the needs of the affected community. Differently from FNS, JNS equipped each frontline vehicle with a tablet though, they were not able to access cloud-based applications but could only utilise the pre-loaded applications on the tablet. Therefore, the mobility cannot be achieved simply through having mobile devices, it requires accessibility to cloud-based mobile applications.

Many participants thought that mobile devices had great potential to ease gathering information both in the emergency operation centre and at the frontline. In organisations such as CNS and HNS with operations mainly at the emergency operation centres, mobile devices could serve as an alternative to access their core emergency management systems when anything went wrong with the computers. On the other hand, frontline agencies, FNS, PNS, and JNS, could operate more flexibly due to the enhanced availability of technologies at the frontline. With improved mobility, more actions could be conducted at the frontline, such as receiving and responding to job orders, generating and sending reports, or accessing standard operating procedures. As stated:

> I mean it's the mobility the system does. You could have bunches of information into the cloud and then the devices in the other systems. It goes and grabs the information that you want. (IDl5, FNS)

In addition, the mobile appliances deployed by organisations such as FNS, JNS, and RNS, were helpful to enhance their mobility when conducting frontline operations. For example, FNS would utilise its mobile appliances equipped with computers, especially, in large-scale emergencies for coordinating frontline jobs. The tablets would also be on trial on the appliances soon to enhance the flexibility of accessing cloud-based applications, such as email and resource management solutions. Even though JNS, PNS, and RNS did not own mobile appliances as FNS did, they either utilised tablets or had Wi-Fi access through satellite or data sticks which were considered necessary and helpful to carry out frontline operations.

Redundancy

Redundancy is associated with the extent to which the emergency professionals perceive that C-BTs ensure data certainty when dealing with emergencies. It was one of the perceived benefits that most of the participants considered valuable in managing emergencies. This was because they thought the redundancy ensures data certainty and integrity in case any building collapsed or power outage issue happened during major emergencies, especially in the response stage. Various ways of backing up data were mentioned by participants, such as replicating of contacts in Gmail system or Microsoft Office 365, as well as backing up plans on Google Drives or Dropbox. Another example was that one senior FNS manager considered the cloud-based information collector was useful to conduct rapid assessments of disasters. The reason was that they did not have to worry about losing data that had been collected from the frontline even when the Internet connection was lost. As stated:

> [It gives]… the ability to back your information up so that if the computer dies you don't lose everything because it's all backed up and stored remotely. We just can't be relying on having power all the time or Internet connection so you've got to have backups. (ID4, CNS)

The real-time synchronisation helps to reduce the risk of losing information when unexpected situations happen. This was observed in the regional earthquake exercise *(OB1)* where the system was overloaded so that the exercise was interrupted. However, due to the real-time synchronisation, they were able to pick up the jobs right after the issue was solved. Therefore, through having better resilience in terms of backing up information, emergency professionals were more likely to utilise C-BTs in emergencies. Even though RNS had not established its own specific emergency management system, the large percentage of cloud movement with its business-as-usual operation had made both of the participants trust in the robustness of their future system that they were going to develop.

Most of the participants from all six organisations mentioned that the organisations had either kept multiple communication centres or data centres in several different locations across New Zealand. Thus, the organisations had less concern about losing data during emergencies. The redundant communication and data centres ensured business continuity when one centre did not work in a certain place. As explained:

> In terms of business continuity. That's part of the reason for going to the cloud is to ensure system backups so that we don't lose either information and also we don't lose the ability to talk to each other. It takes away from a single point of failure to more resilience. (ID19, JNS)

Situational Awareness

Situational awareness is the extent to which the emergency professionals perceive that C-BTs can be helpful in being aware of the current situation in a timely manner. Only a few participants from CNS, FNS, HNS, and PNS mentioned the importance of enhancing situational awareness. Nevertheless, it is vital to be aware of situations quickly in natural emergencies since the sooner the emergency professionals can realise the situation that has happened outside, the better they can organise resources and make decisions to deal with the emergency. For example,

> Monitoring social media is our next biggest step in the IT aspect as during an event 'Situational Awareness' is the key component. Situational awareness through social media. (ID13, FNS)

Similarly, one senior CNS emergency coordinator commented that social media, such as Facebook and Twitter, that were utilised by them were considered important to discover what was going on outside of the operation centre. They would make continuous efforts in monitoring social media platforms to supplement the information they did not have at hand. Besides social media, some internal systems, such as internal mapping systems, or alerting systems, were also helpful in enhancing situational awareness. For example,

> Situational awareness is really about understanding what the true picture is as soon as possible…… What I like about the colour coding is something doesn't happen at a time and when it was meant to happen it turns red. So I can see here and go to my door and say why that is red? (ID2, CNS)

Stability

Stability relates to the extent to which the emergency professionals perceive that the C-BT can enable stable performances. This is especially important in the response stage due to the urgency of the tasks that need to be carried out during large-scale natural emergencies. Therefore, the reliability of C-BTs was found important to influence the emergency professionals' perception of C-BT usage in emergencies. In terms of internal C-BTs, participants from CNS and FNS considered email the most reliable C-BT for sharing and updating information internally or externally. For example:

> We have agencies to come to us such as [FNS], [PNS], power company, [HNS]. So we communicate with them physically here and make them log into their own systems, but we still send out situation reports, or media release by email which is probably the most reliable tool. (ID5, CNS)

Despite email, several participants from PNS and HNS considered their internal key C-BTs reliable since safety and the feature of maintaining redundant. Therefore, emergency professionals were keen on the core technology that worked effectively and could help them make continuous improvements in their performance. The following statement reflects one PNS system strategic advisor's strong belief in its internal system:

> One has to be there 100 percent all the time. If the system goes down, it's not going to coordinate the response. Yes, it should be reliable. (ID 7, PNS)

In terms of external cloud-based services, such as social media platform, Dropbox, Microsoft service 365, and Google Maps, some participants from CNS showed a high level of trust in their reliability. For example, during the focus group discussion at CNS, all the members agreed that Facebook and Twitter had really good infrastructure so that they were always able to continue informing the public of critical information during events. The following statement expressed the firm belief of C-BT's reliability by the participant:

> Cloud-based is going to be reliable as long as we can connect to it. I have found since we have moved to more cloud-based technology, we have been more stable. (ID5, CNS)

Conversely, participants from JNS and RNS did not mention the reliability of their C-BT usage. The reason was that there was a lower level of C-BT usage in the field currently.

Transparency

Transparency is associated with the extent to which the emergency professionals perceive that the level of information transparency can be achieved through using C-BTs. Several benefits were gained due to the enhanced transparency achieved through C-BTs, especially during the response stage. The ease of tracking information was mentioned frequently by some participants. The reason was that tracking information in terms of tasking, reporting, making changes and comments were the main jobs of emergency professionals to conduct in the emergency operation centre during the response stage. With enhanced transparency, the speed of decision-making was enhanced. As noted:

> I can see who's created, who has modified, since it is time-stamped. When you think anything has been done, if I need to I can go back and look at the version and I can see who's done what and when. It's very transparent in that way. (ID4, CNS)

It was also found that the increased transparency enabled organisations to realise better internal information exchange across branches in New Zealand. Since all studied emergency service organisations owned a number of branches at different locations around New Zealand, the transparent information sharing was helpful to enhance the efficiency of their operations. The transparency allowed people at different locations to share plans, contacts, and records as well as allocate tasks in an easy way. For example, one senior HNS manager described how it was easy for each HNS' branch to share situation reports, plans, and information regarding resources required on the same platform, which enhanced the visibility of what was going on.

In addition, increased transparency also benefitted emergency professionals in the preparedness stage. The reason was that people at different locations could learn lessons from other branches. In this way, the experience of other branches could be transferred to local events. For example, one senior HNS emergency coordinator illustrated that it was useful to read other people's situation reports and learn from each other. The following statement shows how the participant thought the enhanced visibility helped people in different branches to learn from each other:

> Once you have done that, you can put it in a place where everybody has visibility of it and can copy it… makes it a lot easier for everybody else to learn other people's lessons and not repeat their mistakes that other people who might make. (ID6, PNS)

The increased visibility was also considered as having great potential to enhance coordination among agencies. Most of the participants from HNS and PNS thought that if all agencies internal systems could be linked or integrated into one system, the coordination among agencies would be improved greatly due to enhanced efficiency and visibility of information. As stated:

> So everybody's seeing stuff in the same system, each agency... I mean every agency feeding it into one system would be ideal and visible to everybody. (ID25, HNS)

The transparency enhanced the efficiency of auditing the finished job. This was very important in the preparedness stage since it would be helpful to identify anything that was not done sufficiently during the events. One senior HNS system advisor described how their internal HNS' H System allowed them to effectively track the decisions that had been made, which was exceptionally valuable for them to identify why people had made the decisions and make improvements. The following quote illustrates how the participant thought the increased visibility enhanced the efficiency of auditing:

> So, if we get audited by internal departments we have evidence of work. So we have a log of everything that occurred at that job on that piece of software. (ID15, FNS)

Perceived Disadvantages

Perceived disadvantages relate to the negative aspects that emergency professionals have in C-BT deployment in natural emergencies: compatibility issue, the complexity of system design, cost disadvantages, security and privacy concerns, system and infrastructure vulnerabilities, and unexpected situations that would interrupt the continuity of C-BTs usage. They are discussed in the following section.

Compatibility Issue

Compatibility is associated with the extent to which the emergency professionals have concerns regarding system incompatibility when using C-BTs. No significant compatibility issues were found when using internal systems or external cloud services. Most of the participants thought their internal systems went well. Nevertheless, the main compatibility issue of using internal C-BTs was the incompatible document format among agencies rather than the C-BT itself. This issue was mentioned especially by participants from FNS and PNS since there was a lack of a mechanism to standardise the type of the file format in the sector. For example, one senior FNS area manager asserted that it was almost impossible to get compatible mapping files with buildings information from local authorities while FNS' mapping data was compatible across the nation. Thus, it was not efficient for sharing information when dealing with emergencies. Therefore, having a generic file format was a prerequisite for easing the concern of incompatibility when using C-BTs to share information across different agencies. The following statement reflects the same view:

> The problem in New Zealand is that we don't have a common operating platform that we can all use together. I think the thing that I would like to firstly address is to agree on common data standards so that we can make sure that the things you have are compatible… make it easier to communicate. (ID6, PNS)

Regarding external cloud services, very few participants made comments on it due to the reliance on internal system usage. Only the CNS' participants who had usage experience of the external clouds expressed their views regarding the compatibility issue. Overall, they showed their confidence in external services. Even though there would be a possible compatibility issue of C-BTs, the increasing commonality of cloud-based products helped to reduce the participants' concerns in external cloud services. As stated:

> Because a lot of the migration was from Outlook into the 365. Maybe it is just the time that we need to spend such as moving the templates into OneNote. I don't think it would be an issue. All the files that we have at the moment are Microsoft- or Adobe-based. (ID3, CNS)

Even though the incompatible file formats still existed, most of the participants had positive attitudes towards using C-BTs. This was because participants believed that the compatibility issue would be reduced with the increasing similarity of platforms across various agencies. For example, HNS' current system used a similar platform to CNS, so that all HNS' participants thought that fewer compatibility issues would happen.

Other issues were more related to software issues that were associated with the old version of browser or inappropriate operating systems in CNS HNS, JNS and PNS. For example, CNS and HNS had similar problems of running their core emergency management system on the old version of browsers at the local level. However, it was not easy to upgrade the browsers at all local level immediately. As explained,

> Compatibility is more of old versions of Explorer, they say the system doesn't work and we go out and see it is actually because of the outdated versions of Explorer. We can't fix the problem quickly since they need to schedule for an upgrade to a more recent version of the explorer. (ID1, CNS)

Overall, the compatibility of C-BT itself seemed to be a minor issue to all six organisations.

Complexity

Complexity refers to the extent to which the emergency professionals perceive the C-BTs are complicated to use. Most of the participants, except HNS and RNS, considered that the current internal system design was complex to a certain extent. For example, all HNS' participants considered its core cloud-based emergency management system was easy to use. This was because the organisation was continuously working on system improvement to make it more user-friendly. While RNS did not have any specific emergency management system yet, it relied on its enterprise system, RNS' R System, which was considered easy to use. Regardless of whether the organisations had established a particular emergency management system or not, almost all participants preferred to use intuitive and straightforward cloud-based systems.

On the other hand, CNS' system was considered most complex to use by not only all CNS' participants but also by some participants from other agencies, such as FNS, PNS, JNS, and HNS who had used CNS' E System during the multi-agency exercises. The reason the system was complex was explained by the CNS national manager:

> We wanted it to do too many things, and we ended up in a complex system. When they go to response and suddenly they confront by this complex system, they didn't like it. (ID1, CNS)

Hence, the complexity of the system design resulted in people being confused about the functions or layout of the system, which reduced the efficiency of the performance. Other organisations had the similar problem in terms of having less user-friendly systems. For example:

> With the exception of Mapping and GPS location, there are few trusted and simple programmes around that add value when it is needed. You need people skilled in using the programmes to access and collate the needed data. (ID13, FNS)

Many participants also asserted that inadequate training and unfamiliarity with the system was another key reason that made the participants feel that the system was complex. It is understandable that it is difficult for the emergency professionals to use the system if they are not familiar with it or they feel overwhelmed. For example, one senior PNS manager claimed that it was better to reduce the number of the organisation’s applications into one platform, but it was complex for people to become accustomed to all applications. Participants from organisations, such as FNS, PNS, and JNS that owned many different applications with a complex login process, asserted that the login process should be much easier. As noted:

> One of the issues is with all the different web-based programs and it would be nice to have a single login to all [JNS] sites. (ID20, JNS)

Cost

Cost is the extent to which the emergency professionals perceive it would be costly to use C-BTs. Even though cost-saving was considered as an advantage when using external cloud services as discussed in the section of perceived advantages, many participants thought that cost was a disadvantage of hosting an internal cloud-based system. The private cloud is sometimes much more expensive to hold than cloud outsourcing. This happened in CNS. Although CNS was the leading agency in natural emergencies, it was burdensome for the organisation to host the CNS’ E System within the limited budget. The budget spent on CNS’ E System included the maintenance cost on the infrastructure, cost for fixing problems of the system, and the cost for redeveloping the system for further enhancement. As reflected in the CNS focus group discussion:

> We can't keep up because every time we change the system, it costs you a lot of money. (FG1)

Similarly, some participants from FNS, JNS, PNS and RNS thought that cost was a huge factor that influenced the organisations’ decisions on whether to deploy internal or external cloud. For example, one senior PNS emergency management officer shared that the organisation would further invest only when it thought there was a need to do so. Another participant expressed a similar view:

> The cost analysis is necessary. It will be quite important as [JNS] is a partially funded service. (ID20, JNS)

While several participants from HNS agreed that the cost of maintaining an internal system was expensive, they thought that it was worthwhile for them to invest in the system. As long as the system could add value to their performance, HNS was more than willing to invest in cloud-based systems. As stated:

> It responded to [location] earthquake where we were using our current system more effectively than when we were using our old system...I don't

> think there's anyone in New Zealand would say' No' or 'It wasn't worth the money.' (ID23, HNS)

Security Concern

Security concern is associated with the extent to which the emergency professionals perceive the usage of C-BTs will cause security issues. To date, none of the participants had encountered any issue, but they still put emphasis on the security requirement. It was considered an important factor that influenced the decision of C-BT deployment in emergencies. It seemed that most of the participants had more confidence in their internal systems than in external cloud-based systems. This was because there was a lack of trust in external service providers. It particularly happened in PNS where almost all of the participants only trust its private cloud-based systems. Further, most of the participants believed in the firewall that had been deployed by the organisations. For example:

> It is behind two firewalls. It's pretty secure. (FG1)

Despite the confidence in the system, many participants illustrated that certain actions were still taken to further protect the organisations' internal systems, such as setting up restrictions of system access, isolating important systems, initiating projects to enhance security, or improving the antivirus process. Further, participants from JNS and PNS expressed concern of joining to other agencies' system or having a common platform. The reason was that it would be a more complex situation where a higher level of security mechanism should be in place to protect multiple parties' security in the system. As noted in JNS' focus group discussion:

> We are trying to build us at the moment as an organisation very much for [JNS] to be integrated with all the health information in New Zealand. That takes a long and slow road of trust building. When we use the information, we have to write a lot of policy and procedure to ensure the thing that we use to send our information day-to-day is secure. (FG3)

Even though the security issue was regarded as a disadvantage in terms of C-BT usage by most of the participants, it would not act as an obstacle to using C-BTs when dealing with emergencies. The reason was that none of the participants mentioned that organisations would avoid using C-BTs merely due to the potential security risk. As long as the organisations could be cautious about the security issue, C-BTs would be of great help on the jobs.

Privacy Concern

Privacy refers to whether the emergency professionals have privacy concerns about leaking private information when using C-BTs in emergencies. None of the participants from all six organisations had yet encountered any privacy issue. Nevertheless, a few participants still mentioned that the possibility of leaking private information, such as details of buildings, victims, volunteers, or other people's contacts, would be a big concern for them to either use external C-BTs or share information among various agencies. For example, one senior CNS group manager argued that there would be the risk of leaking welfare information if they were going to use an external cloud service provider on its systems. As confirmed by another CNS' participant:

> It's got personal details, contact details of anybody that are required during an emergency. So it's a concern. (ID4, CNS)

In terms of sharing information stored on the internal cloud-based system with other agencies, the privacy concern still existed. For example, one senior HNS emergency planner argued that all agencies should work closely to avoid such issues:

> You will see the new [CNS] plan. [PNS] has got the job about inquiry and [HNS] has to provide information to the [PNS] about who we are looking after because they're going to try and reunite people with the victims and health will hold the victims. So we have to work closely together. So that is the privacy thing. This is a bigger need and privacy. (ID25, HNS)

There was a debate over whether or not such kinds of information should be stored in the system. Therefore, various agencies were cautious about the extent to which the private information should be shared with other agencies according to the Privacy Act.

System and Infrastructure Vulnerability

The system and infrastructure vulnerability refers to the deficiencies of current systems and infrastructures that are perceived by the emergency professionals while using C-BTs in managing emergencies. With regard to system vulnerability, some participants from all six organisations thought that the internal system was quite slow and cumbersome for various reasons, such as the clunky password process, overloaded system, heavy firewall requirements, and slow operating system. For example:

> Generally good access but it's clunky because of using different programmes. (ID18, JNS)

Another aspect of the system vulnerability was due to the immature system design, which was most referred to by all CNS participants. CNS was the only organisation that owned the specific system in New Zealand for dealing with natural emergencies. Therefore, CNS experienced more problems with systems design for natural emergencies than other agencies. The problems included the overloaded database due to problematic coding and deficient functionalities regarding direct communication in the system and smooth information sharing among different branches. Therefore, CNS' participants considered that the immature system development would influence the operation performance significantly. As stated:

> So when we're looking at redeveloping it and one of the things that I've asked for is we need to make more tools for group level and not focus just on the emergency operations centre side of things because it doesn't apply at the group level (ID4, CNS)

In terms of infrastructure vulnerability, most of the participants from all six organisations mentioned the weak infrastructure support from the telecommunication service providers. First, the overloaded telecommunication network was a huge issue during the emergencies, which resulted in both overloaded phone network and Internet. For example, one senior RNS manager shared the experience of not being able to access the Internet for the first couple of days even with data sticks during one large earthquake. The following statement from CNS' focus group discussion reveals a similar perception:

> There was a delay for all of the information and notices going out which was apparently… we did say in the June floods as well that [telecommunication service name] was getting overloaded and also there was an earthquake when you were the duty officer in [location] [telecommunication service name] went down...... Yes, so that means our technology depends on the carriers of New Zealand which is not very good. (FG1)

In addition, some participants from frontline agencies, such as FNS, PNS JNS, asserted that the coverage of network in remote areas was not strongly supported. For example, one FNS senior area coordinator claimed that even though with the fourth-generation network equipped the mobile truck, it was not usable in the remote area. Therefore, the lack of robust network infrastructure was a big issue to support continuous C-BT usage in natural emergencies.

Unexpected Situations

Unexpected situations refer to the circumstances that interrupt the C-BT usage unexpectedly. Internet disconnection was the most vulnerable liability perceived by almost all participants from all six organisations. It is a weakness of C-BTs that immediate recovery is difficult. Therefore, most of the participants had concerns that the disconnection would happen suddenly, which was a big issue, especially in the response stage. The reason was that it would significantly reduce the efficiency of the performance so that all people would be required to go back to manual paperwork, and the communication would rely on traditional tools, such as radios. The following statement reveals how the participant perceives the stability of Internet connections:

> The only problem with cloud-based is you have to have connection, don't you? If you don't have connection and a lot of our businesses do not work. (ID14, FNS)

In addition, some participants from frontline agencies, such as FNS and JNS, asserted that there was a need to get priority of the network access since there was always the network overload issue due to the shared usage of telecommunication networks with the public. Findings show that Internet disconnection also took place when the frontline agencies were operating in remote areas where the connection was not covered. Even though connections could be gained through satellite, the slow speed and high expense were the two significant concerns of most organisations. One participant noted:

> The biggest difficulty is the cost of the satellite connector and making sure that works. (ID15, FNS)

Additionally, other unexpected situations included sudden system breakdowns or power outages. In terms of the system breakdown, only CNS' participants experienced such issues due to the deployment of its relatively new and immature emergency management system. According to CNS' national manager, CNS' E System stopped working during the response stage of an emergency. As a result, the operation was converted to manual operation until the system was fixed. The system breakdown was also observed in the regional earthquake exercise *(OB1)* in which the system was overloaded so that the exercise was stopped until the issue was recovered. Therefore, CNS was still making improvements on the system.

Power outage was another issue. Even though all organisations had backed up the generator for gaining electricity during emergencies, this issue could not be underestimated. For example, it was observed in the geothermal exercise *(OB5)* led by RNS where the generator on the mobile truck stopped working at the very beginning of the field operation. Thus, WiFi on the truck was not able to be used. If it was in a real natural emergency, it would be vulnerable to continue the job. The following statement also reveals how the participant thought the power outage would interrupt the job even with a hardcopy of the procedure:

> So if we have a power cut right now, we know our systems and procedures so that we could manage but when it comes to finding out the detail of something that you might not use on a regular basis, we probably wouldn't have that hard copy for us to easily retrieve. (ID11, PNS)

Usefulness

Usefulness is the extent to which the emergency professionals perceive C-BTs are useful to support the emergency operations. Several aspects of C-BTs that were considered useful: data storage, communication, warning/alerting, resource management, and training management.

Data Storage

Data storage was found to be the most preferred function of C-BTs that the emergency professionals thought was useful both in the preparedness and response stages. The storage function was the basic need so that C-BTs could support emergency professionals to back up important documents that were ready to be used in the response stage. In the preparedness stage, all six organisations used internal C-BT to store different types of documents, such as emergency plans, standard operating procedures, business continuity plans and contact lists etc. These documents were particularly important for emergency service organisations to cope with emergencies. As noted:

> Storage of plans is an advantage… it brings up procedures, brings up specific site information… we can draw down information on the [FNS' F System] which is specific to that particular job. (ID17, FNS)

In this way, C-BTs were supportive in providing immediate knowledge of what actions to perform when it was moving to the response stage of natural disasters. The storage of key documents was also useful in the training exercises. This was mentioned specifically by many participants from CNS due to its leading role in organising multi-agency exercises of natural emergencies in New Zealand. As stated:

> Our response procedures are published and stored on the system so when people do training or want to know what the processes are, they go to [CNS' E System] to actually find the documents (ID1, CNS)

This was also observed in both of the multi-agency exercises *(OB1* and *OB4)* led by CNS where all the details of the exercise instruction were stored in CNS' E system. In this way, all of the exercise participants had clear documents to refer to.

In the response stage, most participants thought that the storage function was still important. This was because any information needed to be exchanged during the response stage was required to be stored on the cloud-based systems. Some of the CNS local groups utilised the external cloud, such as Dropbox or Microsoft 365, to store documents while this phenomenon was not found in the rest of the organisations. Further, organisations, such CNS and HNS, that owned the particular cloud-based emergency management systems mainly stored information regarding situation reports, action plans, contact lists, tasking information as well as other incoming updated messages. As explained:

> In the response, it's mainly around the situation report and action plans and we basically use them to provide that information externally. (ID27, HNS)

Even though FNS, PNS, JNS, and RNS did not own specific types of emergency management systems, they stored their action plans and contact lists in their internal systems and were able to access either CNS or HNS system to get the important reports.

Communication

Communication was found to be another important function of C-BTs that the emergency professionals considered useful in sharing information internally and externally. Most of the participants from all six organisations thought that communication within the organisation or with other organisations was predominantly conducted through email both in the preparedness and response stages. For example, during the preparedness stage, training messages, plans or other key documents were shared through email. It was observed in most of the exercises *(OB1, OB3, OB4,* and *OB5)* that internal email system or Gmail was the predominant way for communication, apart from cell phones. In the response stage, all organisations relied on email for sharing documents, such as templates, situation reports, action plans, or updating information. As commented:

> So currently we can just share through email. (FG1)
>
> I guess our email system is commonly used to coordinate new information or changes. (ID18, FNS)

Even though certain organisations, such as CNS and HNS, owned their private cloud-based emergency management system, they were not able to directly send files or messages within the system. Therefore, email would be the main tool for exchanging information both internally and externally. As observed in on regional earthquake exercise *(OB1)*, the CNS' E System broke down due to some software issues so that email became the only tool for sharing information in the exercise before the problem was solved.

On the other hand, most of the participants considered that social media platforms had great potential to communicate with the public. This included alerting the public in the preparedness stage and quickly responding to the public or gathering information from the public in the response stage. CNS utilised social media most among the six organisations due to its leading role in aggregating information to support coordination among different agencies. All CNS groups were making efforts to enhance public engagement on its social platforms, which included making the social media page more interesting to attract the public attention or creating YouTube channels to educate the public to be aware of the important issues in the preparedness stage. Moreover, as observed in both multi-agency exercises *(OB1* and *OB4)* led by CNS, social media functional groups were set up to monitor and update the information from the public, which added value to the operation via more current information. Therefore, in the real response stage of a natural emergency, social media would be used extensively by CNS.

HNS was the second organisation that took the advantage of social media platforms but more in the response stage of natural emergencies. The rest of the organisations, FNS, PNS, JNS and RNS, did not appear to use social media platforms extensively during natural emergencies. Each organisation only had a national page on either Facebook or Twitter; however, not each local branch owned a social media page for more efficient information sharing and communication within a certain region. Those organisations had not made much effort in social media usage. Nevertheless, many participants from those organisations had realised the huge benefits that social media could bring to them in enhancing situational awareness and respond to the public. As suggested:

> …what [CNS] would do is through monitoring the social media like Facebook and Twitter which is faster than we can get the information out to the public now… but we are not really good at it. Actually, look at and get information from Facebook in terms of what is going on and doing a special search. So that's helpful stuff. (ID13, FNS)

It was also found that even though there was still large space for improving core C-BTs usage in organisations such as CNS and HNS, participants were aware of the certain level of information integration that had been achieved across New Zealand, especially during the response stage. For example, one HNS' system advisor noted that one significant benefit that HNS' H system could deliver was the capability of integrating different types of information at the same time, such as the current capacity of the hospital, number of patients with typical diseases, and the extent to which hospitals were suffering damage in an earthquake. With further system improvements, they believed that enhanced information integration could be realised. Similarly, participants from PNS also had the same point of view of the system's capability in integrating information across the country. Thus, information integration could better facilitate emergency professionals to make better decisions when dealing with emergencies. As commented:

> From a management level, you've got one place for more information, but everybody's on it and it is a shared platform and it is national. (ID11, PNS)

Warning/ Alerting

Warning both staff internally, as well as other agencies or the public externally in the preparedness stage of the natural emergencies, is particularly important. Most of the participants considered that it was necessary to have a robust warning system. However, it was found that CNS made more efforts in terms of using C-BT for warning agencies in the sector and the public. This might be due to its leading role in coordinating various agencies and supporting communities. For example, the public could receive the alert through CNS' official website as well as Facebook and Twitter. The researcher herself was monitoring the official website and the social media page on the day of the tsunami exercise (*OB4*) at the national level. As a result, both platforms went very well; the alerting message appeared according to the situation which happened on the day. In terms of warning the external agencies, CNS' participants mentioned that the national warning system was utilised. As observed, it worked effectively during the tsunami exercise *(OB4)*: alerting information and hourly updates were disseminated to local CNS groups and registered agencies. The CNS' focus group discussion revealed how the participants thought the alert was important in the preparedness stage:

> …and if you think about one way to measure, it might be to save public life or property because that's the main reason that we are here. I think if you were trying to save life or protect property, there's probably something like the national warning system or public alerting system that allows us to give people a warning that something is going to happen or not happen… alerting tools are probably the biggest thing. (FG1)

Due to the leading role that CNS played in alerting both the external agencies and the public, participants from other agencies, FNS, PNS, HNS, JNS, and RNS, did not mention any specific system that they were utilising to alert the public. Nevertheless, some agencies did have the system for the internal warning. For example, FNS was able to alert staff internally on their internal enterprise system, FNS' F System. Similarly, HNS and JNS shared the usage of a typical email system to alert staff when an emergency happened. In terms of PNS, none of the participants shared views about any particular internal alerting system since it relied on CNS' alerting messages. One participant commented

> … for all types of incidents…we're on the national warning system that [CNS] has. So they will advise, for example, if there is a tsunami that will text or email us the warning message. Say there has been an earthquake in Chile and that's anticipated that there might be a tsunami in NZ in eight or ten hours' time. We'll get that as soon as they have sent out a warning message… we are getting to use that all the time. (ID11, PNS)

Resource Management

Resource management is associated with the extent to which the emergency professionals perceive that C-BTs are useful in managing resources, especially during the response stage. The main aspect of resource management in most of the organisations was managing personnel. For example, participants from CNS and JNS mentioned that the usage of C-BT in managing of shifts was useful in emergencies. The only difference was that JNS had already utilised an automatic cloud-based shift management application while CNS had not yet had an automatic shift management system. For example, one senior CNS group manager claimed that it would be quite helpful if they could manage volunteer shifts in their system during the emergencies rather than typing information manually. In terms of FNS, it focused more on the mapping information so that the right jobs could be allocated to the appropriate numbers of frontline staff. As explained:

> So the tool provides mapping, infrastructure, water supplies, power that gives us a whole map of the whole area and I can use it to bring up the building maps. And I can use it to assign people to different parts of that building. (ID14, FNS)

Similarly, HNS utilised its typical single-point email system to receive resource request messages and then allocate personnel to meet the requests. Even though fewer than ten participants mentioned C-BT usage for resource management, it seemed that C-BTs played a critical role in satisfying different needs of emergency services organisations.

Training Management

Training management relates to the extent to which the emergency professionals perceive that C-BTs have been utilised in managing and conducting training exercises to get prepared for emergencies. C-BTs utilisation in the area of training exercises was not yet extensive. For example, even though CNS and HNS owned specific emergency management systems, most of the participants from both organisations thought that such a system was not used for training extensively at this time. The reason was that the system was relatively new to be used in the sector. Therefore, the emergency service organisations would need to provide more training opportunities for staff to get used to the system. As reflected in the CNS focus group discussion:

> We would like to use more C-BT, but it is not used a lot in the sector yet. That's something we're introducing to people and to give people the opportunity just to train and prepare beforehand anytime. (FG1)

On the other hand, a few participants from HNS mentioned that the only type of C-BT that was applied to manage training was the usage of email or the internal emergency management system to send notifications of the upcoming exercises. Therefore, most of the organisations had not paid much attention to C-BT utilisation in monitoring the training performance. Unlike most of the organisations, FNS seemed to have its own mechanism to oversee its physical training through its internal web-based system. As noted:

> In preparedness, we carry out training and all those types of those are continuous training. We've got a skill-based system for operational skills maintenance. There's a program that we use to monitor our skills in the [ID17, FNS].

Therefore, it seemed that there was a lack of specific mechanisms in place to specify the usage of C-BTs in terms of training exercises in emergency service organisations.

Deployment Model Type

Deployment model type is associated with the question of whether the deployment of different C-BT model types will influence the emergency professionals' perceptions regarding C-BT usage in emergencies. Both private cloud and public cloud were deployed either in the preparedness stage or the response stage according to different purposes. Further, none of the organisations relied purely on one single type of cloud deployment model type. The usage of private and public clouds is now discussed in sequence.

Private Cloud

Private cloud refers to the deployment of internal cloud-based systems that the emergency professionals consider helpful in managing emergencies. It was found that the internal cloud mainly included the official website, internal email system, geographic information system, and the core emergency management system. The official website was a normal way of sharing messages with the public, especially in the preparedness stage. CNS was the leading agency for alerting the public during natural emergencies on its website as well as warning the external agencies through the national warning system. Other agencies played a supportive role to assist CNS to meet the needs of the community. Therefore, other agencies used their websites for sharing plans and guidelines with the public. For example, JNS provided clinical practice guidelines on its website for the public to access.

All six organisations relied on the internal email system, which was a common way of communicating and sharing information within organisations as well as with external agencies both in the preparedness and response stage. For example:

> So I will get an email from [CNS] that typically has a table which says the location of the incident, the magnitude of the earthquake… So it gives you a very brief situation report of the type of the incident that occurred and the expectation from NZ in terms of the fact. (ID11, PNS)

In addition, participants from CNS, FNS, and PNS mentioned that their internal cloud-based geographic information systems were helpful, especially in the response stage. For example, both participants at one organisation who had visited CNS' branch emphasised the usefulness of its online mapping system established for the public to get information regarding the welfare centre during emergencies. CNS also integrated GIS capability into its core emergency management system. Even though there was a lack of valuable map layers, such as layers from transportation agency, power company or other lifeline agencies, participants could foresee the ability of the advanced version of GIS. As stated:

> It is working in progress not very useful so far because we do not have access to all the map layers that would actually add value. (ID1, CNS)

Regarding FNS, most of the participants considered that the internal smart mapping system was valuable in terms of gaining imagery data of key information, such as the location of hydrants and size of the water main, during a response. The only weakness for its current mapping was that it required very wide bandwidths to be effective. Regardless of the mobility that would be enhanced at the frontline soon, the systems might not work in areas with low bandwidths. Therefore, the organisation was working on projects with an external cloud service provider to enhance its effectiveness. Nevertheless, the mapping system was considered useful at the moment. Likewise, most of the PNS' participants were satisfied with the internal mapping system, which functioned well. As stated:

> GIS cloud. It is separated from [PNS' R System]. [PNS' R System] also does have a mapping capability. We can use one or the other.... separate mapping system for us to use in the incidents that can help track people that sort of thing. (ID11, PNS)

Differently from the organisations mentioned above, HNS, JNS and RNS did not invest much in the cloud-based geographic information systems. For example, differently from CNS, HNS' core emergency management system was not integrated with mapping solutions so that the mapping capability was weak when dealing with emergencies. None of the HNS participants mentioned any particular internal mapping system. Most HNS participants said that they were urged to enhance its internal mapping capability. Organisations that did not have strong mapping capabilities would rely on other agencies to share the information. As noted:

> In [location] earthquake, for example, the mapping that was going on by other agencies around the road network is vitally important to our business. (FG3)

Either the core emergency management systems or some other internal applications without a focus on specific types of emergencies were considered useful by participants from different organisations. In terms of CNS and HNS, most participants from these organisations perceived that their core emergency management systems were useful since they could be used in either the preparedness stage or the response stage. Nevertheless, they considered that the systems were more valuable in the response stage for producing situation reports and tasking during emergencies. This was because, in the preparedness stage, the system was mainly used to store critical documents. On the other hand, JNS and PNS owned internal systems that could be utilised both in the non-natural emergencies and major natural emergencies but with the focus on the response stage either for resource tracking, or tasking and coordination. FNS' incident management tool, a pre-planning tool in the preparedness stage, was considered important and useful by many FNS participants. RNS had limited usage of the internal cloud-based system for managing natural emergencies, less than other organisations did.

External Cloud

External cloud refers to the cloud-based systems that are not hosted by the organisations but are perceived valuable by the emergency professionals when managing emergencies. The external clouds utilised by the organisations primarily included the social media platforms, cloud storages, external email systems, cloud-based mapping systems, and cloud-based information management systems. All organisations relied more on their internal cloud-based systems than the external clouds due to the security and privacy concerns as discussed in perceived disadvantages in Section 6.3.3. Thus, the preference of external cloud usage depended on the usage purposes or budget constraints.

With regard to usage purposes, there were various needs: warning, storage, resource management, live video communication, field information collection, and mapping capability. In terms of warning the public in the preparedness stage, CNS undertook the main responsibility due to its leading role in managing natural emergencies. In addition to the official website, various kinds of social media platforms, such as Facebook and Twitter pages, and YouTube channels were utilised by CNS; almost all participants thought that social media platforms had great potential in reaching the public. For example, CNS utilised social media platforms to alert the public when there was an upcoming natural emergency and educating the public on how to be better prepared in various types of natural emergencies. The other five organisations had not put much emphasis on social media usage to reach the public. Nevertheless, most of the participants acknowledge the huge potential of using social media platforms to get more situational information. Therefore, these organisations were moving towards more usage of social media. For example:

> We will look at stuff like social media more because it is the place where you can find out more information. (FG2)

As for storage, participants from CNS, JNS and RNS mentioned that they used external storage, such as Gmail, Dropbox, or One Drive, either in the preparedness or response stages. The reason was the convenience and fast speed that most of the participants perceive that those external cloud products could deliver.

On the other hand, according to managers from key organisations such as CNS and FNS, there was an increasing trend for government agencies to move to external infrastructure as a service. Therefore, government agencies were more open to external cloud services. As commented:

> I think we are only getting started to enter the base with the recent agreements or contracts that government entered into with large data storage capacity such as [name of service provider]. That's what they do, they host data and they serve the infrastructure as a service sort of thing. (ID1, CNS)

In respect of resource management and mapping capability, participants preferred to use the external cloud services because these tools were able to complement the insufficient capability of current internal systems. For example, one senior CNS group manager asserted that there was a lack of personnel management system, especially for managing volunteers in both stages. The manager thus searched an external cloud-based system that could help to manage the volunteer contact details and shifts. This phenomenon also took place in HNS where volunteers that constituted the medical assistance team were required to be managed. The external mapping system, such as Google Maps, Bing Maps, or ArcGIS, was utilised by most of the organisations except for HNS due to its lesser focus on GIS usage. For instance, participants from FNS mentioned that Google Maps was more reachable and up-to-date than its internal smart map during frontline operation. As state:

> We also use Google Maps at times because sometimes ours might be down or outage or sometimes a Google image might be a clearer image or more up-to-date one, possibly sometimes in different situations. (ID17, FNS)

Findings also reveal that a limited budget resulted in the organisation using free external cloud services. It happened especially in RNS where the organisation relied on the open-source external clouds, such as Google Maps and mobile cloud-based application for conducting a needs assessment, due to the budget constraints. It was mainly because RNS was a charity organisation where a large percentage of the funding was gained from fundraising. Nevertheless, these tools were considered very useful to RNS' operation during the response stage. Both participants were satisfied with the usage of external cloud services.

6.3.4 Individual Perception

In addition to organisational factors and technology-related characteristics, the individual factors could not be ignored in influencing C-BT deployment in natural emergencies in New Zealand emergency services organisations. This is associated with the individual perceptions in utilising C-BTs when managing natural emergencies. The enhancement expectation constitutes the important element that influences the individual perception of C-BT usage in emergency management. As shown in Table 6-9, 101 incidents emerged from the interview and focus group transcripts, which constituted three concepts.

Table 6-9 Open coding of individual perceptions concepts with number of incidents in descending order

Concept Code	Concept Name	Source			Number of Incidents
		Interview	Focus Group	Observation	
IP2	System advancement	24	3	0	90
IP3	Uninterrupted connectivity	6	1	0	6
IP1	Cloud preference	5	0	0	5

These concepts were then further grouped into one category as shown in Table 6-10.

Table 6-10 Category groupings of individual perceptions

Category Code	Category Name	Concepts Involved	Number of Incidents
J	Enhancement Expectation	IP1, IP2, IP3	101

This is discussed in the following section.

Enhancement Expectation

Enhancement expectation relates to certain aspects of changes that individual emergency professionals prefer regarding C-BT usage for managing emergencies. These expected enhancements consist of cloud type preference, cloud-based system advancement, and uninterrupted connection. The three elements are discussed in the following sections.

Cloud Preference

Cloud preference relates to the way in which the emergency professionals prefer to host the cloud-based systems. Some of the participants would prefer external service providers so that they did not have to host the systems by themselves. This happened especially in the CNS where there was a lack of IT technical support inside of the organisation. Through hosting C-BT externally, it would be helpful to reduce the burden of monitoring and fixing the system. Similarly, participants from JNS considered that the external service provider could help them to reduce the maintenance effort, such as updating the system constantly by themselves. The following statement shows how the participant thought the issue of overloaded servers could be resolved when the system came to be hosted by an external service provider:

> When we're looking at our improvement with [CNS' E System], one of the things that we're looking at is having it cloud-based so that it is not dependent on a server…. so we have a company that we subscribe to that stores in the cloud and manages the cloud…. and then we won't have issues with the servers becoming overloaded or losing access to them. (ID4, CNS)

Participants from CNS and JNS believed that moving to the external service provider would bring great benefits to them because of the capability of computing sources owned by the external services. The preference for hosting C-

BTs externally was not found in the other four organisations. In terms of RNS, even though it did not yet have its own cloud-based emergency management system, it had moved a large percentage of its business-as-usual process to the external service provider. RNS also had started to use more cloud-based mobile applications for field operations. Therefore, it did not yet have any issue with the burden of hosting C-BTs. On the other hand, HNS seemed to be satisfied with its core emergency management system that was currently hosted by an external party since none of the participants mentioned any issue with hosting the system. Differently from the above-mentioned organisations, participants from FNS and PNS had more concerns regarding security issues. Hence, those two organisations were less likely to accept the external cloud services.

System Advancement

System advancement is the extent to which the emergency professionals like to make improvements on the current systems to better support the operations when managing emergencies. Participants from CNS and HNS particularly would like to enhance the collaboration capability in their current systems since they were the only two of the six organisations that had more experience of using the core specialised cloud-based emergency management system. For example, many CNS participants particularly illustrated that it was not able to share documents straightforwardly in CNS' E System. Thus, it was not efficient for sharing information in a timely manner. Nevertheless, there was no mechanism in place currently to enable communication back and forth between different portals among different CNS groups in the system. Likewise, participants from HNS mentioned that it was not able to enhance the collaboration among different branches in terms of document sharing. As stated:

> I still think there's a bit of issue about how people move documents around. There are certain parts of it which we've had to do work around things like not being able to work on a document at the same time. (ID24, HNS)

Many participants from CNS, HNS, PNS, and JNS indicated that the lack of currency of the technology deployed currently was a problem in not supporting C-BTs smoothly. For example, the use of out-of-date operating systems or browsers was not able to support cloud-based applications. In addition, the lack of technology currency also lay in the absence of the mobile-cloud-based applications for the same level of smooth operation on any mobile device. In other words, the same cloud-based system also did not work properly on mobile devices, such as smartphones or tablets. Other issues included turning useful applications to the cloud-based system, updating the official website more constantly, as well as establishing a web-based mapping site containing hazard information, for public access.

Despite the aforementioned capabilities, most of the participants expected to improve the system design of C-BTs for better performance when dealing with emergencies. First, many participants from CNS and HNS argued that certain functions should be added to the core cloud-based emergency management system. These included learning management, volunteer management and having a dashboard for increasing the situational awareness as a whole in the preparedness stage. It also required functions of the media release, live chat, and instant messaging directly in the system during the response stage. In these ways, the performance could be conducted in a more efficient way. Nevertheless, the current situation was that the information aggregated in the cloud-based emergency management system still needed to be rearranged and then shared through email rather than in the system straightaway. As stated:

> I guess our biggest issue is that our technology is still very chunky. I mean [CNS' E System] fails in that if we want to share a document that we have just produced in it… you have to store a document somewhere on your C drive, my document or whatever then attach it to the email and send it. (ID3, CNS)

To avoid information obsolescence, those expected functions would need to be realised in the new versions of the systems. With those advanced functions in the system, participants thought it would enhance the currency of the information.

Some participants From CNS and FNS expressed that they preferred the system that could be built with the purpose of dealing with specific types of emergencies. For example, one senior CNS group manager mentioned that when designing the system, different types of emergencies, such as the volcanic, flooding, prolonged or short-term emergency, could be set up separately in the system. Thus, information regarding the specific type of emergencies could be gained quickly through the system. As confirmed by the participant from FNS:

> The developed program that was relevant to the specific incident which has the contact information and ways of dealing with the particular incident. That will be quite handy. (ID17, FNS)

In addition, many participants, except those who came from FNS, thought that it was necessary to improve the geographic information system to enhance the information availability either internally or externally. The reason that none of the participants from FNS expressed the need for the advanced geographic information system was their satisfaction with the deployment of its current mapping systems to access building information for internal usage during emergencies. Therefore, there were no further expectations of a higher level of information needs in an advanced geographic information system. However, it was expected by participants from the rest of the organisations. As shared by the participants, internally, a better geographic system could enable the organisation to enhance its ability in resource allocation through having more mapping layers of important, for instance, lifeline information. Externally, the public could gain benefits of knowing the current situations, such as road closure or the location of the welfare centre during the emergency. Additionally, participants also showed that it was challenging to get real-time mapping information from current systems, which was an area into which New Zealand had not yet looked further. Therefore, none of the organisations could access advanced geographic at the moment. As stated:

> I think there's space to improve what we do from the GIS point of view.……So we could geocode all our critical utilities or key providers within the community and if it was an incident that we could run a buffer around a particular area and that would pull out all the data points within the area from where we just click the button and it will provide you with the information. (ID27, HNS)

Many participants from CNS, FNS, PNS and JNS considered that the system design should be aligned with the end-users' needs. Participants from frontline agencies, such as FNS and JNS, thought that there was a lack of sufficient information for the frontline operations during emergencies. For example, in the JNS focus group discussion, it was mentioned that more pre-hospital information could be accessed through the system on tablets so that the victims would be saved more efficiently once they had been sent to hospitals. The FNS focus group had similar views:

> In the big event, where we struggle is that actually, this app is not perfect yet… people can dial 111 anywhere, but they don't always know where they are… So the point is how to get that because the quicker we can get that the quicker we can help. And supporting information such as hydrants or water supplies and how big the pipe is… Having that on the device and being accessible through the cloud would be good stuff. (FG2)

In addition, many participants from JNS and PNS expressed that it would be better if the organisations could integrate different applications into one system, which would be helpful to enhance the efficiency of the performance. For example, with many separated web-based applications, the participants are required to login with different passwords several times. As commented:

> Probably to have everything on one website so then you don't have to go to ten different places. (ID21, JNS)

Uninterrupted Connectivity

Uninterrupted connectivity is associated with the extent to which the emergency professionals perceive the continuous Internet connection as being important to support their job in emergencies. As discussed in the category of perceived disadvantages, one of the perceived disadvantages of C-BT deployment was the unexpected disconnection of the Internet. Most of the participants from all six organisations considered the unexpected Internet loss as one of the biggest barriers to accessing C-BTs. However, most of the participants who mentioned the expectation of improved capability of Internet access were from CNS, with a few participants from FNS, and JNS. This was because of the leading role CNS played in coordinating other agencies and resources in natural emergencies where CNS relied on using its established core C-BT, CNS' E System, more than other agencies did. Hence, continuous Internet connection was particularly important to support the system to aggregate information gathered from other agencies. Otherwise, all the process would go back to the manual operation, which would reduce the efficiency of work apparently. As stated:

> If you don't have Internet connection, the solely cloud-based it's not going to work….if any of those things happen, we won't access [CNS' E System] and we have to go to what we called manual old school which is pretty much work templates, Outlook and what we've been doing for the last ten to 15 years. (ID4, CNS)

One senior CNS emergency coordinator from one of the branches mentioned that they would have to look at what other options they could have to fight against this weakness of C-BTs. This involved enhancing the capability of using the satellite connection. Similarly, participants from FNS and JNS mentioned other ways such as through having dedicated telecommunication network usage priority, which means that the emergency agencies would have the priority to access to the network connection either before or after the connection was lost so that they would enhance the speed of Internet access and try not to lose much information even after the connection was lost.

6.3.5 Individual Readiness

Individual readiness is another important facet of the individual factors that influence emergency professional’s perceptions regarding C-BT usage in natural emergencies. A total of 90 incidents emerged from the interview and focus group transcripts, which constituted eight concepts as shown in Table 6-11.

Table 6-11 Open coding of individual readiness concepts with number of incidents in a descending order

Concept Code	Concept Name	Source			Number of Incidents
		Interviews	Focus Groups	Observations	
IR3	Confidence in C-BT usage	17	1	0	19
IR8	Cloud-based technology concept	14	2	0	14
IR2	Reluctance to change	13	0	0	13
IR5	Personal effort	9	1	0	11
IR7	Cloud-based technology awareness	28	1	0	11
IR6	Trust	16	0	0	9
IR1	System attractiveness	8	0	0	8
IR4	Age	10	0	0	5

The concepts above were then further grouped into two categories as shown in Table 6-12.

Table 6-12 Category groupings of individual readiness

Category Code	Category Name	Concepts Involved	Number of Incidents
K	Human Factor	IR1, IR2, IR3, IR4, IR5, IR6	65
L	Knowledge	IR7, IR8	25

These are discussed in the following section.

Human Factors

Human factors are associated with emergency professionals' individual readiness in system usage within emergency service organisations. It is an important factor that could influence the successful C-BT deployment when dealing with emergencies since these emergency professionals are the key people who need to operate the system in the emergencies. The human factor can be further broken down to system attractiveness, reluctance to change, confidence in C-BT usage, age, personal choice, and trust. These are discussed in sequence.

System Attractiveness

System attractiveness relates to the extent to which a certain type of cloud-based system is perceived as value-added by the emergency professionals in the emergency service organisations. Whether the system had been proved to be value-added is a prerequisite for emergency professionals to enhance their willingness to use the system. Most of the participants, within CNS or from other agencies, were more likely to comment on CNS' E System since the system was specifically established for managing natural emergencies during large-scale multi-agency emergencies. It shows whether a type of C-BT that could enhance situational awareness was considered significant by most of the participants at the management level. For example, some CNS local groups were not satisfied with the established CNS' E System due to its inability to provide a big picture of the situation, even though it was a nationally promoted product. Situational awareness is very important to the emergency sector while the system was not able to offer such value. Therefore, some participants asserted that they would search for other products that could enhance the situational awareness. A senior CNS group manager with extensive experience in emergency management said:

> …but when it comes to situational awareness of what's going on around here, then I'll probably use other systems (ID2, CNS)

However, participants within CNS have different views regarding CNS' E System. For example, the senior system trainer thought that it was much easier to link information from everywhere through the system. Not all CNS groups had been adapted to its newly established platform since some of the groups were trying to convince people to use CNS' E System rather than follow others' steps to use that.

The key factor that influenced the emergency professionals' decisions to deploy a cloud-based system was whether such system had the value-added function.

Findings also reveal views from other key supportive agencies regarding the deficiency of CNS' current core C-BT for managing natural emergencies. Most of the participants thought that there was a need to make improvements to the system in its current version, which was not good enough to support operations during emergencies. For example, a senior district manager of PNS explained that they were only able to allocate tasks in their own system rather than through CNS' E System, which was not efficient. Therefore, the attractiveness of a C-BT that can deal with emergencies plays an important role in motivating emergency professionals to use the system.

Reluctance to Change

Reluctance to change is associated with the extent to which emergency professionals resist using relatively new C-BTs for managing emergencies in the organisations. Commonly, the resistance to change happens when older employees are pursuing stability, resulting in less willingness to learn how to use a new system. Nevertheless, most of the participants from all six organisations were more than willing to use new types of technologies as long as the systems were helpful in improving the performance of emergency management. Therefore, interestingly, reluctance to using new C-BTs was not considered a big issue in emergency services organisations even though each organisation more or less employed people in an older age group. This might be because smartphones had penetrated into people's daily life so that it would not be too difficult for emergency professionals to adapt to new C-BTs for managing emergencies.

Almost all of the participants thought that there was a low possibility of staff resistance to using new C-BTs except one PNS' participant who preferred to use hard copy plans. The following comment is an example of how the participant thought the reluctance to change was not a big issue:

> Most of the people in the organisation have a smartphone so that they are used to the technology and they won't think that would be a much difference versus what we are using. (ID3, CNS)

Another reason most of the participants did not consider reluctance to change as being a big issue was the increasing number of employees who were tech-savvy and young. For example, one senior CNS group manager found that the young people employed were more adapted to their online training than older people. The following comment from a senior FNS manager also shows why younger employees' engagement would reduce the concern for the reluctance of change:

> You've got an increasingly tech-savvy workforce. So young people will pick up more quickly than old people. (ID15, FNS)

However, certain factors would impede the speed of accepting the change: attractiveness of the system and lack of effective training. As discussed earlier, a value-added C-BT would be more likely to be accepted by emergency professionals. For example, the CNS national manager suggested it was hard to attract all the groups to use the established new system as there were still many unsolved problems in the system. The following comment from a senior HNS manager shows the basic attributes that an attractive system should have.

> Whatever system we have, we need to make sure that it's easily usable and efficient. (ID27, HNS)

On the other hand, effective training also played an important role in accelerating the process of emergency professionals' acceptance of new C-BTs:

> So the issue isn't that we would not want to use it, while the issue is that we don't have the staff trained effectively and to be able to use it to its full extent. (ID4, CNS)

Confidence in C-BT usage

Confidence refers to the extent to which the emergency professionals are confident when using C-BTs to manage emergencies. This is particularly important in the response stage since emergency professionals are required to be familiar with the usage of cloud-based systems immediately. Confidence in system usage varied among different emergency professionals, depending on people's computer literacy. The following statement shows how the system was used by a senior area manager from FNS who lacked IT literacy:

> I actually get people to create it so I don't actually know where they put it. If I need them I will go to ask [name of a person] to retrieve it for me. (ID16, FNS)

While in the observation of an earthquake exercise (*OB3*) led by FNS, the controller was quite confident in explaining how to use a cloud-based information collector through showing how to input information such as work site, time, population affected, and priority for assistance. Based on the facial expression of the team members, it seemed that everyone could easily understand the instructions. Therefore, different levels of IT literacy, it would influence emergency professionals' confidence in using the system.

It shows that the views regarding ease of use were different from person to person in various organisations because of the different level of computer literacy in each person. Nevertheless, the simplicity of the system directly influenced emergency professionals' confidence in usage. For example:

> Unfortunately [CNS' E System] falls into the bracket for some people and because it does so much. It's very easy for people to be overwhelmed by it. (ID4, CNS)

Familiarity with the cloud-based system was another huge factor that influenced emergency professionals' confidence in using C-BTs. Many found the new cloud-based system stressful and uncomfortable to work with. For example, CNS' E System was established to be used particularly in the response stage, which was not a business-as-usual system. Therefore, many participants were under great pressure when using such a system. One commented:

> I think because they are not confident, or they are not experienced in using it. (ID22, JNS)

Most of the participants felt more comfortable with the system usage when a technical support person was on-site when necessary. As commented:

> If there is anything new, sometimes it can be handy to have an IT body to show you. (ID 10, PNS)

Additionally, emergency professionals were more likely to deploy C-BTs with the familiar operating system, which would enhance their confidence in system usage. Most of the participants said that familiarity with the operating system would reduce their concern over the usage. As stated by one participant:

> So when they access the cloud, it is a standard product that looking it instead of different versions of an email system. (ID29, RNS)

Nevertheless, people who were not tech-savvy were more likely to have problems even with the same operating platform. For example, one senior CNS group manager noted how people freaked out when he merely changed the desktop and wallpaper since people thought the system was totally changed. Therefore, the confidence of C-BT usage played a critical role in enabling the emergency professionals to perform properly in natural emergencies. The more computer literacy the emergency professionals have, the more they will be confident in using the system.

Age

Age is associated with whether emergency professionals have concerns about whether older people in the organisation will be less likely to deploy new C-BTs. Most of the participants thought that the older generation might have problems with the usage of relatively new technologies. The main reason was that older people, such as in their early fifties or sixties, were more likely to be less tech-savvy so that they would have limited capability to deal with relatively advanced cloud-based systems during emergencies. Therefore, they were more willing to choose the very basic type of C-BTs, such as email, and they relied more on the traditional way of operation through pagers, phones or even hardcopy documents. Thus, older employees were more likely to be organised to do jobs that were not related to complex technologies. For example:

> They could do the peripheral stuff like setting it up and turning the generators all that sort of things, and the IT stuff can be left for the other guys to sort out. (ID18, FNS)

In addition, people who were less tech-savvy were a small portion of the employees in the organisations. There was also a trend that more employees from the younger generation appeared in the organisation. The advanced technologies had penetrated into the younger generation's daily life, which means there was less concern for younger employees to deal with relatively advanced C-BTs. As stated by one participant:

> They are normally pretty good at technology and we got such a large percentage of young people coming through. They all will ask why wouldn't have the latest iPhone that sort of thing. The environment does encourage people to get used to technology. (ID11, PNS)

Personal Effort

Personal effort relates to the extent to which the emergency professionals are willing to make efforts in searching and applying useful C-BTs outside of the organisations for managing emergencies. It was because certain C-BTs that were outside of the organisation could facilitate some aspects of their jobs better or complement the information at hand. Some participants discovered other C-BT sources, especially software-as-service, and utilised their own smart devices with applications downloaded by themselves. For example, one senior CNS group manager made sustained efforts to discover different products that would be most suitable for text alerting and managing contacts of staff who need training and finally targeted a proper one. Further, some of the participants would also use cloud-based applications external to the organisation due to the slowness of the internal system. As commented:

> So we always have the ability to log onto [HNS' H System] on my phone, but it is so cumbersome…. I put a lot of information just in my own cloud storage so that I can access it quickly. (ID27, HNS)

Additionally, compared with JNS, FNS frontline staff were more self-motivated to use their own methods to get information due to the lack of advanced technology on the vehicles on the way to the scene. Most of the participants from FNS confirmed that frontline staff would utilise C-BTs that were external to the organisations to get relevant information in natural emergencies. This was because the internal system, especially the mapping system, was really slow to produce necessary information, such as the exact address of the scene. Through using cloud-based applications, such as Google Maps, it would be more efficient sometimes for frontline staff to get necessary information than from the internal cloud-based system. A senior FNS officer who suggested efficiency can be achieved through using external C-BT sources:

> We are using the pathway [FNS] provides us, which is quite slow. It is another way to try to draw information out of the system. For example, it would take me about two minutes to load smart map which is the mapping systems internally while I can go to Google Earth within 20 seconds or probably load the exact address on the map. (ID18, FNS)

The usage of the external cloud-based source in an earthquake was also confirmed by the FNS focus group discussion:

> GeoNet is useful in an earthquake. We used that a little bit in [Location] earthquake. That provides us with the information that is up-to-date and related to what was happening to the earthquake, such as the time, location and magnitude. (FG2)

Trust

Trust is associated with whether the emergency professionals perceive they have concerns with the types of the cloud-based system they are using in the organisations. Participants from different organisations had different views regarding trust in cloud-based systems. Most of the participants from PNS and

JNS had a more conservative attitude towards external cloud-based services so that they had more confidence in using internal cloud-based systems. One important reason was that most of the participants mentioned that it was necessary to keep private and sensitive information confidential. For example, a JNS territory manager mentioned that he would only put a job roster rather than sensitive information on Google Drive. In other words, the internal system was considered much securer, as it was maintained specifically for a particular organisation. As explained:

> Our IT structure is pretty strict and they have quite a solid framework surrounding firewalls. We have to do a course every year about the data security and handling. (ID11, PNS)

Nevertheless, there were also some participants from CNS, FNS, HNS, and RNS trusting external cloud services or a private cloud owned by a third party. One reason was that it would be helpful to enhance the work efficiency of people at the management level with limited IT capacity. For example, the CNS national manager asserted that moving to the external cloud or contracting out certain types of their IT services would save the effort and cost on IT, thus paying more attention to emergency management issues. Further, participants from those organisations were more open to utilising external clouds or establish contractual frameworks with external service providers. For example, one senior system advisor from HNS thought that the contract between the service provider and their organisations guaranteed the security of using that service, which resulted in a high level of trust in that provider. Therefore, participants would have more trust in different types of C-BTs if they had a more open attitude towards their usage. As stated by one participant:

> I think that's part of the service as you have it with the cloud providers. It is no less secure than from your own since you can be still hacked with your own server. (ID15, FNS)

Knowledge

Knowledge refers to whether the emergency professionals possess a certain level of C-BT usage knowledge. Having basic C-BT knowledge could better facilitate the emergency professionals to choose and apply suitable C-BTs to match their needs in managing emergencies. Otherwise, the emergency professionals will be less confident in applying C-BTs or might choose an inappropriate type of C-BT.

The following section discusses several important factors that contribute to forming the category of knowledge: C-BT awareness, and C-BT concept.

Cloud-based Technology Awareness

C-BT awareness represents the extent to which the emergency professionals are aware of the C-BTs that have been utilised in the sector. The awareness of C-BTs is important for several reasons. First, it is necessary for emergency professionals to fully understand the key C-BTs that have been utilised within the organisations. Thus, they can use the key C-BTs properly for managing emergencies. Second, it will be helpful to enhance the emergency professionals' awareness of useful C-BTs external to their organisations, if the emergency professionals are going to use other appropriate C-BTs for managing emergencies. Most of the participants had only been fully aware of C-BTs that were utilised within organisations for managing emergencies. For example, most of the participants from CNS placed more emphasis on the key internal C-BT, CNS' E System. This was mainly because of the leading role that CNS played in natural emergencies as well as the system having been established particularly for managing natural emergencies. On the other hand, many participants from the frontline agencies, FNS, PNS and JNS, were not certain about other external sources of C-BTs that might be helpful to deal with natural emergencies. As commented:

> In terms of other C-BTs, I am not sure. Of course, there will be some. I just can't think of any other thing. I am only using most of the stuff from the [FNS] network and going there and login (ID18, FNS)

The level of the awareness of external C-BTs was found to be different from person to person in each organisation. For example, most of the participants from all six organisations particularly referred to the well-known C-BT in the sector, CNS' E System, due to its unique purpose for managing natural emergencies during multi-agency emergencies. In other words, other than the CNS' E System, many participants had a low level of awareness of other types of C-BT usage in the sector. Very few participants referred to official websites or Facebook pages utilised by CNS, or one mobile application which was developed by RNS for alerting the public and educating the public in preparedness issues of different natural emergencies.

It is understandable that each agency focused more on its own internal system as different purposes were satisfied by different systems. Nevertheless, it would be beneficial for emergency professionals to be aware of other useful C-BTs so that they could take the advantages of other sources to complement the weakness of their internal system in order to get useful information more quickly and perform more efficiently. For example, even though RNS was not a big player in the CNS' E System at the time, both of the emergency managers had been aware of the usefulness of the system, which would help RNS to avoid some weaknesses of the system when developing their own emergency management system. Therefore, the awareness of current C-BTs that are utilised in the sector is particularly important to emergency professionals in different organisations.

Cloud-based Technology Concept

The C-BT concept refers to the extent to which the emergency professionals understand the basic concept of cloud computing well. Even though the main responsibility of the emergency professionals is to get key information about the current emergency situations and organise the resources required to solve problems caused by the emergency, it is inevitable that they need to use the system to deal with the emergency. If they could have a certain level of C-BT knowledge, such as the characteristics and issues of C-BTs, it would be helpful for them to be better prepared, especially in choosing more appropriate C-BTs for managing emergencies. Some participants did not know the different deployment model types of cloud computing since they thought that there was only one type of cloud-based service which was the outsourced cloud solution, such as Amazon and Microsoft cloud services, or some public platforms, such as Google Maps or external cloud storage. All six organisations were using the private cloud, either hosted by themselves or by a third party, while most of the participants have not realised this at all. As stated by one participant:

> I think people might not realise that they are using the cloud though such as the apps that are cloud-based and they used and they wouldn't even know. (ID14, FNS)

The lack of C-BT knowledge might make it difficult for the emergency managers to make decisions in choosing or establishing the most suitable type of C-BT for managing emergencies. This especially happened in CNS since there was no IT unit within the headquarters. Thus, the headquarters was responsible for the IT usage by itself. For example, the national manager of CNS struggled with the key C-BT establishment project since the system was not hosted and maintained by an external vendor while the manager had limited knowledge of C-BTs. As he said:

> ……bring[ing] my own knowledge of these things let me down. (ID1, CNS)

As a result, the established cloud-based system was not so favoured by the local groups where one CNS senior group manager said that he would have more trust in the third upcoming version of the system which would be managed by a professional project management team of people who had IT knowledge. Even though the other five organisations owned IT units within the organisations, the IT units were only responsible for the business-as-usual IT infrastructure or provided remote IT support to local branches. Therefore, when there was a need for choosing an emergency management C-BT, the emergency managers were required to consider external consulting companies. As explained:

> After the Christchurch earthquake we knew we had to have some kind of platform……it was a natural progression to move to [PNS' R System]…It was developed through our IT but it was with outside consultants and programs which I think it is through the [company name]. (ID11, PNS)

Hence, it would be better if the emergency managers had a certain level of C-BT knowledge to facilitate them in selecting appropriate C-BTs for managing emergencies due to the limited IT capacity currently in each organisation.

In addition, the results show the individual difference in terms of the extent of having the knowledge of C-BT usage, with either vague or confident understanding. The weak understanding of C-BT usage made the emergency professionals frustrated while the strong knowledge of C-BT knowledge allowed them to feel confident. As stated by one participant:

> I know where I'd like it to be and I know what it is now… I come from a background of us[ing] these sort of systems many years in the US for 20 years. (ID2, CNS)

The weak understanding of C-BT usage was more likely to appear at the frontline agencies, such as FNS, JNS, and PNS. The main reason might be the frontline job characteristic where people put more emphasis on actions than implementing systems. Hence, people in those organisations would have less focus on system knowledge. For example, one FNS area manager had no idea of where the right places were for storing the planning files and whether there was any compatibility issue with current C-BTs. It would be beneficial for emergency managers to collect the right information and to be aware of issues of current systems.

6.3.6 Offline Back-up

Offline back-up is the last core category that emerged from the results. It also plays an important role for emergency professionals to consider while using C-BTs in emergencies. As discussed earlier, C-BTs might not be able to work continuously when unexpected situations, such as disconnections, or power outages, happen. Therefore, having remedies in place in advance, such as paper-based operations or technologies to recover Internet connections, is particularly important during the emergencies. A total number of 94 incidents emerged from all three sources of data, forming four concepts as presented in Table 6-13.

Table 6-13 Open coding of non-C-BT redundancy concepts with number of incidents in descending order

Concept Code	Concept Name	Source			Number of Incidents
		Interviews	Focus Groups	Observations	
ORD3	Communication redundancy	24	3	2	37
ORD1	Paper-based redundancy	22	1	4	30
ORD4	Connection redundancy	15	2	1	20
ORD2	Storage redundancy	5	0	1	7

The concepts above were then further grouped into one category as shown in Table 6-14.

Table 6-14 Category grouping of non-C-BT redundancy

Category Code	Category Name	Concepts Involved	Number of Incidents
M	Offline Redundancy	ORD1, ORD2, ORD3, ORD4	94

This is discussed in the following section.

Non-cloud-based Technology Redundancy

Offline redundancy is the redundancy or remedy that the emergency service organisations have when usable infrastructures are disabled unexpectedly during natural emergencies. The offline redundancy, which was called “earth-based infrastructures” or “offline option” by the participants, was perceived as particularly important in the emergency management situations, especially in the response stage. This was because if any unexpected situation, such as power outage, or connection lost, happened, they would have alternative ways to continue operations. It can be categorised into four types of redundancies: paper-based redundancy, storage redundancy, communication redundancy, and backup connection option.

Paper-based Redundancy

Paper-based redundancy refers to the hardcopy of manuals, procedural documents, and forms that are required in response to the emergencies. According to most of the participants, the main reason for maintaining paper-based documents was the high possibility of losing power and Internet connections. For example, one senior CNS group manager explained that when emergency professionals work in the sector, they had to think about the worst-case scenario and what the next step would be if unexpected situations happened. With paper-based documentation, an emergency professional can continue with their work in managing emergencies. For example, they can pick up the paper forms to fill that out straightway or take out the manuals in hardcopy and read the procedures for managing the current situations. When the Internet connection is recovered, the content can be typed back into the system for a history check. It was confirmed by most of the participants that combining technology with the paper-based operation was necessary for the operation, especially in the response stage. The results also reveal that most of the participants said that there was always a hardcopy carried by them. The following statements represent two participants’ views:

> I think if you're going to use anything cloud-based, you have to have a paper backup. (ID3, CNS)
>
> It would be dangerous if people are becoming too reliant on technology. So when it doesn't work, people also need to know how to get the information they need to cope with disasters without technology. (ID9, PNS)

All of the participants from the frontline agencies particularly acknowledged the importance of having the paper-based backup. This was due to their job characteristics which required them to make pre-plans, but without advanced technologies, on the way to the scene. Therefore, hard copies of plans, maps, or procedural manuals become particularly important for frontline staff to refer to so that they can do pre-planning as the job escalates. It was also explained that hardcopy of documents was easy to share and enabled discussion on the same page at the scene rather than reading information on small screens of mobile devices separately. Regardless of the less current version of the hardcopy documents referred to by some participants, it was still useful to operate according to the guidance on the way to the scene. The following statements represent the thoughts of two participants from frontline agencies regarding the importance of using paper-based documents:

> We can print it out and have the information on the appliances in terms of how to manage like a specific site or for an operation… the local plans are more paper-based since you can pull them out when you're on the truck (ID17, FNS).
>
> If I pull out this phone and sit in the car, there is no one can read it besides me. Only I can read it, but if we got a hard copy, everyone can read it. (ID10, PNS)

The paper-based redundancy was also verified by the FNS focus group discussion:

> We cannot rely 100 percent on that, we need to have hard ……We are still not very confident on the Internet to be used in emergencies in terms of information thing. (FG2)

It was also observed in the tsunami exercise *(OB4)* where many paper forms were put on the desk to be filled, firstly with information regarding the current situation and resources needed, and then the information was typed into a word file. Some of the content was directly typed into key C-BT, CNS' E System, depending on the urgency of the issue. Some people also imported some contents into CNS' E System when they were not busy with gaining information from other agencies or the on-site functional teams, such as logistics, intelligence, or welfare, etc. All the content was typed into CNS' E System for a history check until the end of the exercise. Such operations tried to cope with the problem of unfamiliarity with the system usage as well as having paper-based back-up once unexpected power outages or disconnections were encountered.

The same operation was also observed in the earthquake exercise *(OB3)* led by the FNS urban search and rescue team where some paper-based forms were filled with tasks first and were then typed into internal C-BTs for maintaining a history log. Other types of paper-based things were also observed, such as large maps of the current location on the table and task forms for recoding the detail of the tasks on the wall. During all five exercises observations, it was observed that the usage of whiteboard was quite common. It was always the first choice due to the urgency of the issue that required the emergency professionals to write down and think about in a quick manner rather than spending time on logging in to the system and finding where to type the information.

Storage Redundancy

Storage redundancy is associated with the alternative places that emergency service organisations choose to back up critical documents without interrupting the productivity when unexpected disconnections happen. Several participants from CNS, HNS, JNS and FNS explained that they put important documents, such as plans, templates, or manuals in a shared drive or an external hard drive in case they were not able to access the Internet. One senior regional planner from HNS expected that it would be better to work offline in the current system when disconnections happened so that staff could sit back and keep preparing a situation report and storing them in the system. Given the different ways of documents backup, Some emergency professionals had considered the suitable storage option they had currently. The following statements are the examples stated by the participants:

> So we created the document and we may have here in a shared drive and we could put it on but again that was very much wasn't cloud-based. (ID3, CNS)

> …… the staff is on a hard copy of the risk plans stuff and that's backed up, I think they did a back-up every month, but again it's just to an external hard drive. It's not done on the cloud server or cloud-based at all. (ID18, FNS)

Communication Redundancy

Communication redundancy means the alternative way that emergency service organisations choose to communicate within organisations or with external stakeholders when unexpected situations happen. All emergency services organisations kept using some conventional technologies, such as text messaging, phone calls, radio networks, broadcasting, or sirens. Most of the participants thought that the main reason for continuing to use conventional methods for communication was the reliability of those technologies encompassed. The following statements are the examples provided by two participants:

> So in terms of notification, we have redundancy of systems. So we have paging and cell phones in terms of activation. Sometimes the cellular network will go out. That's why we have paging so that [when] the cellular network goes out, the paging systems are still there to go through the notification process. (ID19, JNS)

> ……will come to the local commercial radio stations and then broadcast it. That's a more reliable methodology at the moment. (ID2, CNS)

It was observed in the geothermal exercise *(OB5)* that despite having phones, the very high-frequency hand-held radios were utilised by people in the exercise for communicating with each other during the outreach activities for sending out welfare needs.

A more advanced option for communication by most of the organisations was through a satellite phone. Most of the participants said that the satellite phones had a huge impact on their work in terms of communicating when normal ways of communication were interrupted. For example, a senior manager from JNS thought that the satellite phone was the most stable technology that could be used in remote areas with poor phone reception. With satellite phones, emergency professionals did not have to worry about the Internet disconnection interruption except for power outage. As stated by one participant:

> We have one in each local authority in Canterbury. And that still allows us to communicate at least via voice with unlimited data. (ID3, CNS)

CNS, as the leading agency in managing natural emergencies, had made great efforts in maintaining various types of means of communication. Additional to the conventional technologies and satellite phones, CNS also invested heavily, for example, in the advanced public alerting system in addition to the social media platform that was used at the moment. Participants from CNS' focus group demonstrated that the organisation was working on a national project that would push alerting messages to people in the public without them having to install any applications on their phone. CNS also established the microwave system as the default system that helps to transmit information to all different groups of CNS in New Zealand.

Connection Redundancy

Connection redundancy represents an alternative way that emergency service organisations use to reconnect to the Internet when unexpectedly losing Internet connection or power. The key for running C-BTs is the connection to the Internet without interruption. Nevertheless, it is the weakness as well for C-BTs to keep working during large-scale natural emergencies where the Internet connection can be interrupted suddenly. Hence, emergency professionals need to consider possible ways to cope with this problem. Most of the participants from all six organisations mentioned that they relied on a portable satellite Internet for reconnection if it was interrupted, or a cell tower was overloaded. As described:

> We can still share information and find out what's going on. So that [the] beauty with [satellite product name] is that they don't rely on any earth-based infrastructure apart from power. (ID3, CNS)

It was observed in RNS' geothermal exercise *(OB5)* that there was a box of backup technologies, including the satellite phones and satellite Internet in the control room even though the researcher did not see any usage of such technology. It verified what the RNS emergency managers said in the interview that the satellite phones would be prepared in case Internet connections were lost.

The emergency professionals in emergency services organisations were quite proactive in considering as many ways as they could to cope with the problem of Internet disconnection. For example, one senior CNS group manager suggested trying several means for maintaining Internet connections depending on the extent of the destruction of the building and infrastructure, which included switching back to fixed line connection if the damage was small, using Spark hotspot if telecommunication system was down, or utilising satellite connection with high speed Internet if everything was down. Similarly, it was observed in the RNS geothermal exercise *(OB5)* that data sticks were maintained as the backup solution for Internet disconnection. Another senior manager of HNS also had the initiative to search for an advanced type of satellite system using both Wi-Fi and Bluetooth functions so that the usage would not be influenced by the disconnection. In addition to the Internet connection, the power outage was also an issue for the interruption. Some organisations had prepared sufficient generator back-up. As explained by one of the HNS' senior managers:

> So we have a generator power and key IT systems and other key clinical systems that are all connected to the generator. In addition to the generator, we also have [an] uninterruptible power supply system that backs up the key areas…. So if there are a power outage and generator doesn't start or there's a delay in the generator start that we don't lose that system. (ID27, HNS)

Additionally, agencies with frontline jobs in remote areas were more likely to have chances to use satellite systems. Most of the participants explained that this was due to a lack of Internet coverage in remote areas. Despite traditional technologies, such as radios, that could be used to communicate, the satellite system was mentioned as the only means that was helpful to communicate and get Internet connections in remote areas. The frontline agencies always prepared satellite systems on their vehicles in case there was an urgent job in remote areas. This was confirmed by FNS and JNS focus group discussions:

> If we cannot get out through the cellular system because we cannot get coverage in somewhere in the country, then we can use the satellite. (FG 2)
>
> We might lose all local cell communications until we get cell phone network. But [satellite product name] which is the majority of what people hold the broadband satellite at the moment. (FG3)

Therefore, emergency professionals would be more willing to take the risk of power outage or disconnection to C-BT during the response, if they had sufficient different types of redundancies.

6.4 Chapter Summary

In summary, this chapter presents the cross-case findings derived from the data. The cross-case discussion revolves around the multi-dimensional elements that influence the emergency professionals' C-BT deployment perceptions in natural emergencies. The final theoretical framework presents that the factors influencing the emergency professionals' perceptions against the actual C-BT usage in natural emergencies are not limited to the three pertinent technology adoption factors stemming from the literature: relative advantage, compatibility, and complexity. The findings show that C-BT usage perception is influenced by multidimensional elements: organisational readiness, coordination, C-BT characteristics, individual perceptions, individual readiness, and non-C-BT redundancy. The six elements as a whole provide a more comprehensive understanding of how the emergency professionals' perceptions against the actual C-BT usage are influenced when managing natural emergencies.

CHAPTER SEVEN - DISCUSSION

This chapter presents the discussion of the cross-case findings that have been described and analysed in the previous chapter. When undertaking grounded theory research, normal practice is to undertake a second review of the literature based on the inductive findings that emerged. This literature review may, in fact, be more extensive than the first review. Thus, a second phase of the literature review was conducted after completing the data analysis process. This second review of the literature provided the basis for the discussion of the findings, resulting in the formation of the propositions and final theoretical framework. Six main categories emerged: *organisational readiness, coordination, individual perceptions, individual readiness, C-BT characteristics as well as non-C-BT redundancy*. As a result, 13 propositions (as shown in Figure 7-1) are subsequently formulated based on the findings. They are discussed in the following section.

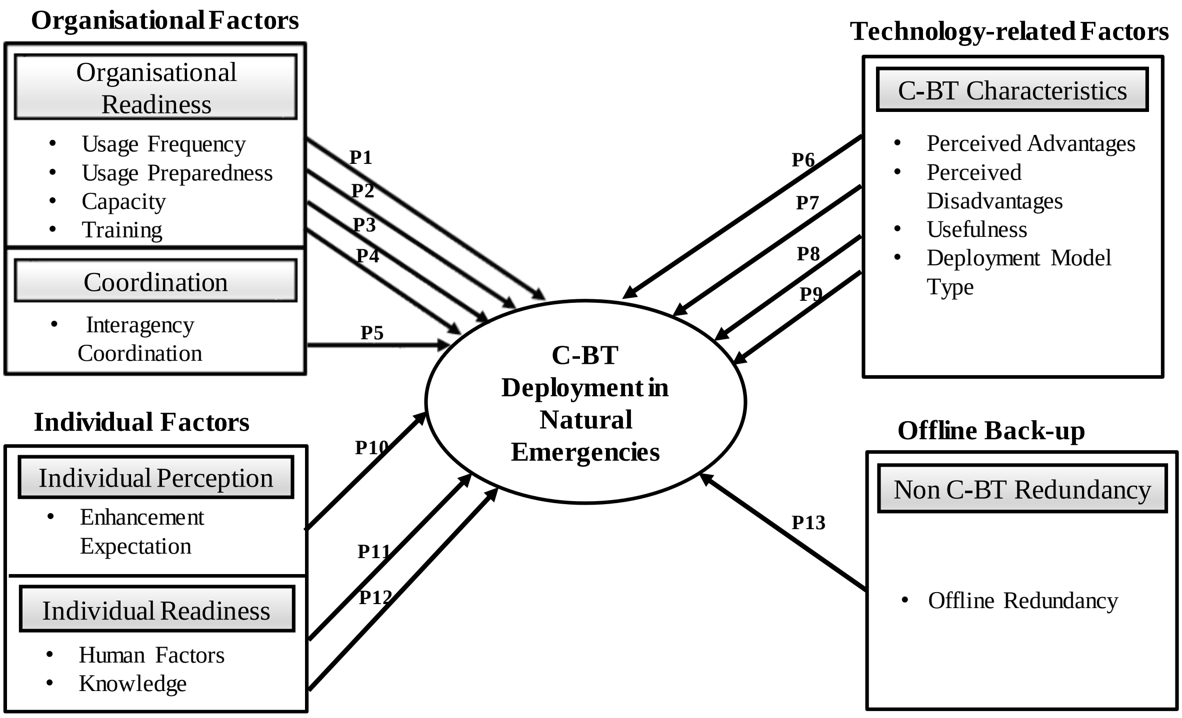


Figure 7-1 Theoretical model of multi-dimensional elements in influencing the perceptions of C-BT deployment in New Zealand emergency service organisations

7.1 Organisational Factors influencing Cloud-based Technologies Deployment

The discussion in this section focuses on the *organisational factors* that influence the emergency professionals' perceptions regarding C-BT deployment in natural emergencies: usage frequency, usage preparedness, capacity, training, and inter-agency coordination. Consequently, the discussion supports the first five propositions' establishment based on the results. Figure 7-2 presents the first five

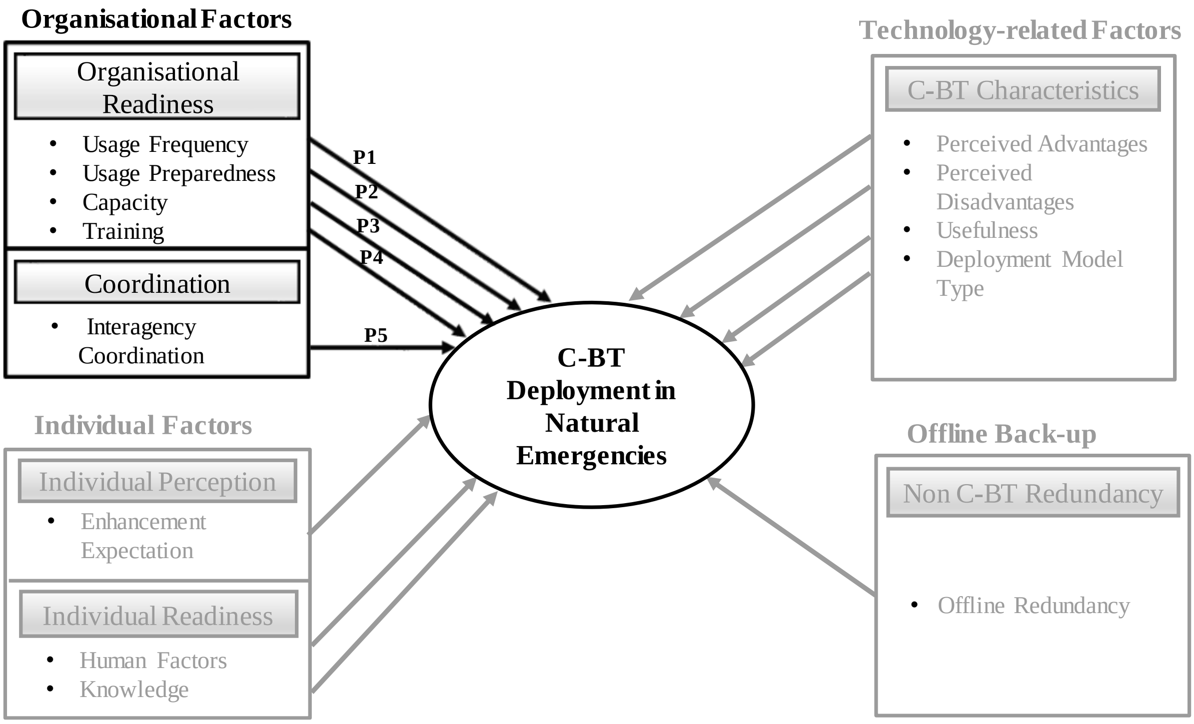


Figure 7-2 Propositions based on organisational factors influencing C-BT deployment in natural emergencies

7.1.1 Usage frequency

The analysis of the findings reveals that the enhancement of the familiarity with the system usage was a significant requirement in the emergency services organisations. The emergency professionals were more familiar with frequently utilised cloud-based applications, mainly email, external storage as well as some well-known external cloud services, such as Google products or Microsoft Office 365, rather than key internal C-BTs. The finding is aligned with limited studies (i.e., Granholm, 2017; Khawaja et al., 2014) that have highlighted the significance of being familiar with the technology usage in order to generate enhanced performance in emergencies. However, both previous studies only identify the issue of unfamiliarity with the usage of general ICTs rather than the usage of a typical type of technology. Therefore, the findings in this research not only confirm previous research but also extend by discovering the importance of enhancing the emergency professionals' familiarity with the private cloud usage in emergency services organisations.

During natural emergencies, internal cloud-based systems were mainly used by all six organisations. Nevertheless, findings indicate that emergency professionals lacked the familiarity with the critical internal systems in all six organisations due to not having used the systems on a frequent basis. Previous literature emphasises the importance of using technology within organisations on a frequent basis (Baturay et al., 2017; Nantembelele & Gopal, 2018), but these studies were not conducted in the context of emergency management. Only one study (e.g., Khawaja et al., 2014) was found to highlight that it is necessary to use critical technologies on a routine basis; otherwise, they will not be utilised in an effective way during real emergencies. CNS, as the leading agency, had most concerns over such issues since CNS' E System were required to be used most by all key agencies in the multi-agency emergency, but the familiarity with the system was low. It is claimed that improved familiarity with a system helps to enact better coordination and communication in emergencies (Granholm, 2017; Steigenberger, 2015). This is because the acceptable level of digital skills is required during the cooperation and interaction among different organisations and sufficient practice is necessary to accumulate the skills in advance (Granholm, 2017). Therefore, the emergency professionals would have more positive perceptions regarding C-BT usage if the familiarity with the system is enhanced through frequent usage.

It was also found that the current usage level of key internal cloud-based systems in the emergency service organisations was low, leading to less smooth operation of key C-BTs. For example, the opportunities for emergency professionals to use CNS' E System or HNS' H System in large-scale natural emergencies or training exercises were quite limited so that the usage experience was inadequate. The finding is, to some extent, in line with the previous literature that stresses the significance of using important ICTs extensively to increase usage experience so that better performance can be produced gradually (Čudanov et al., 2012;

Kivunike et al., 2015; Sakurai & Watson, 2015). However, only Sakurai and Watson's (2015) study is conducted in the context of managing natural emergencies; the other two studies focus on either the system usage in healthcare delivery sector (Kivunike et al., 2015) or the knowledge-based industry (Čudanov et al., 2012). In Sakurai and Watson's (2015) study, it is found that, normally, it requires great efforts, in both time and money, in preparing appropriate systems, such as satellite phones or public alerting systems, for responding to natural emergencies; however, these systems are more likely to be used only in real emergencies, which actually constrains the emergency personnel's training opportunities on the system.

As is shown by the research findings, other supportive agencies had even fewer chances to use CNS' E System or HNS' H System in the preparedness stage, which posed even more difficulties to those agencies since it required them to operate the systems immediately on site in the response stage. Although Scholl et al. (2017) assert that when more agencies are involved in the emergency for the response but with different technology platforms, it becomes increasingly challenging for coordination due to the heterogeneous responsibilities of different agencies, the research does not address the issue of technology usage frequency by various agencies. There is also a lack of research that has explored the technology usage frequency in multi-agency natural emergencies. With limited usage of the key systems, it is even more difficult and complex to manage the overall situation of the response in a cooperative manner. Therefore, this research contributes to the existing emergency management literature by emphasising the importance of providing more frequent chances for the supportive agencies to use other organisations' key C-BTs frequently to better prepare for the multi-agency emergency.

It was also found that since C-BT was relatively new in the New Zealand emergency management sector, there was less C-BT usage in the preparedness stage than in the response stage. Further, the C-BT usage was minimal at the frontline. These findings are difficult to link to previous literature because there is a lack of research that has been conducted to discover the usage level of C-BT in emergency services organisations.

On the basis of the arguments above, it is proposed that:

P1: Greater frequency of C-BT usage in the preparedness stage increases the emergency professionals' positive perceptions of C-BT deployment in natural emergencies.

7.1.2 Usage Preparedness

Based on the findings, it still required great efforts for all organisations to enhance the readiness for using C-BT when managing emergencies. It was found that the slow movement towards cloud computing usage was due to the lack of the clear strategic goal and plan for using C-BTs in the long run, although organisations acknowledged the trend of moving to more C-BT usage, especially the external cloud services, in emergency management. The researcher found only one study that supports this finding. Kaufhold and Reuter's (2017) case study found that the main obstacle to the deployment of the external cloud, social media, is the lack of organisational long-term goals to clarify the usage. Therefore, having clear goals for utilising C-BTs is critical to the successful deployment in emergency service organisations. Therefore, clear goals of cloud movement positively influence the emergency professionals' perception regarding C-BT usage in natural emergencies.

In addition, it was found that the lack of C-BT usage consistency resulted in a low level of usage preparedness. Organisations without a centralised IT approach were more likely to encounter the problem of inconsistent C-BT usage within the organisations. It is nevertheless important to utilise C-BTs consistently at both central and local levels. Otherwise, it is difficult to evaluate the real effectiveness of the technology usage. This happened especially in CNS and HNS which had a large number of local groups with different IT strategies, thus making it difficult to ensure the consistency of C-BT usage. It is only, to some extent, consistent with Tallon's (2014) study which finds that reaching a consensus of information system usage is less likely to lead to problems of system usage throughout the organisations.

According to the findings, the usage commitment to key cloud-based emergency management system was low in CNS and HNS. For example, specific C-BTs, such as CNS' E System and HNS' H System, had not been well institutionalised within emergency services organisations that have many standalone branches.

Previous literature highlights the importance of having commitments to using cloud computing (Haider & Pishdad, 2013) or ERP systems (Pishdad & Haider, 2013) to better achieve the organisational goals but without a focus on specific industries. This finding not only confirms these studies but also extends them by identifying the importance of enhancing key C-BT usage commitment in the field of emergency management. The usage commitment relates to the technology institutionalisation process emphasised by Pishdad and Haider (2012), as well as Pishdad and Haider (2013) where the routine usage of the technology results in the institutionalisation of the technological innovation. This entails a comprehensive understanding of the technology innovation so that it can be rooted into the organisation's working process (Pishdad & Haider, 2013). Therefore, the commitment to using the technology constitutes an important step to the consequent technology institutionalisation (Fichman & Kemerer, 1997; Tolbert & Zucker 1999). Due to the standalone characteristic of local groups of CNS and HNS, the two organisations required great effort to gain high commitment to using the system. The reason is that cloud service institutionalisation requires the usage commitment to enable users to take for granted complete deployment of the system throughout the organisation (Haider & Pishdad, 2013). Hence, the high usage commitment will be more likely to result in the emergency professionals' positive perceptions regarding C-BT deployment in natural emergencies.

It was also found that how the emergency service organisations promote the current cloud-based emergency management system was quite conservative. For example, CNS, HNS, and FNS had invested a large amount of money in establishing new systems or mobile application projects, but the speed of promoting the systems was quite slow. It was because the organisations were more willing to promote the system extensively after they had proved the systems were value-added. Hence, the organisations studied in this research made investment decisions carefully in new systems and tested effectiveness thoroughly before roll-out. There is a lack of research that can be found to support the finding in the context of emergency management. Nevertheless, previous literature highlights that innovativeness of the organisation is a significant determinant of cloud computing adoption in the healthcare industry

(Kuo et al., 2013) or SMEs (Alismaili et al., 2016a; Alshamaila, Papagiannidis, & Li, 2013). The innovativeness of the organisation is associated with the degree of willingness of firms to take the risk of trying new innovative technologies that had not been tested in the past. It is found that the less willingness to take the risk of using the technology, the less likelihood for the users to have perceptions of its usefulness (Kuo et al., 2013). Therefore, it is necessary for an emergency service organisation to enhance its willingness to take the risk of innovative solutions and enhance the speed of system promotion. It is because, through better promotion of the technology, more users could be aware of how the technology could facilitate them in achieving business performance optimisation (Tallon, 2014). Hence, better cloud usage preparedness could be achieved through enhancing organisations' willingness to take the risk of using new technology, resulting in the emergency professionals' positive perceptions regarding C-BT usage in natural emergencies.

Based on the discussion, it is proposed that:

P2: The greater C-BT usage readiness the emergency service organisations have in the preparedness stage, the more positive perceptions the emergency professionals have regarding C-BT deployment in natural emergencies.

7.1.3 Capacity

Research findings indicate that large organisations did not necessarily have sufficient organisational resources to support the C-BT deployment. Previous studies find that it is more likely for organisations with an adequate level of resources to adopt cloud computing than those without them (Hassan et al., 2017; Lynn et al., 2018; Oliveira et al., 2014). Organisational resources, such as financial capital and expertise access, are critical to the adoption of cloud computing (Hassan et al., 2017; Li et al., 2015; Srinivasan, 2013). The finding is supported by only one study which argued that due to the characteristic of being more bureaucratic and inflexible, it is more difficult for large organisations to change quickly in the adoption of innovative technologies (Hsu et al., 2014). However, the finding is different from that of Hassan et al. (2017) and Oliveira et al. (2014) who found that it is more possible for larger organisations to have sufficient level of resources in terms of covering the cost and tackling the risk of the investment in cloud computing. The finding in the current research is reasonable. Since most of the large organisations studied had a large number of local groups or frontline staff, it was difficult to allocate sufficient resources to enable C-BT deployment throughout the country.

It was also found that the leading agency had the most concern about not having internal expertise since there was no IT unit within the organisation and all IT related issues relied on external consulting companies. However, it is more beneficial to have internal technical support on cloud usage so that the emergency professionals do not have to be highly vulnerable to solve IT problems. Therefore, the lack of internal expertise was a big barrier to gaining support on the usage and maintenance of the private cloud in the emergency service organisation. Previous literature (e.g., Findik & Ozkan, 2013; Kluckner et al., 2014; Olivera et al., 2014; Srinivasan, 2013) emphasises that it is vital to have internal IT expertise to facilitate the usage of cloud computing but only one study (i.e., Kluckner et al., 2014) is carried out in the context of emergency management. The finding in the current research is thus consistent with previous studies but also extends it by highlighting the perceived importance of onsite IT support on C-BT usage in emergency management. As for the external cloud-based systems, it is acknowledged that organisations can utilise the system even without a high level of IT expertise (Shayan et al., 2014). Nevertheless, it is not viable for organisations to hold private cloud with total ownership. It is argued that the lack of the availability of IT expertise within the organisations is a barrier to helping the organisation to manage the requirements of integrating their existing applications onto a particular external cloud platform (Olivera et al., 2014). Therefore, the lack of access to expertise specialised in managing and supporting private cloud usage poses difficulties to the deployment of cloud computing.

According to the findings, the insufficient capacity in hosting C-BT inhibited the successful deployment of private cloud. CNS lacked the capacity most among the other organisations due to not having a specialised IT unit within the organisation. The key CNS' E System had to be maintained by the national manager without sufficient IT knowledge, which resulted in vulnerability for hosting the system. This is in line with previous literature which suggests that organisations with limited capacity in maintaining IT infrastructure can shift their burden through outsourcing the IT capacity, thus saving time and cost on holding infrastructure while focusing more on the strategic tasks (Gonzalez et al., 2010; Gonzalez et al., 2015). Therefore, a more efficient way of hosting C-BTs enhances the emergency professionals' positive perceptions regarding C-BT usage.

Additionally, it was found that there is a lack of human resources to perform certain tasks relating to C-BT usage in emergency service organisations. This lack manifested itself in the shortage of personnel to monitor social media. CNS utilised social media most among the six organisations and it lacked personnel in terms of maintaining the social media presence in the preparedness stage and monitoring social media in the response stage. Consistent with the finding, previous literature emphasises that the lack of staff and skills significantly inhibits the social media deployment in emergency service organisations (Anikeeva et al., 2015; Hiltz et al., 2014; Kaufhold & Reuter, 2017; Lian et al., 2014). For example, in Kaufhold and Reuter's (2017) study, it was found that there was insufficient capacity in personnel to be trained and allocated to utilise social media in one key emergency service organisation in Germany. Therefore, increasing human resources in maintaining and monitoring social media is significant in emergency service organisations since social media has been proved to have great potential in enhancing situational awareness in emergencies (Cresci et al., 2015; Kryvasheyeu et al., 2016).

The study also found that the emergency service organisations were limited by the budget to invest in advancing the current cloud-based system. Nevertheless, the emergency professionals acknowledged the importance of the advancement of current systems and more investment in enhancing mobility for the frontline agencies. This is consistent with previous literature which highlights that having sufficient budget is critical to the success of achieving ICT advancement (Bryant et al., 2014; González-Páramo, 2017; Li et al., 2015). For example, in Bryant et al.'s (2014) study, the insufficient budget was found to be the institutional inability to accelerate the speed of utilising cloud-based learning system in the institution. The cloud-based system can be seen as a disruptive change so that sufficient financial capability is a fundamental factor which determines the pace of change towards the technology usage (González-Páramo, 2017). Therefore, the increased capacity in having more budget for advancing systems enhances the emergency professionals' positive perceptions in C-BT deployment in natural emergencies.

In addition, it is found in this research that many participants considered the capacity in terms of improving cloud-based systems was critical to the success of C-BT deployment. All six emergency service organisations had made efforts in C-BT improvements though with different levels. CNS and HNS had established specific emergency management systems and made further improvements on current versions. Even though other agencies did not own specialised cloud-based emergency management systems, they tried to make improvements on certain functions of currently utilised systems. Extant literature highlights the importance of improving systems design and evaluation to enhance the emergency management performance in terms of enhancing collaboration, resource allocation or information dissemination (Eisenberg et al., 2014; Farag et al., 2013; Han et al., 2014; Mangla et al., 2016; Wu et al., 2013). However, these studies do not address the issue of emergency professionals' perceptions of using C-BTs in natural emergencies. The finding in the current research thus adds to the body of knowledge by highlighting the critical role of having system advancement capacity in influencing the emergency professionals' perceptions of C-BT deployment in natural emergencies. Therefore, emergency service organisations with more initiative to enhance cloud-based systems are more likely to result in emergency professionals' positive perceptions regarding C-BT usage.

Based on the discussion, it is proposed that:

P3: Greater capacity increases the emergency professionals' positive perceptions of C-BT deployment in natural emergencies.

7.1.4 Training

Training on system usage is important since the good performance of system operation depends on training. The discussion in this section focuses on training frequency, consistency of training and training expertise. It was found that all organisations acknowledged the importance of frequent system training. Nevertheless, the frequency for the key system training was far from sufficient in all organisations. For example, FNS, PHS and JNS only relied on self-learning on internal systems usage as there was a lack of a standard training mechanism in place for people to be trained on system usage. Nevertheless, in the emergency management area, training on system usage plays a critical role for the emergency personnel to accelerate the speed of becoming used to the new technology in the process of the work, thus producing better performances when dealing with emergencies (Anikeeva et al., 2015; Haugstveit et al., 2015). The finding is aligned with what previous studies highlight, ICTs that are critical to facilitate emergency operations are required to be utilised on a regular basis, which helps to enhance the emergency preparedness through ensuring the correct match between the tools used in training and actual events (Gomez & Passerini, 2010; Tveiten et al., 2012). In this way, the improvement of the system usage can be built through the frequent usage of the system (Gangwar et al., 2015; Van der Waldt, 2016). Hence, it is critical for organisations to build the capacity for having more personnel who are skilful in using the system in order to acquire the benefits of the technologies (Machogu & Okiko, 2012). With more training experience in using the system, it is much easier for trained employees to perform their tasks through using the cloud-based systems to enhance the performance in emergencies due to the increased familiarity gained on using the system (Gangwar et al., 2015; Steigenberger, 2015). Therefore, system usage training on a regular basis is the prerequisite for enhancing the familiarity of current C-BTs. In turn, it is helpful in producing a much smoother operation when utilising the system during the response stage.

On the other hand, findings of the current research reveal that there was a lack of goals and plans for system training in CNS and HNS while other organisations did not have training in place. It was found that a plan was required to ensure the consistency of the system training since all organisations studied in this research had many branches which were geographically dispersed. Extant literature points to the importance of having standards for course training or physical training in the emergency management sector (Fahey et al., 2014; Kapucu et al., 2013; Scott et al., 2013), but very limited studies address the importance of conducting consistent ICT training for emergency management (Adams, 2016). The finding in the current study confirms what Adams (2016) highlights, consistent ICT-related training needs to be offered to emergency professionals for managing mass casualty disasters and extends by highlighting the importance of having consistent C-BT training for managing natural emergencies. Therefore, having a standard training mechanism in place is critical to maintaining C-BT usage consistency among different branches.

Despite training frequency and consistency, access to system training expertise also plays a significant role in enhancing the effectiveness of the training. Organisations studied in this research with on-site training expertise were more likely to enable employees to adapt to the new system faster. Organisations, such as JNS, PNS and FNS that relied on self-learning without on-site expertise, were less likely to get used to their internal systems quickly. Previous studies in the non-emergency management area identify that having ICT training expertise has a positive influence on the adoption of the particular system within the organisations (AlBar & Hoque, 2015; Alismaili et al., 2016a; Machogu & Okiko, 2012). Machogu and Okiko (2012) further emphasise that the lack of suitable technical and managerial staff with sufficient ICT expertise is a major barrier for adopting ICT. The finding in the current research echoes these previous studies, but also extends them by highlighting the emergency professionals' perceptions of the importance of having support on C-BT usage in natural emergencies.

On the basis of the discussion, it is concluded that:

P4: Frequent and consistent training conducted in the preparedness stage increases the emergency professionals' positive perceptions in C-BT deployment in natural emergencies

7.1.5 Inter-agency Coordination

All six organisations studied in this research acknowledged the importance of maintaining a close relationship with each other. The relationship was sustained through engaging in natural emergency exercises to practise using the core cloud-based emergency management system at both local and national levels, and attending multi-agency courses and workshops in the preparedness stage. It is aligned with previous research emphases that successful operation in large-scale emergencies cannot function without close cooperation among different agencies (Curnin et al., 2015; Qi, 2013). The finding also confirms what previous literature acknowledges, the multi-agency coordination is a challenging task when managing emergencies (Curnin et al., 2015; Kapucu et al., 2013). This is because a single organisation is not capable of solving all problems in large-scale natural emergencies on its own so that various agencies from different organisations are forced to work together to tackle the overwhelming issues (Jung & Song, 2015; Kapucu et al., 2013; Steigenberger, 2015).

The findings, interestingly, show that forming trust and sustainable relationships indirectly enhances the emergency professionals' confidence in C-BT deployment. Extant literature highlights that using information technologies will enhance the formation and sustainability of the effective networks to support collaboration among emergency professionals (Breen & Parrish, 2013; Kapucu et al., 2013; Kapucu & Garayev, 2013). Many have drawn attention to investigating multi-agency collaboration in emergency management, such as designing collaborative tools to enhance multi-agency operations (Dinh et al., 2013; Wu et al., 2013) or discovering factors influencing network sustainability and effectiveness in emergency management (Hu & Kapucu, 2016; Kapucu et al., 2013). However, none of these studies investigates the critical role of relationship establishment in influencing the emergency professionals' perceptions of C-BT usage. Due to the leading role that CNS played in natural emergencies, it was necessary for all supportive agencies to use the key emergency management information system provided by CNS. Maintaining relationships on a frequent basis is beneficial to accelerating the speed of accepting the new system due to the mutual trust established throughout the network. The current research thus contributes to the existing literature by discovering that relationship establishment has an indirect influence on emergency professionals' C-BT usage perception. Therefore, it is important to ensure the effectiveness of the emergency management network through establishing trust and sustainable relationships, especially, before the emergencies happen (Kapucu & Garayev, 2011; Kapucu & Hu, 2016; Steigenberger, 2015).

Despite all six organisations recognising the importance of establishing close relationships among agencies, obstacles to smooth information sharing still existed. One of the main problems was the usage of different internal systems among agencies. Thus, it was more likely for each agency to focus on its own operation. This finding is, to some extent, aligned with what Ley (2014) highlights, that it is difficult to share information with varying kinds in a fully smooth way among different agencies, but also extends by emphasising the usage of C-BTs in natural emergencies.

It was also found that there were organisational boundaries among agencies when using C-BTs during cooperation, such as the concern of leaking private information, particularly in PNS, FNS, and JNS, and accessibility to other agencies' systems due to policy and law restrictions. This not only confirms what previous studies argue that the organisational boundaries exist which are difficult to get across for many reasons such as conflicting interests or legislations (Karlsson, et al., 2017; Khawaja et al., 2014), but also extends them by highlighting that such boundaries influence the emergency professionals' usage of C-BTs in natural emergencies. The inability to access and share sensitive information acts as an obstacle to better inter-organisational coordination in emergency management (Baskerville et al., 2014). Nevertheless, it is highlighted that overcoming the barrier of information gathering and sharing during the response stage is particularly important due to the complex situation and inadequate time for making decisions (Kapucu et al., 2013; Khawaja et al., 2014; Ley et al., 2014). Curnin et al. (2015) argue that it is necessary to address the constraints related to the privacy or security concerns of accessing other agencies' information system in the preparedness stage in order to reduce the barrier to the smooth information flow in multi-agency coordination during the response stage.

Findings also show that there was a lack of a common platform for all agencies to enhance situational awareness simultaneously. For example, CNS had established a single system to enable enhanced speed for gathering information from various agencies, but it is far from enough to enable a common operating picture in such system during the collaboration in a multi-agency emergency. The reason was that different agencies were not able to see the information from others immediately in a single dashboard. As a result, each agency still could not get real-time information in an immediate manner. This way of operation reduced the efficiency of the operations since duplication of tasks might occur due to not having shared the information of actions on a common platform. The finding confirms extant literature which highlights the significance of having a common platform for enhancing multi-agency collaborations in emergency management

(Dorasamy et al., 2013; Kapucu et al., 2013; Khawaja et al., 2014; Tatham, Spens, & Kovacs, 2017). The reason is that the common platform or integrated system could enable the information flow in a seamless way among agencies, thus supporting emergency activities and solving prominent issues in the natural emergencies (Dorasamy et al., 2013). Consistent with this view, it is argued that only through a more consolidated approach, the collaboration actions in terms of mobilizing the resource allocation among various agencies could take the most advantage of using the ICTs to achieve the common goals in disasters (Ginige et al., 2014).

Additionally, findings show that the frontline agencies also needed a common cloud-based platform to enhance the work efficiency at the scene. Participants thought that having a common platform to enhance the overall situational awareness was particularly important during the large-scale multi-agency natural emergency. Otherwise, each agency could only be aware of the situation from the single side rather than all aspects of key situational information from different agencies. This is consistent with the view that it is necessary to require the "same situation awareness for all the elements" in a single system, which supports sharing the same level of situation awareness among different agencies during the complex collaboration in the multi-agency event (Curnin et al., 2015, p.304). Therefore, having an advanced common platform which facilitates agencies to receive information from each other is critical to enhancing the emergency professionals' positive perceptions regarding C-BT usage in natural emergencies.

Additionally, most of the emergency professionals thought that the higher the possibility for linking various agencies' cloud-based systems, the higher the likelihood for them to enhance the collaboration practices, thus leading to more positive perceptions of C-BT usage in natural emergencies. Due to the barriers of bureaucracy and privacy concerns, such integration was not to be easily achieved at the moment. Nevertheless, it is critical to improving the coordination practices among agencies. Previous literature acknowledges the importance of utilising information systems in multi-agency coordination (Curnin et al., 2015; Hu & Kapucu, 2016), but there is a lack of research examining whether C-BT linkage among different agencies is helpful to enhance the effectiveness of the collaborative operation. The finding only confirms what Janssen et al. (2010)

highlight, that a smoother inter-organisational cooperation process between agencies can only be achieved through integrating information systems due to the interoperability issue between different systems, resulting in isolating operations or overlapping functions and contents. Therefore, through system linkage, critical information could be delivered in a timely and accurate manner and avoid the existence of operation isolation. Hence, emergency professionals will have more positive perceptions regarding C-BT usage in natural emergencies if, when necessary, each organisation's system can be linked with all others during the emergencies.

More than half of the participants highlighted the shared usage of the C-BT resources between agencies. For example, CNS' E system was shared by all key supportive agencies in the emergency operation centre during the response stage and national warning system in the preparedness stage. Other aspects of shared capacity included project cooperation on mapping systems and shared usage of mobile appliances equipped with cloud-based systems. It is aligned with previous research which highlights the resource dependency theory claims that individual organisations are incapable of surviving since they do not have all the resources they require to accomplish their goals (Abbasi & Kapucu, 2016; Mitchell et al., 2015). Therefore, emergency service organisations studied in this research acquired C-BT resources that they did not own from other organisations. This helps to reduce the level of uncertainty in terms of gaining resources in short supply through stabilising the inter-organisational linkages (Mitchell et al., 2015). Therefore, the shared capacity among agencies enhances emergency professionals' positive perceptions regarding C-BT usage in natural emergencies through inter-organisational support to reduce the shortage of C-BT resources.

In conjunction with that:

P5: Greater inter-agency coordination increases the emergency professionals' positive perceptions in C-BT deployment in natural emergencies in both preparedness and response stages.

7.2 Technology-related Factors influencing Cloud-based Technologies Deployment

This section discusses the *technology-related factors* that influence the emergency professionals' perceptions of C-BT deployment, including perceived advantages, perceived disadvantages, usefulness of C-BTs and deployment model types. The discussion in this section supports the establishment of the four propositions. Figure 7-3 presents the following four propositions.

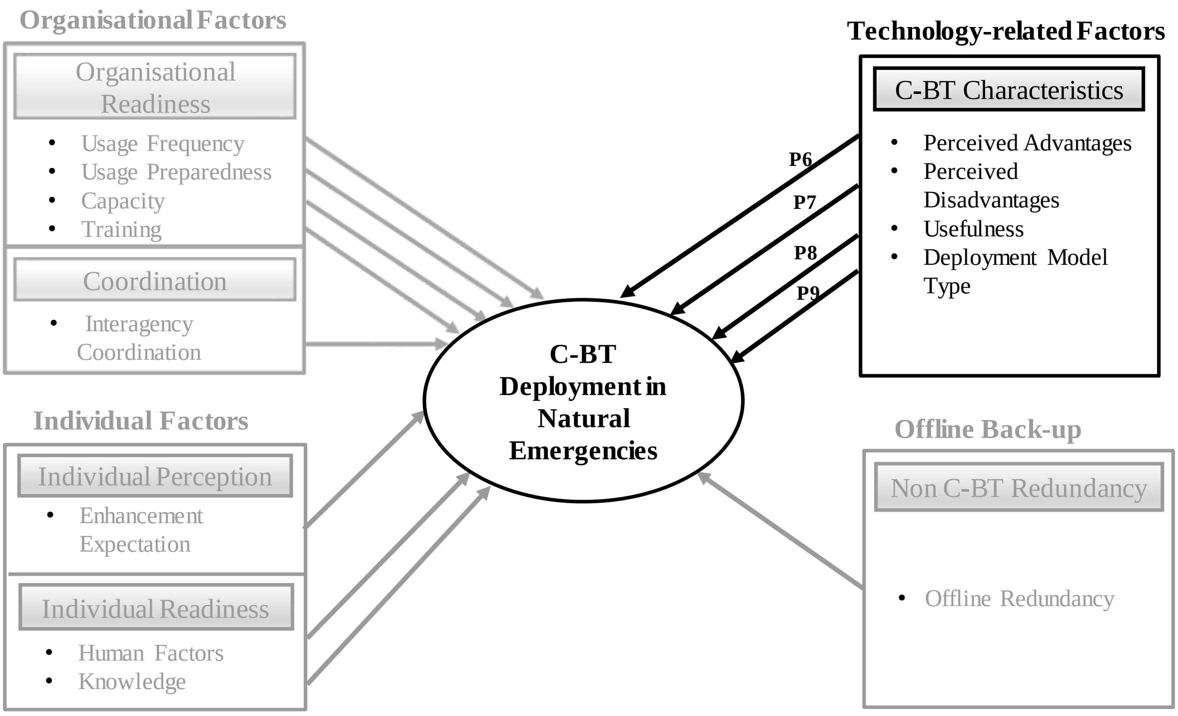


Figure 7-3 Propositions based on technology-related factors influencing C-BT deployment in natural emergencies

7.2.1 Perceived Advantages

A significant number of participants considered that the accessibility was the most important advantage of utilising C-BTs, as this enhanced their working flexibility even under the situations of building collapse or unexpected power outage issues. With ubiquitous accessibility, the participants thought that they were able to work flexibly. This finding is aligned with previous literature which highlights that the ease of access is one of the important factors to drive the organisations in the adoption of cloud computing (Alismaili et al., 2016a; Friedrich-Baasner et al., 2018; Gutierrez et al., 2015; Hassan et al., 2017). However, none of these studies are carried out in the field of emergency management. The finding thus extends knowledge by highlighting the emergency professionals' views of the importance of accessibility to C-BTs when managing natural emergencies. It is argued that accessibility is an apparent and significant factor associated with the benefits of adopting cloud computing since it enables the users to access to information in an easy, fast, and flexible way, leading to enhanced productivity and performance (Alismaili et al., 2016a). Cloud computing also allows for urgent access to computing resource without much upfront capital investment for organisations (Ghaffari et al., 2014; Gupta et al., 2013). Therefore, the perceived ease of accessibility enhances the individual emergency professionals' positive perceptions regarding C-BT usage in natural emergencies.

In terms of consistency, it was found that the individual emergency professionals with the experience of using CNS' E System or HNS' H System had a stronger sense of the benefits of C-BTs in delivering consistent performance throughout the organisation. For example, it was considered important, especially in the response stage, for producing reports based on the same templates and working in a collaborative way. This finding, to some extent, confirms the extant literature that highlights the importance of having a common platform when utilising an information system to keep a consistent performance during natural emergencies (Ginige et al., 2014; San-Miguel-Ayanz et al., 2012; Sweta, 2014). Due to the synchronisation of data on the same platform, it is more likely to produce consistent performance throughout the organisation (Awad 2014; Herrera & Janczewski, 2014). Therefore, the perceived enhanced consistency leads to the emergency professionals' more positive perceptions regarding C-BT usage in natural emergencies.

Findings also show that individual emergency professionals who had used C-BTs, such as Dropbox, Google Maps, or Microsoft Office 365 which were external to the organisations, had a stronger sense of cost-saving on C-BT usage due to the requirement of less capital investment on infrastructure and maintenance. For example, emergency professionals in RNS favoured the free open-source C-BTs most among the six organisations due to its organisational characteristic of being volunteer-based with limited capacity for investing in the specialised cloud-based emergency management system. Many previous studies emphasize the cost-effectiveness of the cloud outsourcing (Ghaffari et al., 2014; Gupta et al., 2013;

Gupta et al., 2016) since the organisations are outsourcing computing capabilities from external service providers which is helpful to reduce the infrastructure overhead. It is further argued that the cost of using open-source applications can be almost ignored (Davidovic et al., 2015). The finding in the current research, to some extent, confirms the view from previous literature and extends this by highlighting that cost is one key advantage influencing the emergency professionals' choice of C-BT usage when managing natural emergencies. Therefore, the perceived cost-effectiveness in using external cloud-based systems increases the emergency professionals' positive perceptions regarding C-BT usage in natural emergencies.

In association with efficiency, findings show that many participants emphasised the capability of C-BT in carrying out jobs efficiently, such as generating the up-to-date situation report, information gathering and dissemination, data management and resource allocation. Previous literature stresses the importance of having information systems that can enhance the efficiency of the performance when managing emergencies (Frigerio et al., 2018; Shahrah & Al-Mashari, 2017; Xu et al., 2016), such as in information gathering (Geumpana, Rabhi & Zhu. 2015; Mao et al., 2015) or data processing (Helmi et al., 2018; Xu et al., 2016). However, these studies do not address the role that C-BTs play in enhancing emergency management performance. Another stream of previous studies suggest that it is more likely for organisations to accept an innovative technology if they have a firm belief in its ability to enhance the efficiency and effectiveness (Lin & Chen, 2012; Herrera & Janczewski, 2014; Oliveira et al., 2014). This finding is aligned with these studies but further highlights that the perceived efficiency of performance influences the emergency professionals' C-BT deployment in natural emergencies. It is argued that whether a cloud-based system can assist with efficient performance influences the managers' decision-making when considering its adoption (Gutierrez et al., 2015; Oliveira et al., 2014). Therefore, enhanced efficiency though C-BTs increases the emergency professionals' positive perceptions regarding C-BT usage in natural emergencies.

In addition, many individual emergency professionals could foresee the potential benefits of increasing the mobility of the job through using mobile devices to access cloud-based applications. Participants from frontline agencies were eager to gain the benefits of access to cloud applications through mobile devices due to the lack of technology on trucks at the frontline for retrieving and reporting information. The finding, to some extent, echoes the prior literature which argues that cloud computing allows for enhanced mobility which is a significant advantage that other technologies could not deliver (Gangwar et al., 2015; Hsu et al., 2014), but also extends it by highlighting the perceived mobility as being particularly important to emergency professionals in frontline emergency services organisations. It is argued that the way of accessing cloud-based platforms has been simplified via smart mobile device usage (Davidovic et al., 2015; Kim & Kim, 2018). Therefore, the enhanced mobility increases the emergency professionals' positive perceptions regarding C-BT usage in natural emergencies.

More than half of the participants emphasised the data certainty of C-BT in the case where any unexpected situations happen, especially during the response stage. It is, to some extent, aligned with extant literature that stresses the importance of data back-up when managing emergencies (Formisano et al., 2015; Kuhnert et al., 2015; Mitra & Ahlund, 2014). It is argued that cloud computing exactly owns the capability to provide data redundancy to counteract unexpected disturbance of using systems in natural emergencies due to geographically dispersed data centres (Davidovic et al., 2015; Gupta et al., 2013; Poorejbari & Vahdat-Nejad, 2014). Important files can be duplicated when it is created with a high level of accessibility even when the power outage or the network disconnection takes place in natural emergencies (Gupta et al., 2013). Therefore, having sufficient redundancy increases the individual emergency professionals' positive perceptions regarding C-BT usage in natural emergencies.

On the other hand, participants, though a small number, acknowledged that perceived improved situational awareness would increase their willingness to use C-BTs. Individual emergency professionals with more experience in utilising situational awareness tools, such as social media or mapping system, had more positive perceptions regarding C-BT usage in natural emergencies. Previous literature claims the need for enhancing situational awareness when managing emergencies (Mitra & Ahlund, 2014; Poy & Duffy, 2014; Wu et al., 2013). This is because the potential of ICTs to enhance the situational awareness has not been fully realised yet in terms of collecting, processing, and disseminating relevant information in a timely and accurate manner (Mitra & Ahlund, 2014). An increasing number of studies have drawn attention to the ability of social media (Cresci et al., 2015; Houston et al., 2015; Kryvasheyeu et al., 2016) or crowdsourcing platforms (Degrossi et al., 2014; Liu, 2014; Xiao et al., 2015) in terms of enhancing situational awareness in natural emergencies. However, none of these studies have explored the emergency professionals' perceptions of C-BT usage in terms of situational awareness. The finding thus contributes to the emergency management literature through identifying the importance of enhancing situational awareness in influencing emergency professionals' C-BT usage in natural emergencies.

According to the findings, some individual emergency professionals were more willing to deploy C-BTs if the perceived stability and reliability were gained, especially during the response stage. For example, the internal cloud-based systems were considered reliable since the emergency professionals believed in the systems' security. On the other hand, the external cloud-based systems were also considered reliable due to the belief in the external service providers' stronger capacity of holding the infrastructure but limited to several commonly used external clouds. This finding is consistent with extant literature that emphasises that the reliability of cloud computing is the key driver to the adoption (Dinh et al., 2013; Gupta et al., 2013), but also extends it by highlighting that perceived reliability of C-BT significantly influences the emergency professionals' willingness to use C-BTs in natural emergencies. This is because applications within the organisations are so significant to support the business operation so that reliability is critical to the success of its continuous performance (Ghaffari et al., 2014). It is argued that the private cloud is more likely to be adopted by organisations due to better reliability of the data management and the overall system control (Davidovic et al., 2015; Herrera & Janczewski, 2014). Therefore, the perceived stability enhances the individual emergency professionals' positive perceptions regarding C-BT usage no matter which type of cloud services are utilised.

It was also found that individual emergency professionals were more likely to deploy C-BTs when they perceived that a high level of information transparency could be achieved through C-BTs. The aspects related to the transparency achieved included the ease of tracking information and better internal information exchange. Although some previous studies acknowledge that using information system is beneficial to enhancing the information flow in managing emergencies (Saeed et al., 2013; Qi, 2013), these studies do not highlight the role of C-BTs in enhancing information transparency in natural emergencies. Therefore, the current research contributes to the existing literature by highlighting the critical role of C-BT in enhancing information transparency in influencing the emergency professionals' C-BT usage during natural emergencies. Some participants also perceived that there would be great potential for the enhancement of the inter-agency coordination if an advanced common cloud-based platform were to be available in the near future. The finding, to some extent, is aligned with what previous literature highlights, that cloud-based services can better enhance the information transparency due to the synchronisation on the same platform (Xu, Huang & Fang, 2015; Stupar & Mihajlov. 2016). Therefore, increased perceived transparency gained through C-BTs leads to the individual emergency professionals' having more positive perceptions regarding C-BT usage in natural emergencies.

Based on the discussion, it is proposed that:

P6:Greater number of perceived advantages increase the emergency professionals' positive perceptions of C-BT deployment in natural emergencies in both preparedness and response stages.

7.2.2 Perceived Disadvantages

From the information system adoption research perspective, compatibility refers to the extent to which an innovative technology is aligned with the potential adopters' needs and values (Rogers, 2003). Findings in the current research indicate that individual emergency professionals perceived that no significant issue was encountered except that some of the files shared among agencies were incompatible, which reduced the efficiency of the performance, especially during the response stage. Previous studies show inconsistent results on whether compatibility issues influence cloud computing adoption. Some suggest that the enhanced compatibility increases the perceived usefulness of cloud-based systems, resulting in there being more likelihood of cloud computing adoption (Al-Hujran et al., 2018; Gangwar et al., 2015; Wilson et al., 2015; Yang et al., 2015) while others argue that compatibility has no significant impact on cloud computing adoption (Gutierrez et al., 2015; Lynn et la., 2018; Oliveira et al., 2014; Senyo et al., 2016; Tashkandi & Al-Jabri, 2015). The finding is, to some extent, aligned with prior studies which emphasised the importance of enhancing information processing and sharing through having compatible file format (Murphy et al., 2016; Liu et al., 2016). The finding also extends the literature by identifying that compatibility influences the emergency professionals' actual C-BT usage in natural emergencies. Further, it was found that the compatibility issue was associated more with the usage of browser or operating systems. This is consistent with the prior literature which highlights that any prototype requires testing on different versions of the operating systems for a cloud-based system (Lin & Chen, 2012; Starov et al., 2013). Hence, the increased compatibility will reduce the emergency professionals' unwillingness to use C-BTs in natural emergencies.

In addition, a significant number of participants considered that complexity is one of the key inhibitors to using C-BTs in natural emergencies. Complexity is associated with the extent to which the users have perceptions of having difficulties when operating an innovative technology (Lin & Chen, 2012). Participants perceived that the complexity lay in the complicated system design and login process which potentially reduced the efficiency of the performance. Infrequent utilisation and insufficient training further increased the emergency professionals' perceived complexity in system usage. Previous studies show different results in terms of whether complexity has an impact on cloud computing adoption. Some highlight that the complexity acts as a barrier to cloud computing adoption (Gutierrez et al., 2015; Lin & Chen, 2012; Tashkandi & Al-Jabri, 2015; Wilson et al., 2015) while others suggest that complexity has no significant impact on it (Alharbi et al., 2016; Lynn et al., 2018; Oliveira et al., 2014). This finding confirms previous studies that suggest that complexity inhibits cloud computing adoption and extends this by highlighting that complexity does influence the emergency professionals' actual C-BT usage in natural emergencies. It is argued that it is better to provide simplified systems for emergency personnel to utilise under stressful conditions when managing disasters (Steigenberger, 2015). Hence, the perceived complexity negatively impacted the emergency professionals' perceptions of C-BT deployment in natural emergencies.

Additionally, findings show that more than half of the individual emergency professionals considered cost as being a large factor when investing in internal cloud-based systems for managing emergencies due to the increasing cost of hosting, maintaining, and upgrading the system. Even though one of the key drivers for establishing the private cloud is the ownership of the complete control and configuration of the infrastructure as well as the protection of data within the organisations (Wang et al., 2011; Chang, 2015), it is argued that the ownership of the cloud is exactly the reason why holding a private cloud is more expensive than utilising the public cloud (Hsu et al., 2014; Purcell, 2014). Therefore, prior studies highlight that the higher cost of hosting private cloud is a large factor influencing the adoption of cloud computing by organisations (Goyal, 2014; Wilson et al., 2015). This finding is consistent with the previous research that suggests cost influences cloud computing adoption but without centring on emergency professionals' perceptions in the context of managing natural emergencies. The finding thus extends the literature by emphasising that cost is a large factor when utilising C-BT in the context of emergency management. Hence, the increased cost is the inhibitor to the emergency professionals' positive perception regarding C-BT deployment.

Based on the findings, individual emergency professionals had more trust in the internal system due to more guaranteed security and thus were less in favour of the external cloud. Even though individual emergency professionals did not perceive that significant security issues had taken place, they still emphasised the continuous security enhancement of their internal system. This finding is aligned with previous literature highlighting that the private cloud is considered as having more security in maintaining critical data within the organisations (Gangwar et al., 2015; Purcell, 2014; Saini & Kaur, 2017). This is because the private cloud provides the organisation with more control over the infrastructure even though it is more expensive to hold (Purcell, 2014). Therefore, the emphasis is placed on reducing the security risk through continuously maintaining and monitoring the service level agreement, which is a challenging task (Jabbar et al., 2016; Puthal et al., 2015). Therefore, the increased perceived security enhances the emergency professionals' positive perceptions regarding C-BT usage in natural emergencies.

In terms of privacy concerns, even though none of the individual emergency professionals had encountered any privacy issue through utilising the internal cloud-based systems, they had privacy concerns over the usage of external cloud or providing system access to other agencies when necessary. This is aligned with previous literature's emphasis that one key barrier to the adoption of cloud computing is the anxiety of losing the privacy of the confidential data (Friedrich-Baasner et al., 2018; Lin & Chen 2012; Oliveira et al., 2014). It is argued that the security and privacy issues arising from the usage of external cloud platforms are because of the reduced control over the cloud infrastructure (Lin & Chen, 2012). It is further contended that the lack of data protection raises concerns of privacy intrusion, especially during the emergency (Büscher et al., 2014). Therefore, privacy concerns negatively impact the emergency professionals' perceptions of C-BT deployment in natural emergencies.

It was also found that the individual emergency professionals perceived that the system and infrastructure vulnerability inhibited the usage of C-BTs, especially in the response stage, which was manifested in the currently utilised immature and cumbersome system, and the weak telecommunication network which resulted in issues of less coverage of Internet and more overloaded networks. It not only confirms what previous literature highlights that the vulnerability of infrastructure is a barrier to maintaining the business continuity in natural disasters, which includes the infrastructure damage (Schlosberg et al., 2017), poor coverage (Anikeeva et al., 2015), or network overload (Friedrich-Baasner et al., 2018), but also extends the literature by emphasising that the perceived system and infrastructure vulnerability influence the actual C-BT usage in natural emergencies. Hence, the vulnerability of systems and infrastructures has a negative impact on the emergency professionals' perceptions regarding C-BT usage in natural emergencies.

Another finding is that the individual emergency professionals perceived C-BT usage as being quite vulnerable when encountering the unpredictable situations of network disconnection, power outage, system breakdown, especially during the response stage. For example, the individual emergency professionals from the frontline agencies, FNS, PNS, and JNS, especially required priority to access the network during the response stage. This is aligned with prior literature highlighting one key barrier to utilising cloud-based technologies in natural emergencies is the possible unexpected network failure and power outage (Anikeeva et al., 2015; Chang, 2015; Srivastava & Ray, 2016). It is found in Anikeeva et al.'s (2015) study that ensured continuous network connection is critical to individual emergency professionals' perceptions regarding cloud-based systems usage so that they can link to each other in receiving important updates needed at a particular point of time during the response stage. It is further highlighted that it is important to make sure the frontline responders are able to take the priority to access the network due to the high possibility of network overload (Khawaja et al., 2014; Klein, 2017). Therefore, the perceived vulnerability arising from unexpected situations negatively influences the emergency professionals' perceptions regarding C-BT usage in the natural emergency.

It is important to reflect that some of the concepts, such as cost advantage, compatibility and complexity, related to DOI theory were previously discussed in Section 2.6. These concepts were found important to influence the emergency professionals' perceptions of C-BT usage in this study as well. The difference is that more than one perceived relative advantage, the cost advantage in DOI, were found significant in influencing the emergency professionals' perceptions regarding C-BT usage in this research, which are unique in the context of emergency management. In terms of compatibility and complexity, it is found in prior literature that both of the factors influence the adoption of cloud computing in different contexts, but the findings of current research emphasise that both of the factors influence the emergency professionals' perceptions regarding the actual C-BT usage in natural emergencies.

Based on the discussion, it is proposed that:

P7: Fewer perceived disadvantages increase the emergency professionals' positive perceptions of C-BT deployment in natural emergencies in both preparedness and response stages.

7.2.3 Usefulness

According to the findings, most of the emergency professionals thought that if certain C-BTs were useful to them in the emergencies, it was more likely for them to deploy the technology. This finding is aligned with prior literature suggesting that perceived usefulness is an important factor that influences the decision-making in terms of system usage (Al-Mamary et al., 2014; Prasanna & Huggins, 2016; Rauniar et al., 2014; Yao et al., 2010). C-BTs with more performance expected would be more likely to be deployed by the emergency professionals. The performance of the C-BTs that was considered useful in the current study included data storage, communication, warning systems, resource management, and training management. These are discussed in the following sections.

Data storage was found to be considered by most of the participants as the most useful function when utilising C-BTs in both the preparedness and response stages of natural emergencies. Although previous literature emphasises the importance of data storage in emergency management (Hadiguna et al., 2014; Yang et al., 2017), these studies focus on the technical design of the cloud-based emergency management system to enhance the storage capacity. Therefore, little is known about the emergency professionals' perceptions of using cloud storage in managing natural emergencies. The current research thus contributes to the emergency management literature by identifying the important role of cloud storage perceived by the emergency professionals in natural emergencies. Cloud storage is important because the collected data and key files are efficiently stored on the cloud storage platforms (Mvelase et al., 2015; Yang et al., 2017). Therefore, the perceived usefulness of cloud storage increases the emergency professionals' positive perceptions regarding C-BT usage in natural emergencies.

With regard to communication, findings show that it was more likely for emergency service organisations to utilise C-BTs when the tools were perceived as useful in facilitating communication among different stakeholders. Most of the participants considered that emailing was useful both in the preparedness and response stage. There is a lack of research that has examined the perceived usefulness of emailing in natural emergencies. This research adds to the body of emergency management knowledge by highlighting that email is the main type of cloud-based communication tool that is perceived as useful when emergency professionals are dealing with natural emergencies. On the other hand, it was found that social media was utilised most by CNS both in the preparedness and response stages. HNS was another organisation which utilised social media most, but more in the response stage. The other organisations studied had not made much effort to take advantage of social media in dealing with emergencies. Nevertheless, these organisations had realised the great potential of social media and were prepared to look into that deeply. It is, to some extent, consistent with considerable previous literature that highlights the usefulness of social media for gaining real-time information from the public in natural emergencies (Alexander, 2014; Chatfield & Brajawidagda, 2013; Hiltz & Plotnick, 2013; Kaufhold & Reuter, 2017; Imran et al., 2018), but also extends the literature by identifying that social media usage is most useful to the leading agency rather than the supporting agency in the key stages of natural emergencies. It is argued that social media can facilitate emergency responders and key decision-makers to both inform and gain insights into the information from the public (Imran et al., 2015). Therefore, the perceived usefulness in communication both in the preparedness and response stage through C-BTs enhances the emergency professionals' positive perceptions regarding C-BT usage in natural emergencies.

As for warning systems, it was found that emergency service organisations acknowledged the importance of having an effective cloud-based alerting system, especially in the preparedness stage. CNS made the most effort among the six organisations in deploying the useful alerting system. Thus, CNS' national warning system was shared among all registered agencies and considered a critical and useful alerting system. Although there are previous studies that highlight the importance of cloud-based alerting system (e.g., Fang et al., 2015; Henriksen et al., 2018; Pengel et al., 2013), these studies strive to design a better cloud-based warning system so that the system could be more aligned with users' requirements. For example, Pengel et al.'s (2013) study focuses on designing a web-based early warning system for flooding, which aims to provide real-time information to predict the escape routes for people in the affected area. There is little evidence showing that the perceived usefulness of using the cloud-based alerting system in natural emergencies have been examined in the previous research. This finding contributes to the emergency management literature by highlighting the critical role that the cloud-based alerting system plays in influencing emergency professionals perceived usefulness in the preparedness stage of natural emergencies.

It was also found that there was a lack of specific cloud-based resource management tools in emergency services organisations in New Zealand. Participants from CNS, JNS and HNS, emphasised the significance of having a useful resource management system, such as in shift management or managing resource requests in the preparedness stage. It is, to some extent, aligned with a small number of previous studies that acknowledge the need of having a cloud-based resource management system for emergency management, but with more focus on the technical designs of the system to realise efficient resource allocation (e.g., Bennett, 2011; Fang et al., 2014; Gubbi et al., 2013). For example, Gubbi et al.'s (2013) study aims to design a system that enables efficient resource management through monitoring critical utilities status in the emergencies. The finding extends the previous research by emphasising that having a cloud-based resource management system in place is perceived as critical to assisting the emergency professionals' operations in natural emergencies.

Additionally, some participants mentioned that there was a lack of a useful cloud-based training system and standard system usage training mechanism in place in New Zealand emergency services organisations. Therefore, the organisations studied had not placed much emphasis on the management of training. With an exception, emergency professionals considered that email was useful in organising an upcoming functional exercise. There is a lack of prior research concerning specific cloud-based training management system usage in emergency management but some limited research focusing on designing a training system for emergency command and control (Ntuen et al., 2006) or creating a prototype for training mass gathering in the preparedness and recovery stage of emergencies (Haghighi et al., 2013). Therefore, there is a lack of research that examines the perceived usefulness of the cloud-based training management system in emergency management. Nevertheless, it is argued that it is important for organisations to have an effective training management system when managing emergencies due to the large number of employees who require training to become more familiar with the processes in the exercise (Al-Mamary et al., 2014;

Sanchez-Gordon et al., 2015). It is further claimed that it is critical to digitalise the training process in order to better standardise the procedures of training for the emergency responders, thus facilitating the operation in the real emergencies (Hijji et al., 2015). Hence, the findings in the current research add to the body of knowledge in the emergency management area through highlighting the usefulness of a cloud-based training management system perceived by emergency professionals in the preparedness stage.

Based on the discussion, it is proposed that:

P8: Greater usefulness of cloud-based technologies increases emergency professionals' positive perceptions of C-BT deployment in natural emergencies both in the preparedness and response stages.

7.2.4 Deployment Model Type

The type of cloud deployed that was perceived useful was mentioned by most of the participants was a private cloud. Therefore, different types of internal clouds were utilised: the official website, email system, cloud-based mapping systems, key emergency management system, and some mobile applications. Although an increasing number of studies have investigated the private cloud-based system for emergency management (e.g., Chang, 2015; Gubbi et al., 2013; Aazam & Huh, 2015), these studies focus on the architectural design of the systems. Therefore, little is known about the emergency professionals' perceptions of using a private cloud in managing natural emergencies. The current study thus contributes to the emergency management literature by identifying different types of private cloud that are considered useful to emergency professionals.

In terms of the official website, some participants considered the official website a standard way to reach the public for education and dissemination of early warnings in the preparedness stage. For example, as the leading agency, CNS utilised the official website most among the six organisations since it found the website useful in terms of warning and sharing educational information regarding emergency preparedness with the public. Previous research acknowledges the usefulness of the privately owned official website in natural emergencies (Chartfield & Brajawidagda, 2013; Lee et al., 2012). For example, tsunami early warning was conducted through using the official website to direct the public to the link of the official Twitter account by Indonesia meteorology, climatology and geophysics agency (Chartfield & Brajawidagda, 2013). The finding in the current research is not only consistent with previous literature but also extends it by highlighting that the leading agency placed more emphasis on using the official website in natural emergencies.

Interestingly, the internal email systems were found important to all six organisations since the communication that was conducted internally or externally in the preparedness and response stages relied on the internal email systems. This finding is aligned with only one study that highlights the usefulness of internal email system in emergencies (Bhandari & Curnin, 2012). External email systems, such as Gmail, was only noticed in one earthquake exercise, which means all organisations relied more on internal email systems due to the security concerns. However, Jones et al.'s (2017) research shows that some UK councils, as the early adopters of the public cloud, decided to remove their current internal email but use public cloud Gmail instead due to the benefits of cost saving. The finding of this research is different from that of Jones et al. (2017) as New Zealand emergency organisations took security as the priority even though the cost was also a big concern. Thus, this research contributes to the emergency management literature by identifying that internal email systems still play an important role in New Zealand emergency services organisations.

Additionally, all organisations highlighted the value of cloud GIS, which could facilitate them in making decisions about resource allocation, especially in the response stage. Nevertheless, only participants from CNS, FNS and PNS highlighted that their organisations had a certain capacity in deploying cloud-based GIS. Although all six organisations were far from reaching full satisfaction with the current cloud GIS, the systems utilised at the moment were considered valuable. Previous literature draws more attention to the architectural design of cloud GIS, such as in accelerating the decision-making process (Yusoff et al., 2015), enhancing ability in processing geospatial data (Kharouf et al., 2017), or evaluating risk level of meteorological hazards (Li et al., 2014). Little is known about the emergency professionals' perceptions regarding the actual usage of the privately owned cloud GIS during natural emergencies. Therefore, the finding in the current research adds to the body of knowledge in emergency management literature by emphasising the perceived usefulness of cloud GIS when managing natural emergencies, especially in the response stage.

In addition, CNS' and HNS’ specific emergency management systems were considered more useful in the response stage for information gathering and reporting while in the preparedness stage, the system was only able to store key documents, such as plans. This finding is aligned with extant research that highlights the usefulness of the specific types of emergency management information system in the response stage (Brooks et al., 2013; Homma, 2015; Kanbara et al., 2017). It is emphasised that such a system is especially useful in the response stage, better facilitating emergency professionals to organise available information and resource in an easy, effective and cooperative way (Kanbara et al., 2017). For example, Homma (2015) highlights the important role the emergency medical information system played in 2011 Great East Japan Earthquake where the system was utilised by a dispatched medical assistance team to share critical medical information in order to coordinate activities and conduct the aeromedical evacuation.

Even though all six organisations mainly used the private clouds, it was found that a large number of participants considered the public clouds helpful. The main types of the external clouds utilised by these organisations were social media, external storage, mapping systems and the free open-source applications. The main reason for using those types of public cloud was that these tools were able to complement the inadequacies of the internal C-BTs currently owned by the organisations. Second, it was because public clouds provided the organisations with convenience and cost-effectiveness. This is consistent with the extant research that highlights that external cloud providers had more capacity in providing enhanced efficiency, convenience (Chen et al., 2012; Cowick & Cowick, 2016; Han, 2011) and cost-effectiveness (Ren et al., 2012; Hashem et al., 2015; Nebert & Huang, 2014) of services to satisfy the users’ needs.

Based on the discussion, emergency professionals are more likely to use both private and public cloud since a single type of cloud is not able to better facilitate the operation.

Therefore, it is proposed that:

P9: Mixed usage of C-BT deployment model types has a greater effect on emergency professionals' positive perception of C-BT deployment than the usage of a sole type of C-BT in natural emergencies in both preparedness and response stages.

7.3 Individual Factors influencing Cloud-based Technologies Deployment

This section focuses on the discussion of the *individual factors* that influence the emergency professionals' perceptions regarding C-BT deployment in natural emergencies. The factors are enhancement expectation, human factors, and knowledge. The discussion contributes to the establishment of the next three propositions. Figure 7-4 presents the next three propositions.

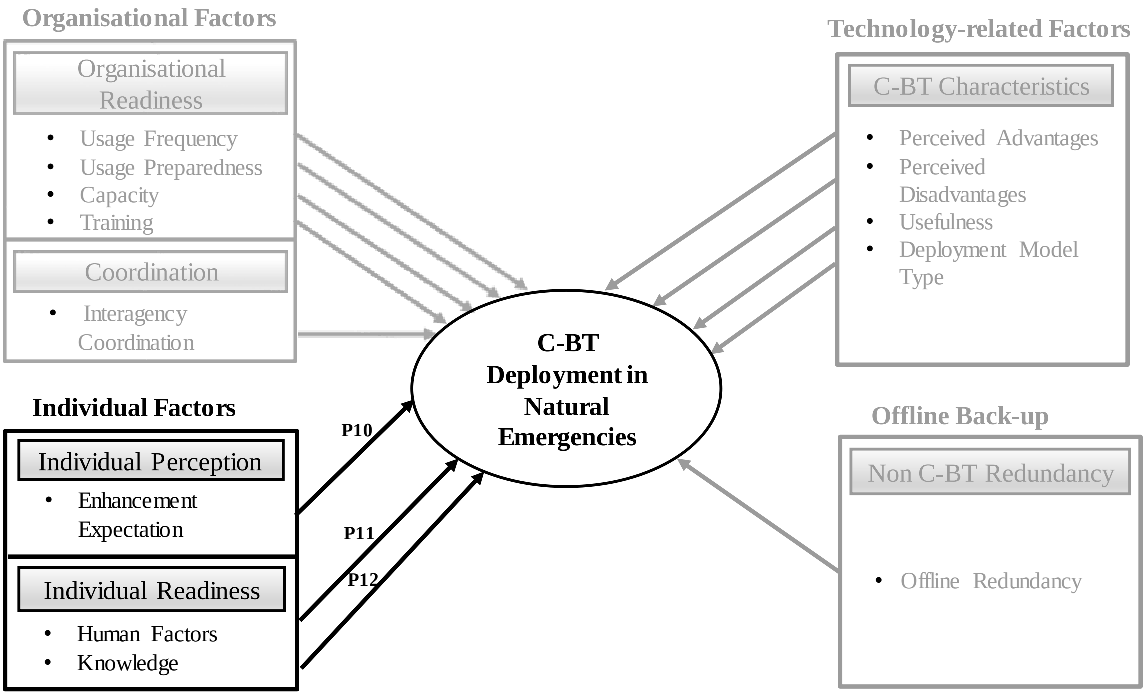


Figure 7-4 Propositions based on individual factors influencing C-BT deployment in natural emergencies

7.3.1 Enhancement Expectation

According to the findings, improvements were expected to be made in terms of C-BT usage by most of the individual emergency professionals. For example, this included how to host key C-BTs, better system designs, and uninterrupted connections. Findings show that hosting private cloud externally was preferable to organisations due to insufficient IT capacity and support, thus helping to reduce the maintenance effort on the infrastructure. This finding is in line with previous literature highlighting that external hosting is suitable for organisations without sufficient IT capacity, gaining the benefits of pay per use and avoiding huge efforts of maintaining infrastructure (Carroll et al., 2011; Vuppala & Kumar, 2014; Zhang et al., 2010). It is argued that private cloud is securer than the cloud that is fully hosted externally due to the relatively higher degree of reliability, security, and control over the system (Wan et al., 2013). Nevertheless, private cloud deployment requires capital and a highly skilled IT team (Gupta et al., 2013; Puthal et al., 2015). This reflects why the emergency professionals wanted to move to external services: that is, the benefits that could be gained through hosting cloud services externally, such as reduced confusion, and the extensive IT capability (Waga & Ragah, 2014).

In terms of system advancement, most of the participants were eager to make improvements to the current systems. This included certain aspects that were not available in the current system, especially in terms of the enhanced collaboration and GIS capabilities. The finding confirms what previous research suggests, that the improvements on current emergency management system usage are sought after by individual emergency professionals (Little et al., 2015; Vatcharapong & Shirahada, 2014; Yao et al., 2010) so that better performance can be delivered when dealing with emergencies. Participants from CNS and HNS expected the better collaboration capability in their key emergency management system where it was not able to share information or documents immediately at that time. Nevertheless, it was particularly important in the response stage since real-time information was required. It is, to some extent, consistent with extant research that emphasises the importance of a collaborative feature when designing an emergency management system (Li et al., 2014; Wu et al., 2013). Emergency professionals will be more likely to have positive perceptions regarding the type of C-BT that is able to support performance in a collaborative manner. Apart from that, participants expected to enhance the GIS capability to enhance the situation awareness through accessing real-time information, thus allocating resources more effectively. This, to some extent, confirms what previous studies indicate, that better cloud-based geographic information system is critical to enhancing situational awareness (Adam et al., 2012; Hiltz & Plotnick, 2013; Romano, 2015).

The better system design was important to many participants. For example, participants in CNS and HNS expected to share formation directly in the key emergency management system. Likewise, previous literature highlights that it is important to share critical information in a timely manner when dealing with emergencies (Francalanci et al., 2017; Seppänen et al., 2013). This finding, to some extent, is also aligned with prior literature that focuses on designing the emergency management system but emphasises the significance of satisfying the end-users' need of the system in emergencies which could improve the emergency personnel's overall performance during the operation (Johnston et al., 2014; Munadi et al., 2011). Therefore, the improved function in the current system was particularly pursued by emergency professionals in the current research.

Another finding in this study was that some participants considered that uninterrupted connection was particularly important to keep the C-BTs working, thus supporting their jobs in emergencies. However, connection lost was perceived as a big barrier to deploying C-BTs during large-scale natural emergencies. Likewise, previous literature acknowledges the challenge of an unexpected interruption of Internet connection in natural emergencies (Geumpana, Rabhi & Zhu, 2015a; Johnston et al., 2014; Schimak et al., 2015; Srivastava & Ray, 2016). It is argued that the data collection process during the response stage of natural emergencies may be exacerbated and disrupted due to the absence of Internet connection, thus preventing vital information reaching the emergency operation centre in time to respond immediately (Geumpana et al., 2015a; Maryam et al., 2016). Therefore, having a continuous connection was exactly what the participants in the current research would like to improve the key emergency management systems working. It was also found that some participants mentioned that they tried to look at other options to counteract this problem, mainly the utilisation of the satellite Internet to support the continuous work even though the cost was high. The finding is, to some extent, consistent with a small but growing number of studies which highlight the importance of having uninterrupted Internet connections but focusing more on discovering how to counteract the problem of keeping applications running while the Internet connection is lost, such as designing an Internet-less deployment mechanism for running emergency related applications (Al-Akkad & Raffelsberger, 2014), investigating a system for disseminating mapping information with a low power sensor system (Johnston et al., 2014), or examining the effectiveness of solar-powered Internet system in enabling continuous performance (Srivastava & Ray, 2016). Therefore, emergency professionals will have more positive perceptions with C-BT usage when solutions for uninterrupted Internet connection or alternatives to support continuous system performance are available.

For these reasons, the findings suggest that:

P10: The greater the enhancement expectations are satisfied, the more positive perceptions emergency professionals will have of C-BT deployment in natural emergencies, especially in the response stage.

7.3.2 Human Factors

Findings in the current research show that the individual emergency professionals were more willing to use the cloud-based system attractive to them. Extant literature indicates that system attractiveness is a key factor in influencing the individual's adoption of a new technology in non-emergency management settings, such as e-learning (Al-Jumeily et al., 2012), a railway management system (Laroche & Guihéry, 2013), or a supply chain governance system (Ran et al., 2016), but limited literature has highlighted that the system attractiveness influences the individual emergency professionals' perceptions of C-BT usage in natural emergencies (Lee et al., 2011). The finding in this research confirms what Lee et al.(2011) emphasise, that due to the personal interest of the individual emergency professionals, there is the possibility for them to prefer other specific systems that they have already known and have proved themselves to be value-added in facilitating the tasks even though they might have been encouraged to use required information system by the higher authority (Lee et al., 2011). Findings also reveal that the lack of system attractiveness especially happened on the CNS' E System which was required to be used by related agencies during the multi-agency emergencies. However, some participants did not perceive that the system added value. The finding in this research is, to some extent, aligned with extant literature that discovers the perceived value positively influences individual emergency professionals' intention to use C-BTs in emergencies (Lee et al., 2011; Rao, Plotnick, & Hiltz, 2017; Plotnick, Hiltz, Kushma, & Tapia, 2015). Therefore, the system's attractiveness significantly influences the individual emergency professionals' perceptions regarding C-BT usage in natural emergencies.

It was also found that most of the individual emergency professionals were not resistant to using relatively new C-BTs in managing emergencies as long as the technologies were helpful. This finding is different from prior research that indicates that the reluctance to change is one key inhibitor to the adoption of new technology, such as in the educational technology (Watty et al., 2016), health IT system (Bezboruah et al., 2014) or enterprise system (Soja, 2015), although none of these studies examined reluctance to use C-BTs in the emergency management arena. According to Soja (2015), the reason for the reluctance to change is the stability that people are pursuing, and having difficulties with new technology, results in negative attitudes towards the adoption. However, in the context of managing natural emergencies, it is understandable that near real-time information is required within the limited time so that the technology which can support retrieving necessary information in a timely manner is sought after. Therefore, there was a higher acceptance level for using C-BTs among the individual emergency professionals in New Zealand. The diminished reluctance to change contributes to the emergency professionals' more positive perceptions regarding C-BT usage in natural emergencies.

The study also found that emergency professionals acknowledged that older employees might have problems with relatively new technologies. Thus, the older employees who were less proficient in technology usage were allocated to other jobs with more traditional technologies. This finding is aligned with prior research claims age as an inhibitor of technology adoption and technology anxiety (Chou et al., 2013; Johnson et al., 2012; Wu et al., 2015) or having moderating effect on IS adoption (Guo et al., 2015; Leong et al., 2013). This is because that older system users are found to be less tech-savvy and have lower self-confidence and interest in new technologies, leading to higher level of technology anxiety (Russo et al., 2012; Wu et al., 2015). Further, the change in the way of thinking and physical status may cause the unwillingness to accept new technologies (Charness & Boot, 2009).

In addition, findings show that the confidence in C-BT usage varied among individual emergency professionals, depending on IT literacy and perceptions regarding the simplicity of the system. It was found that emergency professionals with higher IT proficiency had more confidence in using cloud-based systems since they were not afraid of using different types of browsers, operation systems, and cloud-based platforms. Thus, low IT literacy resulted in lower confidence in the usage of different platforms. Aligned with the previous research, it is argued that the lack of computer literacy negatively influences the confidence in technology usage (Ichikohji , 2016; Mac Callum & Jeffrey, 2014). This is because the individual users of the system will be sceptical about their own ability to operate the system properly (Kuo et al., 2013). In Findik and Ozkan's (2013) study, it is found that employees with higher computer literacy have more confidence in utilising the learning management system to deliver performance in the organisation. Further, findings in this research reveal that individual emergency professionals who perceive the system as complex to use were more likely to have a low level of confidence in C-BT usage. It is argued that less complex systems are more likely to reduce the users' technology anxiety, resulting in more self-confidence in their system use (Mac Callum & Jeffrey, 2014; Kang, 2014). Even though prior literature highlights that the simplicity of the system results in enhanced self-efficacy in the system usage (Findik & Ozkan, 2013; Kang, 2014), none of these studies are conducted in the context of emergency management. Therefore, this research not only confirms previous research findings but also extends them by identifying that self-confidence positively influences the emergency professionals' actual C-BT usage in natural emergencies.

It was also found that emergency professionals who were more willing to make personal efforts in searching and applying C-BTs external to the organisations were more likely to have positive perceptions regarding C-BT usage. For example, it was found that participants from the key frontline agencies were highly self-motivated in utilising their own smart devices to access applications, especially software-as-a-service, that were external to the organisations to enhance the flexibility and efficiency of the frontline jobs. This finding is partially aligned with prior literature highlighting that with the emergence of cloud computing, bring your own device (BYOD) is better enabled where it is more convenient for employees to use their personally owned mobile devices at the workplace, resulting in enhanced flexibility (Jo et al., 2015; Wang et al., 2015).

On the other hand, findings show that emergency professionals with fewer privacy concerns were more likely to trust an external cloud. For example, emergency professionals from PNS and JNS had more conservative attitudes towards external cloud usage due to the concern of leaking private information. This finding is consistent with previous literature that highlights privacy concern as one key barrier to the adoption of cloud computing (Friedrich-Baasner et al., 2018; Oliveira et al., 2014). It is argued that whether cloud computing usage can adequately ensure the protection of private information is not clear so that organisations still have concerns about the adoption of cloud computing (Avram, 2014). It was also found that emergency professionals who had more trust in the service level agreement provided by the cloud service provider were more likely to use external cloud services. This is consistent with the literature which highlights that the external cloud services are more likely to be adopted by consumers when all requirements in the service level agreement are met and the requirements are continuously guaranteed by the services providers (Almorsy et al., 2016; Avram, 2014; Hussain et al., 2014; Manuel, 2015). Therefore, a higher level of trust in using cloud-based systems will lead to the emergency professionals' having more positive perceptions regarding C-BT usage in natural emergencies.

Based on the arguments, it is proposed that:

P11: A higher level of personal interest and more positive attitudes towards new technology increase the emergency professionals' positive perceptions of C-BT deployment for natural emergencies in both preparedness and response stages.

7.3.3 Knowledge

At the individual level, findings show that having a certain level of knowledge and awareness of C-BTs was important to individual emergency professionals in emergency service organisations since it could better facilitate in making appropriate choices over the application that they wanted to use in the operation and have more confidence in C-BT usage. It is consistent with the previous literature that suggests that the lack of awareness of cloud-based systems is huge inhibitor to applying such technology as necessary in certain contexts, such as SMEs or IT companies (Alismaili et al., 2016c; Mohlameane & Ruxwana, 2014; Trigueros-Preciado et al., 2013; Yeboah-Boateng & Essandoh, 2013; Awosan, 2014), but none of these studies concern emergency management. Therefore, this research extends the literature by highlighting the importance of enhancing awareness of C-BT in the context of emergency management.

It was also found that most of the emergency professionals had more awareness of the internal cloud-based system within the organisations. In other words, individual emergency professionals were less likely to be aware of cloud-based systems that were external to the organisations. The reason was that each organisation focused more on its own needs that were required to be satisfied through its own system. Nevertheless, the awareness of useful C-BTs in other organisations is beneficial to the improvement of C-BT usage. This finding is consistent with previous research highlighting that through enhancing the awareness of other organisations' cloud computing usage, lessons in terms of the benefits and challenges can be learned to contribute to the future usage, especially in the context of SMEs (Ghaffari et al., 2014; Mohlameane & Ruxwana, 2014). Therefore, having a certain level of awareness of both internal and external cloud-based systems is beneficial to enhancing the emergency professionals' positive perception regarding C-BT usage when dealing with emergencies.

Apart from the findings on the awareness of C-BTs, it was also found that some emergency professionals lacked the knowledge of cloud computing in terms of its definition and deployment model type. Thus, they did not realise that the deployed internal systems were private clouds while they only knew of the outsourced cloud solutions. The weak knowledge owned by the emergency professionals resulted in the frustration when there was a need for establishing, selecting or improving a particular type of C-BT. The finding is consistent with previous literature that acknowledges the importance of possessing a certain level of knowledge in cloud computing, which is beneficial to the organisation's real utilisation (Alismaili et al., 2016a; Awosan, 2014; Khan & Al-Yasiri, 2016; Trigueros-Preciado et al., 2013; Yeboah-Boateng & Essandoh, 2013). Findings also show that most of the emergency professionals who lacked C-BT knowledge in this research were from large government organisations. This finding is different from prior research that highlights that large organisations have fewer problems in mastering knowledge of cloud computing than SMEs due to having more knowledgeable employees (Alismaili et al., 2016b; Mohlameane & Ruxwana, 2014; Trigueros-Preciado et al., 2013). Nevertheless, it is argued that as the emergency personnel and first responders, they must be well educated in technology knowledge and usage skills to better assist the community in emergencies (Russo, 2014). The enhanced effectiveness of the performance could be achieved through the C-BT usage. Hence, the more the emergency professionals know about cloud computing, the stronger the likelihood for them to have less vulnerability in choosing and using C-BTs.

On the basis of the discussion, it is proposed that:

P12: The more C-BT knowledge and awareness the individual emergency professionals have, the stronger the likelihood of increasing their positive perceptions on C-BT deployment in natural emergencies in both preparedness and response stages.

7.4 Offline Redundancy influencing Cloud-based Technologies Deployment

Findings in the current research suggest that all six organisations placed emphasis on having redundancies in advance to deal with unexpected situations that would interrupt the usage of C-BTs in the response stage. Therefore, four types of *non-C-BT redundancies* were categorised from the findings: paper-based operation, different ways of storage, multiple ways of communication, and alternatives for Internet connection. Without these redundancies, the operation in the response stage would not be working continuously. Figure 7-5 presents the last proposition.

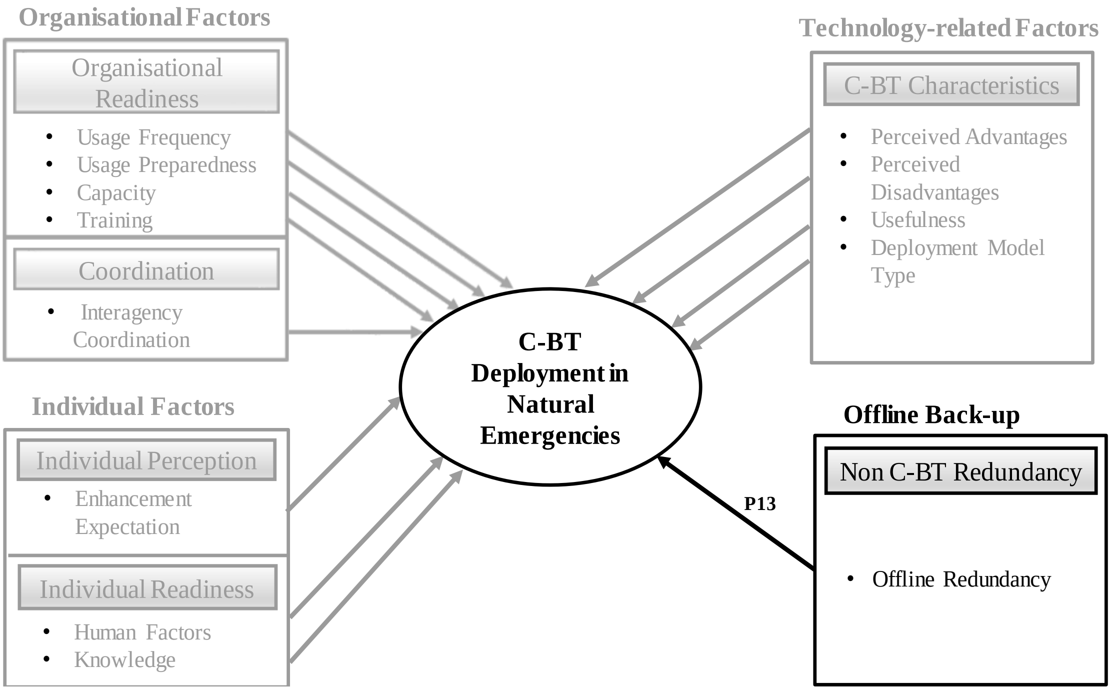


Figure 7-5 Propositions based on offline redundancy influencing C-BT deployment in natural emergencies

In the current research, it was found that having paper-based plans, procedures, templates in place before the unexpected situation happens was considered important to keep business continuity in the response stage, which helped the emergency professionals to ease their concerns of not having connections to support C-BTs. There is a lack of previous emergency management research which directly stresses the importance of having paper-based redundancies, with the exception of Farfel et al.'s (2011) research regarding the deployment of a computerised system for hospital information gathering in the Haiti earthquake. The finding confirms what Farfel et al. (2011) clearly indicated that the lesson learned in the earthquake is that having hardcopy paper forms should be mandatory. On the other hand, limited previous literature highlights the importance of having the business continuity plan, which indicates the importance of having paper-based redundancies to enhance the readiness for the unforeseen natural emergencies (Matchen & Hawkins, 2015; Whitworth, 2006). For example, Whitworth (2006) asserted that it is important to keep the continuity of the operational plans, ensuring that the necessary functions still work during the emergency. One of the significant components of continuity of operations plans is an alternative way of access to critical data (Whitworth, 2006). This is because there is a high possibility for any technology to break down during unexpected large-scale natural emergencies. Even though not many previous studies emphasise the significance of having paper-based redundancies, the finding reveals that paper-based redundancy was important to enhance the emergency professionals' perceptions of using C-BT in current research.

In addition, findings show that storing key documents on the hard drive was considered another important way of backing up files in case of any unexpected situations in the response stage. For example, some participants preferred to have alternate places to store key documents which had been stored on internal systems. Previous studies highlight the importance of having an alternative way of backing up data emergencies since there is still a high possibility of losing data even though it is stored in cloud-based systems (Chang, 2015; Kazim & Zhu, 2015). However, these studies do not address the issue of the role that storage redundancy plays in influencing emergency professionals' perceptions regarding C-BT usage. The finding thus contributes to the existing literature by emphasising the significant role of storage redundancy in enhancing the emergency professionals' positive perceptions in using C-BT during emergencies. It is argued that despite which type of the cloud is utilised: public, private, or cloud, it is a continuous challenge in terms of fully ensuring that data will not be lost or corrupted at any time (Chang, 2015). Therefore, having alternative ways of redundant files was perceived as very important regardless of whether or not the cloud-based systems are used.

In terms of communication redundancy, most of the participants thought that it was important to keep some conventional technology for communication, such as radio networks, phone calls, or text messaging, even when C-BTs were still functioning in the response stage. This was because the participants thought the reliability of traditional tools was not completely substituted. Further, the advanced tool, the satellite phone, was also prepared in case there was no means of communication with key stakeholders. Previous studies emphasise that having alternative ways of communication is significant in natural emergencies (Feldman et al. 2016; Sakurai & Watson, 2015; Ruiz-Martin et al., 2016), which is even better before the internal key emergency management system can be operationalised (Elachola et al. 2016). For example, Sakurai and Watson (2015) highlight that, in the 2011 Japan earthquake, the municipalities relied on satellite phones for information sharing although the frequently-used channels, such as Internet mail, official website, or social media platforms were also deployed. This echoes the viewpoint which emphasises that the role that the relatively traditional communication tools play in natural emergencies should not be underestimated (Romo-Murphy et al. 2011). These studies highlight the importance of having communication redundancies in natural emergencies but do not address the role that the communication redundancy plays in influencing the emergency professionals' perceptions of using C-BTs during emergencies. The finding thus contributes to the existing literature by emphasising the significant role of the communication redundancy in easing the emergency professionals' concerns of C-BT usage in natural emergencies.

With regard to connection redundancy, almost half of the participants had concerns about losing Internet connection to support C-BT usage. They mentioned the alternative ways, such as data sticks, or satellite Internet, to reconnect to the Internet if any disconnection took place in the response stage. It was particularly important to emergency services organisations in large-scale natural emergencies where the infrastructure might be destroyed. Many previous studies acknowledged the importance of having a stable Internet connection during large-scale natural emergencies since it is the prerequisite to support the key cloud-based systems to work continuously in the response stage (Geumpana et al., 2015; Tarif et al., 2016; Wen et al., 2018). Another stream of previous studies emphasise the significance of having the connection redundancy, especially, through using satellite Internet in natural emergencies (Goldstein, 2010; Oseni et al., 2016; Patel et al., 2016; Ryan, 2013). For instance, Goldstein's (2010) research shows that the alternative ways of Internet connection through satellite helped aid workers to coordinate the rescue operations in the 2010 Haiti earthquake where the telecommunication infrastructure was damaged severely. However, these studies focus mainly on humanitarian organisations' satellite Internet usage in natural emergencies. Little is known about the role of having connection redundancy in influencing the emergency professionals' C-BT usage perception in either government or humanitarian organisations. Therefore, findings in the current research add to the body of knowledge through highlighting that the connection redundancy increases the emergency professionals' positive perception of C-BT usage, especially in the response stage.

Based on the discussion, it is proposed that:

P13: Greater offline redundancy increases the continuity of emergency professionals' C-BT deployment in the response stage of natural emergencies.

7.5 Chapter Summary

In summary, this chapter discusses the findings, which helps to address the research question of

What are the perceptions of emergency professionals on the usage of cloud-based technologies in the preparedness and response stages of natural emergencies in New Zealand?

Based on the literature review in Chapter Two, an initial conceptual idea (Figure 2-6) was proposed in terms of the key technology attributes that influence emergency professionals' perceptions regarding C-BT deployment in natural emergencies. The final model (Figure 7-1) in Chapter Seven emerged from data analysis, and shows that the factors influencing the perceptions of C-BT deployment are not limited to the three pertinent technology attributes, relative advantage, compatibility, and complexity in the emergency management context. Rather, a more comprehensive model concerning organisational factors, individual factors, C-BT-related factors and non-C-BT remedies emerged from the data. Findings from the current research reveal *organisational readiness, inter-agency coordination, individual perceptions, individual readiness, C-BT characteristics, and non-C-BT redundancy* constitute the six categories of elements influencing the emergency professionals' perceptions of C-BT deployment in natural emergencies. As a result, 13 propositions were formed. These propositions are presented here which shows the area of influence regarding emergency professionals' perceptions of C-BT usage, and also provides the direction for future research that is discussed in Section 8.5.

Section 7.1 discusses *organisational factors* influencing emergency professionals' C-BT usage perceptions in natural emergencies. In terms of the usage frequency, the enhanced C-BT usage familiarity and usage level contribute to the emergency professionals' positive perceptions of C-BT usage in natural emergencies (***proposition1***). The findings extend previous literature by discovering the importance of enhancing the familiarity with private cloud usage in managing natural emergencies and highlighting the important role of supportive agencies in using key C-BT frequently. With regard to usage preparedness, the emergency services organisations' increased usage readiness enhances the emergency professionals' positive perceptions of C-BT usage in natural emergencies (***proposition2***). The findings extend prior literature by identifying the importance of enhancing key C-BT usage commitment when managing natural emergencies. As for capacity, the greater organisational capacity in supporting C-BT usage increases the emergency professionals' positive perceptions of C-BT usage in natural emergencies (***proposition3***). The finding that is different from previous research is that large organisations do not necessarily have sufficient resources in covering the cost and taking the risk of investing in cloud computing. In terms of training, the frequent and consistent training of C-BT increases the emergency professionals' positive perceptions of C-BT usage in natural emergencies (***proposition4***). The finding extends previous literature by highlighting the importance of having consistent C-BT training rather than general ICT training for managing natural emergencies. In association with inter-agency coordination, the greater inter-agency coordination enhances the emergency professionals' positive perceptions of C-BT usage in natural emergencies (***proposition5***). The finding contributes to the existing literature by discovering that relationship establishment has an indirect influence on emergency professionals' confidence in actual C-BT usage.

Section 7.2 discusses *technology-related factors* influencing emergency professionals' C-BT usage perceptions in natural emergencies. The greater perceived advantages increase the emergency professionals' positive perceptions of C-BT usage in natural emergencies (***proposition 6***). The findings extend by highlighting the perceived mobility as being particularly important to emergency professionals in frontline organisations. It also contributes to the literature by identifying another two important perceived advantages (i.e., situational awareness and transparency) that was not addressed by the previous literature.

Further, the less perceived disadvantages increase the emergency professionals' positive perceptions of C-BT usage in natural emergencies (***proposition 7***). Findings are consistent with the previous studies, but there is a lack of study in the context of emergency management. Moreover, the greater usefulness of C-BTs perceived by the emergency professionals increases their positive perceptions of C-BT usage in natural emergencies (***proposition 8***). The findings highlight the critical role of email in both preparedness and response stages. The findings also extend prior literature by identifying that social media usage is most useful to the leading agency rather than the supportive agency in the key stages of natural emergencies. In terms of deployment model type, it is proposed that mixed usage of private and external clouds contributes to the emergency professionals' positive perceptions of C-BT usage in natural emergencies (***proposition 9***). Little is known about the emergency professionals' perceptions of the actual usage of private cloud in natural emergencies. The findings make contributions by identifying the types of private clouds that are perceived as useful by the emergency professionals

Section 7.3 relates to *individual factors* influencing emergency professionals' C-BT usage perceptions in natural emergencies. The greater enhancement expectation results in the emergency professionals' more positive perceptions of C-BT usage in natural emergencies (***proposition10***). A higher level of personal interest and more positive attitudes towards new technology increase the emergency professionals' positive perceptions of C-BT usage in natural emergencies (***proposition11***). The resistance to C-BT usage was not found to be a huge issue which is different from previous studies in non-emergency management field. Additionally, more C-BT awareness and knowledge increase the likelihood of the emergency professionals' positive perceptions of C-BT usage in natural emergencies (***proposition12***). This finding is different from previous research which highlights that large organisations have fewer problems of mastering C-BT knowledge than SMEs.

Section 7.4 presents a discussion of how *offline redundancy* influences emergency professionals' C-BT usage perceptions in natural emergencies. It is proposed that the greater offline redundancy increases the emergency professionals' positive perceptions of C-BT usage in natural emergencies, especially in the response stage (***proposition13***). The findings contribute to the existing literature by highlighting four types of offline redundancies that influence the emergency professionals' perceptions of C-BT usage during the response stage of natural emergencies.

CHAPTER EIGHT - CONCLUSION, IMPLICATIONS, LIMITATIONS AND FUTURE RESEARCH

8.1 Conclusion

The use of cloud-based technologies (CB-Ts) has had a disruptive impact on business generally, but, to date, significantly less in the key area of emergency management. Equally, the role that C-BTs might play in emergency management from a research perspective has not been examined. This research explored the potential positive disruption that C-BT might have in the key stages of the emergency management life cycle and understand the emergency professionals' perceptions of C-BT usage in emergencies associated with natural events. The research addressed the first research question of *'How can cloud-based technologies benefit emergency services organisations in the preparedness and response stage of natural emergencies?'* by carrying out a comprehensive review of the extant literature to propose a conceptual idea which depicts the potential usage of C-BTs in the preparedness and response stages. Whilst understanding the potential usage of C-BTs in the key stages is important, it is even more important to understand the emergency professionals' perceptions of the actual potential usage of C-BTs in natural emergencies because they are the key decision makers who will ultimately adopt and then use C-BTs when dealing with emergencies. The research thus addressed the second research question, '*What are the perceptions of emergency managers on the usage of cloud-based technologies in the preparedness and response stages of natural emergencies in New Zealand?'* by establishing a comprehensive framework of multi-dimensional elements that influence C-BT deployment for managing natural emergencies in New Zealand emergency services organisations. This framework outlines four critical aspects that influence C-BT deployment in natural emergencies: *organisational factors, technology related factors, individual factors, and offline back-up,* which were further broken down into six core factors: *organisational readiness, coordination, C-BT characteristics, individual perceptions, individual readiness and non-C-BT redundancy*. The core of the framework suggests that the likely utilisation patterns of C-BTs for managing natural emergencies in emergency services organisations are influenced by diverse factors as a whole.

This research makes two significant theoretical contributions. Little has been suggested by previous literature in terms of classifying the potential usage of C-BTs in the preparedness and response stages in emergency management life cycle. This research proposed a conceptual idea which categorises the potential usage of three well-known types of C-BTs (social cloud, cloud GIS and cloud storage) in the preparedness and response stages. This research posits that understanding the potential usage of C-BTs in the key stages of emergency management life cycle is important since each stage has a different focus on the applications of C-BTs. The conceptual idea highlights the different focus of the applications of the three C-BTs in the preparedness and response stages.

The other significant contribution of this research is the comprehensive framework of multi-dimensional elements that influence C-BT usage in natural emergencies. Prior research focuses on the technical designs of C-BTs for managing emergencies, however little is known about how C-BTs are perceived by emergency management professionals, especially in terms of the preparedness and response stages. This research investigated the emergency professionals' perceptions against actual usage of C-BTs across six cases of major emergency management organisations in New Zealand with a focus on the preparedness and response stages of natural emergencies. Applying grounded theory analysis to multiple sources of data, a framework was established to examine the multi-dimensional elements that influence the utilisation patterns of C-BTs in emergency services organisations during emergencies associated with natural events. The thesis concludes that the New Zealand emergency management organisations wish to take the advantage of the clear benefits afforded by cloud-based technologies in emergency preparedness and response since the current usage level of C-BTs is low, especially in terms of training in the preparedness stage and the lack of mobile devices to facilitate real-time communication at frontline operation in the response stage. The awareness of these patterns can help the use of C-BT to improve and integrate emergency situation preparations and responses.

8.2 Theoretical Implications

The thesis makes several major theoretical contributions. First, this research adds to the body of knowledge about C-BT deployment specifically in the context of emergency management. The thesis makes an important contribution by establishing an in-depth understanding of the factors influencing the emergency professional's perception of C-BT deployment in natural emergencies. Findings from the research offer a comprehensive framework of multi-dimensional elements that influence the deployment of C-BTs in the context of emergency management. Six elements derived from the findings and constituted the framework, including *organisational readiness, inter-agency coordination, C-BT characteristics, individual perception, individual readiness, as well as non- C-BT redundancy*. This framework comprehensively encompasses the organisational factors, technology-related factors, individual factors as well as the non-C-BT redundancy in the context of natural emergencies. This framework could be used in future research as a theoretical lens to discover the factors influencing C-BT usage in specific types of emergencies. It will help to address a significant theoretical gap in the literature by extending the framework to other contexts.

This research also contributes to the extant literature concerning the understanding of the use of different ICTs in emergency management which, to date, gives little attention to cloud-based technologies. This research's specific focus on C-BT utilisation in emergency services organisations has been rarely examined previously. While previous research has a strong focus on designing the conceptual architecture of cloud-based systems for the purpose of managing emergencies, no evidence has shown that C-BT deployment in natural emergencies has been examined in the emergency services organisations. Thus, this research is one of the first to examine the real usage of C-BTs in emergency services organisations.

Thirdly, this research makes a significant contribution by complementing the findings of extant literature that examines cloud computing adoption. Much of the prior literature has examined cloud computing adoption in business contexts. Some perceived attributes of C-BTs are unique to the context of emergency management, including *enhanced situational awareness, and transparency*. These attributes are not commonly examined in the previous research while all these elements contribute to a smoother operation in the key stages of emergency management. Similarly, the perceived disadvantages also contain attributes that have not been examined in the previous literature, including *the system and* *infrastructure vulnerability as well as unexpected situations*. These elements are obstacles to C-BT deployment in natural emergencies. Further, previous research discusses the benefits and challenges of adopting the private or public cloud. This research identified that the mixed usage of the cloud deployment model type is more favoured in emergency service organisations, but the public cloud is likely to only play a supportive role. Hence, the thesis provides a theoretical lens for examining cloud computing adoption in the specific context of emergency management. In addition, previous research has produced inconsistent results when examining *compatibility and complexity* in cloud computing adoption. This research provides evidence to reveal that compatibility and complexity significantly influence C-BT usage in the context of emergency management.

Previous literature acknowledges the importance of utilising information systems in multi-agency coordination, but there is a lack of research that specifically examines the influence of inter-agency coordination on C-BT deployment in emergency management. Findings from this research show that establishing relationships in the preparedness stage indirectly enhanced the emergency professionals' confidence in using key cloud-based emergency management systems possessed by other agencies during the response stage of the multi-agency emergencies. This finding provides insights into inter-agency coordination as an influencing factor on C-BT utilisation in emergency management.

Non-C-BT redundancy was found to be important and distinctive in the context of managing natural emergencies. This is because there is a high possibility of losing access to C-BTs during large-scale natural emergencies due to the damage of infrastructure. Previous studies merely acknowledge the importance of having different types of redundancies which were also identified by this research. However, no evidence reveals that the non-C-BT redundancy has been considered in examining the emergency professionals' perceptions against actual C-BT usage in natural emergencies. Hence, this research offers insights into possible future research examining the role of non-C-BT redundancy in influencing C-BT deployment in various types of natural emergencies.

As a final point, the thesis also contributes to the emergency management literature that gives little attention to the important preparedness stage. This research focuses on C-BT utilisation in both preparedness and response stages of natural emergencies and findings show that C-BT usage frequency, C-BT usage readiness, and C-BT usage training are especially important in the preparedness stage. Hence, it provides insights for future research to examine the influence of these elements on C-BT deployment in other types of emergencies.

8.3 Practical Implications

This research also has several implications for practice. First, findings could be particularly applied in similar emergency services organisations in New Zealand and other countries that have limited experience of utilising C-BTs for managing emergencies in the emergency management sector. The findings can serve as a knowledge base for the emergency professionals to enhance their organisational and individual readiness in C-BT usage when managing natural emergencies, leading to a more effective emergency management performance. The findings could also be helpful to various organisations, such as government, non-government, or military organisations that are *indirectly* involved in supporting emergencies, when considering deploying C-BTs in emergencies.

The theoretical framework developed based on the empirical investigation could usefully be translated into practical guidelines for emergency services organisations seeking to utilise C-BTs in managing emergencies and to enhance the organisational readiness in deploying C-BTs. The theoretical model presented in this research suggests that usage frequency, usage preparedness, capacity readiness, and the quality of training on system usage are particularly critical to the success of C-BT deployment. Subsequently, findings from this research could reduce the uncertainty of using C-BTs.

Findings also provide insights to organisations that utilise C-BTs in the emergency management sector to rethink its inter-agency coordination practices associated with the C-BT utilisation, which is critical to achieving a smoother cooperation in both preparedness and response stage.

This research also highlights that individual factors influence C-BT deployment in natural emergencies, which cannot be overlooked. This is because these C-BTs are eventually utilised by the individual emergency professionals in the organisations. It is necessary for emergency professionals to gain a certain level of knowledge and enhance the awareness of key C-BTs in emergency management sectors. In this way, it would help the organisations to adopt and utilise C-BTs effectively, reducing the possibility of wrong investment on C-BTs

This research also provides valuable insights for emergency service organisations that have not fully prepared for the loss of access to C-BTs, especially during the response stage. Findings reveal that the four types of redundancies, including paper-based redundancy, storage redundancy, communication redundancy, and connection redundancy are necessary to reduce the concerns of C-BT reliance for emergency management.

As a final point, the findings presented in this research also provides directions for emergency software vendors and cloud service vendors to improve their products and services when targeting emergency services organisations.

8.4 Limitations of the Study

Since this research explored the emergency professional's perceptions of C-BT utilisation in the context of New Zealand emergency management sector, with a specific focus on natural events, there are several limitations that might constrain the applicability of the findings. The limitations are outlined as follows.

This research focuses on assessing the phenomena of C-BTs utilisation in the preparedness and response stage whereby it emphasises the real-time attribute of C-BTs in facilitating decision making through sharing up-to-date information. The results, therefore, should not be assumed to be applicable in the other two key stages (i.e., mitigation and recovery) of the emergency management life cycle.

The emergency professionals' perceptions of C-BT usage were examined in generic natural emergencies in New Zealand rather than a specific type of natural emergency (e.g earthquake). The level of C-BT usage experience in various types of natural emergencies is low. Future studies may benefit from considering a more specific type of natural emergency or even non-natural emergencies to discover whether differences exist when utilising C-BT in various types of emergencies.

This research primarily focuses on the aspects within the organisational contexts, including the individuals' perception of using the organisations' C-BTs, organisational preparedness and capability, perceived technology characteristics and non-C-BT redundancy preparation. Limited attention is given to external factors, such as government regulations, that might influence the deployment of C-BTs in emergency services organisations. Future research might examine the external forces influencing the C-BT deployment in the emergency services organisations.

8.5 Future Research Directions

Understanding cloud-based technology usage in the preparedness and the response stages was the focus of this research. However, the C-BTs usage in other phases of the emergency management life cycle might be also significant. Diverse findings in terms of the perceived benefits and disadvantages of using C-BTs in other stages of the emergency management life cycle may be worthy of exploring. Therefore, future studies might benefit from the inclusion of the mitigation stage or the recovery stage to examine the effectiveness of C-BTs in emergency management.

This research examined the emergency professionals' C-BT usage perception in generic natural emergencies. Future studies may study the phenomenon in specific types of natural emergencies, non-natural emergencies (e.g. terrorism events) or health emergencies (e.g., pandemics). The emergency professionals' perceptions of C-BT usage may be different in these contexts.

The focus of this research is on understanding C-BT usage *within* the organisational context. However, future research might assess the impact of external factors, such as government imposed regulations, that might influence the C-BT usage. Examining external factors might potentially assist emergency services organisations to make better decisions on using C-BTs.

Future studies might be extended to emergency services organisations in other countries. Since New Zealand is still at an early stage of utilising cloud-based technologies in emergency management, other developed countries might have already utilised C-BTs extensively so the results might differ.

Quantitative research might be beneficial for future research to examine more broadly cloud computing adoption in the context of emergency management. Quantitative studies can be carried out to test the proposed relationships between the multi-dimensional elements and C-BT deployment. Results may suggest that the influence of those elements on C-BT deployment in natural emergencies may have different levels of significance.

Finally, this research draws on the theoretical lens from the Diffusion of Innovation theory. However, other theoretical lenses, such as institutional theory, might also be applied to the study of cloud computing adoption and implementation in emergency management. Institutional theory can be used to study the institutionalisation of a phenomenon within an organisation, which helps to explain how the adoption and utilisation of an innovative technology can be influenced by the socialisation process through passing organisational norms, rules, and structure. An increasing effort has been made to apply institutional theory to cloud computing adoption studies (e.g., Steele & Guzman, 2016; Yigitbasioglu, 2015). Future research may benefit by examining cloud computing implementations in emergency management through institutional theory to fill the gap of lacking existing theory that explains the possible association between cloud computing implementation and emergency management.

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APPENDICES

Appendix A: Interview and Focus group questions

Interview Questions:

Interview Protocol

- Thank you for participating.
- Have you read the information sheet?
- Can you sign the consent form please?
- Are you happy for me to tape this interview?
- Also remember you can decide not to answer any question at any time.
- Thank you again and as you're sharing a lot about yourself today - do you have questions for me about the study or about my work experiences?

Background Information

1. Interviewee's Position/Function:

4. Organisational Size (number of employees):

Current working procedure and technology Usage

1. How do current preparedness and response system work (current workings and procedures)?
2. Who are the actors in these activities?
3. What and how is information used/ shared in these activities?
4. Can you briefly explain the information technology processes related to emergency management in your organisation?
5. What are their benefits and liabilities?
6. What goes right/ wrong in the way current preparedness and response works?
7. Does your IT unit inform you that certain new systems might be beneficial to the emergency management process? What are they?

Perceptions of Cloud-based Technologies Usage

1. What kind of usage of C-BTs in emergencies are you aware of in New Zealand?

2. What types of cloud-based technology are you aware of in your organisation?

3. What possible C-BTs seem appropriate to help?

4. Could you please give examples of emergency management situations (earthquake, Tsunami, Flood) that you think the cloud-based technologies did and did not support you sufficiently? Why do you think that happened? If not, what are the difference between these types of disasters in terms of using cloud-based technology, procedures?

1. What relative advantage over traditional IT solutions have you realised since your organisation first started to use cloud-based technologies?

2. In what ways do you think cloud-based technologies improve your capacity in terms of different responsibilities?

- Information sharing and coordination
- Data security and accessibility
- Less complexity
- Others

3. What compatibility issues have your organisation encountered when using cloud-based technologies in dealing with emergencies?

4. What other factors do you think are important when considering using cloud-based technologies in emergencies?

5. What are the perceived benefits and liabilities of such proposed systems?

6. Are you satisfied with your cloud-based technologies solutions?

- If not, what improvement do you think should be made?

Summary & Closing question

1. Those are all questions I want to ask you today. Is there anything else you would like to say?

2. What do you think has been the most important issue for you that we’ve talked about today?

3. Do you have any final questions for me about what we’ve just talked about the study

Focus group Questions:

1. What natural disasters have you experienced and been focused on preparing for?

2. What types of ICT are you currently using to prepare for and respond to natural emergencies?

3. What cloud-based technologies have you used in preparing for and responding to natural emergencies?

4. Could you please give examples of the cloud-based technologies usage that are helpful in response to natural emergencies?

5. In which phase of emergency management do you think the cloud-based technologies are best suited? Why? What are the major influences?
   - mitigation
   - preparedness
   - response
   - recovery

   What needs improvement?

6. According to your experience, is there anything else you would like to say about the usage of cloud-based technologies in emergencies that is important to your organisation?

7. Suppose that you were in charge and could make one change that would make the cloud-based technology process better in EM. What would you do?

8. Of all the things we've talked about, what is most important to you?

Appendix B Descriptions of Observed Exercises

Exercise 1: Earthquake Exercise at the Regional Level

The first exercise was a two-day functional multi-agency earthquake exercise conducted in one of the CNS' Group Emergency Coordination Centre on 11th and 12th November 2015 both from 9:00 am to 16:00 pm, which is a Tier 3 (Inter-Group) exercise on CNS' National Exercise Programmer tier structure. The CNS' Group was the leading agency with other supportive agencies such as FNS, PNS, HNS, JNS. Therefore, it was a multi-agency exercise.

This exercise focused on the response phase of a major earthquake on the first day while more on the transition to the recovery stage on the second day. The aim was to practice the CNS Group's response processes and procedures to a significant earthquake scenario, through the coordination and implementation of a multi-agency response including the involvement of other CNS groups. One of the objectives was to review systems and processes in the exercise which most related to the research questions of this study.

Scenario

The scenario was a significant earthquake with a magnitude of 7.0 in the northern part of the region occurred late in the afternoon of the day before the exercise started. Strong seismic shaking can be felt widely across the region and the several moderate to large magnitude aftershocks are followed the earthquake. Several significant types of natural impacts occur widely including surface fault, shaking landsliding, and liquefaction. Sever damage occurs in the major urban centres of the region.

Region-wide death and injuries are reported, including several deaths, 54 moderate to severe injuries, and 2000-5000 minor injuries. It is estimated that many injured and frightened people need to be dealt with. Some critical service infrastructures, such as power, telecommunication, and transport links are interrupted and need to be checked and re-established.

Observed Activities

The activities observed mainly involve the technology usage in the operation room in the response stage on the first day. Even though the focus on the second day shifted to recovery stage, it was still valuable to observe the phenomenon of C-BT usage for half of the day. Since there was not a clear cut between the response and recovery stages in the exercise, the system usage was extended for half day while the debriefing activity was carried out on rest of the day. The main function teams of the CNS Group were observed, including

-planning (for overseeing the establishment of action plans),

-intelligence (responsible for collecting and analysing of response information related to status and context of emergencies),

-logistics (in charge of providing and tracking resources to support the response),

-welfare (liable for providing welfare support such as financial, shelters and commendation etc. to the affected communities),

-public information (accountable for informing the public about the incident and actions to be taken) and

-operation and tasks (for the coordination and implementation of the action plans).

During the exercise, either some phone query injections or simulated tasking were conducted. The central phenomena that relate to the research question of this research observed in this exercise were the utilisation of CNS' core emergency management system, denoted as CNS' E System. The behaviour of liaisons from other agencies such as PNS, FNS, JNS and HNS was also observed, such as the face-to-face communication and utilisation of CNS' E System. The observed aspects are summarised as follows:

-The familiarity and effectiveness of using CNS' E System, which was the main means for dissemination of electronic information for the exercise among agencies

-Utilisation of other technologies such as Gmail, and mapping component in the CNS' E System

-Simulated social media deployment for the exercise by public information management team, which was a critical element in the response phase of an event and exercise

-Information sharing through face to face communication and CNS' E System among different functioning teams and liaisons of other agencies within the operation room

Exercise 2: Hazard Substance Explosion

Another half-day observation was conducted by FNS solely at their training centre on 24 November 2015. The observation was not taken long hours which was from 12:00 pm to 15:00 pm on the day. Most of the session was the presentation and table-top discussion regarding situational awareness enhancement of hazards carried out by a leader in FNS together with two short sessions of computer simulation of hazard substance explosion. The aim of the training was to reinforce the importance of situational awareness and dynamic risk assessment on the fire ground. The observed training was conducted according to two of the objectives:

- To apply command and control as a sector commander and incident controller during the response.
- To practise the application of command and control as an incident controller at a multi-crew response

Scenario

The scenario was the general hazard substance explosion around houses and factories. As such, there was not a particular natural disaster scenario in this exercise since it was mainly a table-top discussion on hazard substance explosion.

Observed Activities

The training involves computer simulation on hazard substance explosion, table top discussion and presentation on the main themes. Situations of the hazard substance explosion are simulated in several rooms in the training centre. The none C-BT, a Command Simulator, was utilised to run 3D scenarios of hazard substance explosion on the TV screen. In this way, they can be trained in a near-real-life situation of chemistry explosion around premises. People who are under training conducted role play during the exercise such as doctors, plumbers, and police. Paging systems were also utilised for communication among different fire crews, simulating that they were around the explosion premises but in fact, they were in different rooms. After seeing the computer simulation, a presentation was conducted regarding the reinforcement of situational awareness as well as command and control procedures. This exercise was more of a table-top discussion with minimal usage of technology. Therefore, the observed system usage activities were limited. Nevertheless, it reflected that there was a lack of C-

BT usage in the hazard substance explosion exercise and provided an opportunity to enable the researcher to understand the C-BT usage level in different types of emergencies in FNS.

Exercise 3: Earthquake Exercise (FNS' Urban Search and Rescue Team)

The third exercise was a two-day functional earthquake exercise conducted at the FNS training centre. The researcher was allowed to observe only on the first day which was on 14 August 2016 from 9:00 am to 16:00 pm. The leading agency was FNS' Urban Search and Rescue (USAR) team with the involvement of other agencies such as New Zealand Response Teams, and lifeline authority from a local group. The exercise focused on the response phase of a major earthquake on the day. The aim was to practise the collection of information of rapid disaster risk assessments right after the earthquake occurs and analysis by the control centre to prioritise the resources in the best possible way.

Scenario

The scenario was a significant earthquake with a magnitude of 7.2 in the east of the city of a region occurred one day before the exercise started. In the scenario, many hotels, residential and commercial properties were damaged extensively. Since it is a city that is well-known for its scenic views, many tourists and locals were trapped in the hotels within the city. It is time for the NZ-RTs to undertake the direct instruction from the coordination centre to be involved with search and rescue.

Observed Activities

There were about 40 people taken part in the exercise whereby the majority of them were composed of three New Zealand Response Teams. All of the teams were allocated five scenarios to cope with the information collection and dissemination. These scenarios include horrific crash, house search, car roll over, stretcher carry, and cliff top rescue, which were the aftermath of the earthquake. The main activity was the utilisation of a free open source C-BT, named KoBo Tool box, to collect information about rapid assessment of the damage and death of the earthquake and send it back to the coordination centre. An example of the form for inputing information of the rapid assessment is presented in Table B1. Therefore, each response team were taught in terms of how to set up and log into the applications they've installed in their mobile smartphones. After this, they were sent out to do the tasks according to the five mentioned scenarios. The researcher was only able to observe the activities in the coordination centre since all of the teams were operating at different places; as a result, the researcher decided to stay in the coordination centre to observe the KoBo usage activities at the reception end.

Table B1 Example form of KoBo Tool Box

KoBo Form	**Details**
Date/ Time	
Team ID	
Worksite ID	
Common Place Name	
Location	
Population affected Number	
Is there any change?	
What is the percentage of damage in the assessed area?	
What is damaged in the community?	
Damage-Comments Notes	
Priority for assistance	
Photo ID	
Sign-off Name	
Sign-off Designation	
Start:	
End:	

Due to the urgency of the tasks during the event like this, the first choice for them to allocate tasks was to write down the details of the task on a 'Task Sheet' and then send the copied version to the teams. The KoBo Tool Box was the main technology used in this exercise. Each response team was required to type information regarding the damage to the building, number of death etc. in the above form and send it back to the coordination centre. The controller would input the information gathered into their events reporting system when there was any idle time in between. This process was repeated to practise in the mentioned five scenarios. The efficiency was the main benefit of using KoBo Tool Box.

Exercise 4: Tsunami Exercise at the National Level

The fourth observation was a three-day (including phase 1 warning and impact, phase 2 post-impact with a welfare focus and phase 3 recovery) functional multi-agency Tsunami exercise conducted at the CNS national centre, which was a Tier 4 national level exercise on the National Exercise Programmer tier structure. It was the first full-scale exercise that was held as part of the all-of-government national exercise programme since 2010. The researcher was only allowed to observe phase 1 for several hours from 13:00 pm to 16:00 on 31 August 2016. The exercise involved all CNS Groups and was led by CNS headquarter. The aim of the exercise was to test New Zealand's arrangements for preparing for, responding to, and recovering from a national tsunami impact. One of the objectives was to review systems and processes in the exercise which most related to the research questions of this study.

This exercise focused on the response phase with activations of the National Crisis Management Centre, Emergency Coordination Centres and Emergency Operations Centres around the country on the day. The scenario was based on a regional source tsunami originating in one region that impacts the whole New Zealand coastlines. This exercise tested the sectors' response to the tsunami generated less than three hours away from the nearest New Zealand coastline.

Observed Activities

As mentioned earlier, the researcher was only allowed to observe on-site for several hours. However, there were two important channels for the researcher to observe in the early morning. The researcher herself started the observation in the morning through checking announcements of Tsunami warning from CNS' websites, which showed that they declared the Tsunami warning at 9:55 am. In terms of the second source of the channel, which was the social media platform, Facebook, whereby different CNS Groups announced the exercise to let the public know the national event. Further, they published the updated information regarding the situation frequently so that the public could be informed about the situation immediately.

In the afternoon, the researcher was able to observe the exercise on-site. The activities observed mainly involved the technology usage in the operation room in the response stage on the day. The main functioning teams of CNS were observed, which included the same structure that was observed in Exercise 1 such as planning and intelligence, logistics, welfare, public information and operation and tasks. During the exercise, either some phone query injections or simulated tasking were conducted similar to that in Exercise 1. The CNS' E System was also tested in this exercise, which is critical to CNS operation in large-scale natural emergencies. The observed aspects are summarised as follows:

- The familiarity and effectiveness of using CNS' E System, which was the main means for dissemination of electronic information for the exercise
- Utilisation of National Warning System, ArcGIS mapping component in the CNS' E System
- Social media, Facebook and Twitter, usage for the exercise by public information management team, which is a critical element in the response phase of an event and exercise
- Information sharing through face-to-face communication and CNS' E System among different functioning teams and liaisons of other agencies within the operation room

Exercise 5: Geothermal Eruption Exercise

The last observation was a three-day geothermal eruption exercise led by RNS. The researcher was allowed to only observe on one of the days which started from 7:15 am to 4:00 pm on 5 November 2016. It was the annual exercise that aims to cement the skills taught and to provide a further opportunity for team members to response conditions and stresses under the given scenarios whereby a competence assessment can be conducted. One of the objectives of the exercise was to reinforce and strengthen the team members learning to date by practically exercising those skills in a disaster scenario context. The skill involves the usage of existing technologies within RNS. Therefore, it is related to the research question of this study. It means that through the observation of the exercise, the researcher can better understand and verify the interviewed managers' perceptions regarding the C-BTs usage in natural disasters. The day that was observed focused on the response phase.

Scenario

The scenario was a geothermal event due to the rising temperature of the lake over the last few weeks. The event was activated on the day (i.e. the first day of the exercise) before the researcher started the observation. The RNS was requested to activate and assist the local authority with the establishment of a centre to support the evacuation of the tourists and residents. Further, a significant community outreach was required in the affected communities on the second day of the exercise.

Observed Activities

RNS ran scenarios at different places with the same content, including the community outreach activity in terms of providing relieve items and evacuation centre establishment to receive victims. Therefore, the researcher decided to follow and observe one team at one particular location in the morning and observe the emergency operation centre (EOC) in the afternoon. In this way, the researcher could observe not only the way of how the team works in the field but also the way of how the controller works in the control centre. The researcher mainly interested in observing the C-BTs usage during the outreach activity and in the control centre.

The only counted C-BT was the mobile application called Magpi which is a free open source application. It can provide data on accurate household GPS location, numbers and addresses. Therefore, the controller at the EOC was able to gain a big picture of the outreach process on the website through checking the information that had been input by the outreach team members on the tablet in real time. The observed aspects are summarised as follows:

- The familiarity and effectiveness of using the cell phone, Magpi application and tablets, which were the main means for dissemination of electronic information for the exercise
- Utilisation of computers, radios, mobile phones to generate situation reports.
- The competence of communication among the team members and coordinator mainly via mobile phone

Appendix C: Ethics Related Forms

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Dear Participants:

My name is Ying (Heidi) Lu, and I am required to conduct a thesis in fulfilment of the requirements for the degree of Doctor of Philosophy at The University of Waikato, which forms an important part of my PhD degree. The research aims to explore the cloud-based technologies for enhancing emergency management capabilities in New Zealand. The natural emergency events have led to destructive threats to humans' lives and business operations. The casualties and the annual losses caused by those severe natural emergencies could often be very high and cost billions of dollars. Thus, special attention needs to be paid to countries with relatively high frequency of disasters. It is believed that the emergence of new information technology may provide new opportunities for managing emergencies thus being helpful for managers to minimize the emergency management risks. Basically, I would like to know what cloud-based technologies can be used by your organisations, your perceptions of using such technologies as well as to what extent it benefits your organisations. My supervisor panels will help me to finalise the thesis and assess on it.

<u>What is expected of me?</u>

I would like to invite you to conduct an interview regarding your perceptions of using cloud-based technologies in emergency organisations. The interview will take about 30-60 minutes. No private information is needed in terms of your age, gender, name etc. I will keep all the information about you confidential.

<u>What will happen to my information?</u>

The information provided by the participants will help to complete my thesis and only my supervisor panels will have access to the raw data. The data will be in a password-protected file stored on a password protected computer and will be deleted after the thesis is examined.

<u>Our declaration to you</u>

If you take part in the study, you have the right to refuse to answer any question, or to stop the interview at any time. You also have the right to withdraw from the study through email before 30 July 2016. You are very welcome to ask any further question about the study that occurs to you during your participation by contacting me at the email address below. If you would like to get access to the research results when it is concluded, you can contact me through the email below.
Kind Regards

Researcher's contact
Ying Lu,
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Phone: 02102541352

Supervisors' contact
Dr Stuart Dillon,
Email: stuart@waikato.ac.nz,
Phone: (07) 838 4234

[redacted]

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Dear Participants:

My name is Ying (Heidi) Lu, and I am required to conduct a thesis in fulfilment of the requirements for the degree of Doctor of Philosophy at The University of Waikato, which forms an important part of my PhD degree. The research aims to explore the cloud-based technologies for enhancing emergency management capabilities in New Zealand. The natural emergency events have led to destructive threats to humans' lives and business operations. The casualties and the annual losses caused by those severe natural emergencies could often be very high and cost billions of dollars. Thus, special attention needs to be paid to countries with relatively high frequency of disasters. It is believed that the emergence of new information technology may provide new opportunities for managing emergencies thus being helpful for managers to minimize the emergency management risks. Basically, I would like to know what cloud-based technologies can be used by your organisations, your perceptions of using such technologies as well as to what extent it benefits your organisations. My supervisor panels will help me to finalise the thesis and assess on it.

<u>What is expected of me?</u>

I would like to invite you to conduct a focus group regarding your perceptions of using cloud-based technologies in emergency organisations. The focus group will take about 45 minutes. No private information is needed in terms of your age, gender, name etc. I will keep all the information about you confidential.

<u>What will happen to my information?</u>

The information provided by the participants will help to complete my thesis and only my supervisor panels will have access to the raw data. The data will be in a password-protected file stored on a password protected computer and will be deleted after the thesis is examined.

<u>Our declaration to you</u>

If you take part in the study, you have the right to refuse to answer any question, or to stop the participation in the focus group at any time. You also have the right to withdraw from the study through email before 30 July 2016. You are very welcome to ask any further question about the study that occurs to you during your participation by contacting me at the email address below. If you would like to get access to the research results when it is concluded, you can contact me through the email below.

Thank you for considering participating in this research.
Kind Regards

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THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

An Exploration of Cloud-based Technologies for enhancing Emergency Management Capabilities in New Zealand Natural emergencies

Consent Form for Participants

I have read the **Information Sheet for Participants** for this study and have had the details of the study explained to me. I agree to be audio recorded. My questions about the study have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I also understand that I am free to withdraw from the study through email **before 30 July 2016**, or to decline to answer any particular questions in the study. I agree to provide information to the researchers under the conditions of confidentiality set out on the **Information Sheet**.

I agree to participate in this study under the conditions set out in the **Information Sheet** form.

Signed: ____

Name: ____

Date: ____

Researcher's Name and contact information:
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Appendix D: List of Participants in Interviews and Focus Groups as well as Observations

List of participants in interviews

Interview Participants ID	Position	Organisation
ID1	Managerial- National Manager	CNS
ID2	Managerial- Group Manager	CNS
ID3	Operational- Emergency Planning Coordinator	CNS
ID4	Operational- EM System Training Coordinator	CNS
ID5	Managerial- Group Manager	CNS
ID6	Managerial- Board Security	PNS
ID7	Operational- System Strategic Advisor	PNS
ID8	Managerial- District Manager	PNS
ID9	Operational- Senior Frontline Person	PNS
ID10	Operational- District Emergency Response	PNS
ID11	Operational- EM and Board security	PNS
ID12	Managerial- ICT Manager	FNS
ID13	Managerial- Area Manager	FNS
ID14	Managerial- Assistant Area Manager	FNS
ID15	Managerial- Search and Rescue Manager	FNS
ID16	Managerial- Area Manager	FNS
ID17	Operational- Senior Officer	FNS
ID18	Operational- Senior area coordinator	FNS
ID19	Managerial- Emergency Response Manager	JNS
ID20	Managerial- District Operation Manager	JNS
ID21	Managerial- Territory Manager	JNS
ID22	Operational- Clinical Support Officer	JNS
ID23	Operational- EM System Advisor	HNS
ID24	Managerial- EM Advisor	HNS
ID25	Operational-Emergency Planner	HNS
ID26	Operational- Emergency Planning Coordinator	HNS
ID27	Managerial- EM Manager	HNS
ID28	Managerial- EM Officer Northland	RNS
ID29	Managerial- EM Officer Southland	RNS

List of focus group members

Focus Group ID	Position	Organisation
FG 1	2xEM advisor, 2xCapability development advisor	CNS
FG 2	1x volunteer and training officer, 2x Area managers	FNS
FG 3	3xemergency planning advisors, 2xemergency planning managers	JNS

List of observations

Observation ID	Exercises
OB1	Earthquake at the regional level led by CNS
OB2	Hazard substance explosion led by FNS
OB3	Earthquake led by FNS
OB4	Tsunami exercise at the national level led by CNS
OB5	Geothermal eruption exercise led by RNS

Appendix E: Example of Grounded Theory Data Analysis

The following is an example of how the data is analysed through the three coding stages based a short extract from one of the interviews. This extract has been chosen for coding firstly due to its richness for generating the categories which has been explained in section 4.6.3.

Transcript Extract

Me: What C-BT types are you aware of?
Participant: (1) To be honest very little , (2)I think that's part of the problem is you only know what you know, you don't know what you don't know. (3)I am not an IT professional and I am an emergency manager. **(4) So we are as a ministry we are serviced by an IT shop that's not a part of us and they respond to if I tell them I want this and they will make that happen**. **(5) I don't have the capacity to ask them what do you think? Is there a better way to do this? (6) So we don't really have the access to the expertise to inform us in terms of doing stuff better.** You know what I am saying? **(7) I only know what I know and I don't know what I don't know**. **(8)At the moment we don't use any cloud technology, we hosted all ourselves. (9)Let's just clarify what do you mean by cloud? ... Ok then it's different. (10)We do use web-based systems**. **(11) I was thinking more in terms of (12) data storage in the cloud, (13) but I mean the servers. (14) So you refer to our emergency management information system or Esponder, which are used in our response.** The server for that system is based yah, **(15) I am responsible for it and I manage it**. **(16) Although it is served in the web, the system internal. (17)I prefer to do that by the third party to be honest, at the time when we implement the system**. **(18) It was backing to 2010 and 2011, the idea of hosting stuff in the cloud didn't sit well with the government (19) yet from the security perspective**. **(20) So you know that suggestion didn't even come up at that time. (21) It was simply you have to invest to establish the servers** and **(22) maintain it yourself.** That is still the model that we use and **(23) government is now starting to move away and is more open to the idea of you know external cloud by serving**. **(24) That is the simple way I prefer to go** for two reasons.

Open coding

Firstly, incidents are identified and given descriptive names as below.

(1) Limited cloud usage	(13) Internal cloud
(2) Limited C-BT knowledge	(14) Usage in response
(3) Limited C-BT knowledge	(15) Self-manage
(4) Lack of expertise	(16) Internal cloud
(5) Lack of capacity	(17) Preference of external cloud
(6) Lack of expertise	(18) Unpreparedness of cloud usage
(7) Limited IT knowledge	(19) Security concern
(8) Limited C-BT knowledge	(20) Unpreparedness of cloud usage
(9) Limited C-BT knowledge	(21) Investment
(10) Web-based system	(22) Self-maintenance
(11) Limited C-BT knowledge	(23) Preference of external cloud

(12) Data storage (24) Preference of external cloud

The next step involves grouping similar incidents into concepts. The numbers in brackets represent the incidents found in the previous step.

(A) Limited capacity (4, 5, 6, 15, 22)
(B) Knowledge (2, 3, 7, 8, 9, 11)
(C) Security (19)
(D) Cost (21)
(E) Unpreparedness (18, 20)
(F) Private cloud (13, 14, 16)
(G) Web-based system (10)
(H) Data storage (12)
(I) Current cloud usage level (1)
(J) Preference (17, 23, 24)

The last step of open coding is to establish more abstract category groups of related concepts. The numbers in the brackets stand for the incidents found in the first step.

I. Capacity Issue (4, 5, 6, 15, 22)
II. Knowledge (2, 3, 7, 8, 9, 11)
III. Perceived Disadvantage (19, 21)
IV. Usage preparedness (18, 20)
V. Deployment model type (10, 13, 14, 16)
VI. Usefulness (12)
VII. Usage level (1)
VIII. Expectation (17, 23, 24)

Axial coding

This stage involves finding relationships among categories. It is the process of classifying the categories that have been identified in the open coding stage. The roman numbers in the brackets related to the last stage of the open coding process.

Individual knowledge: Knowledge (II)
Individual perception: Perceived Disadvantage (III) and Expectation (VIII)
Organisational factors: Capacity issue (I), Usage preparedness (VI) and Usage frequency
(VII)
C-BT Characteristics: Usefulness (VI) and Deployment model type (V)

Selective Coding

The last stage, selective coding, involves integration and refinement of categories. The technique of writing storyline is employed to facilitate the process of identifying the core categories to form the central phenomena of the study. It contributes to the formation of core categories related to the research question of *"What are the perceptions of emergency professionals on the usage of cloud-based technologies in the preparedness and response stages of natural emergencies in New Zealand?"* Nevertheless, the question cannot be addressed fully with the extract from the single transcript. The final core category (in appendix F) were derived through the evolvement over several months.

Descriptive sentences written for the core categories identification are presented below.

1. Sufficient C-BT knowledge of individual emergency management professional influence the decision of C-BT deployment when dealing with natural emergencies.
2. Disadvantages of security issue, and huge investment in establishing internal cloud will result in emergency management professionals' negative perceptions regarding C-BT usage in natural emergencies. As such, emergency professionals' have expectations on the improvements of current C-BT usage in natural emergencies.
3. The organisational factors such as limited capacity, unpreparedness in C-BT usage, and limited usage type will influence emergency management professionals' negatively in C-BT deployment in natural emergencies.
4. The useful function and C-BT deployment model type have great influence on emergency management professionals' perception of C-BT usage in natural emergencies.

Appendix F: Final Categories and Core Categories

Final category codes and names

Category Codes and Names		
No.	**Category Code**	**Category Name**
1	A	Usage Frequency
2	B	Usage Preparedness
3	C	Capacity
4	D	Training
5	E	Inter-agency Coordination
6	F	Perceived Advantages
7	G	Perceived Disadvantages
8	H	Usefulness
9	I	Deployment Model Type
10	J	Enhancement Expectation
11	K	Human Factors
12	L	Knowledge
13	M	Offline Redundancy

Final Core categories and categories

Core categories and Categories				
No.	**Core Category Code**	**Core Category Name**	**Category Code**	**Category Name**
1	I	Organisation Readiness	A, B, C, D	Usage Frequency, Usage Preparedness, Capacity, Training
2	II	Coordination	E	Interagency Coordination
3	III	Cloud-based Technology Characteristics	F, G, H, I	Perceived Advantages, Perceived Disadvantages, Usefulness, Deployment Model Type
4	IV	Individual Perception	J	Enhancement Expectation
5	V	Individual Readiness	K, L	Human Factors, Knowledge
6	VI	Non-C-BT Redundancy	M	Offline Redundancy