Opportunities, barriers and challenges for implementing electronic data and information sharing frameworks in organizational response to natural disasters

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Abstract: This paper presents a critical review and analysis of issues in implementing electronic data and information sharing frameworks in organizations involved in response activities during natural disasters. The latest technological advances, opportunities, barriers and challenges are identified and discussed. A case study in New Zealand examines the process and steps to conceive the electronic data and information framework. Also, the approach and involvement of roading authority organizations in conceiving the framework is investigated. Preliminary results show that considerable performance gains in response activities during natural disasters can be achieved if technology is employed according to organizations' needs.

Key words: natural disasters, emergency management; response

1. INTRODUCTION

Response activities to natural disasters involve several organizations collecting, processing and sharing data and information that support resource allocations to minimize societal and economic damages. In order to act in a coordinate and efficient way, organizations require access to data and information characterizing the natural disaster's intensity, location and related damages as well as the availability of human and physical resources. Data and information can be originated from multiple organizations that are ultimately shared and made available to coordinating authorities such as the civil defence, army forces, lifeline organisations, local and regional authorities, etc. Furthermore, intra-organizational exchange of data and information may occur according to several layers of responsibilities and territorial jurisdiction. Through inter and intra organizational exchange and sharing of data and information decisions are made and implemented resulting in the mobilization of personnel and equipment accordingly to assessed needs and priorities.

A critical review and analysis of issues in implementing electronic data and information sharing frameworks in organizations involved in response activities during natural disasters is presented. Based upon the examination of the scientific literature and recent natural disaster response reports as well as the latest technological advances, opportunities, barriers and challenges are identified and discussed. These are used in a New Zealand case study in which the implementation of an electronic data and information sharing framework in a roading authority organization is examined. This case study concentrates in presenting the process and the steps taken to conceive the electronic data and information framework and to involve the roading authority organizations as well as the preliminary results that have shown considerable performance gains in response activities during natural disasters.

This paper is divided into four sections. After this brief introduction, section two examines the scientific and technical reports covering organizational issues in emergency response in order to identify opportunities, barriers and challenges to the implementation of data/information sharing practices. Section three focuses in investigating these issues in the

New Zealand context of emergency management. Finally, section four presents the discussion and conclusion based upon the findings of previous sections.

2. ORGANIZATIONAL ISSUES IN EMERGENCY RESPONSE

Recently, a series of natural and man-made disasters has prompted the production of reports covering a wide range of topics ranging from human and social behavior to artificial intelligence applied in resources allocation. However, intra and inter organizational issues in emergency response are concentrated into three main topics, namely: organizational coordination; emergent technologies and techniques in data/information processing; and evacuation planning.

Almost unanimously, various scholars and emergency management practitioners have indicated that lack of coordination reduces the response efficiency. At the macro level, some claim that the whole process of emergency management has to be integrated with urban and regional activities [1] [2]. Montoya and Masser [3] present a case study in Cartago, Costa Rica in which gaps in current urban planning framework and practices are identified. On the other hand, it is often claimed that organizational coordination is also dependent on cultural background. For example Marincioni [4] uses a cross-cultural perspective to clarify the relationship between two cultures and their different patterns of response to extreme flood events. The results showed that the different human responses observed in floods were linked to basic differences in four cultural elements: experience with floods; socio-political traditions and organization; levels of integration within the community and perception of the physical environment. At the operational level, the Turkish experience with the 1999 earthquake [5], fire events in Quebec, Canada [6] and United States' CERTs [7] highlight the importance of coordination and the problematic nature of multi-organisational collaboration in disasters

Recent developments in data/information processing and tools have also been captured in the literature. On one hand, it is observed a growing concern over the need to obtain and share data during emergency events. Popkin and Rubbin [8] make an informal assessment of United States' Natural Hazards Research and Applications information Center (NHRAIC), while Lindell *et al*. [9] and Hwang *et al* [10] examined 97 Texas government agencies' access to information about hazards in their communities and concluded that printed products are still used more extensively than internet products. Furthermore, Mendonca and Wallace [11] present a method for describing both context and substance of improvisation during the response phase. Slayton [12] highlights the need to identify available sources of information within each participating agency and five key factors that affect the success of local collaborative efforts (the climate in which the initiative begins; the processes used to develop trust and handle conflict; the people involved; the policies that support or inhibit their efforts; the availability of resources to enable their effects to continue).

Many have already adopted Geographical Information Systems (GIS), Global Position Systems (GPS) and Remote Sensing as essential instruments in emergency management and response activities. Zhang *et al* [13] present an overview of the Chinese system used to asses damage and provide relief during natural disasters based upon Remote Sensing, GIS and GPS. Hecker *et al* [14] describes damages and organizational consequences of the Hurricane Hugo and how the U.S. Army Corps of Engineers is taking advantage of GIS and GPS in its activities. Waring *et al* [15] introduces the public health response to tropical storm Allison in the Houston area, USA and the need to quickly evaluate the immediate health and medical needs of the community would not have been possible without the utilization of GIS methodology. GIS has been also applied in: decision-making processes [16] [17], risk and vulnerability assessments [18] [19], network operations and traffic management [20] [21].

Despite considerable progress achieved in recent years, research and implementation efforts towards utilizing the full potential available in GIS should be contemplated. Many scholars have indicated that geo-spatial modelling provided in most commercial GIS desktop software is inefficient, because they are based on very simplistic representation of response systems characteristics, and do not include multiple inter-relationships observed in reality [22]. This provides a very static representation of the variables that contribute to decision-making activities. On the other hand, there are serious concerns about the isolationist tendency adopted by some emergency services. It is very often observed that each organisation will have its own GIS developed according to its specific needs, without contemplating data/information sharing needs. For example, Amdahl [23] describes GIS applications in disaster response, which are very efficient in identifying risks before and after response, but limited in dealing with the dynamic flow of data and information during the response activities. In a few cases, organisations will purchase GIS software without even analyzing whether or not the package will suit its needs during emergency events [15] [24]. Furthermore, in Briton's words [25] "…a key need now is making effective and efficient use of new technologies for gathering and evaluating information to best target response and relief efforts…. Nevertheless, the challenge is to ensure the means exist for sharing information across all agencies, not just in terms of the formats used but also overcoming ownership and funding issues. Central to this, however, is the need to replace a focus on organisational arrangements to focus on resource arrangements to a focus on resource arrangements based on potential hazards consequences…"

The expansion and subsequent reliance on recent telecommunication advances have been also incorporated in the emergency response context [26] in terms of wireless communications, internet and integrated technologies for data exchange. Heavy telephone use by general population caused sudden and sever congestion in the phone system during the Kobe earthquake and the September 11 attacks in New York have motivated Fujiwara and Watanabe [27] to conceive an ad hoc networking scheme and routing for emergency communications, in which the objective of the network is to collect damage assessment information quickly and stably in a disaster, using a hybrid wireless network, ad hoc networks and cellular network to maintain connectivity between a base station and nodes even in a disaster. Combining GIS, GPS and telecommunication capabilities, Laurini [28] describes various applications of Telegeomonitoring in traffic management on toll motorways, fleet management, transport of hazardous materials, river pollution and risk monitoring. In the same direction, Gordin [29] describes applications of GIS software combined with wireless mobile phone networks in the USA. Telecommunications advances have also contribute to popularization of internet-based applications. Harder [30] describes a series of applications in which maps are made available on internet. Gruntfest and Weber [31] reports on the growing value of internet resources for the emergency management profession.

Evacuation studies have also occupied a considerable part of the technical and scientific literature. Jafari *et al* [32] present a survey of various approaches and technologies being developed and used for evacuation planning and emergency management. They divide efforts into evacuation planning and emergency management. Evacuation planning covers: the analysis of site analysis consulting (EPlan and BTG), simulation (EXODUS, OREMS, PedGo, Assisted Evacuation Simulation, SEVEX, CyberSim) and Training. In emergency management, High-Level Architecture (HLA), Multi-agent systems to support an escalating non-combatant evacuation operation (NEO) and E-Team software packages can be highlighted. On the modeling side, Gladwin *et al* [33] focus in individual and household hurricane evacuation behavior using ethnographic decision tree analysis, based on interviews with Miami, USA, residents who had been in South Florida during both Hurricanes Andrew in 19912 and Erin in 1995. Their results show that the model can better inform emergency managers. Other similar initiatives in modeling are presented in [34] [35] [36] [37]. Goldblatt and Weinisch [38] describe the benefits of developing systems for training and effective response in evacuation planning.

In the inter and intra organizational data/information sharing context, this review demonstrates that outstanding advances have been achieved, but considerable challenges ahead can be pictured in terms of adopting knowledge and information management theory and techniques [39]. Throughout this review, it can be observed that very limited attention has been given to conducting comprehensive analyses about the nature and background of involved organisations; the characteristics of their involvement; their data/information needs, their data/information sharing needs and how organisations should share data/information.

3. NEW ZEALAND'S EMERGENCY RESPONSE AND ORGANISATIONAL DATA SHARING

According to Cole *et al* [40] no large-scale events have been observed necessary in New Zealand, possibly due to the short history of European settlement (160 years). The common incidents in New Zealand have been short-lived, and relatively small scale, associated with storms and floods, but there have been three events: the 1886AD eruption of Tarawera, 1931 Hawkes Bay earthquake and 1968 Inangahua earthquake. According to Briton and Clark [1] over the last 50 years, less than 3 people a year have died in natural disasters, but annual flood losses may amount to NZ$180 million and earthquake losses about NZ$15 million. In the most recent event (2004) flooding in the Manuatu-Wanganui area (4 bridges destroyed, 21 seriously damaged, 2500 people displaced, costs on business disruption close to NZ$400 million) [41].

In New Zealand, the Ministry of Civil Defence and Emergency Management (MCDEM) is a semi-autonomous body within the Department of Internal Affairs, which is responsible to ensure the preparedness of the New Zealand community for any natural and technological hazards or disasters [1]. Created in 1999, MCDEM provides policy advice to the Government [42]. In 2002, a Civil Defence act established a national and regional framework in which emergency management strategy and plan were adopted. This act requires that every local authority has to plan and provide for Civil Defence and Emergency Management (CDEM) within its district and to ensure that it is able to function to the fullest possible extent, even though this may be at a reduced level, during and after an emergency. The MCDEM works in coordination with local and regional governments, utilities and the emergency services involved in CDEM. The MCDEM's Director acts as Chief Executive of the Ministry in its day-to-day operations. In cases of national emergencies, the Director has special powers as defined in the legislation. The MCDEM consist of different units: Policy Unit; Communications Unit; Corporate and Development Unit; Readiness Unit and Capability Unit.

In the event of Civil Defence emergency declaration, the local Civil Defence controller, representing the MCDEM, takes control and makes decision about the response actions after communication and consultation with other lifeline organizations like hospitals, fire services, police, transportation organizations, telecommunication organizations, media, local authorities, regional authorities, waste water organizations etc). The MCDEM team interacts with these lifeline organizations to make the decisions on prioritization of response activities. The data/information from all the organizations is expected to be shared with the MCDEM team for facilitating decision making. The organizations involved in the response activities, provide data/information to MCDEM and act as per the instructions from it.

Based on this backdrop, data/information sharing issues specific to a New Zealand roading organization (Transit NZ) responding to a natural hazard event (Matata township flooding) are identified. The following sub-sections present the description of the roading organization and its interactions with the MCDEM, the chronological sequence of response actions and their respective data/information sharing observed *in situ*, and finally a potential framework for data/information sharing is introduced and discussed.

3.1 New Zealand roading organization and its interactions with the MCDEM

New Zealand has about 10 thousand kilometres of state highway network. These roads are a national asset worth approximately NZ$12 billion and Transit NZ is responsible for maintaining these assets. 56 % of the annual budget is allocated for the maintenance and rehabilitation of the existing roads. Typically, Transit NZ appoints the Consultants for the technical services and the Contractors for carrying out the physical works determine service orders according to Transit NZ Regional office's directives. Service orders are then communicated to Transit NZ regional contractors that are responsible for road maintenance activities [43].

During an emergency situation, it is the responsibility of the contractor to carry out the physical repairs and reopen the road to the traffic as soon as possible. The consultants are mainly involved in providing the technical details and strategic advice to the contractors. The consultants also interact with representatives of MCDEM and Transit NZ.

The emergency situations are classified into 3 levels according to time required for the road reopening. They are the small, medium and large events. Based on emergency procedure manuals [43], Table 1 summarises Transit NZ's regional office involvement and interrelationship with other organizations.

Table 1. Transit NZ participation for different types of events.

		Type of Emergency		
		Small	**Medium**	**Large**
Organisations	**Local/Regional Authorities**	Local Roads and Infrastructure	Local Roads and Infrastructure.	Local Roads and Infrastructure.
	Transit NZ	Stand-by unless the emergency affects SH system	SH Emergency Procedure and Contingency Plan fully applied.	SH Emergency Procedure and Contingency Plan used are partially applied.
	Civil Defence (CD)	N/A	- CD Head Quarters (CDHQ) plays a monitoring role; and - Link CDHQ – info where and when (depends on the event).	Civil Emergency declared

In a large event refers to a situation in which severe damage is observed and the Civil Defence dictates the priorities for response and recovery activities. When an emergency is declared during a large event, Transit NZ plays a complementary role. Transit NZ headquarters in Wellington is also involved in a large event and it reports to Land Transport NZ and Ministry of Transport (MOT). In events with Civil Defence Emergency declaration, MCDEM takes control of actions and all organizations have to operate as per the directions of the Civil Defence. In these situations, Transit NZ also interacts with the community through individuals, external organisations telecommunication, energy, water, hospitals and the media). In Figure 1, the square box indicates roading organizations involved for small and medium events whereas for large events, all the roading organizations in the dotted rectangle along with Civil Defence Emergency services and MCDEM are involved in the response activities.

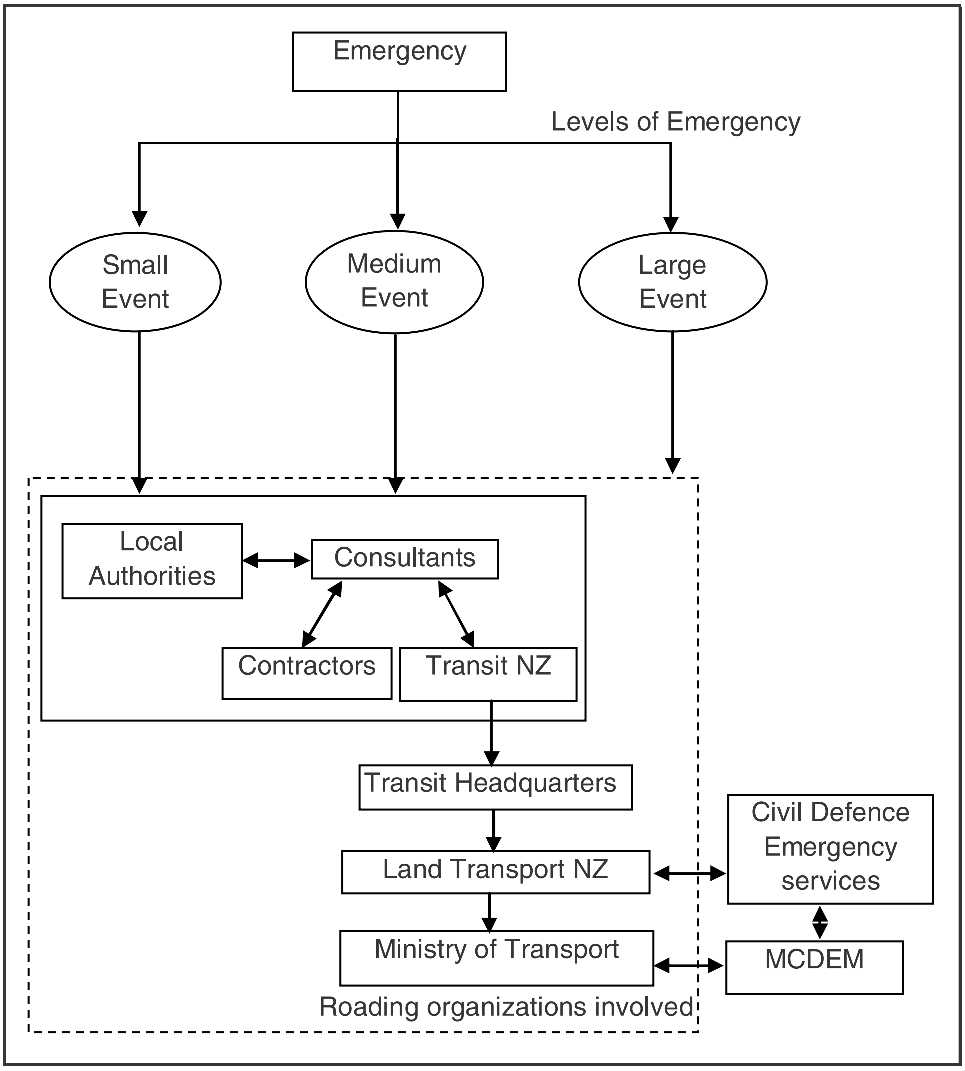

Fig. 1 Levels of Emergency and roading organizations involved

Transit NZ response activities can be divided into 6 phases. They are: (1) event warning; (2) event observation; (3) event assessment; (4) organization action; (5) organization reporting; (6) organizations re-evaluation. At the end of phase (6) the outcomes are used to decide whether response is over or should it be continued from phase (3). During each phase, different organizations are involved. In the phase (1) the external organizations such as Crown Research Institutes like National Institute of Water and Atmospheric Research (NIWA), Geological and Nuclear Sciences (GNS), Meteorological Services (MetService NZ), regional and local councils provide initial warning and their updates. After the event, the contractor along with external organizations and Public verify the initial damages caused to the transportation system (pavement and bridge collapses, obstruction of lanes, damages to traffic signs and controls, etc.). This is part of phase 2 (event observation). Depending on the extent of damage, these conditions are reported to the consultants, Transit NZ, Local/Regional Authorities, Civil Defence, and other lifeline organizations. In the subsequent phase (event assessment), again depending on the type of the emergency all the organizations except external organizations and public are involved and the decision is made by them in the next phase. In phase 4 (resource deployment) the same organizations deploy their physical and personnel resources according to their response responsibilities. Most part of the field operation is conducted by the contractors in small and medium events and in large events, Civil Defence Controller, lifeline organizations and Local/Regional Authorities are also involved. These actions are supervised by the consultant and Transit NZ along with Civil Defence, Local/Regional Authorities and lifeline organizations depending on the damage level. In phase 5, the reports are prepared by the contractor, Civil Defence, Local/Regional Authorities and lifeline organizations describing the conditions after initial round of measures and also development of the original event (better information about damages, more events, etc.). These reports are then taken into consideration during phase 6 (efficiency assessment) in which the organizations compute measures and their efficiency. Finally decision making on whether to continue or stop response activities depending on the efficiency assessment is conducted. If a decision is made to continue, the process restarts from phase 3.

3.2 Roading organization's response in the Matata township flooding event

Matata is a seaside village of approximately 500 people in the Bay of Plenty region, North Island of New Zealand as shown in Figure 2. Matata is located halfway between Whakatane, which is a forestry industry region, and Tauranga, where one of the busiest ports of New Zealand is located. Whakatane and Tauranga are connected by railway and road, where the State Highway (SH) 2 is the most important part of network with observed daily heavy traffic on both directions.

On the evening of May 16, 2005, MetService issued a heavy rain warning to the local (Whakatane District Council) and regional (Bay of Plenty Regional Council) authorities as well as to all infrastructure and lifelines providers in the region, including Transit NZ offices in Hamilton and Gisborne.

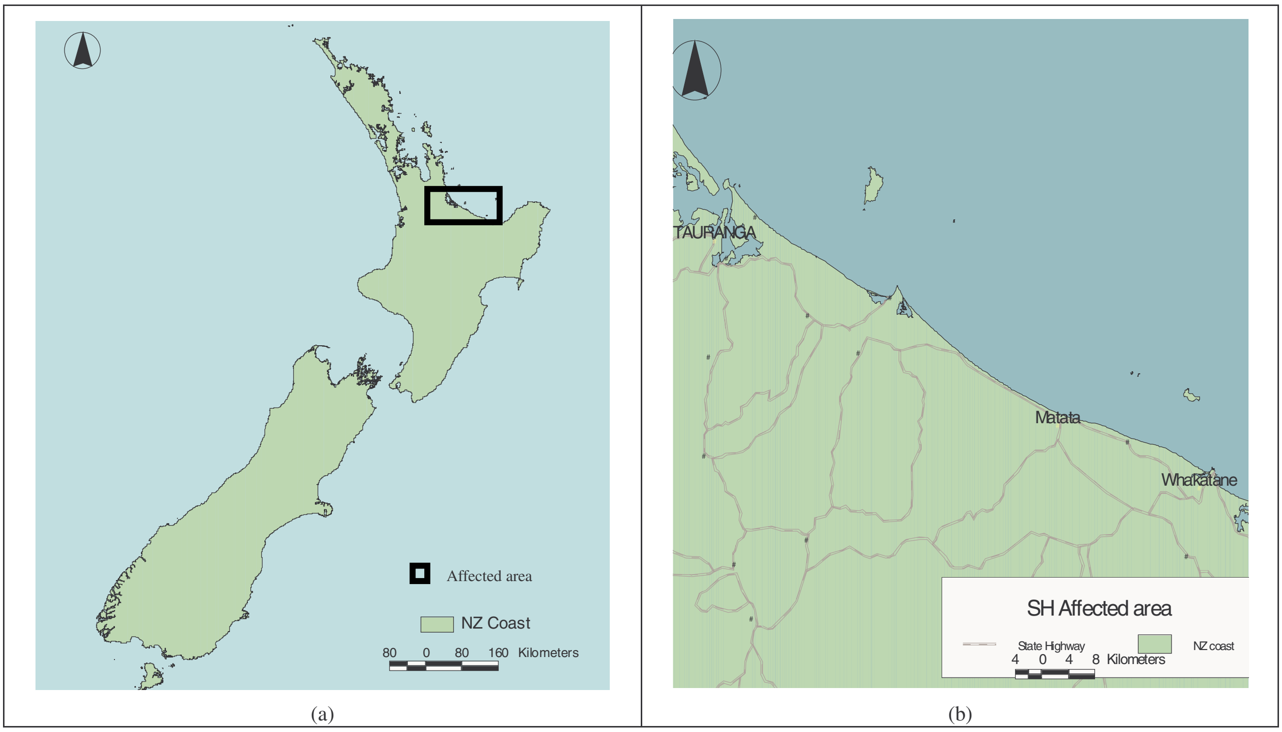

Fig. 2 Location maps: (a) New Zealand and affected region; (b) Matata Township

On the early hours of May 17, Transit NZ area engineer and the consultant engineer, who were coincidently meeting in Whakatane, received initial reports from the local community and Transit NZ contractors about partial road closures on SH 2 due to water on the road surface and localized slips blocking the traffic. Additional Transit NZ contractor's crew was mobilized from various parts of the region via mobile phone. Reopening of the SH 2 occurred at 4:30 am, but during road inspection Transit NZ area engineer and consultant engineer witnessed at 7:30 am the washout of one bridge embankment. Subsequent reports from road users about more washouts prompted the Transit NZ area engineer and the consultant engineer to hire a helicopter in Whakatane and conduct a fly-over inspection. Immediately after the inspection, complete road closure of SH 2 was declared and supplementary personnel and equipment from the Transit NZ contractor were requested.

Up to that point in time, communications and exchange/sharing of data and information were very limited. Transit NZ Headquarters in Wellington had been informed of the road closure, without any precise estimation of the reopening time. The area engineer liaised with local and regional councils sharing the same level of information available to Transit NZ Headquarters. Press releases were given to the media about the road closures. Interaction between the area engineer and the consultant engineer occurred almost instantly as both were *in situ* coordinating and making decisions together. The consultant engineer, originally based in the Whakatane, reported back to office through mobile phone and/or using his deputy road technician. Consultant's reports were used to produce maps of road closures and initial estimates of damages and costs. Transmitted data comprised very general instructions referring to general road assets per kilometre. No specific data on previous road asset conditions (e.g. location and characteristics of roading elements) was made available to the involved parties (Transit NZ, consultant and contractors).

On May 18 at 3:50 pm, Civil Defence Emergency was Western Bay of Plenty Emergency Management Office and subsequently the Whakatane District Council also declared a state of local emergency for the Edgecumbe- Tarawera Ward (Matata township) at 6:43pm, May 18th. Late that night, a band of intense rain passed over the catchments behind Matata and it triggered many landslips (*debris avalanche*), which destroyed 27 homes and seriously damaged 87 properties [44]. Initial response actions commenced immediately, because resources were already available for dealing with road closures in the area. However, a major drawback was the lack of suitable gear to operate during the night, because available batteries for spotlights presented fault.

The landslips in Matata and complete closure of SH 2, which made created difficulties in transporting equipment and personnel from Tauranga. Therefore, alternative routes through mountainous areas had to be used, which incurred in delays in the response actions. On May 20th, SH 2 was partially open to heavy and commercial traffic operating during the nigh (5 pm to 5 am). On May 30th, the SH 2 was completely reopened to general traffic. At that point in time, Transit NZ had no specific assessment on road works costs.

During the response activities, we observed a few issues and perceptions through the interaction with Transit NZ, consultants and contractors. In comparison with previous events, 2005 flooding and damages much more localized, which meant that the allocation of resources was not very complex. The prioritization process was rather simplified, consisting of visual inspection in the consultant deputy technician together with the contractor representative listed assets and decided on a ranking and treatment options, without considering the previous state of the assets and costs. Furthermore on information about assets, the Transit NZ consultant noted that there would be clear gain in efficiency if contractors knew the exact location and characteristics of the roading elements such as signage, culvert, etc. This mainly reflects the limitations of the Road Assessment Maintenance Management (RAMM) employed in Transit NZ daily operations. Ironically, contractors and consultants managed to download television reports about the events from internet using their mobile phones, but they were unable to know what was underneath the mud.

An overview of communications and of data/information exchange/sharing during the Matata events indicates that informal linkages and assessment were predominately observed.

Involved roading organisations depended heavily on individuals' previous knowledge about the area, the assets. Obviously, previous knowledge was very important, but there are many concerns about how it was rationally and efficiently employed to solve complex problems. Moreover, "common sense" overwriting information (or lack of it) was constantly employed. On the other hand, the current information system (RAMM) was perceived as not suitable to cope with the dynamic nature of such an event. This has probably forced Transit NZ, contractors and consultants to respond as observed.

3.3 A potential framework for data/information sharing and implementation issues within Transit NZ

Based upon the need for efficient inter and intra Transit NZ data/information sharing, a conceptual framework is presented. Following the concepts of knowledge and information management [39], the first step is to identify the information needs of the involved organization. Using the Integrated DEFination (IDEF0) modelling language (semantics and syntax) and considering the examination of Transit NZ emergency procedures and reports, the information needs for each response phase and involved organization were identified as shown in Table 2. These needs were considered in the conception of an information flow framework [45] that is presented in Figure 3.

This information framework was applied to a case study in the South Island of New Zealand. Results show that reduction in time and cost of emergency response activities could be reached if the conceptual framework were implemented. The total cost of road closures per year is estimated to be approximately 3 million dollars. By using the data/information framework, the cost of road closures can be reduced to 2.7 million dollars. In the best case scenario, it would generate 5.53% (NZ$ 162,342) reduction while the worst case scenario would generate a reduction of 1.70% (NZ$ 49,952) [45].

The implementation of such a framework would require personnel training, equipment purchase (PDA or mobile phones with GPS receiver units, PC data projectors for Transit NZ control rooms), considerable commitment in changing the organizational culture and further technological and methodological advances. Both training and equipment can be justified based upon the reduction of time and costs as well as with the minimization of social and economic disruption. Nevertheless, preliminary findings not only about Transit NZ but also on New Zealand organizations indicate that there is a need for clear understanding and communication of intra-organisational responsibilities and duties across divisional and geographical boundaries [46]. As for the technological and methodological advances, major natural disasters events require the manipulation of a large variety of data sets for national, regional, local and site specific levels. This has to be seriously taken into consideration because speed and size of each data set will certainly interfere with the final data/information sharing outcome. Specific processing technology to efficiently manipulate the data sets has to be developed and implemented. Fortunately, New Zealand has a solid culture of geospatial data collection and storage, which is provided by Land Information New Zealand (LINZ).

Table 2. Transit NZ and response partners' information needs in response activities

	Regional Consultant info needs	Regional Contractor info needs	Transit NZ Regional Office info needs	CD info needs
Event Occurrence		-Potential damaged area/region -Type of event -Intensity and expected duration -Available resources		
Event Observation	-Damaged area/region -Type of event -Damaged asset type -Partial or complete road closure -Alternative roads -Traffic flow composition -Contractors' resources -CD emergency declaration?	-Damaged area/region -Type of event -Attributes of potentially damaged assets (Location; Original condition; Characteristics; Costs; Priority Repair availability).	-Damaged area/region and event type -Damaged asset type; -Partial or complete road closure -Alternative roads -Traffic flow composition -Contractors/Consultants' available resources -Initial road closure time/ costs estimation -MCDEM emergency declaration?	
Event Assessment	Comparison before and after / damaged asset Location Original condition Characteristics Treatment options Costs Priority Repair availability -Contractors' available resources		-Report on before and after / damaged asset -Summary of damaged assets per type -Summary of treatment options -Summary of Costs/Priorities Repair availability -Consultants and contractors available resources -Initial road closure time estimation -Initial cost estimation -MCDEM emergency declaration?	-Report on road closures (Location; Partial/complete; Expected road opening -Consultants and contractors available resources -Initial cost estimation
Resources Deployment	-Location of Contractors' equipment and personnel -Deployment times -Allocation plan of resources and personnel per damaged asset (Location; Original condition; Characteristics; Treatment; Priority; Effectiveness) -Traffic management plan MCDEM emergency declaration?	-Allocation plan of resources and personnel per damaged asset (Location; Original condition; Characteristics; Treatment; Priority; Effectiveness) -Deployment times -Traffic management plan -MCDEM emergency declaration?		
Event Reporting	Damaged area/region -Attributes of damaged assets: (Location; Original/Current conditions; Characteristics; Treatment; Costs; Priorities; Repair availability)	Damaged asset type Attributes of damaged assets: (Location; Original/Current conditions; Characteristics; Treatment; Costs; Priorities; Repair availability) -Partial or complete road closure -Alternative roads -Traffic flow composition -Contractors' available resources	-Damaged asset type -Partial or complete road closure -Alternative roads -Traffic flow composition -Contractors/Consultants' available resources -Road closure time/costs estimation -MCDEM emergency declaration?	
Event Re-assessment	-Comparison before and after / damaged asset (Location; Original condition; Characteristics; Treatment options; Costs; Priority; Repair availability) -Contractors' available resources Stop response/Initiate Recovery mode/Continue Response?		-Report on before and after / damaged asset -Summary of damaged assets per type, treatment options, Costs and Priorities -Repair availability -Consultants and contractors available resources -Initial road closure time cost estimation -Stop response/Initiate Recovery mode/Continue Response? -MCDEM emergency declaration?	-Report on road closures (Location; Partial/complete; Expected road opening -Consultants and contractors available resources -Initial cost estimation

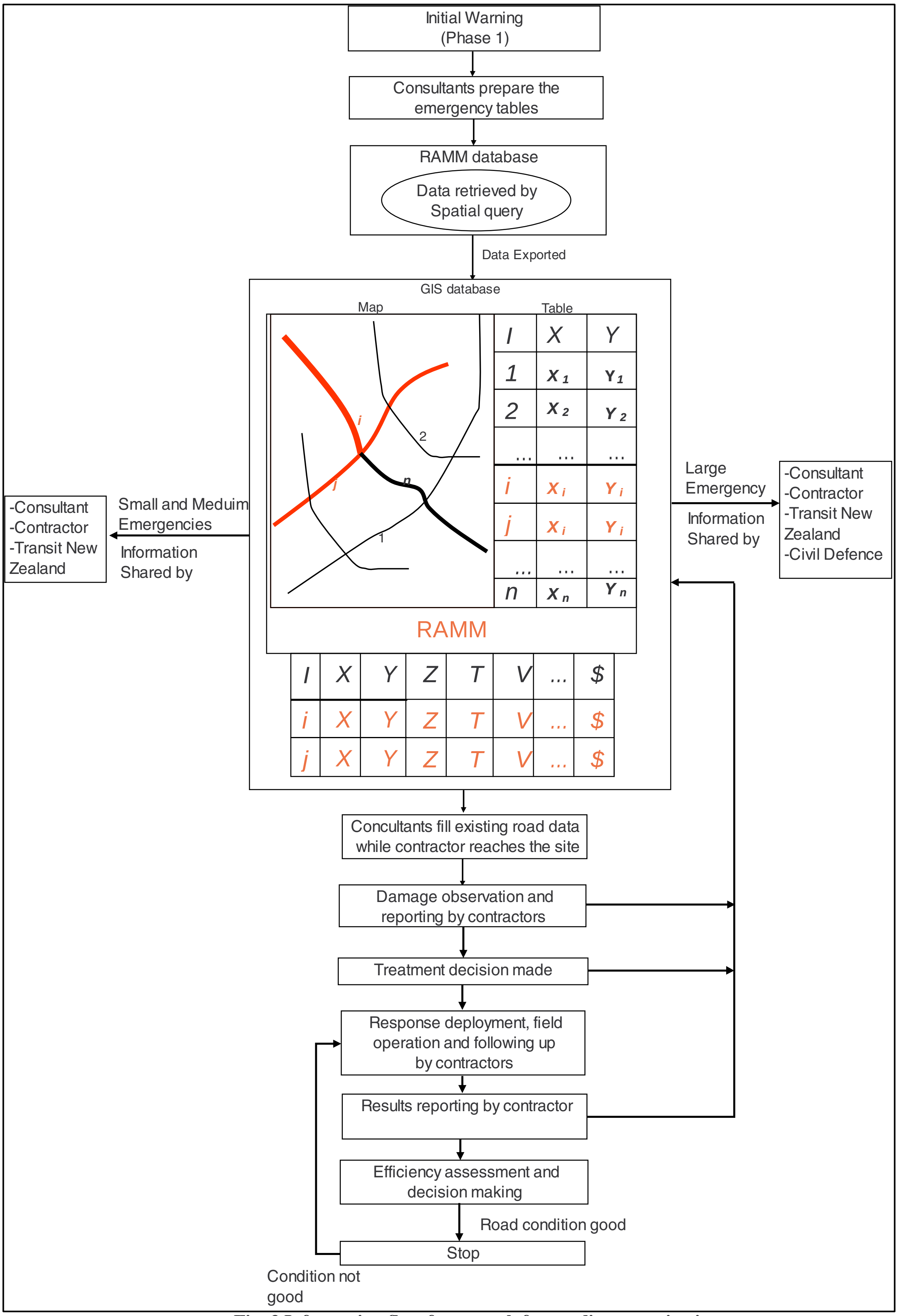

Fig. 3 Information flow framework for roading organizations

4. CONCLUSION

A major outcome of this research work is that perceived barriers can be reduced if technology is employed according to organizations' needs rather than the other way around.

This is possible by involving end-users during all development stages of the electronic data and information sharing frameworks.

From the review of the scientific and technical literature, it can be observed that considerable opportunities lay in exploring new paradigms emergency response with extensive telecommunications and geo-spatial technologies. On the other hand, the case study of the roading organizations in New Zealand has indicated that potential has already been observed and quantified, but implementation of response systems require much more than technology. Organisational reorientation is also fundamental to change misperceptions and pre-conceived paradigms that affect the efficiency of emergency response.

There are various and complex challenges in terms of developing technological and methodological solutions that are according to current and future needs, without underestimating the need for long-term commitments from all involved parties.

Acknowledgements

This research programme is supported by the Foundation for Research Science and Technology (FRST) of New Zealand. We would like to thank Mr. Peter Connors, Mr. Maurice Mildenhall, Daya Govender and Brian Grey (Transit NZ), Mike Skelton (MWH Global), John Reynolds and John Tailby (Opus International), Gavin Treadgold (Kestrel Group), John Fisher (ECAN-Civil Defence) and all others that shared their knowledge and experience about emergency procedures and events.

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