Proceedings of Bushfire CRC & AFAC 2011 Conference Science Day

1 September, 2011

Sydney Convention Centre, Darling Harbour

Edited by

R.P. Thornton

Published by:

Bushfire Cooperative Research Centre

Level 5 340 Albert Street

East Melbourne 3002

Australia

Citation:

R.P. Thornton (Ed) 2011, 'Proceedings of Bushfire CRC & AFAC 2011 Conference Science Day' 1 September 2011, Sydney Australia, Bushfire CRC

Welcome from Editor

It is my pleasure to bring to you the compiled papers from the Science Day of the AFAC and Bushfire CRC Annual Conference, held in the Sydney Convention Centre on the 1st of September 2011.

These papers were anonymously referred. I would like to express my gratitude to all the referees who agreed to take on this task diligently. I would also like to extend my gratitude to all those involved in the organising, and conducting of the Science Day.

The range of papers spans many different disciplines, and really reflects the breadth of the work being undertaken, The Science Day ran four steams covering Fire behaviour and weather; Operations; Land Management and Social Science. Not all papers presented are included in these proceedings as some authors opted to not supply full papers.

The full presentations from the Science Day and the posters from the Bushfire CRC are available on the Bushfire CRC website www.bushfirecrc.com.

Richard Thornton

November 2011.

ISBN: 978-0-9806759-9-3

The changing nature of emergency services multi-agency coordination

C. Owen, University of Tasmania, TAS, Australia

Abstract

One of the key issues arising from the 2009 Victorian Bushfires Royal Commission was whether organisational changes would benefit or hinder future emergency management response. This paper will report on research conducted in the first Bushfire CRC research program. The research included a survey to obtain emergency management personnel perceptions about the suitability of the relevant Incident Control Systems (ICS) in use during fire and emergency management of natural disaster events. The survey was completed with organisational survey data collected from 870 respondents engaged in emergency management work across 25 agencies in Australia and New Zealand.

The research indicates that the original functional purpose of the (ICS) used in Australia (Australasian Inter-Service Incident Management System or AIIMS) and its complement in New Zealand (Coordinated Incident Management System or CIMS) works well, particularly in predictable and routine emergency events. There is, however, evidence to suggest that AIIMS/CIMS processes are strained under conditions of escalation - when emergencies are complex - and that this creates different kinds of tensions for personnel working in different parts of the system.

This paper develops and tests a model of emergency management coordination based on key attributes identified in a factor analysis, and tests the model using structural equation modelling. The findings show that the coordination through organisational processes and distributed collaboration between teams better explained satisfaction with information quality and inter-agency interoperability than within-team communication. Implications for the future of managing dynamic events through the formation of supra-organisational temporary configurations are discussed.

Introduction

What is the role of organisation in emergency management response? This question has been raised repeatedly in various inquiries into emergency events (e.g., Teague, 2009; QFCI, 2011; Keelty, 2011). In the 2009 Victorian Bushfires Royal Commission, for example, a considerable amount of time was spent attempting to understand whether organisational changes would benefit or hinder emergency management response in the future. A range of experts was called to give opinion (e.g., Boin & t'Hart, 2010; Leonard & Howitt, 2010). In its report, the Commission concluded that major structural reform was needed to meet the increasing expectations of community and government. Emergency management performance needed to be able to provide high quality and timely information that could yield suitable warnings to communities and enable strategic emergency management by Government and other stakeholders. According to expert opinion provided to the Commission (Boin & t'Hart, 2010), impediments that needed to be overcome included (in part):

- An obsession on the part of the emergency responders to obtain full information before engaging in action or providing advice to affected communities;
- A total reliance on command and control, rather than a recognition of the variety of stakeholders involved including those who do not fit within a command and control paradigm;
- Under estimating the crisis after the emergency.

Emergency services organisations need to quickly manage the event and in doing so bring together a variety of people drawn from many other agencies to cooperate on the problem. In this respect, emergency management requires the coordination of multiple organisations forming a temporary or incidental supra-organisation. Coordination is defined as "mutually agreed linking of activities of two or more groups" (Quarantelli, 1986, p. 9). In this paper it is argued that those different groups may be different teams operating within a command and control organisation or may represent distributed communication between teams in different organisations. This is important because when multiple organisational stakeholders are involved, there will frequently be differences and sometimes conflicting priorities and goals (Briscoe, 2007; Schraagen & Ven, 2011; Sonnenwald & Pierce, 2000).

The dilemma of multi-agency coordination in emergency management settings is that on the one hand there is a need for tight structuring, formal coordination and hierarchical decision making to ensure a clear division of responsibilities, prompt decision processes, and timely action. However, on the other hand, because of the need for rapid action in an uncertain environment, there is a competing need to rely on organisational structures that support decision making, as well as informal and improvised coordination mechanisms (e.g. Bigley & Roberts, 2001; Brown & Eisenhardt, 1997; Weick & Roberts, 1993).

The aim of this paper is to report on research conducted as part of the first phase of the Bushfire CRC. The purpose of this research study was to:

- Review information and communication flows;
- Review how teams work with the AIIMS/CIMS systems;
- Identify opportunities for improvement.

The research was guided by a number of research questions which included:

- To what degree are the processes embedded within AIIMS to support information flow and coordination practiced by personnel engaged in emergency incident management?
- What collective practices and organisational processes can be identified that need to be improved in order to enhance IMT/ICS work performance?

According to the literature, emergency management coordination raises many challenges. Comfort and Kapucu (2006) have noted that:

> The need for integration intensifies as the number of organisations engaged in response operations increases and the range of problems they confront widens. Since all organizations in the damaged area are affected, private and nonprofit actors, as well as public organisations, become participants in the response system (p. 310).

The challenge then, is to better understand the extent to which existing approaches to emergency incident management support effective information flow, and coordination (Comfort & Kapucu, 2006; Sonnenwald & Pierce, 2000). At issue is the need to find suitable enablers that can help reshape emergency management organisation in the future. The following theoretical constructs have been identified as important in the literature.

Effective incident and emergency management relies on successful team performance. Teamwork is defined as the processes that individuals use to coordinate their decisions and activities, such as sharing information and resources to attain shared goals (Cannon-Bowers & Salas, 1998). It is important that team members have both technical expertise and social interactions that will lead to adaptive coordinated action (Salas, Rosen, Burke, Goodwin & Fiore, 2006). Critical to teamwork is psychological safety that enables personnel to speak up and to have trust in each other (Edmondson, 2005).

Much emergency management work involves work groups coordinating in different locations. This involves enhancing communication across boundaries and enabling personnel to speak up and share what they know (Carmelli & Gittell, 2009). Clark and Jones (1999) and Stewart, Clarke, Goillau, Verrall and Widdowson (2004) all emphasise the importance of developing effective distributed collaboration across different teams and work environments. Teamwork and distributed collaboration occurs in an organisational context, something that is frequently mentioned but rarely systematically examined in the literature (DeChurch & Zaccaro, 2010). Both

individual and collective performance is contingent upon the degree to which organisational procedures and processes are sensitive to the work demands to enable shifts in roles and structures (Guise & Segel, 2008; Salas et al., 2006; Vogas & Sutcliffe, 2007). According to Smith and Dowell (2000) “an incident organisation develops organically, both in the sense of growing and transforming during the incident, and in the sense that individual roles are determined and adjusted flexibly”. This requires appropriate organisational processes to allow and support movement in authority and decision-making and to enable improvisation. A key issue in emergency response organisations in particular is ensuring the appropriate level of resourcing and personnel support is available (Smith & Dowell, 2000; Wise, 2006).

In the command and control literature in particular there is an emphasis on inter-operability between organisations. Interoperability is defined as “. . . the ability of systems, units or forces to provide services to and accept services from other systems, units or forces and to use the service so exchanged to enable them to operate effectively together without altering or degrading the information exchanged” (Stewart, Clarke, Goillau, Verrall & Widdowson, 2004, p. 4). Therefore the inter-operability between organisations (i.e., the way technical systems, policies and procedures and cultures align between agencies) is of obvious importance.

Research method

The research conducted during 2006-2010 included interviews with 130 personnel experienced in emergency incident management; observations of six real-time events as well as 18 exercise simulations of incident management in four states (Queensland, New South Wales, Victoria and Tasmania), and a survey of 870 personnel who have worked within 25 agencies representing all Australian states and territories and New Zealand.

Given space limitations, the focus here will be on the survey data with references to cross validation of some findings from other methods. In terms of the survey component, a questionnaire was constructed to assess perceptions of (i) teamwork during emergency events; (ii) how well responders working on the fire- or incident-ground worked with others who were operating away from the incident but who were responsible for managing the event as well, and (iii) perceptions of the organisational processes underpinning the AIIMS/CIMS systems. A number of likert-type statements were developed on these areas based on the teamwork and organisational behaviour literature. For details of the data collection, reporting and analysis please see Owen and Dwyer (2009), and Owen and Dwyer (2011).

It should be noted that unless otherwise stated the items were Likert-type where the statement offered a ranking of 1 = low and 7 = high. Respondents also had the opportunity to state that they were unable to answer. The use of Likert type subjective measures of individual perceptions of personal, interpersonal and collective performance is consistent with other studies (Frazier, Johnson, Gavin, Gooty, & Snow, 2010; Moon, 2010).

Next, we checked that the assumptions of normality could be met by using the SPSS random selection tool and randomly selecting 50 cases from the data set on the indicator items. On this we conducted Kolmogorov-Smirnov tests to assess the normality of the distributions on relevant items. The assumption of normality of the distribution was met for all items.

Given the limited theoretical development that has occurred in multi-organisational coordination, the analysis first proceeded to explore patterns in the data and to evaluate these in terms of their insights for change. A Principal Components Factor Analysis was undertaken to identify latent patterns and structures in the data.

The factor analysis achieved a Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) of .943 and the six factors reported 71% of the variance. The scores were then standardized so that they could be compared across work groups. Standardised scores result in a normal curve distribution of total responses for the construct which then also has a mean of 50 and a standard deviation of 10. This standardisation then means that scores for different groups can be compared.

A summary of the factors identified from the analysis can be found in Table 6. These factors were then used to indicate perceptions about different aspects of emergency management operations in different parts of the system. The levels included on the fire- or incident-ground, within an Incident Management Team (IMT) as well as within a regional or state level of coordination. It is interesting to note that one in every three personnel also reported in the survey that they experienced factors that inhibited them from being able to effectively carry out their job. Table 7 provides outlines the distribution of the standardized scores on the factors. The Table shows where the standardised score was more than one standard deviation above the mean (Positive); distributed within one half a standard deviation above and below the mean (Neutral); between 0.5 and a full standard deviation below the mean (some concerns); 1-1.5 standard deviations below the mean (Attention required) and more than 1.5 standard deviations below the mean (Serious concern). The Table therefore illustrates areas of dissatisfaction and thus systemic tension when personnel are under pressure. In the Table, the rows represent each of the factors identified and the columns represent each of the work groups in operation within the ICS structure. The Table as a whole represents a colour-coded synthesis of all data analysed. It identifies key areas proposed for intervention in order to improve emergency incident management performance.

Theory development and theory testing

To further develop an explanatory model for the data, a two-step model of theory building and theory testing was used. The factors and their indicators were reviewed in light of the literature outlined above and constructs developed, see Table 3.

A confirmatory factor analysis was conducted to assess the dimensionality of the key constructs using maximum likelihood estimation and varimax rotation. The factor analysis achieved a Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) of

.925 and the six factors reported 75% of the variance. This indicated that the items were loading as single dimensions. Two dependent variables *information quality* and *interoperability* were developed. *Information quality* was based on perceptions of the timeliness, accuracy, relevance and completeness of information available; *interoperability* was based on perceived effectiveness of technical systems, policies and procedures and culture to support inter-organisational coordination.

Given the factors identified, the following hypotheses were proposed:

- H1- that organisational processes would positively support team communication;
- H2 - that both teamwork and organisational processes would be positively associated with information quality and interoperability;
- H3 - that both organisational processes and team communication would support distributed communication;
- H4 - weak signals and organisational impediments would be negatively associated with the information quality and inter-operability;
- H5 - that distributed collaboration between groups would mediate the impact of team communication and organisational processes on information quality.

The hypothesized model was then measured using Structural Equation Modeling (SEM). Although there are a variety of ways of estimating models, SEM was chosen because it can be used to assess both the direct and mediating effects as well as the latent structure of the model (Hoyle, 1995). For example, the latent variable *Team Communication* is a hypothetical construct inferred by the items measured in Table 1. SEM enables measurement error to be controlled by using multiple indicators for each latent variable in the models (Arbuckle, 2008).

To address potential non-independence of groups within the emergency management structure (i.e., that personnel might report differently depending on whether they work at a local, regional or state level) or type of emergency management agency (e.g., urban, land management, rural fire service), these observed variables were also included in the model with paths established to all variables of interest to control for this potential bias.

In order to develop and test the model, the data set was randomly split using the SPSS function into two separate databases. The theory development database contained 444 cases and the theory test database contained 426 cases. The hypothesized model was then measured using Structural Equation Modeling (SEM) on the theory-development dataset. Various measures of fit were used in combination with the chi-square. These included the goodness of fit index (GFI) along with the comparative fit index (CFI) and the root mean square error of approximation (RMSEA). The indexes of the GFI, CFI can range from zero (no fit) to one (perfect fit), with values of 0.9 indicating an acceptable fit and 0.95 a good fit (Arbuckle, 2008). The RMSEA values of less than 0.08 indicate an acceptable fit and

less than 0.5 a good fit (Arbuckle, 2008). The model was then revalidated using the theory testing dataset.

Findings

This includes the descriptive analysis of the Factor Scores by various groups as well as the theoretical development and testing.

Descriptive findings

On the fire- or incident-ground

The concerns of personnel on the fire- or incident-ground are, not surprisingly, for resources. Also highlighted are concerns regarding securing needed support from the IMT in a way that is temporally responsive.

Incident Management Teams

IMTs are comprised of smaller functional units that sometimes have considerable difficulty in getting their own needs met from the "core" IMT members, here called IMT Officers (i.e. the Incident Controller, Operations Officer, Planning Officer and Logistics Officer). Personnel working within functional units of the IMT reported lowest levels of satisfaction with interactions supporting distributed collaboration (see Table 6) between the IMT and the incident-ground. There is a need to strengthen the interconnections between planning and operational functional units within the IMT because it is between these two units where the first disconnects and coordination breakdowns occur. At IMT officer level, the analysis indicated a need for better inter-operability in technical systems, policies and procedures and supporting culture. This is likely to require better systemic connections within the ICS (between the IMT and regional/state levels of coordination) as well as between the IMT and other supporting emergency arrangements (e.g. Municipal Emergency Coordination Centres) and other supporting agencies.

Regional levels

People working at a regional level suffered most from concerns about personnel capability. They reported lower levels of certainty of what needed to be done; less familiarity with the incident management systems being used at that level and less understanding about whom to contact for information or expertise. These indicate a lack of definition and ambiguity of the regional coordination function and of its roles within the overall Incident Management System.

State levels

The State level (in New Zealand this is the national level) had the highest reporting of experiencing *organisational impediments*. This was also mentioned in the interviews conducted where it was evident that coordinating demands at this level emphasise – in addition to the demands associated with control – a need for a different way of coordinating that is more closely associated with what Gittell (2008) calls 'relational coordination' within multi-agency networks. In the survey, personnel at a state level reported experiencing higher levels of contradictions in policies; experienced higher levels of competing demands; reported a greater degree of having to go outside normal procedures, as well as being asked to go outside the chain of command.

Theoretical modeling: Measuring model specification

An initial run of the model using Structural Equation Modeling suggested a moderate fit for the variables. The constructs *weak signals* and *organisational impediments* were removed due to their limited influence in the model. Theoretically this is supportable since the two variables reporting negative impacts are likely to be acting in a different way and probably need to be included in a different model (Sonnenwald & Pierce, 2000).

The chi-square values, associated degrees of freedom, and probability levels for the model are presented in Table 4 and the final estimates presented in Table 5 – see also Figure 1.

Hypothesis 1 stated that *organisational processes* would support *team communication.* The results support this view: (β = .71, t(426) = 7.10). Hypothesis 2 stated that (2a) *team communication* and (2b) *organisational processes* will be positively associated with (2c) *information quality* and (2d) *interoperability.* The results partially support this view. As with the model development dataset, team communication was again not significantly associated with *information quality* (β = .01, t(426) = .20) ns or with *interoperability* (β = .01, t(426) = .14) ns. However, *organisational processes* was significantly associated with *information quality* (β = .43, t(426) = 3.67) and with *interoperability* (β = .60, t(426) = .4.46).

Hypothesis 3 stated that (3a) *team communication* and (3b) *organisational processes* would be positively associated with *distributed collaboration.* The results support this view, with (β = .18, t(426) = 2.68) for *team communication* and β = .86, t(426) = 7.76) for *organisational processes.* The final hypothesis tested within the validation model was that *distributed collaboration* would mediate the impact of *team communication* and *organisational processes* on *information quality.* Again the results support this view (β = .50, t(426) = 8.24).

Discussion

The research reported here provides guidance about areas that could be targeted to achieve improvements in incident management work and organisation. By reviewing

perceptions about the teamwork, coordination and organisational processes, the analysis provides a systematic evaluation and diagnostic framework that identifies areas for improvement and suggests different levels of possible intervention. The findings also illustrate that there is a need to build stronger teamwork practices as well as strategies to enhance coordination between groups.

It is interesting to note that *team communication* was not significant in *information quality* or in *inter-organisational interoperability*, which is surprising. It was also interesting to note that *organisational processes* provided the strongest support for *team communication*, *distributed collaboration* and for *information quality* and *inter-organisational inter-operability*. There are a few possible explanations for these results.

First, given the strength of teamwork found in other research studies, it is suggested that the reports on emergency management response teams here may not be engaging in strong teamwork practices that enable best possible performance outcomes. There are validating supports for this finding in other research collected as part of this broader study. For example, in the observational component of the research, teamwork training was found to be focussed on assisting team members to learn their individual roles and responsibilities – in the literature a practice known as team building not teamwork. These findings suggest there is a need to examine more closely how teamwork performance may be further developed in order to achieve better outcomes.

The findings in the model related to distributed collaboration and organisational processes are also supported in other research. There is some evidence emerging to suggest that it is not effective teamwork *per se* that makes the difference in complex multi-layered multi-team systems, but how the boundaries between teams are managed that is important (DeChurch & Zacarro, 2010). In this respect effective internal processes within teams are an important and necessary, but not sufficient, condition to enable coordination. There were some indications of this in the observation data where teams with Incident Controllers who were engaging in particular types of team coaching practices were yielding higher team performance outcomes. These practices coalesce around three dimensions: *boundary riding* (coaching behaviours and giving explicit feedback to team members on team and internal integration expectations); *boundary spanning* (coaching to support internal coordination between functional units within the team) and *boundary crossing* (coaching to support external coordination between groups).

To return to the issues raised by the Victorian Royal Commission of Inquiry, the challenges facing emergency services organisations include how to provide a coordinated and fully accountable response, and at the same time providing high quality and appropriate information that could yield timely warnings to communities and enable strategic decision-making by Government and other stakeholders.

The findings discussed here suggest a strong reliance on organisational processes and less on team communication. However, is this the appropriate mix to yield timely and adaptable response? Greater attention to getting the most from teams through teamwork (through, for example, training in team communication skills) may be needed to improve team performance. In addition there is a need to develop enhancements between teams involved in the emergency response.

These findings also raise questions about the types of organisational processes that are needed to support coordinated action between multiple stakeholders. If command and control paradigms are insufficient (Helsloot, 2008) – and emergency services organisations are frequently criticised because of their total reliance on command and control, rather than a recognition of the variety of stakeholders involved including those who do not fit within a command and control paradigm – what are the alternative models for these dynamic and safety-critical contexts?

In considering the outcomes of an inquiry like the Victorian Bushfires Royal Commission and its implications for change in the future, the following questions emerge from considering the data presented:

- If the conceptual distinction between routine and crisis events is valid for emergency events, what are the implications for organising the emergency response?
- If decentralisation is to be strengthened, as suggested by experts in the domain, what appropriate triggers are needed and what are the implications for training, doctrine and technology?
- What enablers are required to make unitary command and control on the one hand and inter-agency collaboration on the other effective in producing a successful emergency response?

The findings presented here suggest a need to re-examine the ways in which organisational processes support distributed collaboration in ambiguous circumstances if we are to achieve the resilience and flexibility needed. This is arguably more than a mission command approach to decentralised decision-making which works well when the coordination action required can be located within the boundaries of one organisation. As Elliott and Macpherson (2010) contend, in emergency management agencies there still remains an over emphasis on compliance and standards, but not on how organisational resilience may be developed to support adaptation and emergence – and it is argued based on the findings presented, this is particularly important in the context of distributed collaboration between teams.

How do organisational processes enable the level of bricolage when existing technological and organisational procedures are not able to anticipate the demands faced? These issues need addressing if theory development is to appropriately support emergency management work.

In conclusion, it is critically important that emergency management is underpinned by theoretical models that support evidence-based practice within multi-team complex systems. These issues need to be understood and addressed before the fire and emergency services industry faces the next challenge-test of a complex and overwhelming event where there may once again be failures in both legitimacy and resilience.

References

Arbuckle, J. L. (2008). *AMOS 17.0 User's Guide*. Chicago: SPSS Inc.

Bigley, G. A., & Roberts, K. (2001). The incident command system: high-reliability organizing for complex and volatile task environments. *Academy of Management, 44*(6), 1281-1299.

Boin, A., & 't Hart, P. (2010). Organising for effective emergency mangement: lessons from research. *Australian Journal or Public Administration, 69*(4), 357-371.

Briscoe, F. (2007). From iron cage to iron shield? How bureaucracy enables temporal flexibility for professional service workers. *Organization Science, 18*(2), 297-314.

Brown, S., & Eisenhardt, K. (1997). The Art of Continuous Change: Linking Complexity Theory and Time-paced Evolution in Relentlessly Shifting Organizations. *Administrative Science Quarterly, 42*, 1-34.

Burns, T., Stalker, G.M. (1961). *The Management of Innovation*. London: Tavistock.

Cannon-Bowers, J. A., & Salas, E. (1998). Team performance and training in complex environments: recent findings from applied research. *Current Directions in Psychological Science, 7*(3), 83-87.

Carmeli, A., & Gittell, J. H. (2009). High-quality relationships, psychological safety, and learning from failures in work organizations. *Journal of Organizational Behavior, 30*(6), 709-729.

Chapman, J., & Bearman, C. (2011). Framework for Eliciting Shared Mental Models for use in Bushfire Fieldwork (Report Prepared for the Bushfire CRC Under the Project: Organizing for Effective Incident Management). Melbourne, Australia: Bushfire CRC

Clark, T., & Jones, R. (1999). *Organisational interoperability maturity model for C2*. Paper presented at the Command and Control Research and Technology Symposium.

Comfort, L. K., & Kapucu, N. (2006). Inter-organizational coordination in extreme events: the world Trade Center attacks, September 11, 2001. *Natural Hazards, 39*, 309-327.

DeChurch, L. A., & Zaccaro, S. J. (2010). Perspectives: Teams won't solve this problem. *Human Factors, 52*(2), 329-334.

Edmondson, A. (2005). Psychological safety and learning behaviour in work teams. In C. L. Cooper & W. H. Starbuck (Eds.), *Work and workers* (Vol. 3, pp. 291-329). London, Thousand Oaks, New Delhi: Sage Publications.

Elliott, D., & Macpherson, A. (2010). Policy and Practice: Recursive Learning From Crisis. *Group & Organization Management, 35*(5 Supp), 572-605.

Frazier, M.L., Johnson, P.D., Gavin, M., Gooty, J. & Snow, D.B., 2010, Organizational justice, trustworthiness and trust: A multifoci examination: Group & Organization Management, v. 35, p. 39-76.

Gittell, J. H. (2008). Relationships and resilience. *The Journal of Applied Behavioural Science, 44*(1), 25-47.

Guise, J.-M., & Segel, S. (2008). Teamwork in obstetric critical care. *Best Practice & Research Clinical Obstetrics and Gynaecology, 22*(5), 937-951.

Helsloot, I. (2008). Coordination is a prerequisite for good collaboration, isn't it? *Journal of Contingencies and Crisis Management, 16*(4), 173-176.

Hoyle, R.H., 1995, Structural Equation Modeling: Concepts, Issues and Applications, Thousand Oaks, CA: Sage Publications.

Keelty, M. J. (2011). *A Shared Responsibility: The Report of the Perth Hills Bushfire: February 2011 Review*. Perth, Western Australia: Public Sector Commission, Government of Western Australia.

Leonard, H. B., & Howitt, A. M. (2010). Organising response to extreme emergencies: the Victorian Bushfires of 2009 *The Australian Journal of Public Administration, 69*(4), 372-386.

Moon, T., 2010, Organizational Cultural Intelligence: Dynamic Capability Perspective: Group & Organization Management, v. 35.

Owen, C. (under development) Bulldogs and boundary spanners: contested visions of leadership in emergency management

Owen, C., & Dwyer, I. (2009). *Review of Incident Management Teamwork and multi-agency collaboration*. Melbourne, Australia: Bushfire CRC.

Owen, C., & Dwyer, I. (2011). Strategic implications for incident control systems in Australia and New Zealand. *Bushfire CRC / AFAC Fire Note,* (73). Retrieved from http://www.bushfirecrc.com/managed/resource/strategic_implications_for_imts.pdf

QFCI. (2011). *Queensland Floods Commission of Inquiry - Interim Report 1 August 2011*. Brisbane: Qld Floods Commission.

Quarantelli, E. L. (1986). *Disaster Crisis Management* (No. #113): Disaster Research Centre, University of Delaware

Salas, E., Rosen, M. A., Burke, C. S., Goodwin, G. F., & Fiore, S. M. (2006). The making of a dream team: when expert teams do best. In K. A. Ericsson, N. Charness, P. J. Feltovich & R. R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance* (pp. 439-453). New York: Cambridge University Press.

Schraagen, J. M., & Ven., J. v. d. (2011). Human factors aspects of ICT for crisis management. *Cognition, Technology & Work. , 13*(3), 175-187.

Smith, W., & Dowell, J. (2000). A case study of coordinative decision-making in disaster mangement. *Ergonomics, 43*(8), 1153-1166.

Sonnenwald, D., & Pierce, L. (2000). Information behavior in dynamic group work contexts: interwoven situational awareness, dense social networks and

contested collaboration in command and control. *Information Processing & Management, 36*(3), 461-479.

Stewart, C. E., Clarke, H., Goillau, P., Verrall, N., & Widdowson, P. (2004). *Non technical interoperability in multinational forces.* Paper presented at the Power of Information Age Concepts and Technologies 9th Command and Control Research and Technology Symposium.

Teague, B., McLeod, R., & Pascoe, S. (2010). *2009 Victorian Bushfires Royal Commission Final Report*. Melbourne: VBRC.

Weick, K. E., & Roberts, K. (1993). Collective mind in organizations: heedful interrelating on flight decks. *Administrative Science Quarterly, 38*, 357-381.

Wise, C. R. (2006). Organizing for homeland security after Katrina: Is adaptive management what's missing? *Public Administration Review, 66*(3), 302-318.

Table 6: Description of Factors identified in the analysis

Team Working	The processes decisions and activities that individuals use to coordinate their behaviour, including information sharing and resources to attain shared goals.
Pre-occupation with Failure	Taking note of ALL small warning signals and openly discussing them in a constructive manner.
Shift Resources	The resources available on the shift that were available to meet logistical requirements including fatigue management and continuity of information between shifts.
Temporal Responsiveness	The capacity of the IMT to respond and meet needs in a timely way.
Distributed Collaboration	The ways in which IMT and fire-ground personnel communicate with one another to share information and risks in a constructive manner.
Flexibility	The capacity to be able to adapt performance strategies quickly and appropriately to changing task demands.
Systemic Capability	The organisational systems in place that support information sharing and adaptability vertically within a hierarchy and laterally to external networks
Personnel Capability	The level of confidence personnel have that their training and informal knowledge of the incident provides them with sufficient familiarity with incident management systems in use, including policies and procedures and confidence to do what needs to be done.
Organisational Impediments	The degree to which personnel experienced demands where they needed to go outside normal procedures and/or outside of the chain of command; and where they experienced contradictions in policies guiding the management of the incident.
Inter-operability	The technological systems, policies and procedures and culture that enables the effective inter-operability between agencies.

Table 7: Diagnosis of Incident Management Teamwork and Coordination

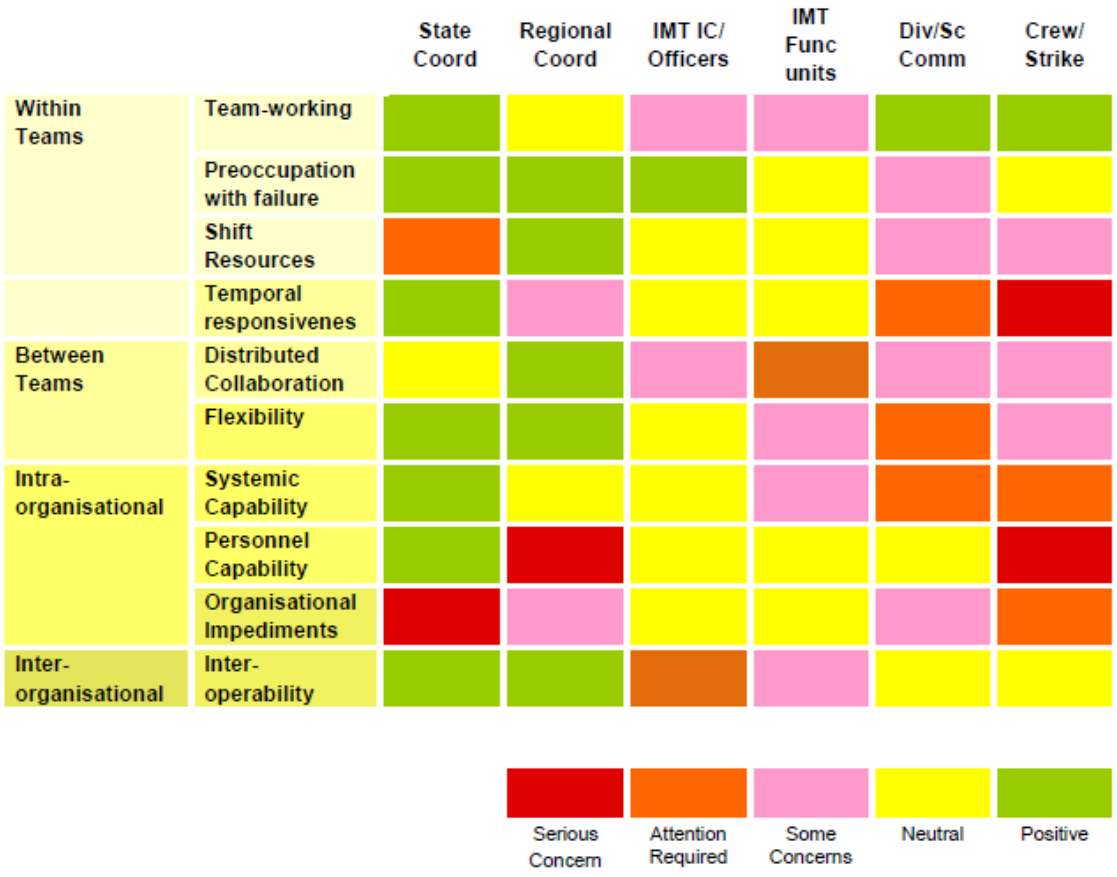

Table 3: Constructs and items included in the theoretical modelling

Latent Variable	Item Label	Hypothesized Item
Organisational Processes	CtctInf	Processes to aid knowing who to contact for information and expertise you needed during the incident
	UseSkl	Your ability to use your skills to maximum benefit
	ComChl	Clearly defined channels for communicating a safety concern
	FrmWk	The effectiveness of the organisational framework for the level of the current incident
Shift Resources	FtgCntl	There were effective provisions used to control fatigue
	ChgOvr	The changeover arrangements were effective
	Trnspt	The transport and logistics arrangements were effective
Team Communication	InfWk	Team members kept each other well informed about work related issues
	Honest	Team members operated in an open and honest manner
	ShrKno	Team members shared their individual knowledge to gain better understanding of the situation at hand
	ShrInf	There were genuine attempts to share information
Distributed Collaboration	Togthr	IMT and Fire/Incident Ground personnel exhibited a strong 'we are in this together' attitude
	FdBck	IMT and Fire/Incident Ground personnel provided constructive feedback to each other
	ExchInf	IMT and Fire/Incident Ground personnel exchanged information clearly and accurately
	Advice	IMT and Fire/Incident Ground personnel provided helpful advice to each other
Information Quality	Time	Timeliness of information
	Cmplt	Completeness of information
	Accrcy	Accuracy of information
	Relev	Relevance of information
Interoperability		Effectiveness of the following in supporting interoperability between agencies
	TchSys	Technology systems
	PolProc	Policies and procedures

Culture Culture

Table 4: Model Fit indices of this study's independence, measurement and validation models

Model	χ^2	*df*	χ_{χ^2}	GFI	CFI	TLI	RMSEA
Independence model	6606.82	229	23.94	.164	.000	.000	.232
Measurement model	596.23	229	2.60	.930	.966	.959	.049
Validation model	434.6	276	1.89	.919	.968	.961	.046

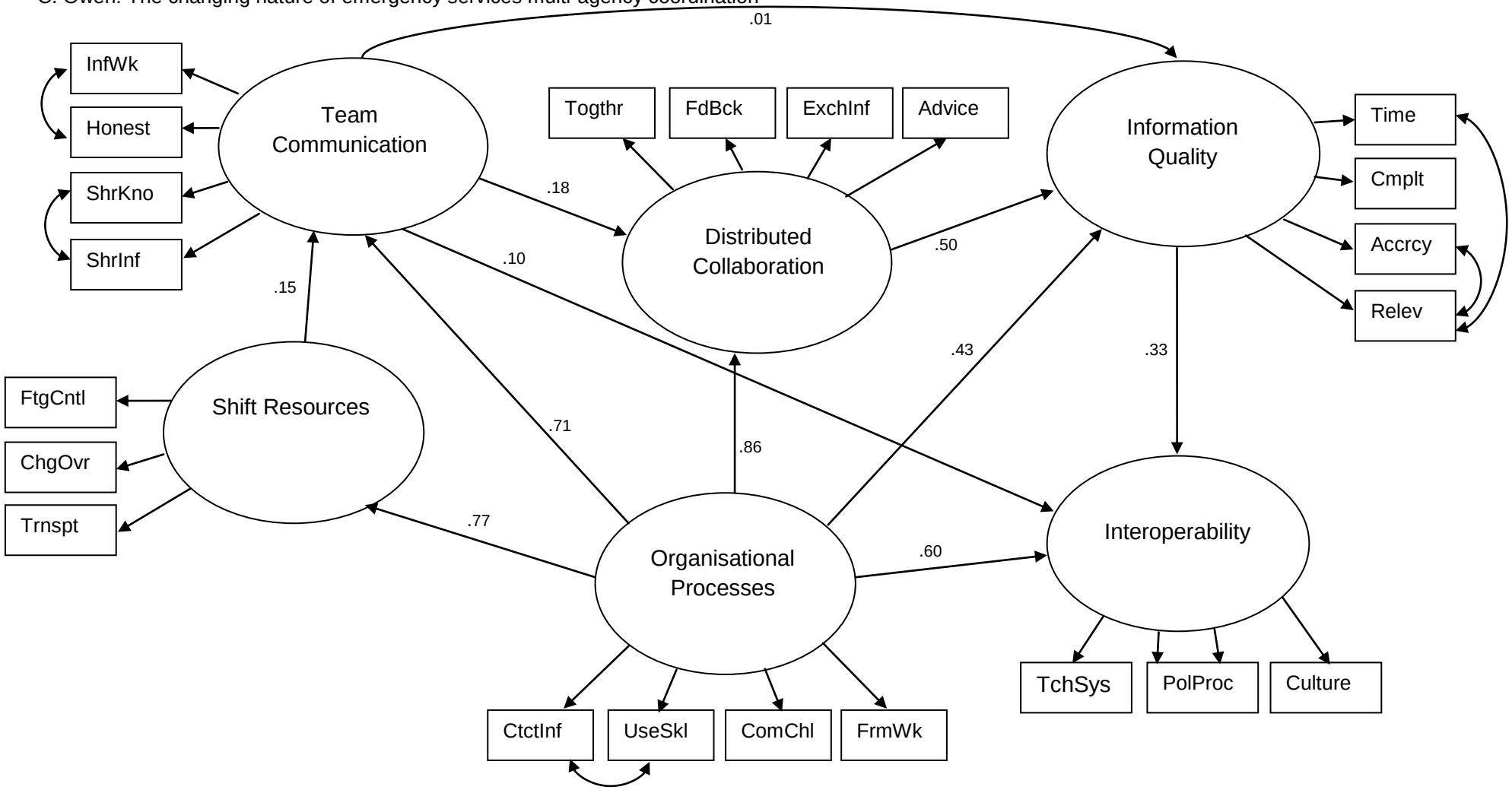

Figure 7: Structural Equation Model showing the relationships between the emergency management coordination factors used in the stud [control for non-independence of group responses from agency type and ICS work layer included in model but not shown for ease of reference]

Table 5: Validated structural equation model

Factor		Factor	Estimate	S.E.	C.R.	P
Shift Resources	←	Organisational processes	.768	.090	8.580	***
Team communications	←	Organisational processes	.709	.100	7.101	***
Team communications	←	Shift Resources	.148	.064	2.301	.021
Distributed collaboration	←	Team communications	.185	.069	2.674	.007
Distributed collaboration	←	Organisational processes	.858	.111	7.758	***
Information quality	←	Distributed collaboration	.502	.061	8.241	***
Information quality	←	Organisational processes	.429	.117	3.669	***
Information quality	←	Team communications	.013	.065	.201	.841
Interoperability	←	Information quality	.327	.062	5.238	***
Interoperability	←	Organisational processes	.603	.135	4.456	***
Interoperability	←	Team communications	.011	.078	.136	.892

Note: *** = .0005