



ORGANISING FOR EFFECTIVE INCIDENT MANAGEMENT

FINAL REPORT FOR THE EFFECTIVE INCIDENT MANAGEMENT ORGANISING PROJECT

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The New South Wales Rural Fire Service coordination centre during the January 2013 bushfires.

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SUMMARY

This project aimed to better understand how multi-agency emergency management coordination at regional and state levels could be improved in order to reduce the consequences to communities of an emergency event.

Failure in emergency incident management coordination in major events has long been recognised in both the national and the international literature. In large events, breakdowns of information flow and coordination are both common and always problematic. The findings from the 2009–2010 Victorian Bushfires Royal Commission, for example, indicate a need to look beyond creating new standard operating procedures or adding to existing role responsibilities. They indicate that, despite the good work that has occurred in the past to build a robust inter-service incident management system, in overwhelming events the first point of breakdown is typically in communication and coordination between organisational layers involved in emergency management arrangements.

State of knowledge

At the commencement of the project, it was acknowledged that there was limited understanding of the challenges facing personnel working above the local Incident Management Team (IMT) level. In the first phase of the Bushfire CRC, there had been considerable attention provided to the information and decision-making needs of personnel engaged on the fire or incident ground as well as within local incident management teams. However, the demands and challenges facing people working above the IMT (i.e. at regional and state or national levels) was little understood.

There was a need therefore to identify key attributes that would support shared understanding and coordination above the IMT level. Without this knowledge, there are considerable weaknesses and risks in emergency management frameworks. The purpose of this research project then was to identify the processes and challenges for those working above the IMT and to identify areas of possible improvement.

The research team began by conducting literature reviews and examined secondary sources to analyse and identify appropriate conceptual frameworks (Owen, Bearman, Brooks, Chapman, Paton, & Hossain 2013). These early findings revealed that ensuring the accuracy and relevance of the information flow from the IMT and the coordination layers operating above the IMT required a clearly defined understanding of various information needs at critical points in that incident control system. Theoretical work in this area suggested that at the individual level, the internal mental representation of the event (i.e. the mental model) would be a key conceptual construct that would support the relevant, accurate and timely transmission of information. Important also were constructs of mindfulness and sense-making, as well as organisational theories of coordination. Clearly, it is important for emergency service personnel to have well-defined and appropriate mental models to manage emergency events, as well as organisational processes that support effective operation and

coordination. Without these elements, it would be difficult for personnel to adequately grasp the situation, to understand what is critical information, to receive and transmit it to others or to identify when individual, team or organisational performance is degraded.

Data collection and analysis

The research team proposed the following research questions:

1. How is emergency management coordination above the IMT organised?
2. How does information flow to and from regional and state levels of emergency management influence the capacity of personnel to adjust to emerging conditions?
3. How has a lack of shared mental models by key personnel in emergency incident management led to breakdowns in coordination in emergency events?
4. What social networks of communication best facilitate effective multi-agency coordination?
5. How might we best train and educate personnel in the most effective emergency management coordination above the IMT?
6. What changes are needed to support effective emergency management at the regional and state levels of coordination?

To address the research questions, the research team has examined:

- Existing practices and challenges facing those involved in managing emergency incidents at regional, state and national levels.
- Key factors involved in breakdowns in coordination.
- Changes that might be needed to support effective emergency management at regional, state and national levels.
- Education and training strategies to enhance capability.

Data collection and analysis have involved:

- Interviews with key personnel who work at a strategic level of emergency management ($n = 34$).
- Two organisational surveys ($n = 206$; $n = 103$) of personnel working at regional, state and national levels of emergency management.
- Observations of team decision-making in simulation and state-level emergency operations centres in Tasmania, Victoria, New South Wales, the Australian Capital Territory, Queensland and New Zealand.
- Classification and analysis of human factors issues identified in major inquiries.
- Reviews and analysis of training exercises and training strategies for capability development.
- Problem-based learning consultation with key industry stakeholders.

Research findings and implications

In investigating the first research question: *How is emergency management coordination above the IMT organised?*, the research team found that the core of emergency management arrangements is organised broadly into three hierarchical layers. There are activities performed by people working on the incident ground, as well as at tactical (local IMT) and strategic levels (i.e. regional and state or national teams). The organisation of work activity at a strategic level is different in content and context from that of those working at the local incident management level. At a *strategic level*, the focus is on two elements: oversight of incident management operations and consequence management for longer-term recovery. The research team also found (and consistent with related bushfire research – see the work of Dr. Michael Eburn¹, for example) that each state has different governance processes in place. These differences arise from different legislation and different arrangements put in place by state governments. These have implications for sharing resources as staff from one state or territory may not be familiar with the arrangements in other states or territories, and indeed, even the spatial configurations of emergency operations centres are different, with impacts on information flow and coordination. How the strategic level measures the performance of the emergency management system is a potential area for future research.

In investigating the second research question: *How does information flow to and from regional and state levels of emergency management influence the capacity of personnel to adjust to emerging conditions?*, members of the research team found that the differences in ways of organising can lead to cross-jurisdictional ambiguity and that clarity is needed in the application of concepts such as command, control and coordination at the state level. In particular, the function of the regional level in the structure of incident management continues to be debated, with some jurisdictions removing this layer and others maintaining it in different ways, e.g. in the ACT, the jurisdiction is small enough that the regional layer is not required; in New South Wales, the role of the region is still present but is centralised within a State Operations Centre. The findings from the secondary-sources analyses by Brooks et al. (2011) indicated that in terms of the impacts of these various layers on the capacity of personnel to adjust to emerging conditions, emergency management systems are often reduced in capacity during emergency incidents. This raises the challenge of how IMTs are able to manage under conditions that are less than ideal, and in particular how they might support adjustment to emergency conditions. The research team has coined the term ‘coping ugly’ to identify less than ideal situations where personnel still need to get the job done but also need to recognise that the situation they are in is degrading and develop strategies to manage under these conditions (in other words, to ‘cope ugly’). From a systems perspective, ‘coping ugly’ means recognising the drift from a safe to a high-risk performance, to situations

¹ <http://www.bushfirecrc.com/projects/1-1/mainstreaming-fire-and-emergency-management-across-legal-and-policy-sectors-joint-research>

that may include accidents and incidents. There is a need for more research examining the ways in which personnel can become aware that they are approaching or crossing these boundaries so that coping strategies can be developed and used in training.

In investigating the third research question: *How has a lack of shared mental models by key personnel in emergency incident management led to breakdowns in coordination in emergency events?*, members of the research team defined breakdowns as a situation where there is a failure in coordination, cooperation or communication that leads to a temporary loss in the ability to function effectively. Such breakdowns are frequently preceded by one or more disconnects (operational, informational and evaluative) that are not picked up or sufficiently addressed. The regional level may have a key role to play here. If the regional level is maintained, one of its functions may be to provide direct oversight of IMTs and to resolve evaluative disconnects identified in Bearman et al. (2010). How the strategic level recognises and remediates coordination breakdowns is a potential area for future research.

The fourth research question was: *What social networks of communication best facilitate effective multi-agency coordination?* Members of the research team found that levels of perceived social connectedness were associated with results that were sometimes positive and sometimes negative. On the one hand, perceived team connectedness suggested a positive significant effect on the capacity for personnel to adaptively respond to dynamic situations. On the other hand, however, sometimes, as in the case of the 2009 Victorian bushfires, some informal networks were over-used and then became overloaded, with negative impacts on formal coordination systems. In addition, use of informal networks can degrade the performance of the formalised systemic networks that should be the preferred conduits. Why people may find informal networks satisfactory is a potential area for further research.

The fifth research question addressed by the research team was: *How might we best train and educate personnel in the most effective emergency management coordination above the IMT?* The findings by the research team suggest new capabilities are required for personnel operating at the strategic level of emergency management. In part, some of the needs can be addressed from experience in other safety-critical industries where activities support the development and maintenance of a range of technical (e.g. fire or flood behaviour) and non-technical (leadership, communication) skills. The research team acknowledge the considerable improvement in contextual learning, and human factors and leadership education that has already occurred within the industry, and propose the future research and development of their use as opportunities to further develop the coordination skills of those in positions above the IMT.

The sixth and final research question was: *What changes are needed to support effective emergency management at the regional and state levels of coordination?* Based on consultations with key stakeholders within the emergency services industry about the implications of the research, seven challenges were identified that must be addressed for the future wellbeing of the industry. They relate to management of incidents that have:

1. Increased uncertainty, complexity and convergence [in the context of]
2. Disaster Risk Reduction and policy disconnects [with changes in]
3. Community expectations and resilience [and increasing use of]
4. Social media – networking and emergence [as well as challenges associated with]
5. The political–operational nexus [and a need for]
6. Measuring emergency management effectiveness [and improving]
7. Capability development, which includes culture change.

The *Discussion Paper*² based on the identified challenges led to a second phase of industry-based consultation that canvassed the views of 38 emergency management leaders about what needs to change to address these challenges. The consultation (found in the *Strategic Issues Paper*³) revealed a variety of perspectives on what is needed in the future. The *Strategic Issues Paper* includes 82 areas of action suggested by the contributors. At the heart of these challenges is the need to develop new ways of thinking about the role of emergency management in the context of a disaster-resilient society. We hope that the findings and outputs provided through this project contribute to assisting the sector to tackle these current and future challenges and that they provide some useful way-points on that journey.

² <http://www.bushfirecrc.com/publications/citation/bf-4218> and <http://www.bushfirecrc.com/publications/citation/bf-4217>

³ <http://www.bushfirecrc.com/publications/citation/bf-4217>

SECTION 1: INTRODUCTION

This final report on the Bushfire Cooperative Research Centre (CRC)-funded *Organising for Effective Incident Management* research project provides an overview of key research activities, major findings and implications for the industry from its commencement in November 2010 to its completion in 2013. The research project forms part of the Bushfire CRC program *Managing the Threat* and focuses on organising for effective incident management above the local incident management team level.

This section provides a background to the research journey by outlining the state of knowledge at the commencement of the project, identifying the research team, and providing an overview of the objectives of the research, research areas and activities.

1.1 Project overview

This project sought to better understand the challenges facing personnel working at the emergency management coordination level above the IMT level in order to reduce the consequences to communities of emergency events.

1.2 Project background

In large emergency events, failure in high-level emergency management coordination has been recognised widely in emergency management literature. Breakdowns of information flow and coordination above the IMT level have historically been problematic, particularly in large, out-of-scale events.

For example, in reviewing the impact of Hurricane Katrina in the US, Wise (2006) identified that emergency management was significantly hampered by a lack of information from the ground, and the lack of communications and situation awareness paralysed command and control. Wise further noted that the inability to connect multiple communication plans and architectures clearly impeded coordination and communication at the federal, state and local levels. The same situation has been reported in the findings of the Royal Commission of Inquiry into the 2009 Bushfires in Victoria (Teague, McLeod & Pascoe, 2010).

State of knowledge in Emergency Management Coordination

At the commencement of the project, it was acknowledged that there was limited understanding of the challenges facing personnel working above the local IMT level. In the first phase of the Bushfire CRC, there had been considerable attention provided to the information and decision-making needs of personnel engaged on the fire or incident ground (see for example McLennan, Pavlou & Omodei, 2005; Omodei, McLennan & Reynolds, 2005; McLennan et al., 2013; Johnson, 2013; Frye & Wearing, 2013) and at a local IMT level (see for example

Douglas, 2013; Dwyer & Owen, 2009; McLennan et al., 2006; Hayes & Birch, 2009; Hayes & Omodei, 2011; Owen, 2013a, 2013b, 2013c; Owen & Johnson, 2011).

Indeed, Commissioner Lee Johnson in his presidential address to the Australasian Fire and Emergency Service Authorities Council (AFAC)–Bushfire CRC conference in 2011 said:

‘The area of local incident management is well defined and supported by the AIIMS [Australasian Inter-service Incident Management System] framework. However, the strategic emergency management domain is less well understood. It is imperative that we fully appreciate and develop the strategic emergency management capability in order to face the challenges of the future.’

At the commencement of the project, then, the processes for identifying key attributes that would support a shared understanding above the IMT level, and the organisational processes that would assist personnel to act strategically above the IMT level was little understood. This represented a weakness in the system. The purpose of this research project thus was to identify the processes and challenges for those working above the IMT and to identify areas of weakness and potential gaps so that they might be addressed.

The research team

In order to investigate the demands faced by personnel operating at regional and state levels in large-scale complex emergency events, a variety of expertise was available in our research team. It included skills and experiences from the following sectors and disciplines: psychological (socio-cognitive) and human factors, organisational behaviour including a socio-cultural focus as well as a focus on individual and collective resilience, and information systems networks analysis.

The research team comprised Dr Christine Owen (Project Leader), Dr Benjamin Brooks, Professor Douglas Paton and Dr Roshan Bhakta Bhandari from the University of Tasmania (UTas); Dr Chris Bearman (Appleton Institute of Central Queensland University (CQU), and previously the University of South Australia) and Professor Liaquat Hossain (University of Sydney) as supervisor for two PhD candidates attached to the project.

Christine Owen had previously been involved with the Australian Bushfire CRC (BCRC) since 2006 in a variety of ways: primarily as Project Leader of a research team examining incident management teamwork and organisational learning, and also as BCRC Program Leader for Education and Training. In the current project, Dr Owen used her skill set and expertise to examine coordination effectiveness at regional, state and national levels of emergency management.

Benjamin Brooks is a human factors researcher and has worked on research in areas such as safety information systems and advanced training and safety systems, and has built tools for the evaluation of safety management systems to support individual and team cognition.

Douglas Paton's research focuses on developing and testing models of emergency team response and decision-making.

Roshan Bhandari had previously been involved in disaster management and has undertaken research with communities impacted by disaster events. In this project, Dr Bhandari examined incident management approaches above the IMT level in different Australian jurisdictions.

Chris Bearman's field of expertise involves applied cognitive psychology and human factors. In the current project, Dr Bearman focused on lack of shared mental models and how it leads to disconnects and breakdowns in emergency management coordination.

Liaquat Hossain's PhD candidates were focused on social network analysis to examine problems of emergency management coordination.

Doctoral candidates attached to the project

Joining the research team were the following PhD candidates:

- Jafar Hamra (University of Sydney): *Understanding attitudes towards performance in disasters: the influence of social networks and learning.*
- Alireza Abbasi (University of Sydney): *Modelling dynamic coordination networks in bushfire emergency management using social network analysis.* (Alireza completed his dissertation and was awarded his PhD in October 2012.)
- Steve Curnin (UTas): *Improving how regional and state-level emergency management teams work together to develop their common operating picture during large-scale emergency events.*
- James Minas (RMIT University): *Operations research for decision support in wildfire management.* (James completed his dissertation and was awarded his PhD in June 2013.)
- Martijn Van der Merwe (RMIT University): *Operation research for bushfire incident controller decision support.*
- Jared Grunwald (CQU) – Masters student: *Identifying and resolving breakdowns at the regional management level.*

In addition, a number of PhD candidates from the first phase of the Bushfire CRC continued to complete their studies and consolidate their research track records within the industry with the support of the existing research team. This included Jan Douglas (UTas: the role of emotion in incident management teamwork); Annette Salter (UTas: learning in context for bushfire-fighter training); Peter Hayes (La Trobe University: familiarity and its impact on incident management team effectiveness); Claire Johnson (La Trobe University: worst-case scenario and contingency planning); and Lisa Frye (University of Melbourne: metacognition in firefighter decision-making).

End-user leader and end-user engagement

Liam Fogarty from the Department of Environment and Primary Industries (DEPI), Victoria, was the Lead End User (LEU) of this project.

The research team was frequently supported by the AFAC AIIMS Steering Committee and reported to this group on progress, drawing on the expertise of the committee to validate the findings and further consult on the implications. In addition, relevant aspects of the research were also presented to the AFAC Learning and Development Group as well as to other industry conferences and fora. There were additional activities involving end-user engagement and these are outlined later in this report.

1.3 Scoping the research

In order to scope out the theoretical foundation to advance the project, two comprehensive literature reviews were undertaken (Chapman & Bearman, 2011 Owen, 2010). These suggested that, firstly, at the individual level, the internal mental representation of the event (the mental model) would be a key conceptual construct that determines the transmission of information in ways that are relevant, accurate and timely (Salas et al., 2006). The second review into organisational behaviour suggested that the constructs of mindfulness and sense-making (Smith, 2001; Weick, 1995, adaptive management (Wise, 2006; Mendonca, Giampiero & Beroggi, 2001) and organisational resilience (Paton & Violanti, 2008) would be important for successful emergency management coordination.

The research team concluded that for emergency management above the IMT level, it would be important for personnel to have well-defined and appropriate mental models to manage emergency events, along with well-developed organisational processes that support effective operations and coordination. Without these elements, it would be difficult to adequately grasp the situation, understand the critical information, receive and transmit it to others, or understand when individual, team or organisational performance was degraded.

To begin the project, the research team needed to scope out the information flow and coordination challenges for personnel working above the IMT level. The following research questions were developed to address the pertinent issues suggested by the present state of knowledge in the area of emergency management coordination.

1.4 Research questions

1. How is emergency management coordination above the IMT organised?
2. How does information flow to and from regional and state levels of emergency management influence the capacity of personnel to adjust to emerging conditions?
3. How has a lack of shared mental models by key personnel in emergency incident management led to breakdowns in coordination in emergency events?

4. What social networks of communication best facilitate effective multi-agency coordination?
5. How might we best train and educate personnel in the most effective emergency management coordination above the IMT?
6. What changes are needed to support effective emergency management at the regional and state levels of coordination?

1.5 Summary of research areas

Table 1 shows the major research areas and the distribution of research activity across the research team.

TABLE 1: MAJOR RESEARCH FOCUS AND RESEARCHER(S) RESPONSIBLE

Major Research Area	Research Activities	Responsibility
Roles, responsibilities and contextual drivers in Strategic Emergency Management	<ul style="list-style-type: none"> • Organisational snapshot of the roles and activities challenges above the IMT level • Roles and decision-making performed and the implications for information systems • Case studies of approaches to incident management organisation above the IMT 	<ul style="list-style-type: none"> • Christine Owen, Steven Curnin • Christine Owen • Christine Owen, Ben Brooks • Roshan Bhakta Bhandari, Steven Curnin
Factors leading to coordination failure	<ul style="list-style-type: none"> • Breakdowns in coordinated decision-making above the IMT • Secondary-source analysis of major fires 	<ul style="list-style-type: none"> • Chris Bearman • Ben Brooks
Formal and informal networks used in emergency incident response	<ul style="list-style-type: none"> • Social networks analysis 	<ul style="list-style-type: none"> • Jafar Hamra, Alireza Abbasi
Capability development – education and training	<ul style="list-style-type: none"> • Reviewed education and training pathways undertaken and needed • Simulation and scenario development for building capability • Strategic leadership attributes 	<ul style="list-style-type: none"> • Ben Brooks, Christine Owen • Ben Brooks, Chris Bearman, Christine Owen • Douglas Paton, Leeanne Brient⁴

⁴ A Psychology Honours student working with Professor Paton

SECTION 2: RESEARCH ACTIVITIES

The initial goal was to establish processes to answer our main research questions as well as to explore opportunities for end-user engagement. Empirical research was guided by research ethics protocols that were approved in May 2010 (see Appendix A).

Some of the key research activities for the three years of the project are outlined in Table 2, Table 3 and Table 4. These have led to a number of preliminary research output reports; for further details, please see the Bushfire CRC website⁵.

TABLE 2: RESEARCH ACTIVITIES AND OUTPUTS 2010–2011

Research Activity and Outputs	Research Team	Objective
Literature reviews	University of South Australia (UniSA) ⁶	Identified a common framework that can orient researchers working on different streams with a shared mental model of the research program
	University of Tasmania (UTas)	Identified published research important in organisational behaviour and in emergency management coordination (what enables or constrains coordination breakdowns)
Development of decision-making model	UniSA, UTas	Developed a model of coordinated decision-making within and between teams above the IMT to map the way that such coordination breaks down
Secondary-sources analysis	UTas, UniSA	Examined the human factors implications (UTas) and how coordination breaks down (UniSA)
Interviews (Phase 1)	UTas	Developed an interview schedule for Phase 1 of the interviews to identify challenges facing personnel working above the IMT level
National survey	UTas	Investigated what enabled and constrained successful performance at the regional and state levels of emergency management, control and coordination in large-scale emergency events
Social network analysis	University of Sydney	Investigated formal and informal networks and their role in emergency management coordination

As can be seen from Table 2, the main focus in the first year was scoping out the work undertaken and the challenges faced by personnel working above the IMT. In the second year

⁵ <http://www.bushfirecrc.com/projects/8-1/effective-incident-management-organising>

⁶ The University of South Australia team moved to Central Queensland University in the second year of the project.

of the project (2011–2012), the focus became more targeted on the kinds of work activity and disconnects experienced, together with exploring potential simulation and training strategies for addressing these challenges (see Table 3).

TABLE 3: RESEARCH ACTIVITIES AND OUTPUTS 2011–2012

Research Activity and Outputs	Research Team	Objective
Interviews (Phase 2)	UTas, CQU	Conducted 35 interviews with emergency management personnel from multiple agencies across Australia and New Zealand
National survey	UTas	Analysed 206 responses and developed a report of the survey results that was provided to the Lead End User and BCRC in January 2012
Secondary-source analysis	UTas, CQU	Analysed human factors issues and coordination breakdown in the 2003 Canberra Firestorm in the ACT, the 2005 Wangary Fire in South Australia and the 2009 Black Saturday Bushfires in Victoria (with a focus on the Kilmore East Fire)
Development of simulation scenarios for training	UTas	Developed training scenarios, with human factors injects, based on the secondary-sources analyses; reviewed scenarios with key members of the AFAC Leadership & Development Group for consultation
French–Australian research exchange	UTas, SDIS-13 ⁷	Conducted an international exchange with researchers and practitioners in France that included participation in simulation exercises to learn various approaches to high-reliability organising
Human–technology interfaces	UTas	Examined information systems and human–technology interfaces; consulted with relevant industry stakeholders and engaged them in reviewing an organisational typology
Development of wiki to consult with Industry	UTas	Provided a synopsis of research and findings to date in order to canvas views of stakeholders including members of the BCRC Research Advisory Forum

The final year of the project (Table 4) has seen a consolidation of the research findings into a synthesis and consultations with stakeholders about the implications for the industry and for change.

⁷ Service Départemental d’incendie et de secours (SDIS)

TABLE 4: RESEARCH ACTIVITIES AND OUTPUTS 2012–2013

Research Activity and Outputs	Research Team	Objective
Shared mental models for use in simulation and training	UTas, CQU	Developed and completed a number of research outputs aimed at industry learning and development programs, including a review of training pathways and facilitating capability development
Development of a Discussion Paper	UTas, CQU	Collaborated with the AFAC AIIMS Review group to produce a discussion paper on challenges and future needs for the emergency management industry
Framework for change	UTas, CQU	Utilised the industry Discussion Paper to consult and work with industry stakeholders to develop frameworks for change, identifying potential areas for capability development implementation and recommended actions for improved coordination of incidents
Final report	UTas, CQU	Outlined the key research activities, main research findings, research outputs and research utilisation opportunities
Development of research utilisation outputs	UTas, CQU	Developed industry-targeted outputs and tools, including Fire Notes, presentations to Research Advisory Forum, AFAC and other industry conferences, development of resources for industry review and promotion
Development of publications	UTas, CQU	Preparation, refinement and submission of a range of publications, including book chapters

SECTION 3: SUMMARY OF FINDINGS

In the following section, we provide a summary of the major findings from the research carried out through compilation of the various research activities that were used to address the research questions.

3.1 Organisation of emergency management above the IMT level

In the first part of this section, we aim to answer the research question: *How is emergency management coordination above the IMT organised?*

To address this research question, we conducted interviews, observations and surveys to scope out the various emergency management organisational arrangements that are typically in place. Emergency management personnel working above the local IMT level in Australian jurisdictions often deal with large-scale multiple emergency events and are focused on considering the broader problems that might occur in the future.

In large-scale emergency events, there are a range of emergency management activities performed by people working on the incident ground, and at tactical and strategic levels (Paton & Owen, 2013). On the *incident ground*, first responders are working directly on the frontline. At a *tactical level*, local IMTs work at supporting frontline responders in containing and mitigating the event and in enabling communities to make good decisions. At a *strategic level* (which may be regional, state or national), the focus is on two elements: oversight of incident management operations and consequence management for longer-term recovery (see Table 5).

TABLE 5: LAYERS OF EMERGENCY MANAGEMENT

Layers of Emergency Management	Description	Australia and New Zealand Application
Incident ground	First responders; front-line personnel working directly on the fire or incident ground	First responders
Tactical	Local-level incident management work is directed at containing and mitigating the event	Local IMT
Strategic	Activity occurring above the local operational and tactical levels; may involve regional, state or national activity. Concerned with addressing the strategic issues across the whole-of-government and community	Regional or state, national (NZ)

Hence, strategic-level emergency management objectives are addressed in the state⁸ arrangements in terms of response orientation, state-level emergency management facilities, long-term thinking, external stakeholder management, leadership, organisational adaptation and emergency management capacity (Owen, 2013; Owen, Bosomworth & Curnin, 2013).

Emergency management in Australia has become a central inter-organisational activity at the state, regional and local levels and requires collaborative action for comprehensive disaster management to prevent, prepare for, respond and recover from emergency events (Bhandari, Owen, Curnin & Brooks, 2012; Owen and Dwyer, 2009). The AIIMS articulates the organisational processes used in emergency response to cope with natural hazards in Australia. AIIMS is a management system tool to manage the response to an incident within Australian jurisdictions. A primary intent of AIIMS is to standardise incident management activities and to provide flexibility and scalability for the needs of any incident size or scope (AFAC, 2013). However, AIIMS does not address strategic-level emergency management above the local IMT level. The latest edition acknowledges that the manual is still primarily focused at the incident or tactical level (AIIMS 4th edition, AFAC, 2013). What is needed is to develop doctrine and practices that map out the work involved at a strategic (i.e. regional, state, national) level of emergency management. The research reported here contributes to this purpose and in particular articulates the challenges and changes needed to enhance capability in strategic-level emergency management. To this end, it is useful to consider practices at a state level of emergency management.

In large-scale emergency events, most states form a State Emergency Management Committee (SEMC), which comprises emergency services agencies and functional agencies. The Chair of the SEMC is supported by the legislative power and authority provided by the emergency arrangements and is empowered to direct resources to manage emergency events. There is also a State Emergency Operations Centre (EOC), which is the central location where the coordination of information and resources to support state-level emergency management activity is carried out.

Through the case studies undertaken at various state-level emergency operations centres, it was noted that the spatial configuration of EOCs differs and that this might affect the working arrangements, information flows and potential cohesion of the centre in managing major events (Bhandari, Owen & Brooks, 2014). However, it was also observed that they adopt similar functions of command, operation, planning, logistics, public information and the provision of support. Typically, State EOCs provide a coordinating mechanism for a range of other agencies. These include emergency services agencies, government functional agencies, non-government

⁸ National level in New Zealand.

organisations (NGOs) and utility companies that may be either permanently or temporarily located in the EOC.

Different information systems are also used in the EOCs to fulfil their task of internal management, resource management, external management and issuing community warnings. There has been significant progress in building the relationship between strategic-level emergency management and intelligence systems; however, still more needs to be done in this area. The challenges of incompatible information systems between agencies engaged in emergency management coordination still exist at the strategic level. In multi-agency coordination, various interdependent relationships require multiple information flow pathways that need to be managed in a way that is both tailored and timely in order to build a 'common operating picture' and shared situation awareness among agencies operating above the IMT level (for discussion on the challenges of breakdowns of shared mental models, see the findings addressing research question #3 on page 15).

Emergency management personnel in strategic roles are expected to think ahead about possible changes and guide operational processes at local, regional and state levels. Strategic emergency management teams at the state level in Australia primarily involve senior managers who are expected to have sufficient experience in planning for, preparing for, responding to and recovering from crisis events. In principle, these people need to achieve emergency management goals by linking strategic initiatives to operation processes.

Implementation of effective state-level emergency management plans depends on how we foster capacity building through organisational adaptation and learning in keeping with a strategic management approach (Choi, 2008). Canton (2007) has pointed out that the next generation of emergency managers should not limit themselves as technocrats and deal only with the micro-management of incident response. He further asserts that if an emergency manager's role is to assist in managing community risks and dynamic changes, then there is a need to emphasise strategic thinking and skills to administer a risk-management program. While observing the state-level operations and interviewing the state-level emergency management personnel in Australian jurisdictions, it has been noted that a number of tools and processes have been developed to enhance state-level emergency management performance. To cope with unexpected emergencies, senior emergency management officials need to further commit time to develop their capacity, maintain communication skills and provide direct leadership, particularly through appropriate resources and training.

3.2 Information flows and the capacity of personnel to adjust to emerging conditions

In this section, we focus on the research question: *How does information flow to and from regional and state levels of emergency management influence the capacity of personnel to adjust to emerging conditions?*

To address this research question, we first examined the kinds of activities that occur at local and state levels of emergency management to ascertain information needs. The interviews, surveys and observations revealed that the kind of work undertaken at the strategic level is different in both content and context from the challenges facing personnel working at tactical and operational levels. The strategic level is typically engaged in out-of-scale events and is concerned with the high (direct and indirect) event consequences, which also results in high political involvement. This level is concerned with post-event strategies that support community well-being and recovery; prioritisation of resources across potentially multiple events and regions; and when local or state-level resources are likely to be overwhelmed or exhausted, making inter-state or international deployment requests. Out-of-scale events also require engagement with political and whole-of-government liaison, particularly with a focus on assessing the reliability of the overall response and recovery effort.

Table 6 highlights the differences in focus and responsibility when working at a *local incident management level* compared with a more *strategic emergency management level*.

TABLE 6: FEATURES OF LOCAL INCIDENT AND STRATEGIC-LEVEL EMERGENCY MANAGEMENT

Aspects	Local Incident Management	Strategic-level Emergency Management
Event complexity	Usual operating mode is appropriate to address most situations	High-impact, non-routine, multiple events and consequences; emphasis on moving from response to recovery
Location	Locally defined	Broader context
Time span	Immediate, reactive	Longer duration, proactive, forward thinking (consequence management of indirect effects)
Resourcing and prioritising	End-of-shift handovers, upwards requests for more resources	Prioritisation of resourcing across events. Anticipation of resource exhaustion. Inter-state and international deployment requests
Information flows	Structured command and control policies	Emphasis on state level and political
System oversight	Safety monitoring and assurance through structures (e.g. safety officer roles and responsibilities)	Reliability assurance. While the focus is not to micro-manage, there is a responsibility to monitor, evaluate and to take action to address any breakdowns in communication or coordination
Inter-agency liaison	Minimum to moderate	Significant engagement with whole of government

It is important to recognise that *local-level incident management* is a core component of emergency management. Both AFAC and Emergency Management Australia (EMA) define incident management as ‘the process of controlling the incident and coordinating resources’.

Based on the AIIMS framework, there should be one (local) incident management team per incident. At a strategic level, where the incident is potentially one of state or national significance, information flows are needed to monitor local tactical incident management and operations to be attuned to changes that may escalate routine events into large out-of-scale events. In addition, there may be multiple events that need to be monitored and managed (e.g. fire and flood or multiple fires). For personnel working at a strategic emergency management level, the focus on the time-frames for managing the event will be different because at this level, there is a need for longer-term thinking about the indirect consequences of an event (e.g. loss of tourism for a regional economy) to be considered.

Table 6 also highlights how the information needs at the local and strategic levels are different in both content and context . For example, the information pertinent to local incident management is not necessarily politically pertinent at the strategic level. At a strategic level, there is a role in working with state-wide media and meeting the information demands of political leaders. Requests for information from political leaders and their staff need to be considered and addressed in time-frames that may compete with tactical or operational needs and it is up to the strategic level to manage these .

The focus of local incident and strategic emergency management is also different when considering issues of safety assurance (Owen & Hayes, 2013). At a strategic management level, it is important to evaluate the success or failure of local-level tactics as well as identify potential future areas of weakness. There is also a greater emphasis on monitoring and assuring the overall reliability of the emergency management frameworks at this level. Such emphases require engagement across multiple jurisdictions and government departments. In contrast, at a local incident management level, only those agencies and businesses directly affected are engaged. Finally, the various activities occurring at operational, tactical and strategic levels must be coordinated such that they support each other to cohesively meet the above-mentioned needs.

The research methods used were also aimed at investigating the kinds of decisions made and challenges faced at regional and state levels of emergency management, so that the implications of information flows between the various layers could be better understood (see also Bhandari, Owen & Trist, 2013; Bearman & Bremner, 2013). Two organisational surveys of emergency management personnel working at regional and state or national level were used for this purpose and are reported here. Drawing on the work of Rasmussen (1991) and Rasmussen and Svedung (2000) and based on consultation with industry stakeholders, five key work activities occurring at state level were identified. How information systems could be better deployed to support these activities was also canvassed.

Information flows need to support the following strategic-level activities:

1. Problem detection and situation assessment
2. Task execution, resource management

3. Anticipation and prediction for future states
4. Interpretation, sense-making and the development of strategy
5. Evaluation and quality assurance.

Problem detection and situation assessment

At regional and state levels of incident management, personnel need to gain an understanding of the initial assessment of the impacted areas so that they can consider the consequences of the level of damage and so that risk assessment processes can be initiated (Bhandari & Curnin, 2013). Rasmussen (1991) has highlighted the importance of anomaly detection, which is a combination of activities associated with situation assessment and intelligence gathering. The challenge here, in terms of information flow, is that personnel on the ground are not easily able to provide this information if they too are in the midst of a dynamic and escalating situation.

Personnel at the operational level can become overly focused on what is happening around them, and lose sight of the more strategic-level implications of what might be starting to be anomalous with the management of the incident (Owen, 2011). Given the responsibilities of personnel above the IMT to provide supervisory support as well as quality assurance, this would seem to be an important area for future investigation and development. Personnel above the IMT need have the ability to detect incident anomalies. Capability development and information systems design should support personnel above the IMT to fulfil their supervisory role and quality assurance responsibilities.

Task execution, resource management

Personnel operating at regional and state levels need to prioritise scarce resources in order to meet operational, community, government and political expectations. At this level, coordination of resources and deployments within and between multiple agencies are managed. There are challenges for information flow between layers in the emergency management framework in terms of clarity of task execution and resource tracking. To add to this challenge, computer-aided dispatch systems of different agencies are not always compatible, making task execution and its tracking more complex.

The issue of resource management was raised as problematic in the secondary-sources analyses undertaken by Brooks et al. (2011). In his assessment of both the ACT fires and the Kilmore East fire in Victoria, Brooks showed how accessing the personnel with the right levels of competence, and making information about their skills easily visible, was particularly challenging.

Anticipation and prediction for future states

Personnel working above the IMT are engaged in activities to determine likely future impacts and develop strategic plans. To do this, they need to develop shared mental models of the

emerging situation and project it into the future. Incomplete and inconsistent information is a challenge for information flow between emergency management layers to serve this purpose (for discussion on breakdowns in information flows, see research question #3 on page 15). Given the challenges associated with gaining an assessment of the situation, it is not surprising to learn that personnel operating above the IMT raised concerns relating to difficulties in gaining and maintaining situation awareness and in being able to use this awareness to determine potential impacts and developing strategy (Owen, 2011; Bearman et al., 2013).

Interpretation, sense-making and the development of strategy

This activity at state and regional levels includes managing competing government and political interests, and ensuring consistent community warning. Information systems design needs to take into account emergency alert processes to communities so that they can be timely. Providing updates and meaning with situational advice for stakeholder groups is found to be particularly important during times of uncertainty and emergency situations (Weick et al., 2005). In order to bridge the interests of different stakeholder groups and align strategic goals with existing government policy goals, boundary-spanning roles, particularly across agencies, become important. As information brokers, boundary-spanners help to provide situational updates and advice for stakeholder groups. The continued output of PhD candidate Steve Curnin examining the information needs of emergency management liaison officers (EMLOs) will assist in addressing this information challenge (see also Curnin & Owen, 2013; 2014).

Evaluation and quality assurance

Evaluation and quality assurance are associated with activities that help to monitor the safety health of the incident management system. Developing such measures has been found to be important in other safety-critical industries. The challenges for information flow between layers in the emergency management framework include incomplete and untimely information, and withholding of information by different stakeholder groups. To overcome this challenge, information systems need to track processes designed to capture the status of various activities and any pressure points within the system. A continuous and ongoing evaluation at state and regional levels can help to maintain the consistency of emergency management performance. A new research project, sponsored by the Bushfires and Natural Hazards CRC, is aimed at addressing this challenge.

3.3 Factors leading to coordination failure

The third research question was: *How has a lack of shared mental models by key personnel in emergency incident management led to breakdowns in coordination in emergency events?*

The research methods associated with the secondary-source analysis of major inquiries, as well as interviews, were used to address this question. As discussed, a large-scale emergency response requires a variety of implicit and explicit relationships between actors and technical

systems (Johansson & Hollnagel, 2007). Incident management, then, can be thought of as a series of complex, distributed teams passing information within and between teams, up and down a chain of command. Information flows from the fire ground to the IMT, which is usually located some distance away from the actual fire, and that information in turn is sent from the IMT to regional and state emergency control centres. At regional and state levels, incident management involves teams of people with different skills, roles and responsibilities coming together to make coordinated decisions about the best way to support the management of that incident. From time to time, the different pressures the team experiences and the team dynamics will cause breakdowns in team coordination.

When a team does not appropriately share information about its situation assessment, or the way plans are being developed or executed, then disconnects and breakdowns will occur (Bearman et al., 2010; Bearman et al., 2013). Bearman et al. (2010) formally define a breakdown as ‘a situation where there is a failure in coordination, cooperation or communication that leads to a temporary loss in the ability to function effectively’ (p. 173). At a more fine-grained level, Bearman et al. refer to individual instances of disagreement between participants as disconnects. Disconnects can be further categorised as three key types: operational, informational and evaluative (Bearman et al., 2010; 2013).

Operational disconnects occur when there is ‘either a difference between the actions of one party and actions expected by the other party or a mismatch in the plans that each party has about the physical operations of the response’ (Bearman et al., 2010, p. 178). Informational disconnects occur when there is ‘a difference in the information that each party possesses’ (Bearman et al., 2010, p. 179) and evaluative disconnects occur when there is ‘a difference in the evaluation or appraisal of information that is available to both parties’ (Bearman et al., 2010, p. 179).

Examples of disconnects and breakdowns can be found in the following extract from the Canberra Firestorm Inquiry (Doogan, 2006):

There is in the evidence some conflict about whether or not it was agreed at the meeting that using the Baldy Range trail as the eastern containment line would be reconsidered the following morning. Mr <A>’s memory was that they were going to try to use the Baldy Range trail as the first option, the fall-back option being Dingo Dell Road. He was definite that at no stage did he convey any opinion that, on the basis of the information he had from Mr , the Baldy Range trail could not be used as a containment line because of the intensity of the fire burning across it. [...]

Ms <C> did not remember anyone saying at the meeting that the fire on the Baldy Range was containable. Her memory was that it was reported “They are there. It is across the track and we are getting out.” Hence, on the basis of her understanding of the information provided to her at the meeting by those who were observing the Baldy spot

fire at the time, Ms <C> formed the view that the Baldy trail had been lost as a possible eastern containment line.

These extracts show three disconnects between the joint agencies team: an informational disconnect, an evaluative disconnect and an operational disconnect. The first disconnect (informational) represents a difference in the presented information, where important information is either not distributed to the team or not understood by the team members. This leads to a second disconnect (an evaluative disconnect) where there is a difference in the evaluation of information about the containment strategies that is caused by the information not being presented or understood. This leads to the third disconnect (an operational disconnect) where there is a difference in the containment strategies between the two agencies. This example shows that when important information is not shared or does not make it into the shared team situation awareness, divergent plans can be created and executed.

A useful way of understanding team functioning is through Burke et al.'s (2006) model of adaptive teamwork. Burke et al.'s framework (see Figure 1) describes how an individual's understanding of their situation is shared into team situation assessment, and how team situation awareness and mental models underpin the team's ability to plan, coordinate and carry out its tasks effectively.

There are four main phases in Burke et al.'s (2006) framework: situational assessment, plan formulation, plan execution and team learning, each of which has its own emphasis on shared mental models and shared situational awareness. The initial phase, situational assessment, focuses on information-gathering based on environmental cues that signal a need for change or adaptation. This process involves searching for information that triggers the need to change the team's activity in some way. The information is shared with other members of the team, thus allowing other individuals to use different perspectives to aid in the formation of a shared team situation assessment. This shared perspective allows individual team members to predict and identify future states and cues regarding the actions of other members.

The information that is shared in the situation assessment phase is used by the team in the plan formulation phase to shape the goals, strategies, tasks and responsibilities of the team. Information about each of these is shared by the team so that each person understands the team's goal and their role in achieving it.

In the plan execution phase, the team uses information about a shared plan to orient the team members towards the outcome they want to achieve. This also provides a way of monitoring performance to ensure that all of the team members are performing their role effectively and are not being overwhelmed.

The last phase of the model is team learning where the team reflect on their performance. The information gained from such reflection feeds back into the shared situation, plan formulation and plan execution process, and helps to shape them.

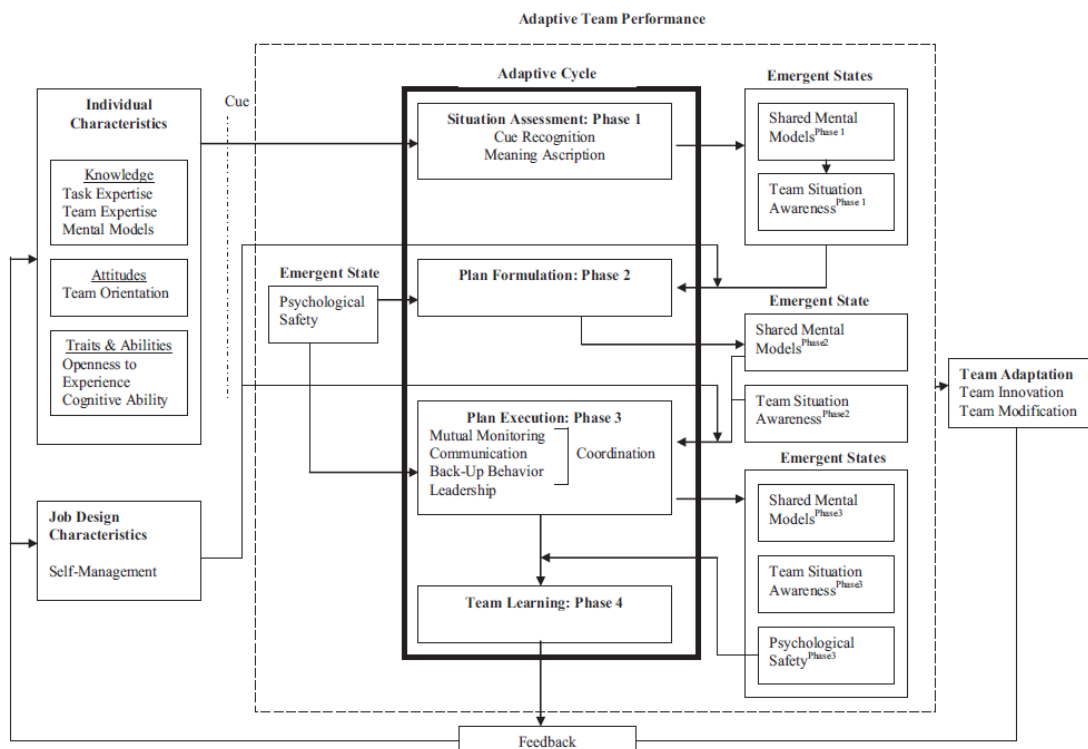


FIGURE 1: BURKE ET AL.'S FRAMEWORK OF ADAPTIVE TEAM PERFORMANCE (FROM BURKE ET AL., 2006)

Burke et al.'s framework is particularly useful in explaining the impact of breakdowns on the team process because it is cyclical. The cyclical nature of the framework demonstrates how disconnects can form chains that increasingly disrupt team performance. Once an unresolved disconnect enters the shared situation awareness–team planning–plan execution process it may circulate, causing further problems, until the disconnects are identified and resolved. Burke et al.'s framework can also be used to predict where breakdowns are likely to occur. For example, in large-scale responses that require coordination between multiple agencies, representatives of the different agencies will often meet to form a common operating picture, but will then sometimes disperse to develop local plans and plan execution strategies. Burke et al.'s model predicts on the basis of the disconnect data that this practice is likely to introduce significant opportunity for breakdowns in coordination because important operational information is not being shared with other members of the joint team. This will lead to divergent plans being developed and executed.

In out-of-scale emergencies, sharing information with other team members and other teams can be particularly difficult. Out-of-scale emergencies often include people in teams who do not know each other, may have very different skill sets and knowledge, and may be from different agencies that have different priorities and perspectives on the incident. As an incident scales up, new members of the team are added, increasing the functional unit and coordination complexity.

While researching recent experience of out-of-scale events in Australia and New Zealand, Bearman et al. (2013) found problems in information sharing that led to a number of issues,

such as: a lack of understanding of the skills and abilities of team members; problems taking over control from another team; people bypassing the proper pathways for information flow; and conflict between different agencies. In out-of-scale events, people can become overwhelmed and tasks that would normally be carried out are dropped as people try to cope with the high levels of stress and workload. These tasks include: finding out information about other team members or members of another team; finding out details of the operation that are already occurring; not missing out people when passing on information; and respecting others' need for information. They are extremely important in maintaining team situation awareness and effective team performance. Bearman' et al.'s research demonstrates the need to ensure that tasks that maintain information flow in teams are kept up even under the extreme pressures of an out-of-scale response so as to avoid breakdowns in coordination and a degraded operational response.

While it is important to provide teams and individuals with the skills to identify, cope with and mitigate or recover from psychological pressures and degraded situations, it can be difficult for teams that are in the 'heat of the moment' to recognise that they are suffering from breakdowns or other degraded situations. Such situations can be particularly difficult to recognise when the situation is complex and involves multiple responding agencies. It is important then to identify and embed indicators of breakdowns into regular performance-monitoring activities by more senior staff or specially appointed monitors.

Grunwald and Bearman (2013) have examined the kinds of information that Regional Controllers (RCs) use to determine whether there is a problem in the teams they are supervising and the strategies that are used to resolve these problems. Regional commanders coordinate the regional-level response during large-scale emergencies and supervise IMTs, providing additional resources and support where required. The RCs are remote from the fire ground and must generate their situational awareness by processing information from situation reports and communication with personnel who are on the fire ground. Grunwald and Bearman (2013) identified four strategies that were employed by RCs to identify breakdowns and seven direct resolution strategies.

The four identification strategies were: information-based, intuition-based, network-based and proxy-based. While all of the categories utilise information, the information category was reserved for the direct information received from the fire ground. Such information could contain discrepancies or could be inconsistent with the RCs' situational awareness, indicating there is a problem at the team level. RCs were also generally very experienced and they could use this experience to 'sense' that there was a problem in the way the team was operating, even when there were no explicit cues they could point to. RCs could also identify breakdowns through information passed through their informal and formal networks, and through the use of proxies (designated people who act on behalf of the RC).

The seven direct resolution strategies identified by Grunwald and Bearman (2013) were: providing physical assistance, negotiation, using authority, delegation, sending a

representative, mentoring, and replacing incident controllers. The RC could resolve breakdowns by directly influencing the situation (by providing additional resources, through negotiation with people to meet shared goals or by using their authority), working through others who could influence the situation (such as a delegated person or the RC's representative) or working with the incident controller (by providing helpful suggestions and advice – mentoring – or replacing the incident controller). Grunwald and Bearman also identified a number of indirect strategies that could be used to avoid breakdowns, such as preplanning, building a cooperative culture and building rapport with others. Preplanning in particular was emphasised by most participants and consisted of developing an understanding of the training, experience, personality and teamwork skills of people who would form IMTs and any recent issues that could prevent effective team work.

Together, these direct strategies provide a toolbox of different approaches that may be used to resolve breakdowns in many different situations. Like any toolbox, some tools will be better suited to some situations than others. For example, a robust disagreement between two members of the IMT may require the RC to use authority to resolve the dispute, while a discrepancy in information may require a supportive enquiry.

In conclusion, in addressing this research question, the findings have led to the identification of different components of breakdowns and explained how these components result from a lack of shared mental models by members of the team. In addition, we have examined how disruption to teamwork can occur in out-of-scale events and explored ways that RCs can identify and try to resolve breakdowns in the teams they are supervising. To some extent, breakdowns and disconnects are an inevitable part of coordinating IMTs. It is important then to be able to recognise and recover from these breakdowns quickly and effectively so that the effective team functioning is maintained and the operational response is not impaired.

3.4 The role of formal and informal networks in emergency incident response

Approaches to investigate the fourth research question: *What social networks of communication best facilitate effective multiagency coordination?* included using secondary-source analysis of the reports outlined above as well as the survey data collected.

First, the effects of social connectedness among different team members were used to investigate the perceived quality of coordination (Abbasi, Hossain, Hamra & Owen 2010; Abbasi, Hossain & Owen, 2013). Second, we applied a network analysis to identify the individuals playing a role controlling the flow of resources in a coordination network (Hamra et al., 2012). Finally, using a case study, we explored the structural dynamics of cooperation networks over time during a response operation (Abbasi et al., 2013).

Social connectedness and coordination

Social network analysis can be applied to evaluate team connectedness, a factor in successful emergency management performance. Therefore, from this perspective, it is important to find the network structure, which reveals the connections of individuals within and between teams that can have a significant impact on coordination.

As discussed above, in emergencies different agencies need to be coordinated in order to manage and respond to events. Agencies use cooperative information exchanges in order to respond to the disaster effectively and efficiently (Hamra, Hossain & Owen, 2012). As was discussed in the third research question (see page 15), poor coordination is a fundamental problem for an emergency response, and is primarily due to lack of shared mental models and good communication between organisations, which results in a lack of up-to-date and relevant information circulating through the emergency response network, further undermined by insufficient access to data and action plans (Hamra et al., 2013; Van Borkulo et al., 2005).

To support the development of shared mental models, we investigated the effect of social relations among teams involved in managing emergencies and their perceptions of coordination effectiveness as well as perceptions of adaptive behaviour during emergency events. For our analysis, we used organisational survey data and found that that levels of perceived team connectedness suggested a positive significant effect on the capacity for personnel to adaptively respond to dynamic situations. For more information, see Abbasi et al. (2010; 2013).

We further analysed response coordination by exploring variables such as the quality of participants' preparedness, the role of their incident action planning, and of the accessibility of resources. Our analysis showed that access to resources was not as important as the capacity to adapt in response planning during the incident. This finding is intriguing and needs further attention in future research. The findings support the proposition that IMTs will make do with what they have available to them at the time. While planning and access to resources are clearly important, the findings suggest that it is the internal connectedness between actors in the team that will give the most leverage in terms of enabling adaptive behaviour. Therefore, if policy-makers and managers want to enhance adaptive behaviour in complex emergency events, these results indicate that they would do well to concentrate on the internal connectedness of teamwork. For more information, see Abbasi et al. (2010; 2013) and Hamra et al. (2012).

For further discussion on building capability to enhance team effectiveness, see the findings on research question #5 on page 22.

Coordination roles in response networks

The researchers also conducted an analysis using secondary sources from the situation reports tabled at the Victorian Bushfires Royal Commission (Teague, McLeod & Pascoe, 2010) to investigate the dynamic changes of inter-personal response networks in the Kilmore East fire (one of the February 2009 fires in Victoria). The data used in this research came from content analysis collected by reviewing Victorian Bushfires Royal Commission situation reports (Teague, McLeod & Pascoe, 2010) after Black Saturday (7 February 2009). Transcripts and individual statements from the Victorian Bushfires Royal Commission repository were analysed to extract individual names, positions and agencies they belonged to; communication between them; their location during the communication; and the devices and technologies they used. We analysed the response over the period of the first shift, which had been closely scrutinised during the Commission. We used social network analysis measures and we found that most of the central actors over time were just seekers or providers of information and were not good candidates for coordinating the emergency management network, which requires them to play an intermediary role between givers and receivers of information. As coordinators, they attend to receiving requests from some organisations as well as responding to them or forwarding requests to the appropriate organisations. Therefore, central actors are not necessarily the best potential coordinators.

This also highlights the importance of connectedness as a form of social capital for building trust, which can lead to further interactions in the future. Therefore, emergency response organisations should dedicate a significant amount of time and resources to establishing and maintaining formal and informal relationships before an emergency happens. If these network ties are not established and nurtured over time, they will not function properly in times of emergency.

3.5 Education and training needed for capability development

The fifth research question addressed by the research team was: *How might we best train and educate personnel in the most effective emergency management coordination above the IMT?*

Training and participating in exercises are key components needed to support multi-agency coordination above the IMT. These activities support the development and maintenance of a range of skills that can be separated into *technical* (e.g. knowledge of fire or flood behaviour) and *non-technical* (i.e., leadership, communication) skills. The analysis that addressed this research question was based on interviews, secondary-sources analysis and observations that enabled the team to:

- develop an understanding of how and when errors occur in coordination above the IMT;
- examine current formal and informal training pathways in emergency management that support the development of non-technical skills;

- consider these pathways in the context of the broader types of skills and knowledge that have been recognised as relevant to emergency management coordination;
- reflect on approaches taken in other work domains that are high risk and seek high reliability;
- assess developments in the key area of exercises and simulation; and
- test associated tools to improve operational outcomes (e.g. pre-mortems).

One overall observation that is important to note is that there has been far greater emphasis on training at the IMT and below than there has been above the IMT. The reduced emphasis above the IMT is in part due to the variability across jurisdictions and between agencies on the way coordination at this level is organised.

This led the research team to the conclusion that there are a number of specific opportunities to develop products to support current training and exercising practices within emergency management coordination above the IMT. In making this assessment, it is clear that we need to acknowledge the improvements in contextual learning and human factors and leadership education that have already occurred within the industry, and use these as opportunities to further develop the coordination skills of those in positions above the IMT. It is also necessary to acknowledge that many of the solutions to gaps in this area have already been identified in reports from the Bushfire CRC and other organisations. The challenge, therefore, is not that there is a lack of knowledge of what to do, but of how to implement this in an environment that is both time- and resource-challenged.

How do errors occur above the IMT during out-of-scale fire events?

Early in the research project, we applied The Human Factors Analysis and Classification System (HFACS) (Wiegmann & Shappell, 2003), to interrogate secondary sources of information for three out-of-scale Australian fire events. HFACS has been widely applied to accidents but is untested with respect to these more complex, temporally extended emergency events. The aim of the study was to identify the frequency and distribution of human error associated with selected major bushfire events across Australia, with an emphasis on error above the IMT. The results are recorded in Table 7.

The results indicated that:

- Regional Control Centres struggled to effectively supervise IMTs. This reflects the challenges of supervising while allowing IMTs to manage their span of control, and is also a product of the complexity inherent in multi-team systems.
- Crew resource management-related errors accounted for approximately 20% of errors across both regional and state levels of coordination.

- Violations of procedures also accounted for approximately 20% of errors across both regional and state levels of coordination, and were categorised as ‘exceptional’ to recognise that these were linked to the exceptional nature of the event itself, and not necessarily ‘normalised’ within the operational environment.

TABLE 7: DISTRIBUTION OF ERRORS FOR THREE SELECTED FIRES AT REGIONAL AND STATE CONTROL LEVELS

Regional level <i>n</i> (of errors) = 26	% Regional Errors
Unsafe acts – decision errors	12
Unsafe acts – exceptional violations	19
Preconditions (crew resource management)	19
Unsafe supervision (inadequate supervision, planned inappropriate actions)	38
Organisational (resource management and organisational processes)	8
State level <i>n</i> = 30	% State Errors
Unsafe acts – decision errors	33
Unsafe acts – exceptional violations	20
Preconditions (crew resource management)	20
Organisational issues (resource management and organisational processes)	27

In keeping with the findings presented addressing the earlier research questions, this analysis of secondary-source material suggests that when coordination ‘goes wrong’ in out-of-scale bushfire events, it occurs because disconnects occur (see discussion on research question #3 on page 15), leading to poor decision-making for a variety of reasons, and those decisions are not subject to the sort of scrutiny necessary to ‘catch’ and correct them. This occurs where the organisational processes and systems (discussed on page 11) sometimes cannot adjust to the scale of the event.

What are the skills necessary for coordination above the IMT?

Hayes and Omodei (2011) have previously identified a range of skills necessary to perform IMT roles. Technical expertise, along with AIIMS knowledge and processes might be considered technical or task-related competencies. The skills identified by Hayes and Omodei (2011) are being disciplined, flexible and adaptable, calm and level-headed, self-confident, maintaining a sense of humour and demonstrating initiative. These are essentially qualities of the individual, strongly linked to personality type, and also correlated with expertise and experience. Finally, there is also a range of non-technical or teamwork competencies that include communication and management skills, leadership, decision-making and an ability to maintain situational awareness. Therefore, the initial split between *non-technical* and *technical* skills identified in the introduction to this section, which has been emphasised in other industries (i.e. commercial

aviation, maritime), does not appear to be as emphasised in the emergency management industry (Brooks 2013).

The inclusion of personal characteristics would appear to have both costs and benefits. For example, knowledge of an individual's ability to remain calm during the event is of course desirable. However, in an environment where multi-agency teams can be formed of individuals who don't know each other, it is also important to be able to 'trust' that the system (training, education, certification, policies, procedures) is robust enough to place appropriately qualified staff in appropriate positions at the appropriate time. It seems at least possible that a progression from 'I trust her because I know her' should, in a High-Reliability Organisation (HRO), lead to 'I trust her because I trust the system'.

Above the IMT, it may well be that we need to be able to replicate Klein's (1997) early work in urban firefighting:

What the instructional manuals seemed to need the most was an explication of the critical cues and judgements, so that readers could learn how more experienced commanders saw the world, and could thereby make progress in thinking (and seeing) as an expert. (Klein, 1997, p. 347)

One way to consider this translation of expertise is that we need to teach people to think like experts. However, expertise is a complex concept, and in part built on the rich and diverse experience of the individual. This leads to the proposal that we need to instead teach people to learn like experts (Brooks 2013). This comes from recognising the variation in the (i) individuals; (ii) the systems and organisation within which they work above the IMT, and (iii) the dynamic nature of the events. While strategies supporting this approach such as compiling an extensive experience bank and enriching experiences via review to derive lessons learnt and identify mistakes are already being developed in the Australian emergency management domain, there is much more that could be done to move in this direction.

How are current training pathways supporting the development of these skills?

Within the various levels of the Australian Qualifications Framework are units relevant to training for effective emergency management coordination. The core units contained within Certificates II and III in Firefighting and Emergency Operations reflect the competencies required by firefighters involved in structural firefighting operations. Certificate IV covers leadership and supervisory functions, while the Diploma and Advanced Diploma address management functions.

The AIIMS training documentation also includes modules covering a range of human factors issues, albeit addressed in a preliminary way. Supplementing the formal training system and the operational training in AIIMS is a range of Continuing Professional Development (CPD) courses that have either been implemented or are under discussion within the research utilisation remit of the Bushfire CRC and in collaboration with AFAC.

Through our analysis, it is apparent that although the categories of skill might be similar between the IMT and above, there are nuances that need to be accounted for. At or below the IMT, it is appropriate to talk about decision-making, whereas above the IMT, we need to consider in far more detail the possibility that decision-making can lead to difficulties, and more subtle techniques such as ‘sense-making’ may be more appropriate for multi-agency coordination and consequence management. While some of this is due to role differentiation, it is also possible that the level of non-technical expertise required above the IMT is significantly greater.

The other significant finding regarding non-technical skill development is that the training pathway (see Figure 2) should be considered from a broader perspective that includes the strategic development of the organisation, operations, the coordination system and training and exercises. Disconnects between these elements lead to reduced levels of reliability, and training systems in HROs are increasingly moving to improve the consistency between these elements. Under such a scenario, of retention of concepts and competency during training would be taken into the field and measured under operational conditions; would be embedded within the policies and procedures of the formal management system; and would be consistent with the goals and change-management practices of the organisation.

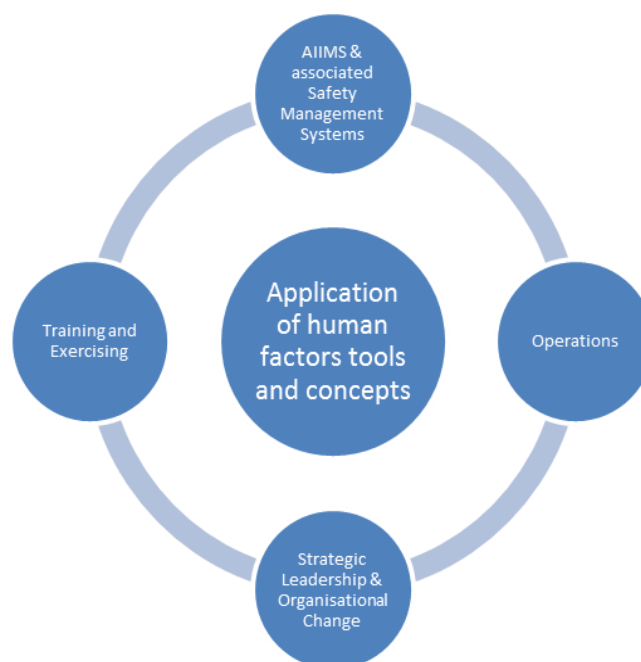


FIGURE 2: TRAINING PATHWAYS FOR HUMAN FACTORS

In conclusion, the answer to the research question *How might we best train and educate personnel in the most effective emergency management coordination above the IMT?* is a many-faceted one. We suggest:

- provide effective non-technical skill training at and below the IMT so once individuals come to working above the IMT, their knowledge of the basic concepts is sound;

- improve the integration between training, strategy, operations and the coordination system; and
- develop products to support training above the IMT.

There are a number of potential product guides that could be developed and these are discussed in the research utilisation section.

3.6 Building effective strategic-level emergency management

The sixth and final research question was: *What changes are needed to support effective emergency management at the regional and state levels of coordination?*

Emergency events continue to grow greater in duration, intensity and geographic spread. As was discussed in research question #2 (see page 11), the challenges facing those working above the IMT level are different in both content and context from the challenges facing people working at tactical and operational levels.

Drivers of change and their challenges and opportunities

The interviews and survey research reported to date has identified several empirical findings as well as several contextual drivers for change that will need to be addressed by the industry to manage future events. External drivers include climate change exacerbating vulnerabilities of communities and our environment, as climate change intersects with other out-of-scale dynamics such as global socio-economic shifts, demographic changes and biological system shifts. Internal drivers for change include changes in local, national and international policy as well as internal changes within the emergency services sector. Through analysing the research findings of this research project as well as a review of the literature and in discussing these findings with key emergency services leaders in the context of drivers for change, seven key areas that need attention to support effective emergency management in the future have been identified. These areas of change relate to the management of incidents that have:

1. Increased uncertainty, complexity and convergence [in the context of]
2. Disaster Risk Reduction and policy disconnects [with changes in]
3. Community expectations and resilience [and increasing use of]
4. Social media, networking, and their emergence [as well as challenges associated with]
5. The political–operational nexus [and a need for]
6. Measuring emergency management effectiveness [and improving]
7. Capability development, which includes culture change.

These challenges and the implications for change are now discussed. The first five pertain to external drivers and the last two are enablers internal to the sector.

1. Increased uncertainty, complexity and convergence

Managing out-of-scale emergency events presents increased levels of complexity and uncertainty for strategic emergency management teams. The growing number of events is likely to increase risks of injury to personnel and community members, raise exposure to health-related pathogens, increase psychosocial and mental health impacts, and place higher cognitive demands on leaders and teams. More out-of-scale and unprecedented events will amplify demands on emergency services, at the same time that these services and support agencies such as local governments are managing economic cut-backs, workforce rationalisations and an aging workforce. There will be more stakeholders engaged, resulting in larger teams and increased interdependencies, alongside higher potential for breakdowns in coordination, particularly when coupled with the other pressures. Thus the issues discussed in research question #3 (see page 15) are likely to become more prevalent if action is not taken to address breakdowns in shared mental models.

The adversarial nature of post-event inquiries can also make leaders and teams risk-averse, which impedes decision-making in such complex contexts. Growing pressures to provide seamless delivery of services and real-time information stem from a diversity in information media streams and a growing number of stakeholders. This places higher demands on organisational interoperability and interdependencies (discussed in research question #2 on page 11). More positively, addressing these challenges presents opportunities to clarify scope and responsibilities and capture emergent opportunities of breakthrough technologies in aiding coordination.

2. Disaster Risk Reduction and policy disconnects

There is a perceived disconnect between funding for different Disaster Risk Reduction strategies and emergency management in practice at all levels of government. Populations, housing and infrastructure continue to develop in hazard-prone areas. Climate change will exacerbate these consequences with communities that hitherto have not experienced severe natural hazards being increasingly exposed. All of these issues challenge existing policies and practices built upon assumptions of a stable risk environment. A plethora of research also points to the problematic disjunct nature of various policies that limits actions to address complex and multi-disciplinary challenges such as climate change. These also exacerbate the challenges in strategic-level emergency management as discussed in research question #1 (see page 9). There is an uneasy political relationship between state and federal governments, and tensions exist between administrative areas of responsibility within and between levels of responsibility. This can all undermine coordinated efforts. While there has been some shift

toward the idea of a 'whole-of-government' approach, it has yet to evolve in regular practice. This highlights the need for strategic emergency management to engage in a broader and long-term view of disaster management planning, alongside reflection upon conceptualisations and management of unanticipated and emerging problems.

3. Community expectations and resilience

Through the various research methods, the research team have learned that personnel working at a strategic level of emergency management are concerned that the expectations of communities and elected representatives are increasingly unrealistic: that those emergency services will manage any event well, regardless of its scale. Many respondents suggested that while policies include exhortations to 'enhance community resilience', in some communities it has declined, placing even greater expectations on emergency services. Equally, there is little agreement and some disquiet upon what constitutes resilience and the concept of self-reliance. Some argued that both are undermined by mixed and sometimes contradictory messages from emergency services, governments, communities and other groups. Using insights into factors contributing to variations in communities and individual capacities, vulnerabilities 'resilience' is crucial (Wisner et al., 2004), especially in light of climate change. We found a perception among emergency services leaders that our way of life is currently unsustainable and increasingly unlikely to cope with out-of-scale events, and the social change required may take too long, even if such a thing is achievable. This adds pressures to the information flow needs discussed in research question #2 on page 11.

4. Social media, networking and their emergence

Social media has become increasingly important in recent disasters, driven by the proliferation of social media and communities' needs to find information when it is not forthcoming from emergency services. Strategic emergency management must somehow live with the tensions of potential information distortion, greater information gathering and self-organised (informal network) emergence in communities 'outside official channels'. These new forms of social media technologies add increasing pressure to developing and maintaining the shared mental models discussed in research question #3 (see page 15), draw attention to the possibilities and problematics of managing emerging social networks discussed in research question #4 (see page 20) and also indicate areas that need to be addressed in training and capability, discussed in research question #5 (see page 22).

Social media within emergency management remains a controversial and contested space (Owen, 2012), presenting both an opportunity for dialogue and partnership with communities and potential additional strains on information and intelligence processes.

5. The political–operational nexus

Political representatives have key roles in emergency management, particularly in policy administration and support for emergency services during events. Yet the roles, relationships

and expectations of and between political and operational aspects of emergency management can be challenging. Out-of-scale disasters such as Queensland's 2010 floods or Victoria's 2009 fires come to mind. This provides an opportunity to engage with political decision-making before times of crisis to develop productively functional relationships that operate well in the entire Preparation, Planning, Response, Recovery spectrum, and increase the skills of strategic emergency management teams and politicians. Developing skills of diplomacy and influence will need to be included in capability development discussed in research question #5 on page 22.

6. Measuring emergency management response effectiveness

Developing criteria to evaluate the management and outcomes of emergency events needs attention, including the question of *who* conducts such evaluations. Currently, external sources (such as the media) arbitrarily judge the success of emergency management. Several other safety-critical industries consider sole reliance on the idea of 'a good outcome' flawed. Outcomes may still be successful despite the taking of high risks and unsafe practices. Conversely, the best measures and processes might have performed well, but while harm was minimised, the outcome could still be negative (but might have been much worse).

Acknowledging that during out-of-scale events, emergency management operations are frequently degraded is important (e.g. communications failure, insufficient resources, escalating and uncontrollable conditions) (Brooks, 2013). Personnel need support in managing despite these conditions, and also in recognising shifts toward unsafe conditions.

Development and capability

Addressing many of these challenges requires a proactive change strategy. However, this then challenges an emergency services culture that is traditionally reactive and operational, and characteristically limited in opportunities (time) to critically reflect and adjust, whether because of constant preparedness to respond – and actually responding – or ongoing responses to various inquiries. Expectations of communities and political leaders exacerbate such constraints, engendering change fatigue and an increasing aversion of individuals to manage future events for fear of litigation.

Changes are needed in how leadership and capability development above the IMT level are approached. A number of reports suggest that while tactical and operational training is well established, training for novel or out-of-scale events, or for those operating within strategic emergency management is less so (Murphy & Dunn, 2012), placing undue stress on people who care deeply about the outcomes.

It is crucial to understand and develop the skills required for out-of-scale, multi-jurisdictional, cross-agency strategic emergency management, equally, to enhance the sector's capacity for reflection and learning (Brooks, 2013; Owen, Bosomworth & Curnin, 2013). The proposed changes identified addressing research question #5 (see page 22) and throughout this report

provide a platform for change for the future. Discussion around the implications of these challenges for change is continuing and industry consultation will be ongoing.

What is required is adaptive behaviour, effective teamwork coordination, learning as part of the process of adaptive coordination, and flexible strategies. The ways in which emergency management is organised discussed in research question #1 (see page 9) provide the context for this future discussion. The information flow needs identified in addressing research question #2 (see page 11); the ways in which mental models breakdown discussed in addressing research question #3 (see page 15); and the social networks discussed in research question #4 (see page 20) are all pertinent here. There is a need to develop agreed processes and outcome measures for emergency management, including awareness of shifts towards degraded operational conditions in the development of training capability discussed in addressing research question #5 (see page 22). These findings will all contribute to facilitate positive outcomes, and confidence among officers that they are supported in the work with which they have been charged. In short, the findings discussed to date and the various research outputs, including the research utilisation taxonomies and other components, provide a valuable foundation that can be used as a launching pad for the new research agenda, funded through the Bushfire and Natural Hazards CRC. In so doing, these contributions continue to add to an evidence-based platform for change.

SECTION 4: RESEARCH UTILISATION

As part of the research utilisation responsibility of the project, we ensured engagement with a variety of stakeholders. In this section, we outline the various research engagement activities and provide a summary of research utilisation products that have emerged throughout the project.

4.1 Industry engagement activities

Various stakeholder groups involved in key engagement activities include:

- the Lead End User
- end users from the Bushfire CRC
- key secondary end users from planning, bushfire and emergency management sectors across case study areas
- the AFAC industry groups
- the fire and emergency management community, including through the Bushfire CRC
- the planning community
- associated research colleagues

Table 8, Table 9 and Table 10 outline the major engagement activities throughout the project.

TABLE 8: 2011 INDUSTRY ENGAGEMENT ACTIVITIES

2011 Industry Engagement Activity	Stakeholder Involvement
Research Group meeting (members from UTas, USyd and UniSA, including PhD candidates) with presentations from all members	LEU Liam Fogarty (Department of Environment and Primary Industries, Vic) (DEPI)
Paper prepared for the AFAC Doctrine Review Panel to seek end-user engagement in the project	AFAC, end users
Christine Owen and Chris Bearman presented to the Research Advisory Forum meeting in May	Research Advisory Forum members
Douglas Paton collaborated with TFS on organisational resilience	End user TFS
Engagement of end users to participate and provide feedback in survey pilot	End users Tasmania Fire Service; Tas Parks, Department of Environment and Heritage (SA) Country Fire Service (CFS-SA), Country Fire Authority (CFA Vic), Department of Environment and Primary Industries (DEPI), Metropolitan fire and Emergency Services Board (Vic), New South Wales Fire Brigades
Research group meeting held in Melbourne, which included engagement with personnel in the State Control Centre; simulation scenarios were reviewed	LEU Liam Fogarty (DEPI), stakeholders, BCRC Research Director Richard Thornton
Christine Owen presented at the <i>EMQUAL Conference 2011: Enabling Emergency Management Coordination</i> in Christchurch, New Zealand	International emergency management community
Presentations at the RAF meeting: PhD candidate Jafar Hamra (University of Sydney), 'Learning through networks within emergency management response' PhD candidate, James Minas (RMIT) 'Operations research to support bushfire management'	RAF, LEU Liam Fogarty (DEPI)
A method of reviewing Year 1 outcomes and findings utilising wiki technology was developed, providing summaries and suggested discussion questions. Invitations to provide feedback were extended	LEU Liam Fogarty (DEPI); 70 RAF members received participant invitations
Christine Owen, Sue Stack and Jan Douglas were invited to observe and participate in the Tasmania Parks Staff Ride and provide advice	Tasmania Parks and Wildlife Service

2011 Industry Engagement Activity	Stakeholder Involvement
General consultation and engagement were undertaken during the year to better understand the issues and challenges in managing at strategic level	Fire Services Commissioner of Victoria and the Victorian State Control Centre; key stakeholders in Victoria from DEPI, CFA, State Emergency Services, Vic Police; NSW Fire and Rescue, including NSW State Coordination Centre, Fire and Rescue NSW and the Major Incident Coordination Centre; TFS and the Tasmanian State Fire Operations Centre; presentations to other stakeholders interested in the research work

TABLE 9: 2012 INDUSTRY ENGAGEMENT ACTIVITIES

2012 Industry Engagement Activity	Stakeholder Involvement
Roshan Bhandari and Steve Curnin (PhD candidate) involved in discussions with key stakeholders at the State Control Centre in Victoria	LEU Liam Fogarty (DEPI); Fire Services Commissioner Craig Lapsley; End users DEPI, CFA, SES; Deputy Manager of SCC Steve Riley
Christine Owen presented research and participated in group discussions at the National Security Lessons and Knowledge Management working group meeting for Australian Emergency Management Institute (AEMI)	AEMI, key stakeholders in the emergency management community
Simulation scenarios piloted and reviewed. These findings were discussed with industry groups	AFAC AllIMS Steering Committee; AFAC Learning and Development group members
Roshan Bhandari and Steve Curnin (PhD candidate) visited the State Level Communication/Coordination Centre in Sydney and met with Paul McGuiggan	NSW Fire and Rescue, NSW State Control Centre
All researchers participated in the RAF in Hobart	BCRC, RAF members
Research Group meeting (UTas and CQU) held at Emergency Services Complex, Kedron, including discussions with key Queensland Fire and Rescue personnel and tours of the State Disaster Coordination Centre and State Operations Coordination Centre	Commissioner Lee Johnson, Assistant Commissioner for Safety and Training Mark Roche, Assistant Commissioner for Rural Operations Neil Gallant, Chief Superintendent Andrew Short, Director Professional Development Branch, Tony Holm and Alan Musk

2012 Industry Engagement Activity	Stakeholder Involvement
Hosted 4-week visit from UTas Research Fellow, Masters candidate and UK National Advisor for Incident Management Chris Mogg. Chris presented copy of the project's Emergency Management Coordination Survey to the UK Incident Management Network	UK Cabinet Office, local resilience forums, Core Cities Groups, Local Government Association, Emergency Planning Society, Regional Emergencies Division, Strategic Coordination Centre, fire, police, ambulance, University of Leeds, Coventry University
Steve Curnin (PhD candidate) conducted 43 interviews with stakeholders performing the role of an emergency management liaison officer across three state level emergency operations centres	MFB, CFA, DEPI, VIC ambulance service, VICSES, VIC POL, VIC Roads, , Dept Health Services, Telstra, , Dept of Transport, Southern Rural Water, Barwon Water, St John Ambulance, Red Cross, Parks VIC, TFS, Tas POL, Tas Ambulance Service, Tas SES, Aurora, Forestry Tas, Sydney Water,
Christine Owen led a contingent of end users to France to examine their approach to HROs with Bouches-du-Rhône Fire and Emergency Services Agency (SDIS13)	Bushfire CRC, LEU Liam Fogarty (DEPI), Dr Claire Johnson (CFA), Australian, NZ, French emergency management personnel (SDIS13)
Feedback sought for typology report project deliverable	LEU Liam Fogarty (DEPI) and AIIMS Review and other members
Steve Curnin (PhD candidate) conducted an observational study during a state-level multi-agency fire exercise at the NSW Rural Fire Service State Control Centre over a 1-day period	FRNSW
Steve Curnin (PhD candidate) conducted an observational study during a state-level multi-agency fire exercise at the Victorian State Control Centre over a 1-day period	MFB, VIC POL
Wiki site to present research outcomes, canvas views of stakeholders and gain feedback on future direction, including a teleconference meeting after the review period. The feedback highlighted general endorsement on directions and progress, as well some concerns about how the industry is placed for changes based on this new knowledge, and the need to develop strategies by the industry to implement these	LEU Liam Fogarty (DEPI) and AFAC AIIMS Steering Committee members, RAF

2012 Industry Engagement Activity	Stakeholder Involvement
Workshop in Melbourne to present emerging findings and gain further feedback. Preceded by two teleconferences with key members of the AFAC AIIMS Steering Committee	Commissioner Greg Mullins (FRNSW), Lee Johnson (QFRS), John Cawcutt (QFRS), Andrew Lawson (CFS, SA), David Nugent (Parks, VIC), Murray Carter (DEC, WA), Paul McGill (NZ Fire Service), Cameron Leary (Environment & Heritage, NSW), Stuart Midgley (NSWRFS), Chris Arnol (Fire & Emergency Services, WA), Damien Killalea (TFS), Stuart Ellis (AFAC), Gary Featherstone (AFAC), Paul Considine (AFAC), Sandra Lunardi (AFAC)

TABLE 10: 2013 INDUSTRY ENGAGEMENT ACTIVITIES

2013 Industry Engagement Activity	Stakeholder Involvement
Christine Owen and Chris Bearman hosted consultation on themes for Discussion Paper deliverable	LEU Liam Fogarty (DEPI), Geoff Conway (AFAC AIIMS Review), Dr Noreen Krusel (BCRC)
Workshop on issues related to Effective Incident Management above the IMT – Christine Owen, Ben Brooks, and Chris Bearman	LEU Liam Fogarty and end-user industry reference group
Researchers Christine Owen, Ben Brooks, and Chris Bearman attended and presented at the RAF in Perth on 14–15 May held at the Department of Environment and Conservation in WA	RAF, DEC and other emergency management stakeholders
Steve Curnin (PhD candidate) conducted two focus group interviews in Victoria on 4 and 18 June to discuss emerging findings	15 personnel who operate in the Victorian State Control Centre
Steve Curnin (PhD candidate) conducted an observational study during the activation of the Tasmanian State Fire Operations Centre over a 2-day period during the Dunalley fires incident	TFS, Forestry Tas, DPWIE Tas
Steve Curnin (PhD candidate) conducted an observational study during the Tier 3 activation of the Victorian State Control Centre over a 2-day period during two major bushfire incidents	VIC POL, VIC AMB, MEL Water, Jemena, DHS, VIC Roads, Telstra, AG Dept, ESTA
Christine Owen presented at the <i>Crisis communication and leadership: talking disaster in the 21st Century</i> forum for AEMI in Perth, 7 June	Department of Fire & Emergency Services (DFES), WA end users and stakeholders; David Parsons, Sydney Water; Bob Jensen, Principal Deputy Assistant Secretary for Public Affairs, Department of Homeland Security, USA; Dr Richard Adams, Royal Australian Navy
Steve Curnin (PhD candidate) conducted a focus group in Tasmania in October	Seven participants who operate in the Tasmanian State Fire Operations Centre
Christine Owen and Karyn Bosomworth conducted industry consultation to synthesise key themes for change needed in the sector	AFAC CEO sponsorship

4.2 End-user products for research utilisation

The end-user products produced for research utilisation are documented in Table 11.

TABLE 11: END-USER PRODUCTS FOR RESEARCH UTILISATION

Product and Purpose	Audience	Status
Fire Note on synthesis of findings from the project	Industry end users, heads of agencies	Submitted
Poster on the outcomes of the project	Researchers and practitioners engaged in CRC public gatherings, meetings and workshops	Submitted
Human factors book of research findings and practitioner implications published	Researchers, students interested in human factors research in fire and emergency services, practitioners and particularly instructors interested in facilitating understanding of human factors	Includes 11 Chapters with the publisher Ashgate. Anticipation publication July 2014
Organisational typology of coordination success and failure. Includes four dimensions and indicators within each dimension	Managers and practitioners of state-level emergency operations centres, researchers focused on observing multi-agency coordination practice	Submitted and approved
Supporting multi-agency coordination in emergency operations centres	A resource package adding value to the above-named organisational typology <ul style="list-style-type: none"> - includes typology - one-page guide for managers - information systems checklist poster for display 	Submitted and approved
Team mental models: a resource to support after-action reviews	Industry instructors, personnel responsible for conducting after-action reviews, emergency operations centres personnel with a focus on continuous improvement	Submitted and approved
Discussion paper synopsis of research findings – a high-level synthesis of the key issues from the research and questions about their implications	Strategic thinkers in industry, heads of agencies	Submitted and approved
Facilitating strategic conversations: change and implications for the future of emergency services	Learning plan for using the discussion paper synthesis as a learning tool for leadership development workshops and available for internal agency use: leaders and future agency and industry leaders	Submitted and approved
Conference paper delivered to the 2013 AFAC Conference	Researcher and practitioner attendees at the conference, users of the BCRC website	Submitted

Product and Purpose	Audience	Status
PowerPoint presentation of the synthesis of the findings and research outcomes presented to the RAF, June 2013	End users engaged in the CRC program who attend the RAF, end users who access the BCRC website	Completed
Identifying potential breakdowns and disconnects: a resource guide for regional level managers	Regional controllers as well as state-level personnel with an interest in reviewing safety assurance, after-action review personnel	Submitted and approved

SECTION 5: RESEARCH OUTCOMES – PERFORMANCE SUMMARY

This section provides tables listing key outputs in the form of reports, presentations, conference papers, posters, journal papers published, literature reviews, and manuscripts submitted and in preparation for national and international journals.

See Table 12: Reports prepared for the Bushfire CRC, Table 13: Journal and book publications, and Table 14: Conference publications and presentations.

TABLE 12: REPORTS PREPARED FOR THE BUSHFIRE CRC

Reports Prepared for the Bushfire CRC	
Research Output	Key Message or Purpose
Owen, C. (2010). <i>Emergency management coordination: a review of the literature</i> (Deliverable 1.2.3 UTas)	The purpose of this literature review was to provide a synopsis of published research important in emergency management coordination and, in particular, to consider what enables or constrains coordination breakdowns in emergency events. The review concluded by identifying key themes emerging in the literature worthy of attention in the research to be conducted
Brooks, B., Owen, C., Bearman, C. & Grunwald J. (2011). <i>Human factors issues in secondary sources</i> (Deliverable 1.3.8 UTas)	This report investigated the frequency and distribution of human factors issues associated with selected major bushfire events across Australia using secondary sources
Brooks, B. (2011). <i>Summary of issues emerging in coordination breakdown from secondary sources (in particular inquiries and similar)</i> (Deliverable 1.2.2 UTas)	The secondary-sources analysis was conducted using the HFACS as a framework. This classification system was drawn from a latent error model of understanding organisational error as a combination of active and latent failures. Preliminary findings in relation to issues emerging were addressed
Chapman, J. & Bearman, C. (2011). <i>Report on framework for eliciting shared mental models for use in bushfire fieldwork</i> (Deliverable 1.3.4 CQU)	This report was designed to provide the research team with a common theoretical framework to orient work in the project. Following a brief review of the literature on complex team processes and shared mental models as related to distributed teams, the report examines a model of adaptive team performance (Burke et al., 2006). This model encapsulates the high-level processes of dynamic team functioning and it was proposed that this model provide a common framework to inform the team's initial thinking about issues around team performance
Owen, C., Bearman, C., Brooks, B., Paton, D. & Hossain, L. (2011). <i>Organising for effective incident management</i> (Deliverable 1.2.4 UTas)	This conceptual paper outlines some of the difficulties associated with multi-organisational emergency management coordination and proposes a framework for advancing understanding of what is a quite complex and multi-layered domain
Owen, C. (2011). <i>Organisational survey results report</i> (Deliverable 2.1.3 UTas)	The report outlined the purpose of the research and methods employed. In terms of preliminary findings, it was shown that participants faced a variety of challenges when engaged in work activity. These challenges were grouped into three themes: concerns for personal or other safety; challenges associated with coordination including operating within degraded technology and communications infrastructures; competing priorities and demands as well as being overwhelmed by the sheer scale and size of the event with no time to scale up and with the consequences of overloaded

Reports Prepared for the Bushfire CRC	
Research Output	Key Message or Purpose
Grunwald, J., & Bearman, C. (2011). <i>Preliminary report on breakdowns in coordinated decision-making in teams fighting large-scale bushfires</i> (Deliverable 1.4.2 CQU)	This preliminary report examines breakdowns and components of breakdowns, known as disconnects. Two large-scale fire incidents (Kilmore East and Wangary) were examined using a top-down and bottom-up qualitative analysis technique. This report examined the relevance of the framework and coding scheme for coding secondary sources from large-scale bushfires and identified several issues for discussion with end users, such as disconnect chains and a low resolution of certain types of disconnects
Paton, D. & Brient, L. (2012). <i>Draft report on analysis of interviews</i> (Deliverable 2.2.3 UTas)	This analysis identified Communication and Leadership as the core categories to which all others could be consistently and comprehensively related. The analysis identified sub-categories: Interoperability, Autonomy, Predetermined Systems, Training and Exercises, Operational Experience, Stress Hardening, Emergency Management Skills, Formal Training, Credibility and Mentoring that contribute to the performance of these roles. The identification of systems and personal competencies required for sustained strategic incident management can inform the training and organisational development needs analyses required to develop adaptive strategic management capacity
Owen, C. (2012). <i>Report on information systems implications for information flow between layers in emergency management coordination</i> (Deliverable 1.3.9 UTas)	This report addressed the first of three information systems deliverables contained within the research project. The report included a framework for understanding work activity in complex socio-technical domains. It also discussed an analysis of the kinds of decisions made and challenges faced at state and regional levels. A number of implications that information systems would need to address in order to support the work that people undertake in those state and regional roles are also outlined
Owen, C. (2012). <i>Simulation scenarios developed and reviewed with lead end user and piloted</i> (Deliverable 2.2.2 UTas)	This deliverable was the first of four that support the education and training components of the research project. The report outlined three simulation scenarios for use at regional and state levels of coordination. This report also provided a brief literature review of the evidence base for the communication skills found to be effective as well as providing an outline of the foundation of scenario development approaches
Owen, C. (2012) <i>Overview of summary of human-technology interface implications provided to lead end user for feedback and comment</i> (Deliverable 2.4.2 UTas)	This report addressed the second of the three information deliverables for the research project. The purpose of the report was to analyse the various information modalities available and in use to map the relationships between information system use and regional and state-level incident management activity, and consult with industry stakeholders to identify the possibilities and constraints of information systems for the future in order to develop principles for information system interfaces and display

Reports Prepared for the Bushfire CRC	
Research Output	Key Message or Purpose
Curnin, S. (2012). <i>Documentation of an organisational typology of coordination failure (above the IMTs) provided for lead end user review</i> (Deliverable 3.3.3 UTas)	This deliverable outlined an organisational typology that is intended for use by practitioners to review the effectiveness of the requirements that facilitate successful multi-agency coordination. The typology consists of four dimensions, identified as crucial to facilitating multi-agency coordination: (1) system enablers; (2) leadership and capabilities; (3) organisational linkages; and (4) mechanisms of communication
Owen C. (2012). <i>Summary of human–technology interface implications: end-user feedback</i> (Deliverable 2.4.3 UTas)	This deliverable was a revision of the deliverable report 2.4.2, which was submitted to the Bushfire CRC on 30 June 2012. The report 2.4.2 was reviewed by end user leader Liam Fogarty and also by Geoff Conway (AFAC AIIMS Group consultant), and feedback provided. Included in this summary was an e-mail from Geoff Conway to industry stakeholders and a set of questions posed for consultation
Owen, C., Johnson, C. (2012). <i>Report on French–Australian research exchange</i>	Report based on the training simulations at the Bouches-du-Rhône training facility during the French–Australian–New Zealand collaborative research exchange
Owen, C., Brooks, B. & Johnson C. (2012). <i>Report on testing of scenarios to enhance communication</i> (Deliverable 2.4.4 UTas)	This was the second report of four deliverables prepared as part of the education and training component of the research project. The report outlined the method, which included participants, pre-mortem intervention and simulation exercises. The findings discussed categories identified in the analysis of the pre-mortem dialogue, examples of codes identified in the pre-mortem discussion, an interaction sequence in the pre-mortem and non-technical issues observed during the simulation
Bearman, C., Grunwald, J., Brooks, B. & Owen, C. (2012). <i>Final report on breakdowns in coordinated decision-making in teams fighting large-scale bushfires</i> (Deliverable 2.1.2 CQU)	This report examined breakdowns and disconnects in three large-scale fire incidents in Australia (Kilmore East, Wangary and Canberra), the Canberra Firestorm being added to the analysis of the other two fires presented in the Preliminary Report. The report identifies that informational and operational disconnects are often not effectively resolved. Further disconnects often cause other disconnects to occur so that there is a divergence in the team’s understanding and management of the emergency, leading to impaired team functioning
Brooks, B. & Owen, C. (2013). <i>Training pathways for effective emergency management coordination above the IMT</i> (Deliverable 3.2.4 UTas)	This report addressed the question: ‘How might we best train and educate personnel in the most effective emergency management coordination above the IMT?’ Gaps were identified and recommendations were made

Reports Prepared for the Bushfire CRC	
Research Output	Key Message or Purpose
Bearman, C., Grunwald, J., Owen, C. & Brooks, B. (2013). <i>Information needs to support the development of accurate and appropriate situation awareness and shared mental models</i> (Deliverable 2.1.4 CQU)	This report provides a statement of the theoretical underpinnings of situation awareness and shared mental models and discusses the research conducted in the project to date in light of these theories
Curnin, S. (2013). <i>Report on organisational typology of coordination failure above the IMTs</i> (Deliverable 3.2.3 UTas)	Report on an organisational typology that is intended for use by practitioners to identify and support the requirements for successful multi-agency coordination. Report was developed based on a review of the research and empirical studies, and included LEU feedback
Brooks, B. & Owen, C. (2013). <i>Report on evaluation of mental model training and strategies for changes in practice</i> (Deliverable 3.2.5 UTas)	Report included how mental models have been defined, and the association between this and other concepts of team cognition. Report also looked at how models have been measured or assessed, and how this might reasonably translate into the exercising and training environments of the emergency management domain
Bearman, C., Owen, C., Brooks, B.P. & Grunwald, J. (2013). <i>The problems of maintaining effective teamwork during out-of-scale events</i> (Deliverable 3.2.3 CQU)	To effectively coordinate out-of-scale events, it is necessary for teams to form and work together quickly and effectively. At the IMT level and above, teams managing out-of-scale events will likely include people who do not know each other, may have very different skill sets and knowledge, and may be from different agencies that have different priorities and perspectives on the incident. This paper investigates the impact of these pressures on teamwork processes and the operational response through semi-structured interviews with people who have recent experience of out-of-scale events in Australia and New Zealand. In out-of-scale events, people can become overwhelmed and tasks that would normally be carried out are dropped as people try to cope with the high levels of stress and workload. The findings from this research demonstrate the need to consider team processes and to ensure effective information flow even under the extreme pressures of an out-of-scale response so as to avoid impaired team performance and a degraded response
Grunwald, J., & Bearman, C. (2013). <i>Identifying and resolving coordinated decision-making breakdowns at the regional level</i> (Deliverable 3.3.2 CQU)	This paper presents the results of the scenario simulation research study. Based on scenario simulations with regional controllers, four breakdown identification strategies and seven direct resolution strategies were identified. This provides a toolbox of strategies to help regional controllers identify and resolve breakdowns

Reports Prepared for the Bushfire CRC	
Research Output	Key Message or Purpose
Owen, C., Bosomworth, K., Bearman, C. & Brooks, B. (2013). <i>Discussion paper on future needs for effective emergency incident management</i> (Deliverable 3.3.2 UTas)	Re-framed as a discussion paper on challenges (previously a White Paper), the content of the paper was drawn from consultation with industry representatives (LEU and end-user industry reference group in 2012) when researchers Christine Owen, Ben Brooks, Roshan Bhandari and Chris Bearman presented their research findings and facilitated group discussions. Circulated to the LEU and the AIIMS Review Committee Leader for review
Owen, C. & Bosomworth, K. Conway, G. (2013). <i>Strategic-level emergency management: some challenges and issues for the future</i> (Deliverable 3.3.3 UTas)	This deliverable was originally called a 'Framework for change'. However, based on consultation with the industry, the end-user leader and the BCRC research manager, this was changed to its current title. The report documents the virtual workshop consultation with the industry as part of gaining industry feedback on the Discussion Paper (3.3.2). The report includes 87 proposed actions to address the challenges facing the industry that were provided by 38 industry leaders consulted
Owen, C. (2013). <i>Report to the AFAC AIIMS Steering Committee including recommended actions to improve the way incidents are managed</i> (Deliverable 3.4.5 Utas)	A verbal report was provided to AFAC in June. This final report to the AFAC AIIMS Steering Committee provided a synopsis on the project outcomes and included the Executive Summaries of the three final deliverables and main bodies of work for 2013: <i>The Bushfire CRC final report</i> ; the <i>Discussion Paper on future needs for effective emergency incident management</i> and <i>Strategic-level emergency management: some challenges and issues for the future</i>

TABLE 13: JOURNAL AND BOOK PUBLICATIONS

Journal and Book Publications	
Publication	Key Message or Purpose
2010	
Hossain L. & Kuti, M. (2010). Disaster response preparedness coordination through social networks. <i>Disasters</i> , 34(3), 755–786	Studies of coordination in human networks have typically presented models that require stable working relationships. These models cannot be applied to emergency response management, which demands distributed coordination in volatile situations. This paper argues that changes to interconnectedness of nodes in a network may have implications for the potential to coordinate. A social network-based coordination model is proposed to explore an organisational actor's state of readiness in extreme conditions. To test this hypothesis, the study investigates survey data from state law enforcement, state emergency services and local law enforcement, presenting agency-based (macro) and cross-agency (micro) analysis on 224 completed questionnaires. The main findings are: (i) there is a positive correlation between network connectedness and the potential to coordinate; (ii) the concept of tiers within an emergency response network may exist and be characterised by the sub-network with which an organisation associates; (iii) a range or threshold characterises how interconnected an organisation at a given tier should be.
Paton, D., Bajek, R., Okada, N. & Mclvor, D. (2010). Predicting community earthquake preparedness: a cross-cultural comparison of Japan and New Zealand. <i>Natural Hazards</i> , 54(3), 765–781	This paper reports on a study investigating cross-cultural equivalence in predictors of earthquake preparedness. Data were collected from Napier (New Zealand) and Kyoto (Japan). These locations were selected because they face comparable levels of seismic risk but differ with respect to their cultural characteristics. This mix of hazard similarity and cultural differences provided an opportunity to assess the degree of cross-cultural equivalence in predictors of earthquake preparedness. Cross-cultural equivalence was examined by assessing the degree to which individual hazard beliefs (outcome expectancies) and social characteristics (community participation, collective efficacy, empowerment, trust) could explain levels of hazard preparedness in each location. Structural equation modelling analyses revealed similarity in the pattern of relationships between predictor variables and intention to prepare in the Napier and Kyoto data. It is argued that this provides support for the existence of some universal, cross-cultural equivalence in how hazard beliefs and social characteristics interact to predict the degree to which people adopt earthquake preparedness measures. Differences between the data sets are discussed in the context of the fundamental cultural differences between Japan and New Zealand. The theoretical and practical implications of the findings are discussed.

Journal and Book Publications	
Paton, D., Frandsen, M. & Johnston, D. (2010). Confronting an unfamiliar hazard: tsunami preparedness in Tasmania. <i>Australian Journal of Emergency Management</i> . 25(4), 31–37	This paper discusses how a lack of experience of tsunami hazards in communities in Tasmania has resulted in low perception of risk being attributed to this hazard, with levels of preparedness being correspondingly low. The paper then discusses whether a model that has demonstrated an ability to predict preparedness in areas in the United States where tsunami risk is accepted can be applied in Tasmanian communities. Following demonstration that this model is not a good predictor when people are dealing with a hazard with low risk acceptance, an alternative model is presented and its utility evaluated. The role of planning and risk beliefs is also discussed.
Uddin, S., Hossain, L., Murshed, S.T. & Crawford, J.W. (2010). Static versus dynamic topology of complex communications network during organizational crisis. <i>Complexity</i> , 16(5), 27–36	The significance of temporal changes in the topology of organisational communication networks during a crisis is studied using static and dynamic social network analysis (SNA). In static SNA, the network of interactions made during an entire data collection period is studied. For dynamic SNA, shorter segments of network data are used in the analysis. Using measures of degree centrality and core–periphery analysis, the prominence of actors is characterised and compared in the aggregate network (i.e. using static topology) and in daily networks (i.e. using dynamic topology) of a complex email network in a large organisation during crisis. We show that while static typology cannot capture the network behaviour completely, there are particular situations where the additional description provided by dynamic analysis is not significant. The limitations of dynamic topological SNA are discussed and we stress the importance of associating function with network structure in moving towards a more informative dynamical description.
2011	
Owen, C. & Johnson, C. (2011). Fire planning helped by research, <i>Fire Australia</i> (Autumn 2011), 22–23. ISSN 1032-6529	This article outlines progress in emergency management human factors. It points to recent findings by the authors including the development of worst-case scenario contingency thinking using a ‘pre-mortem’ approach by Claire Johnson and recent work by Christine Owen on interaction patterns in effective incident management teams.

Journal and Book Publications

2012

Hamra, J., Hossain, L. & Owen, C. (2012). Social network analysis of learning teams during emergency events. In <i>Fusing Decision Support Systems into the Fabric of the Context</i> , pp. 267–278. Amsterdam: IOS Press . ISBN: 9781614990727,	The effect of social network structures on the learning attitudes of emergency personnel during an emergency event is critically important. We first develop a theoretical framework to investigate the effects of network structure on learning outcomes of bushfire incident management teams. Next we empirically test our framework. Empirical results suggest that a network structure of emergency personnel can be identified that plays a key role in the ability of those actors to engage in learning-related work activity, allowing them to adapt and improvise in complex emergency events.
Hamra, J., Hossain, L., Owen, C. & Abbasi, A. (2012). Effects of networks on learning during emergency events. <i>Disaster Prevention and Management</i> , 21(5), 584–598	This paper aims to explore the relationship between learning and the social networks employed within the context of emergency management. Results show that increases in actors' involvement within the social emergency management network influence the ability of those actors to engage in learning-related work activity. The paper infers that by developing learning-related resources within the context of their social interactions, these emergency personnel are better able to adapt and improvise in complex emergency events. By presenting a model of learning-related work activity as an ongoing aspect of network connectedness, personnel within emergency services organisations can strengthen their capacity.
Hossain, L. & Guan, D.C.K. (2012). Modelling coordination in hospital emergency departments through social network analysis. <i>Disasters</i> , 36(2), 338–364	Coordination theory provides a theoretical framework for analysing complex processes of project groups working towards a common goal. In this study, we explore the relationship between coordination and social networks for the development of a network-based coordination model. This model is applied to measure the performance and quality of complex and dynamic project coordination such as in hospital emergency departments. The dataset used for the study was collected by the 2004 National Hospital Ambulatory Medical Care Survey – a national probability sample survey of visits to emergency and outpatient departments of non-federal, short-stay and general hospitals in the United States. Using social network analysis, this study allows us to understand the possible causes of inefficient coordination performance and coordination quality resulting in access blocks.

Journal and Book Publications	
Hossain, L. & Uddin, S. (2012). Design patterns: coordination in complex and dynamic environments. <i>Disaster Prevention and Management</i> , 21(3), 336–355	The purpose of this paper is to provide a conceptual foundation and empirical basis for exploring issues related to the design framework for modelling coordination in complex and dynamic environments. Previous research suggests that interactions among actors in a complex and dynamic environment tend to be more elastic, offering a higher degree of adaptability. Actions of actors in such an environment need to be coordinated to achieve the desired goal. With that purpose, the authors suggest a social network-based (SN-based) framework to model coordination in complex and dynamic environments. The authors successfully apply the proposed SN-based framework to model coordination in the context of soft-target organisation and emergency response preparedness. It is apparent that much work has been done in existing studies on modeling coordination considering the specific domain situation in a complex and dynamic environment. In this paper, the authors propose a unique framework to model coordination in a complex and dynamic environment.
Johnston, D., Becker, J. & Paton, D. (2012). Multi-agency community engagement during disaster recovery. Lessons from two New Zealand earthquake events. <i>Disaster Prevention and Management</i> , 21(2), 252–268	The purpose of this paper is to look at the role of community participation in reducing anxiety and trauma in communities during two New Zealand earthquakes: the 1987 Edgecumbe and 2003 Te Anau events, and explore the effectiveness of various approaches in providing information, reducing stress and facilitating a recovery process. The principal methods of data collection were semi-structured interviews, undertaken between October 2006 and March 2007 with key agencies and individuals involved in the response, and comprehensive analysis of papers, reports and articles in newspapers. The research was undertaken prior to the 4 September 2010 and 2011 earthquakes in Canterbury, New Zealand, and therefore community recovery from these events is not discussed in this paper. The paper offers insight into the effectiveness and benefit of incorporating community participation in reducing anxiety and trauma in communities during earthquakes.
Minas, J.P., Hearne, J.W. & Handmer, J.W. (2012). A review of operations research methods applicable to wildfire management. <i>International Journal of Wildland Fire</i> , 21(3), 189–196. http://dx.doi.org/10.1071/WF10129	Across the globe, wildfire-related destruction appears to be worsening despite increased fire suppression expenditure. At the same time, wildfire management is becoming increasingly complicated owing to factors such as an expanding wildland–urban interface, interagency resource-sharing and the recognition of the beneficial effects of fire on ecosystems. Operations research is the use of analytical techniques such as mathematical modelling to analyse interactions between people, resources and the environment to aid decision-making in complex systems. Fire managers operate in a highly challenging decision environment characterised by complexity, multiple conflicting objectives and uncertainty. We assert that some of these difficulties can be resolved with the use of operations research methods. We present a range of operations research methods and discuss their applicability to wildfire management with illustrative examples drawn from the wildfire and disaster operations research literature.

Journal and Book Publications	
Sinclair, H., Doyle, E.E., Johnston, D.M. & Paton, D. (2012). Assessing emergency management training and exercises, <i>Disaster Prevention and Management</i> , 21(4), 507–521	The purpose of this paper is to investigate how training or exercises are assessed in local government emergency management organisations. An investigative review of the resources available to emergency managers in North America and New Zealand for the evaluation and monitoring of emergency management training and exercises was conducted. This was then compared with results from a questionnaire-based survey of 48 local government organisations in Canada, the USA and New Zealand. A combination of closed and open-ended questions was used, enabling qualitative and quantitative analysis. This study demonstrates that it is largely unknown how effective the training efforts of local government organisations are. Further study inspired by this paper will provide a clearer picture of the evaluation and monitoring of emergency management training programs. These results highlight that organisations need to move away from an ad hoc approach to training design and evaluation towards a more sophisticated and evidence-based approach to training needs analysis, design and evaluation if they are to maximise the benefits of this training. This study is the first investigation to the authors’ knowledge into the current use of diverse emergency management training for a range of local government emergency offices, and how this training impacts the functioning of the organisation’s emergency operations centre during a crisis.
2013	
Abbasi, A., Owen, C., Hossain, L. & Hamra, J. (2013). Social connectedness and adaptive team coordination during fire events. <i>Fire Safety Journal</i> , 59, 30–36	In this study, we argue that improving plans and operations of personnel involved in managing fire-related emergencies is an important area of investigation. Here, we investigate the effects of social connectedness among different team members to manage bushfires. We further analyse response coordination by exploring variables such as participants’ preparedness quality, quality of incident action planning and quality of accessibility of resources. In doing so, we also test the effects of these variables on improved adaptive behaviour. Our results showed high positive correlation between social connectedness for team members and coordination quality and also adaptive behaviour. We also found significant relationship between coordination and adaptive behaviour. By exploring the proposed model, we are able to develop a better understanding of the factors that support adaptive behaviour in incident management teams responding to bushfire events.

Journal and Book Publications

<p>Bearman, C. & Bremner, P.A. (2013). A day in the life of a volunteer incident commander: errors, pressures and mitigating strategies, <i>Applied Ergonomics</i>, 44, 488–495</p>	<p>To meet an identified gap in the literature, this paper investigated the tasks that a volunteer incident commander needs to carry out during an incident, the errors that can be made and the way that errors are managed. In addition, pressure from goal seduction and situation aversion were also examined. Volunteer incident commanders participated in a two-part interview consisting of a critical decision method interview and discussions about a hierarchical task analysis constructed by the authors. An analysis was conducted to further identify potential errors. The results identified the key tasks, errors with extreme risk, pressures from strong situations and mitigating strategies for errors and pressures. The errors and pressures provide a basic set of issues that need to be managed by both volunteer incident commanders and fire agencies. The mitigating strategies identified here suggest some ways that this can be done.</p>
<p>Becker, J.S., Paton, D., Johnston, D.M. & Ronan, K. (2013). Salient beliefs about earthquake hazards and household preparedness. <i>Risk Analysis</i>, 33(9), 1710–1727</p>	<p>Forty-eight qualitative interviews were undertaken with residents in three urban locations in New Zealand subject to seismic risk. The study aimed to identify the diverse hazard and preparedness-related beliefs people hold and to articulate how these are influenced by public education to encourage preparedness. The study also explored how beliefs and competencies at personal, social and environmental levels interact to influence people's risk-management choices. Three main categories of beliefs were found: hazard beliefs, preparedness beliefs and personal beliefs. Several salient beliefs found previously to influence the preparedness process were confirmed by this study, including beliefs related to earthquakes being an inevitable and imminent threat, self-efficacy, outcome expectancy, personal responsibility, responsibility for others, and beliefs related to denial, fatalism, normalisation bias and optimistic bias. New salient beliefs were also identified (e.g. preparedness being a 'way of life'), as well as insight into how some of these beliefs interact within the wider informational and societal context.</p>

Journal and Book Publications	
Curnin, S. & Owen, C. (2013). Obtaining information in emergency management: a case study from an Australian emergency operations centre. <i>International Journal of Human Factors and Ergonomics, Special Issue on Human Factors and Ergonomics in Emergency Management</i> . 2(2/3), 131–158.	Stakeholders involved in emergency management multi-agency coordination require information to inform their situation awareness to plan and coordinate their response and mitigation strategies. This study investigates the perceived information requirements of senior strategic-level emergency management personnel and how they obtain this information. The results are based on empirical data from two sources: an organisational survey and observational study during an emergency event. The findings indicate that the most influential cognitive artefacts used to obtain information are in person communication and use of specialised application software. However, challenges associated with using the latter can result in an increased use of in person communication, which can limit the exchange of information throughout the system of actors. Understanding the strengths and limitations of how these stakeholders obtain information in this Australian emergency operations centre to inform their situation awareness is essential in facilitating multi-agency coordination in this environment.
Hamra, J., Wigand, R., Hossain, L. & Owen, C. (2013). Network effects on learning during emergency events. <i>Knowledge Management and Research Practice</i> , online 21 Jan 2013, http://dx.doi.org/10.1057/kmrp.2012.65	Understanding the factors that enhance or impede learning of individuals is instrumental in achieving organisational performance goals. In this study, the effect of social network structures on the learning attitudes of emergency personnel during an emergency event was investigated. On the basis of a social influence model of learning, a theoretical framework has been proposed to investigate the effects of network structure on learning outcomes of bushfire incident management teams. To test our framework, we investigated social network data that were extracted from the transcripts of the 2009 Victorian Bushfires Royal Commission report. Empirical results suggest that a network structure of emergency personnel can be identified, which plays a key role in the ability of those actors to engage in learning-related work activity, allowing them to adapt and improvise in complex emergency events. By using a model of learning-related work activity based on a social network analysis of its structure, emergency staff can strengthen their capacity to be flexible and adaptable.
Minas, J.P., Hearne, J.W. & Martell, D.L. (2013). An integrated optimisation model for fuel management and fire suppression preparedness planning. <i>Annals of Operations Research</i> Available online. DOI. 10.1007/s10479-012-1298-8	Fuel management and suppression preparedness planning are elements of forest fire management that are strongly interrelated. Despite this interrelation, previous forest fire management optimisation models have tended to consider these components in isolation from one another. Here we present an integer programming model that incorporates both fuel management and suppression preparedness decisions, thus providing an integrated planning framework. A series of hypothetical test landscapes are used to demonstrate the model's functionality with easily interpretable results. A number of possible extensions to the model formulation are also discussed.

Journal and Book Publications	
Owen, C. (2013). Gendered communication and public safety: women, men and incident management. <i>Australian Journal of Emergency Management</i> , 28(2) 3–10.	Managing emergency events requires incident management teams to actively pool their ideas and concerns to resolve challenges, although this frequently does not occur. Using a mix of quantitative and qualitative research methods, this paper explores whether gender may be an underlying factor. The quantitative findings indicate that women report different experiences of communication in IMTs. In seeking to provide an account as to why this might be the case, 24 qualitative interviews with IMT members were examined. The findings reveal cultural challenges to team communication and specifically a masculinist culture (i.e. acting with high confidence and bravado). The legitimacy of these displays is contested by both men and women because of their negative impacts on team communication and co-operation. Strategies for overcoming the negative impacts of masculinist cultures and the role of leadership and training are discussed.
Owen, C., Bearman, C., Paton, D. & Chapman, J. (2013). Developing a research framework for complex multi-team coordination in emergency management. <i>International Journal of Emergency Management</i> , 9(1), 1–17. http://inderscience.metapress.com/content/Y7776KH5238161J0	This conceptual paper addresses previous calls for the development of new theoretical frameworks to better account for the multi-agency emergency management coordination required in complex events. It uses, as a departure point, a teamwork model that includes four phases: situation assessment, plan formulation, plan execution and team learning. The thesis put forward here is that we need to move the focus of analysis beyond the team to one of multi-layered multiple team and multiple organisation systems. To further develop this research framework, indicators from multi-organisational literature are added to those found in the individual and teamwork literature to develop a more comprehensive account of multi-team multi-organisational coordination. The paper identifies key anchor points for future use in data collection.
Paton, D. & Owen, C. (2013). Incident Management. In Bradley Penuel, K., Statler, M. & Hagen, R. (Eds), <i>Encyclopaedia of Crisis Management</i> , pp. 502–506, Sage. Thousand Oaks, CA.	This chapter outlines the organisation of incident management systems. Strategic incident management is responsible for developing requisite policy, plans and capabilities. Faced with more demands than available resources, incident management at the tactical level is concerned with adapting plans and actions to balance strategic objectives with operational (i.e. real-time) realities. The chapter analyses the different demands across strategic, tactical and operational levels of incident management.

Journal and Book Publications	
Uddin, S., Hossain, L. & Rasmussen, K. (2013). Network effects on scientific collaborations. <i>PLoS ONE</i> 8(2), e57546. doi:10.1371/journal.pone.0057546	The analysis of co-authorship network aims at exploring the impact of network structure on the outcome of scientific collaborations and research publications. Using three SNA measures (i.e. degree centrality, closeness centrality and betweenness centrality), we explore scientific collaboration networks to understand factors influencing performance (i.e. citation count) and formation (tie strength between authors) of such networks. In this study, we examine how citation count of a scientific publication is influenced by different centrality measures of its co-author(s) in a co-authorship network. We further analyse the impact of the network positions of authors on the strength of their scientific collaborations. We use both correlation and regression methods for data analysis leading to statistical validation. We identify that the citation count of a research article is positively correlated with the degree centrality and betweenness centrality values of its co-author(s). Also, we reveal that degree centrality and betweenness centrality values of authors in a co-authorship network are positively correlated with the strength of their scientific collaborations.
Bremner, P., Bearman, C. & Lawson, A. (2013). Firefighter decision-making at the local incident and regional/state control levels. In Owen, C. (Ed.) <i>Human Factors Challenges in Emergency Management: Enhancing Individual and Team Performance in Fire and Emergency Services</i> . Aldershot, UK: Ashgate	This chapter examines the literature on decision-making and how it applies to the different levels of fire management in a large-scale fire. While there is some research on how people at local incident management levels make decisions, there is little information about decision-making at regional and state levels. Results of secondary-sources analysis and interviews are presented. The chapter traces the four breakdown identification strategies and seven direct resolution strategies that were identified. This provides a toolbox of strategies to help regional controllers identify and resolve breakdowns. The literature on firefighter decision-making at local levels is also discussed, and how this might apply to regional or state levels of emergency fire management is considered. Areas where more research needs to be undertaken are highlighted. The second half of the chapter contains a discussion of some of the pressures that can lead fire personnel to make poor decisions.

Journal and Book Publications

Brooks, B. (2013). Errors, decisions, coping and training. Non-technical skills and implications for emergency management training approaches. In Owen, C. (Ed.) *Human Factors Challenges in Emergency Management: Enhancing Individual and Team Performance in Fire and Emergency Services*. Aldershot, UK: Ashgate

Training and exercising are key components of a strategic move forward in effective organising above the IMT level. To this point, there has been far greater emphasis on training at the IMT level and below than there has been above. The aim of this chapter is to identify if there are opportunities to enhance training efforts for those that inhabit these roles. To achieve this, it is necessary to explore the nature of non-technical skills and competencies involved with coordination of emergency management events; identify how these skills and competencies might break down; and establish the range of formal and informal training activities that currently occur. It is also necessary to acknowledge that emergency management training and exercising activities face some significant constraints and these in turn constrain what can reasonably be proposed as a training pathway. Jurisdictional approaches above IMTs are not uniform; opportunities and resources for training above IMTs are not infinite. Emergency events are changing in terms of complexity, intensity and duration. In addition, public and political expectations of managers are challenging, if not sometimes impossible to meet.

Douglas, J. (2013). The role of affect in individual and collective performance in a sociocultural context. In Owen, C. (Ed.) *Human Factors Challenges in Emergency Management: Enhancing Individual and Team Performance in Fire and Emergency Services*. Aldershot, UK: Ashgate

Many people who work in high-consequence environments enjoy the challenges and the complexities they face. A number of research studies have shown that positive affect can influence people's work activity such as their quality of problem-solving, decision-making and caution in dangerous situations. Yet research shows that people working in high-consequence environments are also prone to negative affective experiences, which includes not having sufficient time to recover emotionally between critical incidents and psychological distress.

Journal and Book Publications	
Owen, C. (Ed.) (2013). <i>Human Factors Challenges in Emergency Management: Enhancing Individual and Team Performance in Fire and Emergency Services</i> . Aldershot, UK: Ashgate	This book provides an overview of the research that has been conducted within Australia funded by the Bushfire CRC. It will be of particular interest to scholars, students and practitioners in a number of other countries, particularly in the USA and in Europe and fills an important gap in knowledge about human factors in the fire and emergency services industry. Trends both in Australia and world-wide indicate an increase in extreme events, making understanding the human factors issues distinct to this domain particularly important. The original research reported here identifies areas of performance that are critical to the safety and reliability of personnel involved in fire and emergency services. Emergency events frequently involve wicked problems for which there may be unanticipated consequences and highly interdependent consequential effects. As Karl Weick once commented, emergency events do not 'play by the rules'. This means that these research chapters tell us something about a potential future world of work that is highly dynamic, interdependent and for which improvisation and critical thinking and problem-solving are necessary prerequisites. The content of the book is based on research conducted at various levels of emergency management organisation including the incident ground, with local IMTs, and emergency management teams working at regional, state and national levels of coordination.
Owen, C. & Hayes, P. (2013). Introduction: why human factors in emergency services? In Owen, C. (Ed.) <i>Human Factors Challenges in Emergency Management: Enhancing Individual and Team Performance in Fire and Emergency Services</i> . Aldershot, UK: Ashgate	The growing importance of emergency management is described along with the role these agencies play in supporting communities to be resilient. In essence, adverse events are increasing in number and intensity and there is a growing vulnerability in our communities. The challenges facing emergency services workers are outlined. Emergency events can be particularly demanding for first responders and IMTs. This is because emergency events are dynamic and at times unpredictable as situations continue to evolve and change. Emergency services personnel may be required to operate under high levels of uncertainty and to make time-critical decisions using information that may be incomplete, inconsistent or ambiguous, in part because the information available varies in quantity and quality. The chapter also provides a brief overview of how emergency management is organised. The planning and preparation undertaken by federal and state agencies are summarised along with the types of roles and responsibilities of first responders, local IMTs, and regional or state personnel. The structure of incident management systems to coordinate emergency response activities is also discussed and some of the human factor challenges for emergency services personnel are outlined. The challenges posed by increasing amounts of data for decision-makers, greater specialisation, and the combination of increasing incident complexity and greater expectations of emergency managers are described. The discipline of human factors is central to identifying strategies for effective performance in the team- and technology-oriented environment of emergency management.

Journal and Book Publications	
Owen, C. (2013). Leadership, Communication and Teamwork in Emergency Management, In Owen, C. (Ed.) <i>Human Factors Challenges in Emergency Management: Enhancing Individual and Team Performance in Fire and Emergency Services</i> . Aldershot, UK: Ashgate.	Effective communication within and between teams is increasingly recognised as an important component for adaptability to changing conditions. Teams in complex environments rely heavily on their leaders to continually develop and promote a shared understanding of the situation and problems that arise, and what resources (including members' capabilities) might be called upon to ensure safe and effective performance. As teamwork becomes more intense and complex, and as multiple team coordination becomes more interdependent, it is crucial that leaders and their teams are able to manage these dynamic conditions. This chapter contributes to identifying how effective Team Leaders coach their teams under these conditions and in so doing assist others to be able to develop Boundary Riding, Spanning and Crossing capabilities
Owen, C. Bosomworth, K. B., Curnin, S. (2013). The Challenges of Change in Future Emergency Management: Conclusions and Future Developments. In Owen, C. (Ed.) <i>Human Factors Challenges in Emergency Management: Enhancing Individual and Team Performance in Fire and Emergency Services</i> . Aldershot, UK: Ashgate	Emergency management is facing an increasingly complex set of future challenges. This paper discusses eight challenges identified in the literature and discussed by the contributors to the edited volume and their implications for future emergency management at the strategic level.
Stack, S. (2013). Creating cultures of reflective learning in the emergency services. In Owen, C. (Ed.) <i>Human Factors Challenges in Emergency Management: Enhancing Individual and Team Performance in Fire and Emergency Services</i> . Aldershot, UK: Ashgate	Two case studies exploring the role of the staff ride as an opportunity to build individual and organisational capacity for reflective learning. This chapter examines what is known about how scenarios can be designed for use by groups to help them achieve different learning outcomes. The chapter discusses strategies to design a range of case studies and scenarios for different learning outcomes, e.g. ones that might act as examples, as well as cases that pose contradictions that require movement to more critical and complex thinking.
2014	
Minas, J.P., Hearne, J.W. & Martell, D.L. (2014). A spatial optimisation model for multi-period landscape-level fuel management to mitigate wildfire impacts. <i>European Journal of Operational Research</i> 232(2), 412–422. http://dx.doi.org/10.1016/j.ejor.2013.07.026	Elevated fuel loads are contributing to an increase in the occurrence of, and area burned by, severe wildfires in many regions across the globe. In an attempt to reverse this trend, fire and land-management agencies are investing in extensive fuel-management programs. However, the planning of fuel treatment activities poses complicated decision-making problems with spatial and temporal dimensions. Here, we present a mixed integer programming model for spatially explicit multi-period scheduling of fuel treatments. The model provides a flexible framework that allows for landscape heterogeneity and a range of ecological and operational considerations and constraints. The model's functionality is demonstrated on a series of hypothetical test landscapes and a number of implementation issues are discussed.

Journal and Book Publications	
Bhandari, R.B., Owen, C. & Brooks, B. (2014). Organisational features and their effect on the perceived performance of emergency management organisations, <i>Disaster Prevention and Management</i> , 23(3) to appear http://www.emeraldinsight.com/journals.htm?issn=0965-3562&show=latest	This study included a survey of experienced emergency management personnel in Australia and New Zealand to identify the influence of organisational features in perceived emergency management performance. The purpose of the paper was to analyse the influence of organisational features in emergency response performance and to discuss how this knowledge can be used to enhance the response capacity of emergency services organisations. This research has wide implications for emergency services organisations in Australia and New Zealand in terms of developing organisational response capacities.
Curnin, S. & Owen, C. (2014). Spanning Organizational Boundaries in Emergency Management, <i>International Journal of Public Administration</i> , 37(5), pp 259-270,	Multi-agency emergency management coordination requires stakeholders to span organisational boundaries and facilitate collaboration among other agencies within temporary supra-organisations. Multi-agency coordination is important in emergency management as disasters often require the collaboration of multiple agencies into temporary supra-organisations. However, little is known about the boundary-spanning activities that influence this collaboration. Based on 39 semi-structured interviews with senior emergency management practitioners spanning organisational boundaries, this paper proposes a typology of boundary-spanning activities for emergency management. Embracing these activities may address some of the challenges associated with the collaboration of multiple agencies in a disaster

Journal and Book Publications

Forthcoming and under review

<p>Bhandari, R.B., Owen, C. & Trist, C. Incident management approaches above the incident management team level. Submitted to <i>Journal of Homeland Security and Emergency Management</i>, under review</p>	<p>This paper discusses incident management strategies widely used above the IMT level in four Australian states, namely Victoria, New South Wales, Tasmania and Queensland. It begins with an overview of how incident management approaches above the IMT might differ from the local IMT level. By exploring this difference, this paper provides an insight into how emergency management personnel working above or beyond the local IMT level often deal with large-scale multiple emergency events and require an understanding of broader problems that they might confront in the future. Then, it provides an outline of how strategic emergency management objectives are addressed in the state-level arrangements in these jurisdictions. It also discusses some of the challenges associated with incident management above the IMT level.</p>
<p>Brooks, B., Owen, C., Bearman, C. & Grunwald, J. Human error during complex emergency coordination events: an analysis of Australian bushfires using the Human Factors Analysis and Classification System. Submitted to <i>Safety Science</i>, under review</p>	<p>The purpose was to identify the frequency and distribution of human error associated with selected major bushfire events across Australia via the interrogation of secondary sources of information. Little is known about the way errors at different levels of coordination interact to affect coordination performance during these events. The HFACS is widely used to understand accident causal factors but is untested with respect to these more complex, temporally extended events. Unsafe acts were a significant proportion of errors at all three levels of coordination. At the IMT level, unsafe acts dominated, with a smaller proportion of preconditions mainly associated with crew resource management. At the regional level, errors were predominantly supervisory in nature. In statewide coordination, supervisory and organisational issues dominated. The higher proportion of unsafe acts is consistent with other studies; however, the equally high proportion of supervisory errors is not.</p>

Journal and Book Publications

Curnin, S., Owen, C. & Trist, C. Managing the constraints of boundary-spanning in emergency management. Submitted to *Cognition, Technology & Work*, accepted

Stakeholders tasked with boundary-spanning in emergency management are fundamental in facilitating multi-agency coordination. An exploratory case study approach was adopted and applied in a strategic-level emergency operations centre. The study used three very different but interrelated qualitative research techniques based upon the core-task analysis framework to categorise the work of stakeholders fulfilling a boundary-spanning role in this setting. The data identified that stakeholders performing boundary-spanning activities in a strategic-level emergency operations centre face a number of constraints. These can include unfamiliarity with the work domain, its personnel and its structure, which can lead to temporal, cultural and information challenges. In order to manage these constraints, boundary-spanners working in a strategic-level emergency operations centre need to adopt certain characteristics in order to accomplish their activities. A significant outcome from the data analysis was the necessity to engage in these important undertakings in the pre-response phase in an effort to facilitate successful multi-agency coordination in an actual emergency event.

Grunwald, J., & Bearman, C. Identifying and resolving coordinated decision-making breakdowns at the regional level of wildfire management. Submitted to *Safety Science*, under review

Strategies for identifying and resolving breakdowns in coordinated decision-making were explored using semi-structured interviews and simulated event questions based on a real fire-management scenario. Eleven regional-level fire management staff from the CFS, CFA and DSE participated. Results indicated that breakdown identification strategies could be separated into four groups: detection via conflicting or confusing information, detection using experience-based intuition, detection via formal and informal networks, and detection through proxy designation. The major cues for identifying breakdowns were based on operational informational, environmental information, social factors (such as key personnel involved) and resources factors. Breakdown resolution strategies were dependent on the actual event but could be grouped into direct and indirect strategies, with the former focusing on immediate solutions and the latter focused on pre-planning and predictive strategies. These results demonstrate the importance of regional coordinators' ability to identify issues prior to breakdowns occurring and provide a distinct set of cues that can be used by regional commanders or coordinators to identify breakdowns in the coordination of large-scale incidents.

TABLE 14: CONFERENCE PUBLICATIONS AND PRESENTATIONS

Conference Publications and Presentations ⁹	
Publication or Presentation	Key Message or Purpose
2011	
Abbasi, A. (2011). Extracting and analysing the Kilmore Fire Coordination Network, poster presented at <i>AFAC Conference 2011, New World, New Thinking</i> , Darling Harbour, Sydney	This poster outlined Alireza's PhD research progress. See
Grunwald, J. & Bearman, C. (2011). Breakdowns in team decision-making in the coordination of large-scale bushfires in Australia, poster presented at <i>AFAC Conference 2011: New World, New Thinking</i> , Darling Harbour, Sydney	This poster presented our analysis of the team decision-making breakdowns in the Wangary and Kilmore East fires. The poster formed part of the industry engagement around these analyses and comments fed into the final report.
Hamra, J. (2011). Learning through networks within emergency management response, poster presented at <i>AFAC Conference 2011, New World, New Thinking</i> , Darling Harbour, Sydney	This poster outlined Jafar's PhD research progress.
Hamra, J., Hossain, L., Owen, C. and Abbasi, A. (2011). The influence of social networks on learning in disasters, <i>Global Information and Technology Management Association GITMA Conference program</i> , 5-7 June 2011, Las Vegas, NV, pp. 1-13	This paper outlined the role of social networks in facilitating learning during disaster events.

⁹ To access posters and presentations (where available) please see <http://www.bushfirecrc.com/projects/8-1/effective-incident-management-organising>

Conference Publications and Presentations⁹

Minas J.P. (2011). Potential use of operations research in bushfire management, presented at <i>Australia and New Zealand Industrial and Applied Mathematics (ANZIAM) Conference, 2011</i> Adelaide, SA	The Victorian Black Saturday bushfires of February 2009 provided a stark reminder of the destructive potential of wildfire. It was one of Australia's worst natural disasters with 173 people killed and an estimated total cost of over AU\$4 billion. In the coming years, bushfire-related risk is likely to continue to increase owing to population growth at the rural–urban interface and climate change impacts. The Victorian Bushfires Royal Commission made a series of recommendations aimed at reducing the impacts of fire and minimising fire-related loss of life. A number of these recommendations lend themselves to the application of operations research (OR) methods. Several of these opportunities for OR application in the Australian bushfire context are discussed. Bushfire management involves a complex mix of interrelated elements such as fuel management and fire suppression. Previous models have considered these elements in isolation from one another. We propose a mathematical programming approach that provides an integrated framework for planning fuel management and fire suppression resource allocation.
Minas J.P. & Hearne J.W. (2011). Integrated decision-support model for fuel management and suppression preparedness planning. In R.P. Thornton (Ed.) 2011, <i>Proceedings of Bushfire CRC & AFAC 2011 Science Day</i> , Darling Harbour, Sydney	Bushfire management involves a complex mix of interrelated components including fuel management, fire prevention, fire detection and suppression preparedness planning. Previous wildfire optimisation models have tended to consider these components in isolation from one another. Such models fail to capture the interdependency of system elements and can lead to myopic decision-making. We propose an approach that considers both fuel management and suppression preparedness planning within a single optimisation model. The model's effectiveness is tested using a series of hypothetical landscapes, with results indicating that an integrated approach to fuel management and suppression preparedness planning can lead to improved coverage outcomes. Model benefits, potential applications, future testing and possible model extensions are also discussed.
Minas J.P. & Hearne J.W. (2011). Integrated framework for fuel reduction and fire suppression resource allocation, presented at <i>Conference for the International Federations of Operational Research Societies (IFORS)</i> , Melbourne	Wildfire-related destruction is a global problem that appears to be worsening. Wildfire management involves a complex mix of interrelated components including fuel management, fire weather forecasting, fire behaviour modelling, values-at-risk determination and fire suppression. We propose a mathematical programming model that provides an integrated risk-based framework for fuel management and fire suppression resource allocation.

Conference Publications and Presentations ⁹	
Owen, C. (2011). Bulldogs and boundary-spanners: the role of teamwork and leadership in enabling emergency management coordination, presented at the <i>Emergency Management Qualifications (EMQUAL) Conference 2011: Enabling Emergency Management Coordination</i> , Christchurch, New Zealand	This presentation outlined some of the cultural stereotypes in emergency services organisations and discussed their possibilities and constraints. Implications for both emergency services operations and training were outlined.
Owen, C. (2011). The changing nature of emergency services multi-agency coordination, paper presented at <i>AFAC Conference 2011 Science Day</i> , Darling Harbour, Sydney	The research reported on 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. 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.
Owen, C., Bearman, C., Brooks, B. (2011). Organising for effective incident management, poster presented at <i>AFAC Conference 2011, New World, New Thinking</i> , Darling Harbour, Sydney	This poster outlined the current plans and progress for the research project.
2012	
Abbasi, A., Hossain, L., Hamra, J. & Owen, C. (2012). Social networks perspective of firefighters' adaptive behaviour and coordination. <i>Proceedings, The 3rd IEEE/ACM International Conference on Cyber, Physical and Social Computing (CPSCom2010)</i> , Hangzhou, China	This presentation focused on the effects of social connectedness among different team members to manage bushfires. We analysed response coordination by exploring variables such as participants' preparedness quality, quality of incident action planning, and quality of accessibility of resources. By using a proposed model, the presentation outlined factors that support adaptive behaviour in incident management teams responding to bushfire events.

Conference Publications and Presentations⁹

<p>Bearman, C., Grunwald, J., Owen, C. & Brooks, B. (2012). Breakdowns in coordinated decision-making in teams fighting large-scale Australian bushfires. Paper presented at <i>AFAC Conference 2012: Diverse Country, Common Ground</i>, Perth, WA</p>	<p>Complex emergency situations are by their nature difficult to manage. Success in such situations is often highly dependent on effective coordination and communication within and between the teams involved. Problems in coordinating emergency incident management are not uncommon in emergency events and can introduce significant potential dangers into an already difficult situation. This paper examines breakdowns in coordination and components of breakdowns, known as disconnects. Disconnects are the lower-level breakdowns between individuals and teams that comprise a larger breakdown situation. Two large-scale fire incidents (Kilmore East and Wangary) were examined using a top-down and bottom-up qualitative analysis technique. Across both reports, 24 breakdowns in coordinated decision-making were found, which yielded 55 disconnects. The disconnects could be grouped into three main types: operational, informational and evaluative. Operational disconnects occur when there is a difference in the plans between the two parties, informational disconnects occur when there is a difference in information, and evaluative disconnects occur when there is a difference in evaluation of the same information. Across both fires, it was found that neither operational nor informational disconnects were effectively resolved by the teams. When a disconnect was unresolved, it would often lead to further disconnects as the team progressed through their team situation awareness, planning and plan execution activities, leading to a chain of unresolved disconnects. Not resolving disconnects could directly or indirectly result in impaired team functioning, such as not possessing important information, being unprepared for action, developing conflicting plans and not acting in a timely way. The lack of effective resolution of disconnects is a concern, particularly where early resolution could have prevented an extended breakdown in team functioning. Further research is examining how disconnects are identified and resolved.</p>
<p>Bearman, C., Owen, C., Brooks, B., Bremner, P. & Goldrick, K. (2012). Breakdowns in emergency coordination, poster presented at <i>AFAC Conference 2012: Diverse Country, Common Ground</i>, Perth, WA</p>	<p>This poster presented the final report on the research into team decision-making breakdowns at and above the IMT.</p>

Conference Publications and Presentations⁹

Bhandari, R.B., Owen, C., Curnin, S. & Brooks, B. (2012). Organisational features and their effect in the response process of emergency management organisations, poster presented at <i>AFAC Conference 2012: Diverse Country, Common Ground</i> , Perth, WA	This study provided a conceptual theoretical model for organisational performance in emergency situations based on four organisational features, namely adaptability, leadership, stability (mission and direction) and stakeholder communication. It was based on a review of the organisational theory and emergency response literature found to be previously important in emergency management studies. This work contributed to theorising emergency operations by highlighting how organisations need to manage two orientations simultaneously: their own internal as well as external orientations, together with their processes for managing both mission and direction and the need for change and flexibility.
Brooks, B. (2012). Coping ugly in the coordination of large-scale wildfire events, presented at the <i>International Association of Wildland Fire (IAWF) 12th International Wildland Fire Safety Summit</i> , 2012 Sydney	The purpose of this presentation was to discuss a practical application of a widely held theoretical approach to managing complex events. This approach suggests that it is sufficient to make the boundaries between safe and unsafe operations explicit, rather than try and build in-depth strategies that will inevitably fail because of the novel nature of out-of-scale emergencies. We presented the notion that individuals and teams cross this boundary when they 'cope ugly' or use strategies that are themselves novel, emergent and sometimes even have the potential for adverse outcomes, but are deemed in the decision-context to be necessary.
Curnin, S. (2012). Achieving multi-agency emergency management coordination, poster presented at <i>AFAC Conference 2012: Diverse Country, Common Ground</i> , Perth, WA	This poster describes the basis for my thesis exploring how emergency management liaison officers perform their role, the challenges they face and how this role could be enhanced through the development of a suitable conceptual framework.
Hamra, J. (2012). The influence of social networks and learning towards performance in disasters, paper presented at <i>Global Information Technology Management Association (GITMA 2011) Conference</i> , Las Vegas, NV	Understanding the factors that enhance or impede learning of individuals in dynamic emergency events is instrumental in achieving organisational goals. In this study, the effect of social network structures on the learning attitudes of emergency personnel during an emergency event was investigated. Empirical results suggest that a network structure of emergency personnel can be identified, which plays a key role in the ability of those actors to engage in learning-related work activity, allowing them to adapt and improvise in complex emergency events. By presenting a model of learning-related work activity, based on a social network analysis of its structure, emergency staff members can strengthen their capacity to be flexible and adaptable.
Hamra, J., Hossain, L., Owen, C. & Abassi, A. (2012). The influence of social networks on learning in disasters. <i>Proceedings, The 12th Annual Global Information Technology Management Association (GITMA 2011) World Conference</i> , Las Vegas, NV	This presentation discussed the role of social networks and proposed a social influence model of learning to examine networks in emergency events. A theoretical framework was proposed to investigate the effects of network structure on learning outcomes of bushfire incident management teams. To test our framework, we investigated social network data extracted from the transcripts of the 2009 Victorian Bushfires Royal Commission report.

Conference Publications and Presentations⁹

Minas, J.P., Hearne, J.W. & Martell, D.L. (2012). Multi-period spatial optimization of landscape-level fuel management to minimize wildfire impacts, presented at <i>5th International Fire Ecology and Management Congress</i> , Portland, OR	Fuel accumulation arising from modified fire regimes has contributed to an increase in the extent, severity and destructive impacts of wildland fires in a number of countries. Prescribed burning and other fuel reduction treatments are among the few management options available to authorities as they seek to reverse this trend. However, determining the optimal extent, spatial location and timing of fuel treatment is a highly complex undertaking. We present an integer programming model for multi-year scheduling of fuel treatments at the landscape level. Our model incorporates spatially explicit ignition probability and values-at-risk information and considers both asset protection and ecological objectives together with a range of operational and cost constraints.
Minas, J.P., Hearne, J.W. & Martell, D.L. (2012). Multi-year fuel treatment planning, presented at <i>World Conference on Natural Resource Modelling (NRM)</i> , Brisbane, Qld	In recent years, an increase in the extent and severity of wildfires has been observed in a number of countries. High fuel loads arising in part from modified fire regimes have been a contributing factor in many severe fires. Prescribed burning and other fuel-reduction treatments are among the few options available to fire and land-management agencies as they seek to reverse this trend. However, fuel treatment planning is a highly complex undertaking with questions arising as to the optimal extent, spatial location, timing and types of fuel treatment to apply. We demonstrate the application of integer programming methods for landscape-level location and multi-year scheduling of fuel treatments. Consideration is given to both community protection and ecological objectives together with a range of operational and cost constraints.
Minas, J.P., Hearne, J.W. & Martell, D.L. (2012). Spatial optimization of multi-year landscape-level fuel treatment planning, presented at <i>54th Annual Conference of the Canadian Operational Research Society (CORS)</i> , Niagara Falls, ON, June 2012.	We demonstrate the application of spatial optimisation methods for landscape-level location and multi-year scheduling of fuel treatments, with a view to modifying the behaviour and effects of large wildfires. Methods for incorporation of a range of ecological, operational and cost constraints are also considered.

Conference Publications and Presentations⁹

Minas, J.P., Hearne, J.W. & Martell, D.L. (2012). Use of spatial optimisation methods for landscape-level fuel treatment planning, poster presented at <i>AFAC Conference 2012: Diverse Country, Common Ground</i> , Perth, WA	<p>We demonstrate the application of mathematical programming methods for landscape-level location and multi-year scheduling of fuel treatments. The model takes into account the following problem features:</p> <ul style="list-style-type: none"> • Spatial optimisation problem • Landscape-level fuel treatment planning • Multi-year planning horizon • Multiple objectives - community protection, ecological • Risk considerations - likelihood and consequence of fire • Fuel regrowth dynamics – inhibitory effect and persistence of fuel treatment • Operational, ecological and cost constraints
Owen, C. (2012). Bulldogs and boundary-crossers: enhancing communication, teamwork and leadership in incident management teams, presented at the <i>National Emergency Services Training Officers Conference (NESTOC) 2012</i> , Sydney	This presentation outlined some of the cultural stereotypes in emergency services organisations and discussed their possibilities and constraints. Implications for training were also discussed.
Owen, C. (2012). Building emergency management capability, keynote address at the <i>International Association of Wildland Fire (IAWF) 12th International Wildland Fire Safety Summit</i> , 2012 Sydney	This presentation outlined the research conducted over the past 7 years as part of the Bushfire CRC. The presentation also highlighted some recent initiatives that included a comparison of French and Australasian approaches to incident management.
Owen, C. & Bearman, C. (2012). Incident management organising, paper presented at <i>AFAC Conference 2012: Diverse Country, Common Ground</i> , Perth, WA	This presentation provided an overview of the research examining communication and coordination about the IMT and the strategies for addressing challenges in the future.

2013

Conference Publications and Presentations⁹

<p>Bearman, C. (2013). Breakdowns, coping ugly and the safety space, keynote address to the <i>Forest and Rural Firefighters Association of New Zealand Annual Conference</i>, Queenstown, New Zealand</p>	<p>Fire-fighting is a high-risk, complex and resource-constrained work environment where the limitations and benefits associated with human performance are often challenged. We investigated this difficult environment through the lens of human factors research and explored how agencies can 'maintain the safety space' around their operations, even in out-of-scale events. In this presentation, the implications that human error, breakdowns and disconnects in coordination have on operations are considered, and approaches are identified to resolve breakdowns, to 'cope ugly' and to bring the coordination system back to a state that is consistent with agencies' primary functions.</p>
<p>Bearman, C. (2013). Negotiating the safety space in large-scale fire events, keynote address to the <i>National Rural Firefighters Association Science Day</i>, Queenstown, New Zealand</p>	<p>This talk presents the emergency management system as a network of people who need to coordinate for an effective response to occur. This network comprises individuals, teams and teams of teams (or meta-teams). When teams do not share a common understanding of the situation, then disconnects and breakdowns occur. The talk presents examples of breakdowns from large-scale emergencies in Australia and NZ and discusses research into the ways that regional controllers identify and resolve breakdowns in teams that they are supervising. Proposed new research into this area is discussed.</p>
<p>Bearman, C., Owen, C., Brooks, B. & Grunwald, J. (2013). Problems of maintaining effective teamwork during out-of-scale events. <i>Proceedings of the Bushfire CRC and AFAC 2013 Conference Research Forum</i>, 2 September 2013, Melbourne</p>	<p>The coordination of out-of-scale events requires that teams form and work together quickly and effectively. At the IMT level and above, teams managing out-of-scale events will likely include people who do not know each other, may have very different skill sets and knowledge, and may be from different agencies that have different priorities and perspectives on the incident. As an incident scales up, new members of the team are added, increasing the functional unit and coordination complexity. Also, as incidents continue in duration, shift replacements become necessary to manage fatigue. This paper investigates the way that these issues have led to disruptions in teamwork. Fourteen semi-structured interviews were conducted with incident managers with experience at the IMT and above. All participants had recent experience of out-of-scale events in Australia and New Zealand. Key issues that emerged from these interviews were: not getting to know the team and others, bypassing normal communication channels, disrupted coordination between different agencies, and sub-optimal takeover of control from another team. The findings from this research demonstrate the need to consider team processes and to ensure effective information flow even under the extreme pressures of an out-of-scale emergency.</p>

Conference Publications and Presentations⁹

Bhandari, R.B. (2013). Influence of organisational features on the perceived performance of emergency management organisations, poster presented at <i>AFAC Conference 2013: Shaping Tomorrow Together</i> , Melbourne	This study analysed the influence of organisational features (adaptability, leadership, stability (mission and direction) and stakeholder communication) in perceived performance of participating emergency management organisations. It presented a statistical model of the predictive significance of these organisational features in perceived emergency response performance. Also, it distinguished between different types of organisations related to major fires in Australia and New Zealand based on the organisational features that they emphasise in the wake of emergencies. The implications of this study include the need to develop emergency management policies and work practices to further enhance the capacity of emergency response personnel in Australia and New Zealand.
Curnin, S. (2013). Emergency management liaison officers (EMLO): how do they do it? Poster presented at <i>AFAC Conference 2013: Shaping Tomorrow Together</i> , Melbourne	This poster gave a synopsis of the research to date that is investigating how stakeholders who are responsible for state emergency management arrangements fulfil the role of an emergency management liaison officer.
Curnin, S. (2013). Spanning organizational boundaries in emergency management, poster presentation at <i>International Information Systems for Crisis Response and Management (ISCRAM) Conference</i> , Baden-Baden, Germany	This poster outlined the basis of the PhD thesis in a poster format exploring how various agency stakeholders in Emergency Operation Centres span organisational boundaries.
Curnin, S. & Owen, C. (2013). A typology to facilitate multi-agency coordination. <i>Proceedings of the 10th International Information Systems for Crisis Response and Management (ISCRAM) Conference</i> , Baden-Baden, Germany, pp. 115-119	Multi-agency coordination in emergency management presents many challenges. Agencies that normally operate independently have to assemble into a unified supra-organisation to achieve a common goal. To achieve successful multi-agency coordination, organisations need to span organisational boundaries and provide linkages with multiple agencies. This requires inter-organisational compatibility of information and communication systems. Necessary for this success are the stakeholders responsible for facilitating these organisational boundary-spanning activities. This paper proposes that the preliminary research findings can create a typology of dimensions crucial to facilitating multi-agency emergency management coordination. It is envisaged that the typology will culminate in a diagnostic tool that will enable stakeholders to examine the breakdowns and successes of multi-agency emergency management coordination.

Conference Publications and Presentations⁹

<p>Grunwald, J., and Bearman, C. (2013). Identifying and resolving breakdowns at the regional management level, poster presented at <i>AFAC Conference 2013: Shaping Tomorrow Together</i>, Melbourne</p>	<p>Research into several major bushfires in Australia has shown that breakdowns in coordinated decision-making can occur between different levels of an organisation, leading to an impaired operational response. Of the different levels of an organisation, the regional level plays a central role in communication between groups by virtue of its position between the incident management level and the state control level. This paper explores the strategies employed by regional-level coordinators and commanders in identifying breakdown events and the potential strategies for minimising their impact, either through direct resolution or mitigative responses. Eleven situational semi-structured interviews were conducted with regional level commanders or coordinators from the three Australian fire agencies. In this method, semi-structured interviews were combined with simulated-event questions based on a real fire scenario. Results indicated that breakdown identification strategies could be separated into four groups: information-based, intuition-based, network-based and proxy-based. The major cues for identifying breakdowns were based on informational, environmental, social and resources factors. Breakdown resolution strategies were dependent on the actual event but could be grouped into direct and indirect strategies, with the former focusing on immediate solutions and the latter focused on pre-planning and predictive strategies. These results demonstrate the importance of regional coordinators' ability to identify issues prior to breakdowns occurring and provide a distinct set of cues that can be used by regional commanders or coordinators to identify breakdowns in the coordination of large-scale incidents.</p>
<p>Minas, J.P. & Hearne, J.W. (2013). Incorporating habitat requirements in multi-period fuel management planning, paper presented at <i>15th Symposium for Systems Analysis in Forest Resources (SSAFR)</i>, Quebec City, QC</p>	<p>While fire is a natural component of many forest ecosystems, uncontrolled wildfires can cause loss of human life and destruction of property and natural resources. In an attempt to reduce the risk posed by wildfires, land-management agencies in Australia and the USA have implemented extensive fuel-management programs. However, in addition to hazard reduction, fuel-management programs are typically required to incorporate a number of ecological considerations. These include maximum and minimum treatment intervals maintaining proportions of the landscape in various stages of maturity for habitat purposes as well as spatial habitat requirements such as contiguity and shape. We present a spatially explicit mixed-integer programming model for multi-period fuel treatment scheduling for mitigating wildfire risk. Our formulation incorporates a range of ecological constraints such as minimum and maximum treatment intervals and requisite landscape proportions in various habitat growth stages. We then present an extended multi-objective formulation that balances landscape fire resistance with spatial contiguity and compactness of habitat.</p>

Conference Publications and Presentations⁹

Minas, J.P. & Hearne, J.W. (2013). Fuel management for wildfire hazard reduction with spatial and temporal ecological requirements, presented at <i>INFORMS Annual Meeting 2013, Minneapolis</i>	We present a mixed-integer programming model for multi-period fuel treatment scheduling that generates fire-resistant spatial fuel patterns. Our model incorporates ecological requirements such as: minimum and maximum treatment intervals, requisite habitat growth stage proportions, and spatial contiguity and compactness of habitat.
Minas, J.P. & Hearne, J.W. (2013). Applying operations research methods to bushfire management, poster presented at <i>AFAC Conference 2013: Shaping Tomorrow Together, Melbourne</i>	This research explores how operations research methods may be employed to provide decision support to wildfire managers to reduce the harmful impacts of wildfires on people, communities and natural resources. Some defining challenges of wildfire management are identified, namely complexity, multiple conflicting objectives and uncertainty. A range of operations research methods that can resolve these difficulties are then presented together with illustrative examples from the wildfire and disaster literature. Three mixed-integer programming models are then proposed to address specific real-world wildfire management problems. The first model incorporates fuel treatment and suppression preparedness decisions within an integrated framework. The second model schedules fuel treatments across multiple time periods to maintain fire-resistant landscape patterns while satisfying various ecological requirements. The third model aggregates fuel treatment units to minimise total perimeter requiring management.
Owen, C. (2013). Leadership and decision-making during a crisis, presented at <i>The Critical Infrastructure Resilience (CIR) Conference – Critical Infrastructure Resilience: A Smart Investment. Exploring the Value Proposition of Resilience, 2013, Melbourne</i>	This presentation focused on communication in highly reliable organisations, and explored the barriers that can sometimes impede speaking up about concerns and the impacts this has on decision-making during a crisis. The implications for critical infrastructure and strategies to overcome the barriers were discussed.
Van der Merwe, M., Hearne, J.W. & Minas, J.P. (2013). Modelling the assignment of resources during large wildfires to protect assets, poster presented at <i>AFAC Conference 2013: Shaping Tomorrow Together, Melbourne</i>	Incident Management Teams work in high-pressure environments, having to make complex, time-critical decisions. A clear need for decision-support tools exist. Operations Research is the use of analytical techniques such as mathematical modelling to help make better decisions. Applications of OR to fire management have focused largely on long-term planning such as the location of facilities, fleet composition and fuel management. This research considers the application of OR techniques to short-term decision making by IMTs fighting large wildfires.

SECTION 6: END-USER STATEMENT

The pursuit of improvements in the way we manage and use information to build systems that support decision-making is now acutely focused on regional- and state-level personnel and structures. The critical insights for emergency service organisations that are coming from the work of this project are immensely valuable in this task. Those working at this level are well aware of the challenges of managing out-of-scale events and are searching for options that will support them in identifying gaps in preparedness and planning at all levels of decision-making. Agencies can begin applying the knowledge already gained from this project and will continue to benefit from the understanding that is being built by the research team.

Liam Fogarty, Director Knowledge and Engagement, Department of Environment and Primary Industries, Victoria.

SECTION 7: CONTACTS

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AFAC

Appendix A: Ethics approval

Ethics approval was sought to amend the existing application for the Bushfire CRC research project (2006–2010). Approval was provided for a further four years (2010–2014).

From: Frances Martin [mailto:F.Martin@utas.edu.au]
Sent: Sunday, 9 May 2010 11:56 AM
To: Owen, Christine
Cc: Horder, Melanie; Knott, Marilyn; Benjamin Brooks; Douglas Paton
Subject: RE: H8810 amendment: Approval

Dear Christine,

I have reviewed this application for an amendment to this project. On the basis of the application and associated documentation, I am happy to grant ethical approval for this amendment and I wish you well with this part of the study,

Kind regards,

Frances

Associate Professor Frances Martin
Chair
Social Sciences HREC

Phone: +61 3 6226 2262

From: Melanie Horder [mailto:Melanie.Horder@utas.edu.au]
Sent: Monday, 3 May 2010 10:49
To: Frances Martin
Subject: New Amendment - Full Application - Education

New Amendment - Full Application - Education

H8810 – *Optimising information flow through collaborative work performance: enhancing emergency management effectiveness above the IMT level*

CI: Dr Christine Owen

CI2: Ben Brooks

CI3: Douglas Paton



Mel Horder
Ethics Officer

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