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Welcome from Editor

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

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

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

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

Richard Thornton

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Essential aspects of effective simulation-based training for incident management personnel

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Abstract.

An important implication of the changing Australian bushfire environment and highlighted by the 2009 Victorian Bushfires Royal Commission (VBRC) is that fire agencies will need to increase the amount of training and exercising that their Incident Management Team (IMT) personnel undertake. A training method particularly suitable for developing and exercising IMT personnel is simulation. Bushfire Cooperative Research Centre funded research has previously used simulation to investigate IMT performance. This research has highlighted three issues which are important to address in using simulations to comply with the VBRC recommendations for training. The first issue is *simulation fidelity*. More attention needs to be given to ensuring that simulations demand the same knowledge and skills as those required for actual IMT roles, with perhaps lesser emphasis on re-creating the physical environment. The second issue is *participant debriefing*. Although there is a positive shift towards using after-action reviews of training exercises, there is still considerable opportunity to better consolidate learning with more effective post-session debriefing. The final issue is *performance assessment*. Well designed simulations provide the opportunity not only for participants to self-assess but also for objective assessment of participant performance by observers.

Additional keywords: IMTs, assessment, bushfire, wildfire, development

Introduction

Bushfires are proto-typical examples of situations in which dynamic decision making (DDM) is required (Brehmer and Allard 1991; Brehmer 2000). Bushfires can be challenging incidents to manage, demanding considerable skill and coordinated performance by Incident Management Teams (IMTs) (McLennan *et al.* 2006). As a DDM task environment, bushfires are often time critical, have high stakes, fluid, and ambiguous, requiring rapid situation assessment and the implementation of suitable strategy to resolve the incident (Kozlowski and DeShon 2004; McLennan *et al.* 2006). The successful management of bushfires requires IMTs with high levels of expertise in developing effective strategy and coordinating action.

The training and development of IMT personnel to manage bushfires is no simple task, especially for the larger and more complex (level 3) incidents[1]. Fire and land management agencies in Australasia have created a variety of training programmes to develop and maintain the competency of their IMT personnel. The competency requirements for incident management personnel are considerable and involve a range of knowledge, skills, and attitudes (Hayes and Omodei 2011).

The increasing need to manage larger and more frequent bushfires (e.g., AFAC 2010) is likely to increase the size of an incident management workforce and as a result the amount of IMT training that fire and land management agencies undertake. Gould (2010) identified a number of factors that will increase the threat of bushfire and the fire management challenges for fire agencies. Gould observes there is general consensus about the threat posed by the "cumulative effects of climate change, fuel management, population and demographic changes (i.e., increased bushland interface communities), sustainability, and biodiversity management" (p.2). Gould suggests that fire and land management agencies will have the added challenge of operating within increasingly tight budget constraints in the next two to three years.

An important driver of adverse bushfire conditions is climate change (AFAC 2010). Lucas *et al.* (2007) suggested that Australia is entering a period of elevated mean temperatures. For south-eastern Australia this means that the fire season is likely to be more intense and moreover, starting earlier and ending slightly later. Lucas *et al.* predicted the effects of climate change are likely to be apparent by 2020 and very pronounced by 2050. Cleary a shift towards a longer and hotter fire seasons is likely to lead to a greater number of bushfires that are more difficult to manage.

A second factor that is likely to influence the number of IMT personnel required and the training that these teams receive is the increasing community expectations of emergency managers (O'Neill 2004). Whittaker and Handmer (2010) observe that communities now expect up-to-date information on bushfires and the timely provision of warnings. The need for IMTs to ensure that bushfire warnings are provided to communities was also highlighted in the recommendations of the 2009 Victorian Bushfires Royal Commission. We understand that this has resulted in agencies training additional personnel to fulfil public information roles within IMTs and the provision of additional training for incident controllers.

A third factor that is likely to influence the complexity of bushfire management operations and therefore demands on IMTs are the increasing number of communities located in more bushfire prone areas. The Australian peri-urban population continues to grow (e.g., Hugo 2002), and as Haswell and Brown (2002) note these areas are most vulnerable to fire given their mixture of bushland, houses, paddocks, livestock, and people.

Gould (2010) notes that a number of large bushfires over the last 30 years, and most recently the Victorian fires on February 7th 2009 has also shaped the fire management environment. Gould suggests that these events have meant that Australian fire agencies have recognised the need to adopt new levels of bushfire management activity. The recommendations of the 2009 Victorian Bushfires Royal Commission (VBRC) have helped highlight some of the changes needed, particularly in regards to the incident management workforce and IMT training programs. For example, the VBRC recommended that agencies recruit and train sufficient personnel to staff all level 3 incident control centres in the State on days of catastrophic fire danger and ensure these personnel are regularly exercised. The VBRC also recommended that agencies establish effective accreditation and performance review processes to assure the competency of all level 3 incident controllers, and that a traineeship scheme be developed to progress personnel from level 2[2] to level 3 IMT roles.

Taken together the ongoing changes in the bushfire environment highlighted by Gould (2010) and the VBRC recommendations have several important implications for agencies. First, there is a requirement to undertake additional training and exercising of IMT personnel. Second, agencies will need to ensure that IMT training programs develop a demonstrably competent workforce. Lastly, such IMT training will need to be time efficient and cost effective. There are a variety of training and development methods available to prepare IMT personnel (e.g., classroom instruction, field-based activities, simulation, and self-directed learning) and agencies have generally used a mixture of these. In light of the VBRC recommendations, a key challenge for agencies is how to best select from and use these methods to develop and maintain an appropriately prepared IMT workforce.

Simulation-based training offers some particular advantages for preparing and regularly exercising IMT personnel, enabling both individuals and teams to practice and integrate key competencies in a safe environment (Moroney and Lilienthal 2008; Simpson and Oser 2003). However, our experience of developing role-play and computer-generated simulations to assess the performance of individuals and teams managing bushfire scenarios (e.g., Omodei *et al*. 2005) has highlighted three key issues that agencies need to pay special attention to if they are to get the best results from using simulation training. The first issue is simulation fidelity, in other words a simulation's level of realism (Alessi 1998). Kozlowski and DeShon (2004) observe that organisations more often focus on maximising the physical fidelity of simulations (i.e., equipment and environment) and tend to overlook the psychological fidelity of simulations, such as cognitive demands and interpersonal elements. The second issue is participant debriefing. Salas and Cannon-Bowers (2001) note that unfortunately some organisations focus on the learning presumed to take place while undertaking the simulation scenario itself and neglect the learning opportunities by a post simulation review with participants. Effective debriefing offers the opportunity for participants to critically reflect on how they can improve their performance (Bond *et al*. 2007; Ericsson 2009; Kriz 2003; Thatcher 1990). The third issue is performance assessment. Without appropriate measurement processes in place it is difficult to provide constructive feedback to participants or assess the competence of an organisation, region, or team (Kruger and Dunning 1999). Moreover, without good performance assessment processes it is not possible to evaluate the training programs designed to develop and maintain IMT competencies (Morrison and Hammon 2000; Salas *et al.* 2003; Salas *et al.* 2009a).

Goldstein and Ford (2002) observe that trainees in general face two types of challenge, skill acquisition and training transfer. Skill acquisition involves the initial learning of the knowledge and skills required for successful performance, whereas training transfer involves the application of the learned skills and knowledge from the training context to the workplace and includes the associated issues of maintenance and generalisability (Baldwin and Ford 1988; Blume *et al.* 2010; Kraiger *et al.* 1993). The next section of this paper discusses the concepts of training design and training transfer and links these to the three issues that are central to simulation-based training – fidelity, debriefing, and performance assessment.

The design and transfer of training

A training system can be described as a series of experiences that systematically build and develop skills (Kozlowski 1998). Training design focuses on planning these experiences to facilitate learning and skill development (Gagne and Briggs 1979). Effective training design should support both learning and the transfer of the acquired knowledge and skills to the work setting (Kraiger *et al.* 1993).

Barnett and Ceci (2002) suggested that training transfer has two main elements, training content (i.e., what is transferred) and training context (i.e., when and where something is transferred). A key concept from this research is the concept of near and far transfer. This can be thought of as how closely the training context matches the environment that the learned skill may be used in and can also be thought of as the realism or fidelity of the training. For example, we would suggest that deploying classroom trained firefighters to participate in the physical clean-up of a maritime oil spill would involve far transfer. This concept has particular relevance if an agency is seeking to develop adaptive expertise, thus enabling IMTs to manage all-hazards (e.g., bushfires, earthquakes, cyclones, industrial incidents). Near and far transfer can also be considered in terms of the time elapsed between when training is undertaken and when the skills are used in the workplace. Immediate use of the trained skills would be considered near transfer while use of the trained skills more than one year later would be considered far transfer (Barnett and Ceci 2002).

Simulation-based training

Jacobs and Dempsey (1993) note that the use of simulation-based training by organisations to develop and maintain the competency of personnel has become common. Simulation-based training methods involve “a working representation of reality... [that] may be an abstracted, simplified, or accelerated model of process” (Galvao *et al.* 2000; p. 1692). Regardless of whether totally role-played, totally computer-generated or a combination of both, simulations vary in their cost, functionality, and fidelity (Salas and Cannon-Bowers 2001). There is growing evidence for the effectiveness of simulation-based training both in terms of learning and cost efficiencies (e.g., Cannon-Bowers and Bowers 2008; Fletcher 2009; Fletcher and Tobias 2006; Moroney and Lilienthal 2009; Salas *et al*. 1998; Salas *et al*. 2001).

Simulation-based training offers several advantages over other training methods (Cannon-Bowers and Bowers 2010): (1) it can provide the opportunity for personnel to practice managing or operating in environments that may be too dangerous to be practiced in the real world; (2) offers opportunities for personnel to practice tasks or manage events that may not occur very often (e.g., level 3 bushfire incidents); (3) provide opportunities to practice when actual equipment or facilities may not be available; (4) can include embedded instructional features that may provide a richer learning environment (e.g., feedback); and (5) provide considerable cost savings when compared to the use of operational equipment or large numbers of additional personnel for field exercise training.

Fidelity of simulations and transfer

The fidelity of simulations has been clearly linked to the transfer of training (Liu *et al.* 2009). A key issue in the use of simulation is often not the physical similarities of a simulated environment to the real world (i.e., physical fidelity), but the underlying structure of the problem or task that requires the use of particular cognitive processes and interpersonal processes that underlie the relevant competencies, that is, psychological fidelity (Cannon-Bowers and Bowers 2010). It is acknowledged that a certain level of physical fidelity is important to perceptually immerse participants and not mislead them as to key aspects of the situation for which they are training (Salas *et al*. 2002). However, training designers have tended to overly focus on developing the physical fidelity rather than the psychological fidelity of simulations (Hays and Singer 1989). From a training perspective, physical and psychological fidelity are not competing alternatives - they are complementary approaches (Kozlowski and DeShon 2004).

The psychological fidelity of simulations for incident management training requires particular attention for three important reasons. First, learning is multi-dimensional and involves at least three types of outcomes: cognitive, skill-based, and affective (Kraiger *et al.* 1993). It is important that training targets the development of each of these psychological components. Second, the generalisability of training is important for IMTs. Each bushfire is unique; the aim of effective simulation-based training is to develop the generic psychological processes that will be used in the management of any bushfire incident (e.g., decision making and analytical skills) (Hayes & Omodei 2011). Finally, the crew resource management literature highlights that failures in team performance are often due to poor team processes which are fundamentally psychological in nature (Cooper *et al.* 1980; Helmreich *et al.* 1999). For example, poor team coordination, leadership, communication and lack of shared situation awareness have contributed to a variety of aviation and other high reliability organisation accidents (e.g., nuclear and offshore oil power installations; merchant navy; surgical medicine) (Cooper *et al.* 1980; Flin *et al.* 2002).

Kozlowski and DeShon (2004) emphasize that psychological fidelity of simulations is an important aspect of training design. In developing simulation scenarios we need to think carefully about fidelity in light of the participants' characteristics (e.g., novice or experienced), task complexity (e.g., a level 2 or a level 3 incident), and type of skill development (e.g., new competencies or maintenance of existing competencies; routine or adaptive expertise) (Andrews and Bell 2000; Liu et al. 2009). Clearly a complex, high fidelity scenario for IMT personnel with limited experience is likely to overwhelm them and provide little training value, whereas highly skilled participants generally require more complex and higher fidelity scenarios to maintain their competencies (Andrews and Bell 2000; Beaubien and Baker 2004). If we want to develop personnel with competencies that can be used in other incident management settings (e.g., all-hazards) then the simulation scenarios with higher psychological fidelity (e.g., time pressured decision making) will provide superior transfer of training for this purpose (Salas *et al*. 2005).

Other training design factors may also impact on the fidelity of the simulation. If the simulation is designed to develop competencies (i.e., mastery), then it can be important to remove competitive elements (i.e., performance) from the simulation (Goldstein 1993). We have observed situations where competition between participants has led them to focus on "winning" rather than taking advantage of the learning opportunities that the simulation may offer. For example, employing high risk tactics to minimise the area burnt rather than developing a more balanced approach to containing the fire.

Well-designed simulations with sufficient psychological fidelity enable the creation of novel circumstances for participants, providing the opportunity to practice competencies in different contexts and thus supporting training that will generalise and be more adaptive. We suggest that the appropriate level of fidelity for simulation-based training can be particularly important when training personnel to work in conditions different from those they would normally encounter (e.g., inter-state). Recently one of the authors conducted role-play based simulations with personnel that usually manage bushfire in conditions of higher relative humidity (circa > 35%). Almost all of the teams in this location were keen to back-burn in conditions that fire personnel from south-eastern Australia generally would not consider as sensible to back-burn in (unpublished study). A second example is where statutory arrangements may be significantly different. For example, in the role-play based simulations mentioned above, some fire agency personnel struggled when the police did not operate in the same way as they would in their State (i.e., they could not order the evacuation of residents).

Debriefing simulation participants

Debriefing is an essential component of simulation-based training (Bond *et al.* 2007). Recent research has shown that simulation-based training for dynamic decision makers that incorporates debriefing improves subsequent task performance and the time required to make decisions (Qudrat-Ullah 2007). Unfortunately some organisations tend to view the simulation session as the key learning component, failing to recognise the important role of good quality feedback and effective debriefing (Salas and Cannon-Bowers 2001). We have on a number of occasions observed personnel spend several hours in a simulation session yet only receive a brief collective debrief. We suggest that the adoption of more structured after-action reviews by some Australian fire and emergency agencies is improving the opportunities for personnel to reflect on their performance following simulation-based training. However, we note that after-action reviews often tend to be conducted at the team-level and thus unlikely to offer individuals the opportunity to critically reflect on the various challenges they may have personally encountered during the exercise.

Organisations invest considerable time and money developing simulation-based exercises yet often do not maximise the learning opportunities for participants by fully debriefing such exercises (Crookall 1992). Effective debriefing encourages deeper processing and superior transfer of learning (Thatcher 1990). One-on-one debriefing in an environment where they feel able to interact free of criticism and embarrassment (i.e., psychologically safe) helps ensure participants critically reflect on their experiences (Edmondson 1999). The aim of debriefing is to assist the participants to develop self-critical thinking skills so that they can reflect on their own thoughts and actions and identify possible improvements in managing these (Thatcher 1990). As suggested by Andrews and Bell (2000) the opportunity for self-reflection during debriefing helps participants learn more from the sessions (i.e., greater mastery) and to further develop their metacognitive skills (i.e., think about their own thinking). Well-trained personnel with a sound knowledge of incident management, excellent interpersonal skills, and a good understanding of human factors should conduct the debriefings. A particularly useful tool for debriefing is the replaying of audio or video material from the session (also known as cued debriefing). Cued debriefing following a simulation can re-engage participants in their thoughts, emotions and behaviours at play during key moments of a scenario (McLennan *et al.* 2005). Effective debriefing helps participants focus on achieving enduring mastery of key competencies rather than on merely optimising observed performance in the particular exercise.

Performance assessment

The effectiveness of simulation-based training is also dependent on the quality of the associated performance assessment practices (Salas *et al.* 2009*a*). Information collected about the performance of personnel undertaking training provides core data for three important purposes: (1) to support the learning and development of the participants; (2) to generate evidence of the competency of participating personnel; and (3) to evaluate the effectiveness of training programs (Goldstein and Ford 2002; Kirkpatrick 1979). In some instances simulation sessions may also provide the opportunity for organisations to pilot or test new protocols, processes or technologies (Jones and Hutchinson 2008; Thompson *et al.* 2009).

Goldstein and Ford (2002) observe that many organisations fail to properly assess the effectiveness of their training programs. Ralph and Stephan (1986) found in their survey of Fortune 500 companies that most organisations only assessed the first two components of Kirkpatrick's (1979) four-level training evaluation framework (i.e., *reaction, learning, behaviour and results*). Ralph and Stephan noted that while most companies in their survey "usually" assessed whether trainees' were engaged by the training (*reaction*), only a smaller number of organisations tested trainees' learning at the end of a course (*learning*). Unfortunately very few of the surveyed organisations assessed whether training influenced the behaviour of trainees' on-the-job (*behaviour*) and even fewer organisations assessed whether the training translated into results that benefited the organisation (*results*). To ensure successful IMT training it is important that fire agencies evaluate the effectiveness of these programs including any simulation-based components. This requires agencies to conduct performance assessment at a variety of points in time including during instruction programs, whilst trained personnel are working on-the-job, and during subsequent IMT exercises and to collate and analyse this data.

We suggest that clear communication of the purpose of the simulation is particularly important because it is likely to influence the behaviour of the participants. For instance, participants should be aware of whether the session is being used as a training opportunity, or whether they are being assessed for accreditation purposes (e.g., Level 3 Operations Officer). If the session is training-oriented then participants may be more likely to be mastery-oriented, that is to experiment in the way they manage their responsibilities so that they might learn from failure and otherwise test the boundaries of their skills (Kozlowski *et al.* 2001). However, if the purpose of the simulation session is for accreditation or promotion purposes, then we suggest that the participants' focus will most likely be performance-oriented.

Regardless of the purpose of the simulation-based training, effective performance assessment should allow trainers to monitor participant performance, diagnose possible performance issues, and ensure that appropriate feedback is provided (Salas and Rosen 2010). To do this a variety of data needs to be collected at several different levels. For IMT training there is a requirement to consider both individual and team levels of performance. In using the term performance we also need to recognise that it is important to distinguish between performance in terms of sets of desirable behaviour (e.g., timely decision making) and performance in terms of the outputs produced by an individual or team (e.g., high quality situation report delivered on time). This distinction of performance as both a process and outcome indicates that both behavioural and outcome data should be collected.

Salas and colleagues have published a useful set of principles for the performance measurement of simulation-based training. The seven principles that we suggest are most important for training and assessing IMT personnel from Salas *et al.* (2009*b*) are:

Know the behaviours, attitudes, and cognitive competencies required for performance

Derive behavioural markers of performance for each learning outcome

Develop metrics that are diagnostic of performance

Capture performance at multiple levels of analysis

Develop and implement training programs for observers and instructors

Provide structured tools or protocols for observations

Do not overburden observers and maintain a good ratio of observers to trainees

Good psychological fidelity is particularly important for providing performance assessments (Morrison and Hammon 2000). We suggest that psychological fidelity increases the opportunity to observe a greater range of behaviours in simulations while providing greater insight as to underlying competency of participants. A particular advantage of simulation-based training is the opportunity to assess teamwork and interpersonal skills in a fairly realistic setting, providing greater clarity about how the individual or team may perform on-the-job (Kozlowski 1998).

Conclusion

The challenge of effectively training and maintaining the competency of a large IMT workforce is considerable. A key question for agencies is how to maximise skill acquisition and transfer of training for the workforce within existing time and cost constraints. Given the current need to swiftly develop additional IMT personnel and ensure regular exercising, simulation-based training provides an excellent method to develop and maintain the competency of these personnel. However, to get best value from an investment in simulation-based training, agencies need to ensure that the scenarios used are appropriately designed so that they offer appropriate psychological fidelity, ensure participants have the opportunity to undertake effective post-session debriefing, and carefully measure the performance of individuals, teams, and the adequacy of the training program itself.

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Notes

The Australasian Inter-agency Incident Management System (AIIMS) classifies incidents into three levels with Level 1 the simplest and Level 3 the most complex (AFAC 2005). In Level 3 incidents the three functions (i.e., Planning, Operations, and Logistics) are usually delegated into separate units, and Divisions on the fireground are typically established for effective management. Generally these incidents involve large numbers of personnel (> 100) and run for anywhere between a few days and weeks.

Level 1 incidents are usually resolved through the use of initial response of local resources, whereas Level 2 incidents are more complex and require: (a) the deployment of additional resources beyond initial response, or (b) the deployment of resources into sectors for management, or (c) the setting up of functional sections (Planning, Operations, and Logistics) due to the complexity of the incident, or (d) a combination of (a), (b), and (c) (AFAC 2005).

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