# Information flow and teamwork in Incident Control Centers

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## ABSTRACT

This paper reports research in progress into a study of information flow and teamwork in Incident Management Teams (IMTs) in Australia. The research project, funded by the Bushfire Co-operative Research Centre. The overall research design includes interviews with experienced personnel, observations of real-time incidents and training simulations and a national questionnaire of incident management practices. Data reported in this conference session will focus on a sample of observation data conducted in two training simulations of a wildfire incident. Observations were video recorded and key IMT members wore lapel microphones. Video data has been coded for use of artifacts (e.g., maps, status boards) and room movement. Audio data has been coded for by the quantity and quality of interactions within and between IMT functions. The presentation aims to contribute to an understanding of what enables and constrains effective teamwork and information flow within Incident Control Centers (ICCs) in Australia.

### Keywords

Information flow, teamwork, incident management teams, wildfire

## INTRODUCTION

Australia is one of the most bushfire-prone areas in the world and annually there are many fires that need to be managed. Fire and emergency service work is becoming increasingly important as the impact of climate change results in more extreme weather events that need to be managed in terms of their effects on communities (Henessey, Macadam & Whetton, 2006). These events coincide with political and economic contexts that are less forgiving of mistakes caused by either a lack of service integration or poor coordination (Moynihan & LaFollette, 2007).

The process of organizing for effective incident management used in Australia is based on the US system of National Incident Management Systems (Department of Homeland Security, 2004) where an IMT is established, which comprises the following units:

**Control :** The management of all activities necessary for the resolution of an incident.

**Planning** The collection, analysis and dissemination of information and the development of plans for the resolution of an incident.

**Operations** The tasking and application of resources to achieve resolution of an incident.

**Logistics** The acquisition and provision of human and physical resources, facilities, services and materials to support achievement of incident objectives.

These units can expand or contract depending on the size of the incident and its complexity. IMTs can comprise between 4 and more than 100 people. The advantage of such systems is that they can scale-up as an emergency escalates and to scale down as necessary (Australasian Fire Authorities Council, 2005). However, the question remains, what is it about these ways of organizing that create effective teamwork and information sharing within the Incident Command System (ICS)? Research in other emergency management domains suggests that there are

particular practices that support the development of effective teamwork (Cannon-Bowers & Salas, 1997; Weick, Sutcliffe, & Obstfeld, 1999) including patterns of decision-making (McLennan, Omodei, Holgate & Wearing 2006); and particular practices and organizational processes (e.g., Iannella & Henricksen, 2007; Militello, Patterson, Bowman & Wears, 2007; Sonnenwald & Pierce, 2000); and designs that can support shared representation and distributed cognition (Artman & Waern, 1999; Xiao, 2005).

### Research Aims

This paper reports research-in-progress into a study of information flow and teamwork in IMTs in Australia as they are deployed to fight wildfire and as they work in static and mobile Incident Control Centers (ICCs) that form part of Australia's Incident Command system (ICS). It is a four year study (currently in its second year) and is funded through the Bushfire Co-operative Research Centre. It has involvement from 12 fire and emergency management agencies in 5 states of Australia. The current phase of empirical data collection focuses on management of wildfire in Australia. However, it is anticipated that later data collection may include other kinds of emergencies the 12 fire and emergency management agencies involved in the study have to manage (e.g., storms, cyclones). The project includes the following research questions:

1. What (individual and collective) work practices can be identified that enhance effective communication, collaboration and shared understanding between operators involved in ICS/IMT performance?
2. What organizational structures and cultures can be identified within emergency management agencies and how do these enhance and inhibit effective ICS/IMT work performance?
3. How might IMT/ICS work performance be optimized through development of new practices (e.g., protocols, training) developed for localized and specific needs?

### Research Design

The overall research design involves both qualitative and quantitative methods. Following a review of the literature and a synthesis of the key findings from previous inquiries, semi-structured interviews (n=75) have been conducted with experienced personnel about what enables and constrains successful information flow though the ICS. In addition observations have been conducted of planned (training simulations, n=7) and unplanned (real-time fires, n=4) incident management teamwork. These have involved video observations (138.8 hours). From the 138.5 hours collected, 91.9 hours was assessed as being unsuitable for this study (e.g. lack of teamwork interaction in the video footage; post-training exercise debriefing). The 46.5 hours remaining was included because it provided a good frequency of incident management teamwork interaction. From these data a sample of 30% (13.5 hours) was chosen to provide examples of incident management activity that included (i) low level task demands (e.g., little urgency, processes running smoothly) (ii) activity where the incident escalates (e.g., a change in strategy needed as a result of deteriorating weather) and (iii) high level of task demand (urgency; high resource coordination demands). In addition to the video observation data, key IMT personnel (i.e., IC, Planner, Operations Officer) wore audio-lapel microphones, and samples of their interactions coinciding with the video-analysis, have been transcribed. In total within the video-observation data 21 participants (19.4 hours) in training and 5 participants (22.6 hours) in real-time incidents wore audio-lapel microphones. This is currently being analyzed in NVivo, a qualitative software package.

In addition two questionnaires have been included in the study design. One questionnaire is a pre-post training self-assessment questionnaire of teamwork effectiveness indicators and group potency/efficacy (Vogus & Sutcliffe, 2006). The second questionnaire is a national survey of ICS/IMT practices as they occur in the 12 agencies participating in the study and will be distributed in April 2008. Once the data have been collected workshops with agency personnel based on the data collected and aimed at identifying organizational improvements that can be suggested based on discussion of the findings.

#### *Observation data reported in this presentation*

As time is limited and collection coding and analysis of all of the data is not yet complete, the focus of the presentation to ISCRAM will be on samples of data collected during the observation phase of the study conducted in selected training scenarios. The purpose of the training exercises are for developing/refreshing incident management teamwork in the case of wildfire.

### *The training exercise*

The training exercise is a four-hour computer-supported IMT simulation exercise, where a wildfire is reported and an IMT needs to be established. During the course of the exercise the fire escalates and threatens local assets (a forest plantation and a town). The two exercises observed were conducted in genuine incident control centers in local fire stations. Thus participants employed the usual communication processes they would normally use if managing an incident from the Center (e.g., radio, telephone, facsimile and paper-based reporting templates). To operate the exercise requires skilled practitioners to project scripted "injects" or inputs into the IMT simulation from the fireground/other levels of emergency coordination. The training is facilitated by an accredited trainer.

### *The participants*

The participants had all had experience in fire-fighting and the majority had previous experience of being involved in an IMT. All have had training in their IMT role/function and were assumed to already be considered competent for their IMT role or have the capacity to undertake the role allocated . The exercise is aimed at personnel ready and able to manage what develops to a Level 3 incident (i.e., highest level of incident complexity, requiring delegation of all IMT functions). The two training exercises reported here both involved 15 and 20 personnel engaged in the exercise.

### *Research methods*

Having briefed participants about the purposes of the exercise, the pre-training questionnaires are administered. Four digital video cameras were positioned at strategic points to capture IMT interaction and activity. Personnel responsible for three main IMT units (IC; Operations Officer and Planner) agreed to wear audio-recording devices.

Analysis of the video-based component of the observation involved using Transana, a software program, where segments of activity can be "clipped" and coded at nodes, where data on clip start, end and total clip length can be recorded. The nodes developed included

- who was the target of the observation (IC, Planner, Operations officer);
- with whom were they interacting (another IMT function or within their own function)
- communication modality (e.g., whether the interaction involved one-to-one or one-to-many personnel; use of telephone, computer)

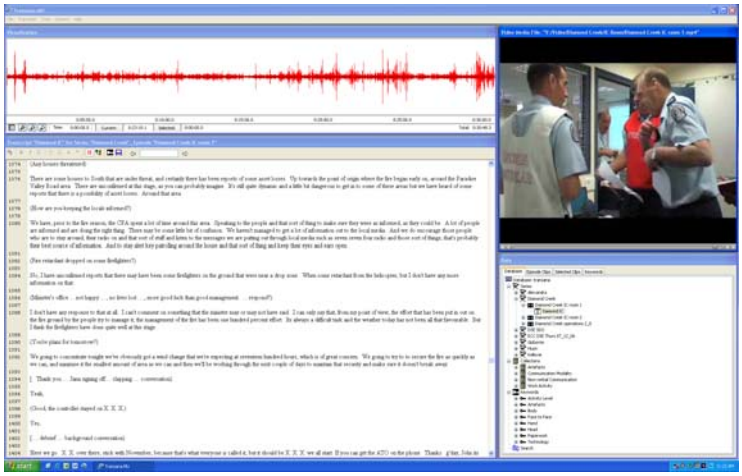

**Figure 1 Example of Observation coding**

- artifact use (maps, whiteboards, paper-based reports),
- time spent walking from one location in the ICC to another and time spent in a particular location (when on camera)

An example of the ways in which the data were coded for analysis is presented in Figure 1.

*Triangulation of coding*: Four separate coders were used to code video-observation data. Each coded the same twenty minute segment which was then reviewed and discussed. A decision was taken to code the activity observed on the video independent of the talk collected on the lapel microphones. In part this was because it was not always possible to synchronise the talk with the activity due to the level of ICC room noise. This also allowed for recognition of multiple and sometimes overlapping physical movements that may occur within any one phrase or sentence. Doing so enabled a 88% inter-rater reliability.

The data collected on audio-lapel corresponding with the video period was transcribed and coded using NVIVO qualitative analysis. Codes included

- Direction of information exchange (target initiates or responds);
- Information flow (within the IMT or between the IMT and other functions within the ICS);
- Types of communicative practices (factual statements; action, planning statements; uncertainty, instructions/giving directions, statements for the purpose of providing situation awareness; incomplete statements, banter/ humor;)
- Teamwork behaviors (supporting behavior: offering, requesting, receiving assistance; monitoring/cross-checking; interactions associated with integrating and connecting across boundaries)
- Type of IMT activity (establishing/managing the ICS or IMT functions; Assessing/monitoring the incident; reporting)
- Cognitive load (low: casual conversation, no time pressure; medium: demands placed on target to perform/complete tasks within time constraints; high: challenging task demands, unexpected events; very high: disturbances, breakdowns).
- Breakdowns, disruptions

*Triangulation of coding*. Three coders worked through 5 pages of transcript and achieved an inter-rater reliability of 72%. Points of difference were discussed, the codes used simplified (to reach those indicated above) and the process repeated, resulting in a 83% inter-rater reliability.

It will be possible to connect segments of the talk with the video data (e.g., persons hovering around talking in a group around a status board).

## FINDINGS

The finding reported here represent research in progress. Two hours from each exercise was selected for further analysis. Using two exercises that employed the same computer-supported simulation allowed for comparison of how two differing training groups manage the same problems presented in the scenario.

The two observations reported here have been selected (from the 12 training observations included in the overall data set) because they provided statistically significant differences in the pre- and post-training questionnaires completed on perceived teamwork effectiveness. Differences between groups was also triangulated from subjective feedback assessments gained from the subject matter experts conducting the training. In short, based on the questionnaire data and the feedback from subject matter experts, T1 represented a group with limited experience and who did not manage as well as T2. Questions of interest here include; did the two groups establish their work flow within their incident control centers differently? How did the groups use the artifacts present in the center to coordinate their activity; and to what extent did they engage in similar or different patterns of interaction?


**Figure 2 Training Venues for observations 1 (L) and 2 (R)**

The observation data indicate that the way in which ICCs are physically established sets the tone for how information flows throughout the IMT. Observation of interaction within the IMT illustrated how different configurations created either a smooth flow of information or congestion. Figure 2 illustrates how the main areas available to the IMT in the differing locations were of similar size. Training Exercise 1 chose, half way through the exercise, to move some of the IMT units (planning) to locations in adjacent buildings (Figure 3). Training exercise #2 chose to remain in the existing ICC space but to position two whiteboards in the middle of the room (see Figure 3, which illustrates points F and G in Figure 3). Also, of interest in Training venue 2 was the use of electronic data displays that could dynamically provide updated information (see Figure 2-R). However, as will be discussed later, there were not used by participants.

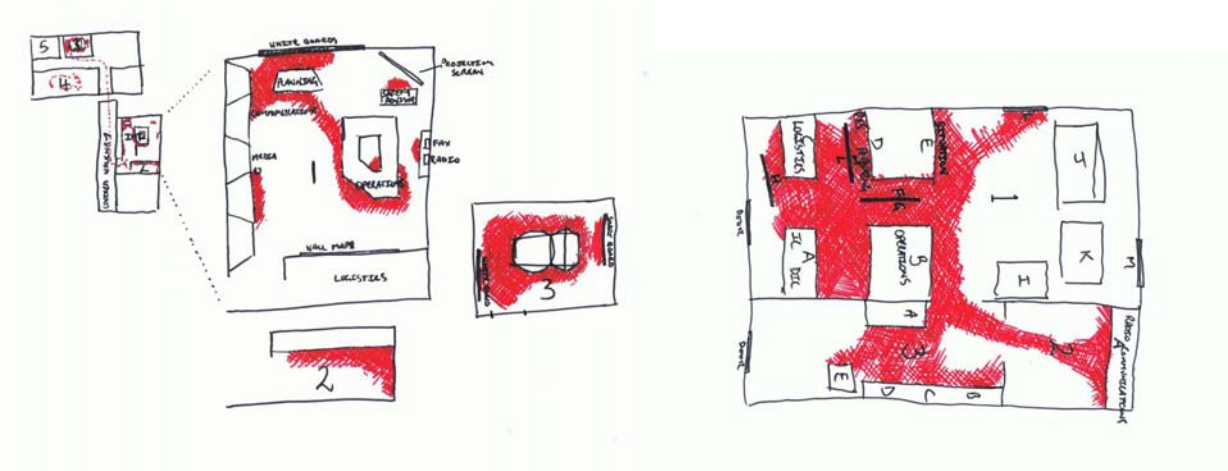


**Figure 3: Schematic impression of room movement and congestion: training exercises 1 (L) and 2 (R)**

Figure 3 illustrates the organization of IMT units and provides a schematic illustration of human movement within the two ICCs. Training Exercise 1 commenced in one space and then units moved to adjacent offices to overcome noise problems. In training exercise 2 all units remained in the same room, despite the high volume of noise.

### *Use of artifacts in the ICC*

Although the exercise was the same simulation and both groups had access to similar tools and resources, differences were observed in their use of artifacts, notably use of maps and whiteboards. The finding that emergency management in Australia does not extensively use electronic forms of reporting and relies more heavily of paper-based forms has already been made by Ianella (2007). A chi-square comparison of map and whiteboard artifact use between Training Exercise 1 and 2 showed Training Exercise 2 made significant more use of whiteboards than Training Exercise 2. The way in which artifacts such as whiteboards can aid in shared representation for coordination purposes is not new (see for example Wears, Perry, Wilson, Galliers & Fone,2007). What is of interest

here is the way in which such artifacts can be used in establishing information flow within an ICC, how frequently they are used and by what IMT unit function.

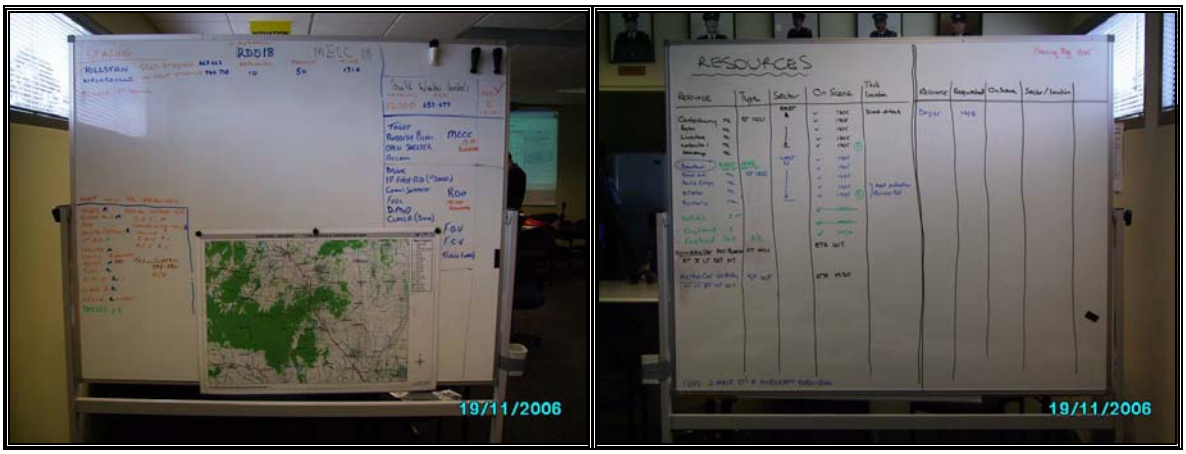


**Figure 4 Left and right side of one whiteboard positioned in Training Exercise 2 (see Figure 3, RHS legend "F/G")**

As an illustration, Figure 4 shows the use made of the whiteboards positioned in Training Exercise 2. The image on the left represents the legend "F" used in the right hand side diagram shown in Figure 3, and faces from the middle of the room into the planning section. The image on the right represents "G" in Figure 3, and faces into the operations section. Tables 2 and 3 shows the number of times target participants used either a map or a whiteboard and the amount of time spent engaging with the artifact for both exercise groups.

| | N count | Sum (secs) | Mean (secs) | Std D (secs) |
|---|---|---|---|---|
| T1 IC | 33 | 976.86 | 29.6 | 56.4 |
| T1 Ops | 10 | 132.28 | 13.28 | 10.8 |
| T1 Planner | 29 | 673.83 | 23.23 | 19.6 |
| T2 IC | 23 | 1079.50 | 46.9 | 44.09 |
| T2 Operations | 106 | 4208 | 39.69 | 46.11 |
| T3 Planner | 114 | 3765.77 | 33.03 | 44.24 |

**Table 1: Map use in Training Observation 1 and 2**

| | N count | Sum (secs) | Mean (secs) | Std D (secs) |
|---|---|---|---|---|
| T1 IC | 1 | 22.7 | 22.7 | 22.7 |
| T1 Planner | 4 | 69.06 | 17.26 | 12.7 |
| T2 IC | 20 | 345.76 | 17.28 | 16.26 |
| T2 Operations | 15 | 435.89 | 29.05 | 36.7 |
| T3 Planner | 56 | 1127.88 | 20.14 | 33.39 |

**Table 2: Whiteboard use in Training Observation 1 and 2**

Table 1 highlights the type of personnel involved in the training exercises. It shows how, for example, the IC in Training exercise 1 was observed on 33 occasions to engage with a map, for a total of 976 seconds. The mean time

being 29.6 seconds. The Table shows how the target personnel involved in the exercise made not only greater use of maps but also spent more time looking at them. The reasonably high variance is indicative of the small n's. The data presented are thus exploratory and will be revisited when the rest of the observations have been included in the data set. Table 2 shows that greater use was made of whiteboards in Training Exercise 2. The high use by the planner is probably also conflated by the map attached to the whiteboard, as indicated in Figure 4.

The observations have noted how some IMTs used status boards better than others. Examples of how status boards are used in different training exercises are illustrated in Figure 5.

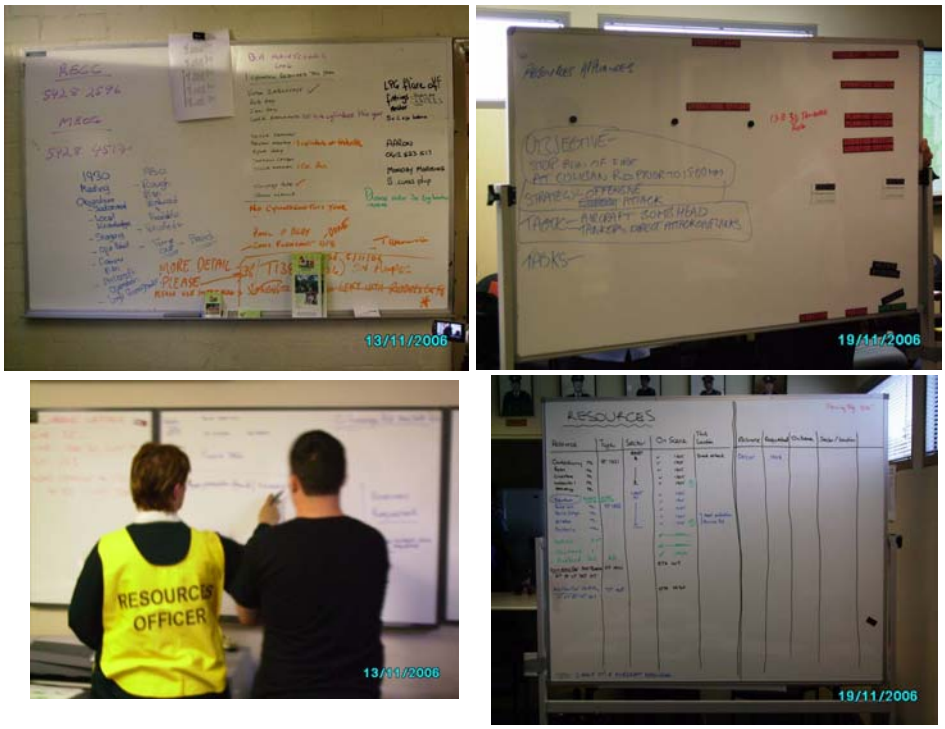


**Figure 5: Use of status boards in IMT work activity**

The observations noted how some IMTs used status boards better than others. A practical outcome of this component of the research may be to suggest guidelines for their use and format and to thus learn from experienced others. Status boards provide an interesting means of sharing information and their role in coordinating complex activity has been noted (Wears et al, 2007). The authors commented the ways status boards are used provide indicators of how experienced personnel think and reason about their activity and what they see as important in their work. As Wears et al (2007) conclude, the use of a status board has a number of characteristics. They are informally organized, locally owned by participants and are easily reconfigured and changed and they are widely accessible. However their use also comes with certain risks. These include information dissemination outside of the usual ICS reporting and logging systems as well as risks associated with information being inadvertently lost or changed.

### *Interaction within and between IMT functions*

There were significant differences in both the quantity of interaction and in the use of artifacts between the two exercises. Table 3 shows the amount of interaction observed between various members of the IMT and the personnel targeted in the observation.

| | Training Observation 1 | | | | Training Observation 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | IC | O | P | Total | IC | O | P | Total |
| DIC | 24 (68%) | 3 (8%) | 8 (22) | 35 (100%) | 22 (29%) | 26 (35%) | 27 (36%) | 75 (100%) |
| IC | - | 5 (33%) | 10 (66%) | 15 (100%) | - | 75 (83%) | 20 (22%) | 90 (100%) |
| L | 3 (50%) | 1 (20%) | 2 (40%) | 5 (100%) | 2 (8%) | 1 (4%) | 20 (87%) | 23 (100%) |
| O | 6 (50)% | 6 (50%) | - | 12(100%) | 22 (19%) | 66 (57%) | 28 (24%) | 116 (100%) |
| P | 20 (43%) | - | 26 (56%) | 46 (100%) | 32 (17%) | 30 (16%) | 123 (66%) | 185 (100%) |
| Unknown | 47 (51%) | 11 (12%) | 34 (37%) | 92 (100%) | 56 (18%) | 100 (32%) | 158 (50%) | 314 (100%) |

**Table 3: Amount of interaction: from whom to whom (targeted personnel)**

A noticeable difference was with the sheer volume of interaction occurring in Training Observation 2 compared with Observation 1. Some disconnects between planning and operations for example, are also evident in Observation 1 with no interaction being observed between the operations and planning functions. However, since it is difficult to imagine how an IMT can function if operations and Planning are not communicating, this is likely to be sampling error. Of interest is the level of interaction occurring within the various functions (e.g., planning to planning) and who targets whom. The observations of personnel unknown approaching the target observees is due to the fact that not everyone in the exercise was wearing a tabard.

### New technologies to facilitate dynamic updates and shared representation

One technological innovation to improve the timeliness of information flow between the fire-ground and the IMT, and to provide a means of overcoming the difficulty of working with a static map to create a shared representation of the fire and its trajectory has included the introduction of projections of real-time updates of the fire on what has sometimes been called a 'smart board'. This is an electronic display of the fire, its location and shape.

Figure 6 provides an illustration of Training Observation 2 where room movement of the various target observees are shown by their colors (black represents the movement of the IC; red indicates the movement of the Operations officer and yellow represents the movement of the planner). The time spent in each of the grid reference points is cumulative and represent segments of approximately 5 minutes. Thus, the Operations Officer standing at C5, where he was joined for approximately 5 minutes by both the planning officer and the IC.

In Figure 6 the electronic display board showing the map of the fire and its trajectory is found at grid reference M9-11 and the log of information coming in from the fire-ground is found at grid reference B/C-14. It can be seen from the Figure that only one member of the IMT participating in the study (the Planning Officer) went near the electronic map. He remains in from of the map for a period of less than five minutes. The data are illustrative only. However what they do suggest is the importance of explicitly embedding the use of new technology into training if it is to be adopted.

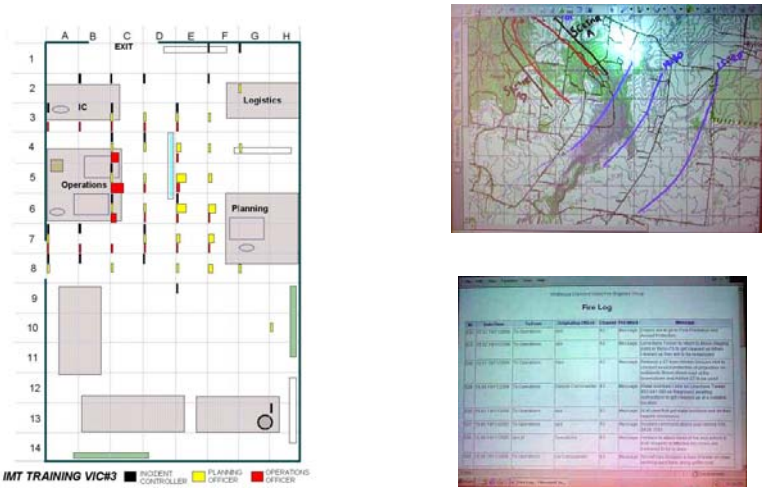


**Figure 6: Room movement layout Training Observation 2 and electronic whiteboards**

## CONCLUSION

This paper has provided some preliminary findings of research in progress investigating information flow and teamwork activity in IMT's established to respond to wildfire in Australia. The data presented here provide some interesting observations of how, in two of the exercises observed, there are differences in how ICCs are set up and how artifacts are used. The data also provide some interesting differences in patterns and quantity of interaction within and between units in an ICC. The issue of the qualitative nature of those interactions, how they are supported or constrained by ICC room set up or artifact use, or indeed, whether what has been reported here is supported in the rest of the data collected will be discussed in the conference presentation.

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