

# The Demonstration of Electronic Systems to Assist in the Management of a Significant Incident

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## ABSTRACT

This paper is a demonstration of the techniques developed during an Australian Coal Association Research Program (ACARP) funded research project aimed to develop aids, principally computer based, to assist mine personnel to more efficiently manage significant incidents in coal mines. These aids include software to aid in the location of the incident, electronic information storage and retrieval, online site emergency response manuals and software to aid in decision-making.

## INTRODUCTION

One of the recommendations of the inquiry into the 1994 Moura No 2 underground coal mine disaster, where 11 miners lost their lives, was that an emergency response exercise be conducted at an underground coal mine each year to test the mine's internal emergency response system. It also aims to test the response of the Queensland Mines Rescue Service and other external agencies' ability to respond and render assistance to the mine. Eight such exercises have been completed. In addition to this level one exercise each mine is required to carry out emergency exercises based on operating sections (level 3) and whole of mine (level 2) annually. These exercises have led to significant improvements in the way mines prepare for emergencies and in their abilities to manage the incidents. The findings of the exercises have been reported elsewhere (Rowan *et al*, 1998 - 2002, Reece *et al*, 2004, 2005).

The scenarios were tailored to conditions and situations that had occurred at the mines, eg roof falls, frictional ignitions, etc in addition to including historical incidents.

Many valuable lessons have been learnt from these exercises including:

- the move to compressed air breathing apparatus for in seam rescue and response;
- the use of sophisticated computer fire simulation programs;
- the use of life lines;
- the use of visibility impairment aids;
- the use of refuge bays/fresh air bases (FAB); and
- increased awareness/familiarity with using self-contained rescuers.

In general one of the areas that is dealt with least effectively is that of information management, ie collection, analysis and reporting. The information management issues relate to a number of key areas.

## Mine environment monitoring systems

1. Despite the fact that all mines tested had sophisticated computer based communications systems and gas monitoring systems, much of the communication was done verbally and transmitted via handwritten notes. This led to a number of significant delays in obtaining appropriate

information and on occasion incorrect information was obtained. Often the gas monitoring data was only displayed in the control room. The full capabilities of the gas monitoring software and computer system were not used.

2. No one person had the responsibility for obtaining and analysing ventilation and gas concentration data. Thus no one had responsibility for ensuring the quality of the data. Often key decisions were made without any understanding of the limitations of the data being used as the basis for those decisions.

## Information flow/record keeping

3. Often there was no accurate information flow not just gas information but also relating to vehicle and personnel movements and locations. No effective recording procedures or logs of actions and decisions with reasons or evidence supporting those decisions.
4. There was often limited or no control over communications into and out of the incident management room. Often the briefings of incident management team (IMT) personnel were unstructured.
5. On a number of occasions there was ineffective communication of information to mines rescue superintendent and to rescue teams and other key personnel. The integration of rescue team organisational issues into IMT decision-making may have provided improved rescue effectiveness.
6. Inaccurate recording of persons underground and movement and location of persons underground. There was a lack of formal method to record and update the status and deployment of resources for rescue operations.
7. On most occasions important incident management decisions were not made until the mine manager could arrive on site – in some cases causing delays of over two hours. Information was transmitted to the senior official offsite by phone. There were several instances of incorrect information being received by the mine manager because of this.

## Incident management room

8. In a number of exercises the Incident control room was poorly resourced, no provision of white boards, accurate mine plans, desktop space, communications facilities and security against intrusion.

## Decision-making

9. All too often there was no record kept of the decision-making process.
10. Decision-making occurred over too long a time period, there was no sense of urgency, direction or focus – best provided by a clearly stated (and written up) set of goals, objectives and priorities.
11. On more than one occasion there was the development of a group think mentality for decision-making.

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### DEVELOPMENTS

The development of tools to address a number of these issues has been progressed through an Australian Coal Association Research Program funded project looking at significant incident, investigation, evaluation and analysis (Cliff, Moreby and Meadowcroft, 2003) and has been presented previously (Cliff, 2003, 2004).

Using a recent emergency simulation exercise as the basis this paper will outline how these techniques may be applied. The scenario generated for the simulation was essentially a frictional ignition in a development heading. This caused a methane explosion that picks up some coal dust and develops sufficient energy to destroy some outbye overcasts – short-circuiting the ventilation to some of the longwall blocks being developed. In addition the shock wave from the explosion dislodges a methane drainage line and the following ignites the methane emanating from it as well as a small pile of coal dust at the drive head of the development heading. Neither fire is very big. Personnel from the area where the blast occurred cannot be contacted. Other personnel escape the mine and provide details of the fires and apparent explosion damage. The aim of the exercise was a search and rescue effort for the lost personnel and a plan for the stabilisation and recovery of the mine.

### Technical information

At many times during the IMT discussion process ready access to key information is required. For example, when discussing whether or not personnel can go underground safely the Mines Rescue Guidelines should be consulted. An easy way for this to occur is to have them in electronic form available on a desktop computer/laptop or on a Pocket PC. E-books are a simple

mechanism of converting text documents into easily readable electronic books with large fonts for easy reading and tables of contents and hot links for quick access to key areas. Microsoft® provide MS Reader® as a free program to convert MS Word® document to e-book format and to read e-books. This project utilised this program and another, ReaderWorks® to create templates that could be imported into Word to allow seamless conversion of Word documents into e-books. The user needs no formal training to use the template merely following the instructions at each stage. This template is provided on the CD with the final report available from ACARP.

Figure 1 outlines how this information would be displayed on either the computer or the pocket computer, explaining how key information can be calculated. The second part of the figure displays key heat/humidity information from the guidelines that defines how long rescue teams may operate in breathing apparatus.

The electronic display works equally well for mine site policies and procedures. Figure 2 outlines an example of a mine's trigger action response plan for spontaneous combustion. A Pocket PC has touch screens to facilitate going between pages. In the example shown in Figure 2, progressing from page 9 to the details of what constitutes a level 3 trigger is easily achieved by touching the level 3 icon on the page.

Electronic books can be used on site computers, pocket computers and available offsite through the internet. These electronic books provide access to site procedures, response plans, trigger points, expert assistant databases and contact lists. The electronic documents permit good version control and restrict modification. For example a mine manager can be anywhere in the world and receive a phone call relating to an incident at their mine and be able to access all the key documentation instantaneously via their Pocket PC or laptop

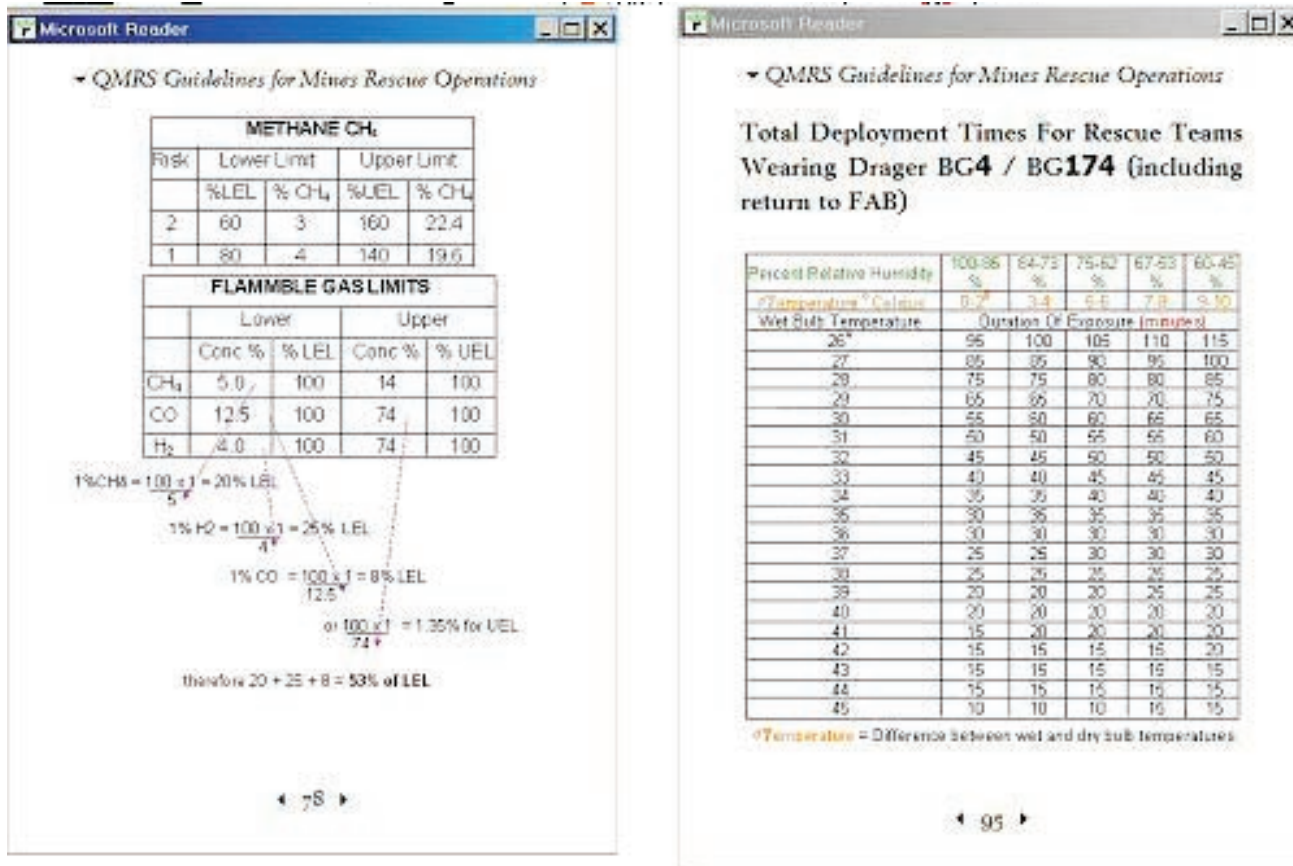


FIG 1 - Display of QMRS guidelines on Pocket PC using e-book technology.

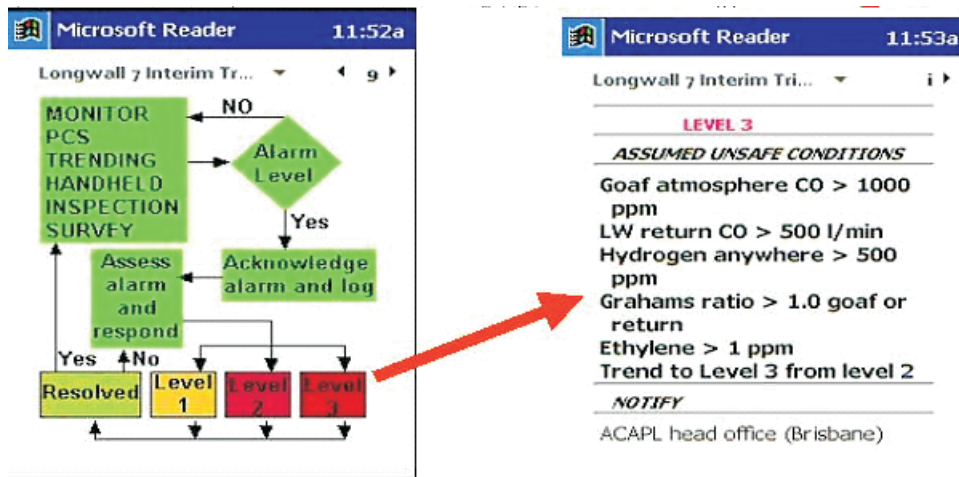


FIG 2 - Example of mine trigger action response plan on Pocket PC.

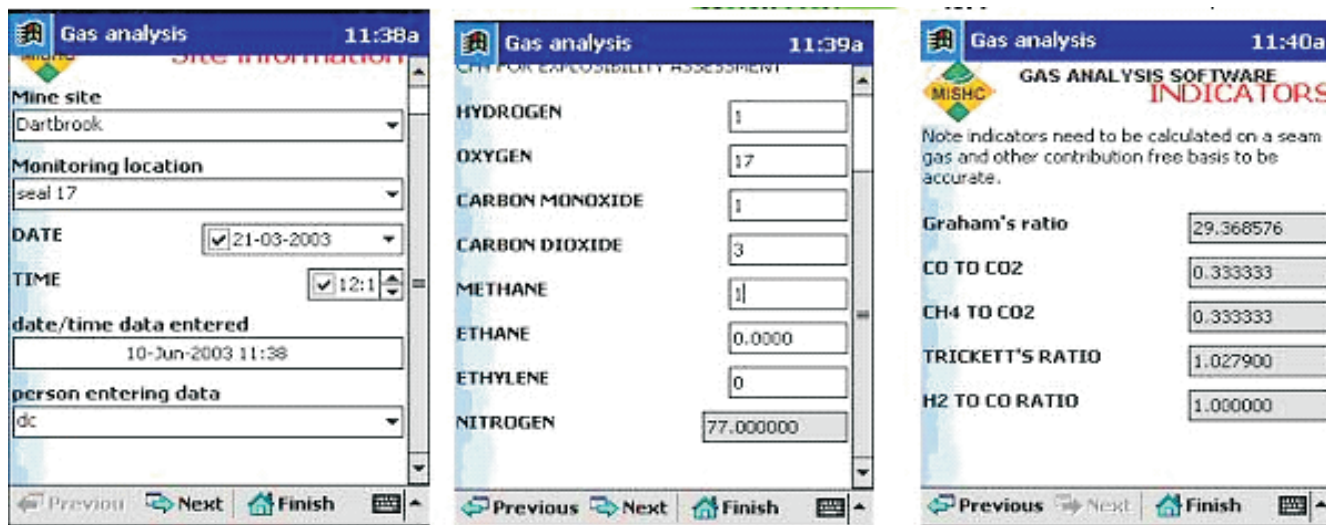


FIG 3 - Pocket PC based gas analysis program.

computer. As part of the ACARP project the mines rescue guidelines for NSW and Queensland were converted to e-book format as were the Queensland Coal Mining Safety and Health regulations, and a gas analysis and interpretation primer was prepared.

Personal pocket computers have been utilised to increase the portability of data communication and speed up the incident initiation process. As they are compatible with normal full sized computers they carry MS Outlook<sup>®</sup> giving access to address books, email and the internet.

In addition as they carry significant processing power (Pentium III processors) they can be used to carry out key calculations such as explosibility analysis. Using a simple easy to use and cheap (< \$150) software package Pocket PC Creations, programs were written for the ACARP project to calculate the various standard gas indicators and explosibility parameters. This is demonstrated in Figure 3. Other programs were compiled to undertake safety surveys and collect information relating to manual handling risks.

**Display of key mine information**

Simple computer software (generic) has been developed to allow quick and simple acquisition of key mine environmental monitoring information, again accessible over the net, both intra

and inter. This software has been developed in MS Excel<sup>®</sup> so that it is not subject to proprietary concerns or huge costs. This software can also be used to track the movements of vehicles and persons underground.

The data can be input directly into one of the input datasheets or connected via dynamic data exchange to mine monitoring systems where this is enabled. Data can be linked to other spreadsheets that might already exist, eg including gas chromatograph data.

Figure 4 shows one of the data entry screens.

Once the data have been entered there are a series of macro commands embedded in the spreadsheet that create the graphics boxes. The user inputs a mine plan graphic and then places the created textboxes as required. The graphics are initiated via a set of control buttons, which lead the user through the setup process.

As the program is Excel it has all the features of MS Paint<sup>®</sup> attached. For the scenario described in Figure 4, the diagram depicted in Figure 5 identifies the overcasts that were identified as being damaged with a red D. This allows people to quickly recognise the ventilation system has been compromised and consider the ramifications of this damage. In addition it is quickly apparent that a number of the fixed monitoring points are damaged (negative values or fresh air where it cannot be) and the information that they report is of no value. This mine has a number of real time ventilation sensors and they provided

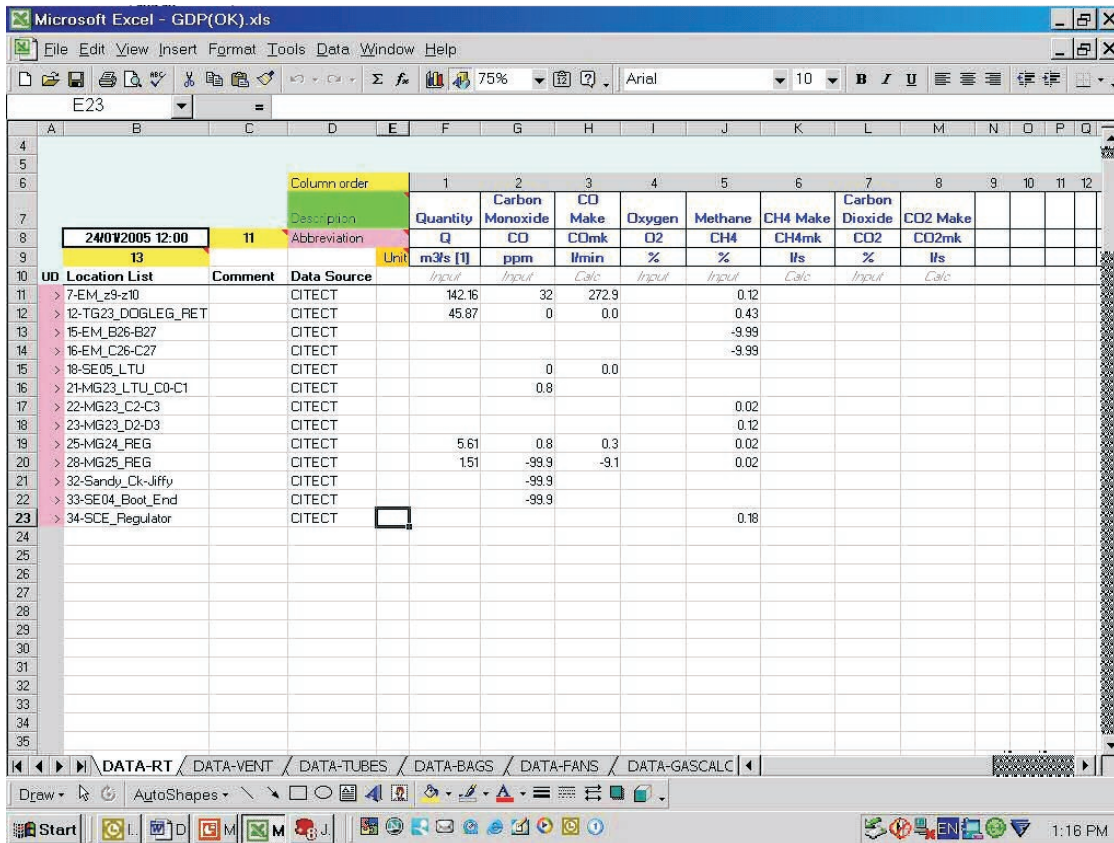


FIG 4 - Example of a data entry screen for display program.

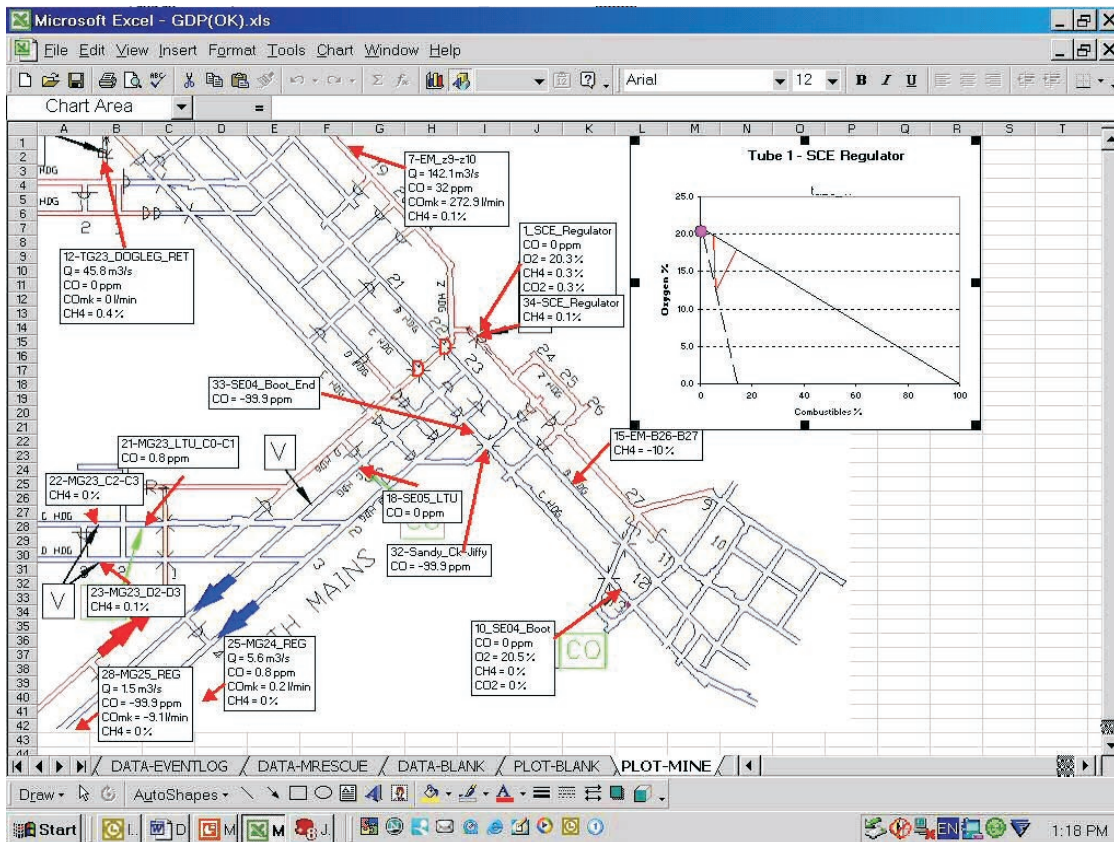


FIG 5 - Example of the output available from the display program.

valuable information to the IMT personnel in relation to the state of the ventilation circuits throughout the mine. The sensors indicate that there is air flowing in TG23 but not much in MG24 or MG25.

A library of symbols has been created to allow quick marking of key features such as fresh air bases and fire locations. This allows the mines rescue function to be planned out including search routes, fresh air bases, etc. Hard copy of the plan can then be given to the rescue teams to use as it already carries all the latest information. Figure 6 outlines a mine plan updated to include the mines rescue projected routes from the FAB marked. In addition the faulty gas detectors have been removed from the plan to ensure that only accurate information is known. This highlights the absence of any accurate gas data from the region where the incident occurred and the need to be careful.

As it is in Excel it can be linked to other spreadsheets or the user can create calculations and graphics as they desire. The program has been configured to create Coward Triangle explosibility analysis directly and this can be overlaid on the mine plan or plotted on a separate sheet as desired.

All types of data can be input including mines rescue information. There is a data entry screen set up to log all rescue teams, their members, function and time under BA. These can then be plotted onto the mine plans to show progress.

Now that the information is electronic it can be shared across the site and offsite as well. This also permits quick and accurate briefings of key stakeholders such as mines rescue teams, and mines inspectors. The diagrams can be printed out to give the rescue teams accurate information.

This technology can reduce the delay in responding to an incident, which is crucial in saving lives and preventing incidents worsening.

**Event logging and record-keeping**

Another use for Excel is to log key IMT information – actions, decisions and events. A feature of Excel is its auto filter function. As can be seen from the example in Figure 7 it can be used to quickly sort through the event log to identify one type of information, it could relate to current tasks, or a particular functional area such as inertisation. Again being electronic it can be shared with others and used to bring stakeholders up to date without disturbing the IMT process.

**Decision-making assistance**

Finally, the ACARP project addressed the issue of decision-making. A number of free or low cost decision-making and logic tree programs have been trialled to enable more effective decision-making to be undertaken. Decision trees have been developed for a number of scenarios. The software tracks the decisions made and logs the rationale behind each decision. The example in Figure 8, using the program Reasonable probes the question of whether or not it is safe to seal a panel.

It establishes a framework to assist the IMT in identifying and considering all the important factors and also flags information gaps.

There are many programs readily available that facilitate decision-making through documenting brainstorming processes. These are easy to use and based on a graphical user interface. The example in Figure 9 using MindManager® demonstrates how an issue can be explored very quickly. Hyperlinks can be included to attach other files to branches of the diagram. These could provide additional information or be action plans to follow if that branch of the decision tree was activated. These programs come with all the graphics support expected of modern computer programs and tutorials are provided to assist in obtaining proficiency. These

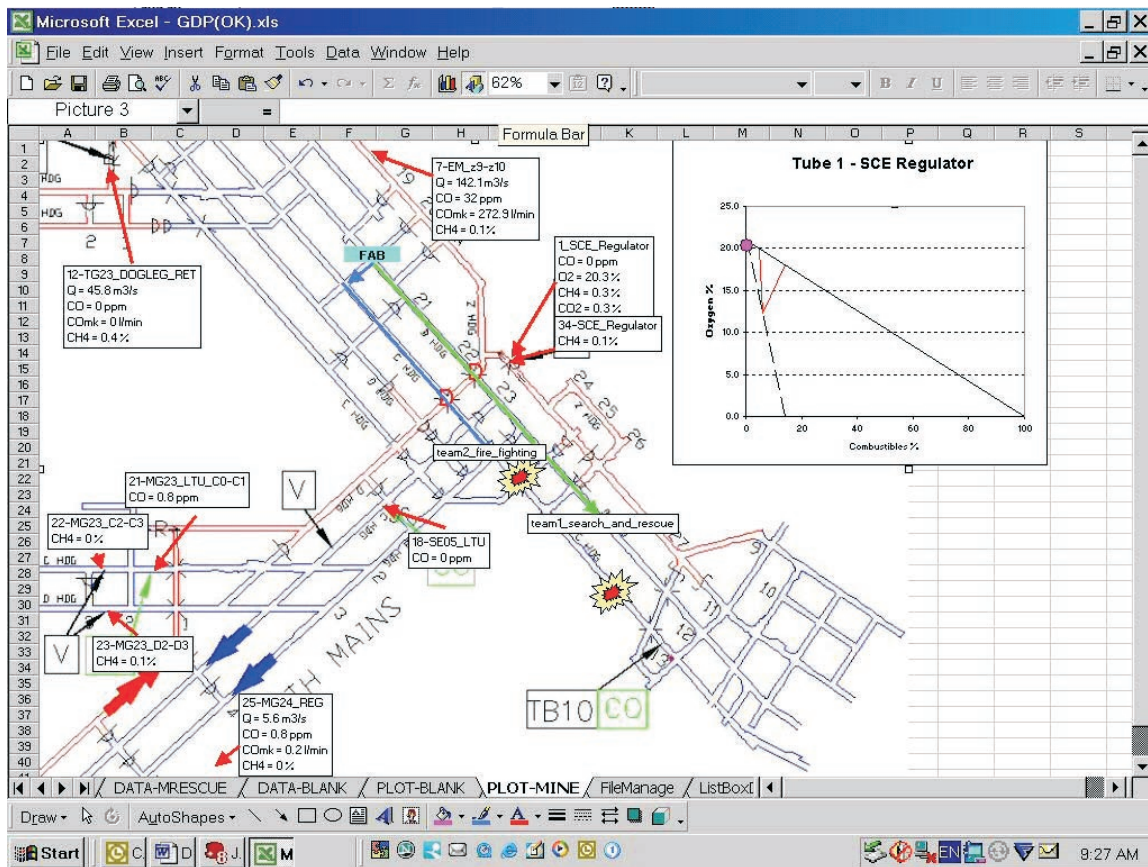


FIG 6 - The example modified to include mines rescue teams and other details.

	A	B	C	D	E	F	G
	Date	Time	Area	Info Actions	Secondary Info/ Action Required	Who	Complete
1	19-May	1230	Nitrogen	Decision to pump Nitrogen into goaf drainage hole 701 ASAP - 4 tonnes per hour	Mine crews to assist in relocation of the Nitrogen pipe	DG	y
191	19-May	1100	Drilling	Decision to drill MIH003 pending success of hole MIH002 remedial works.	MIH002 holed (eventually)		n
192	19-May	1400	General	IMT Meeting			y
193	19-May	1400	Drilling	<b>Ensure all holes sealed at completion of incident</b>		NW	
194	19-May	1400	Drilling	Consider fate of hole MIH001. Depends on survey and other factors. 30/05 decided that hole will definitely be used	Decide as part of re-entry plan. Current drill rig will be offsite 22/05 unless otherwise needed. Another rig on-site 24/05/02	NW	y
195	19-May	1400	Nitrogen	Determine timing of switch to MIH003	N/A - MIH002 OKI		n/a
196	19-May		Gas	Tube 19 determined to be invalid due to incorrect connections	To be rectified when able to access		y
197	19-May		Gas	Tubes 8, 9,10 report increasing H2 since inertisation has stopped	CO reduction across all tubes	MS	y
198	19-May		Vent	Suction to run to CDH009 from GDP002 (T from 606 line)	On hold	DG	n
199	19-May		Vent	Determine gas quality protocols for suction from CDH009 - Risk Assessment?	On hold	DMc	n
200	19-May		Vent	U/G access to open F hdg outbye 25ct and close inbye of 25ct?	Subject to re-entry plan	DMc	n
201	19-May		Drilling	Keep MIH002 capped at all times when not in use.	Valve fitted.	BK	y
202	19-May		Gas	Determine revised GC sampling schedule for 701 N2 injection		DMc	y
203	19-May		Vent	Determine feasibility of using CDH012 to draw air overland from CDH009	Decide between using GDP or sewer pressure. Only 75 Pa difference due to mine vent pressure. GDP seems only practical	DMc	n

FIG 7 - An example of the event log using MS Excel®.

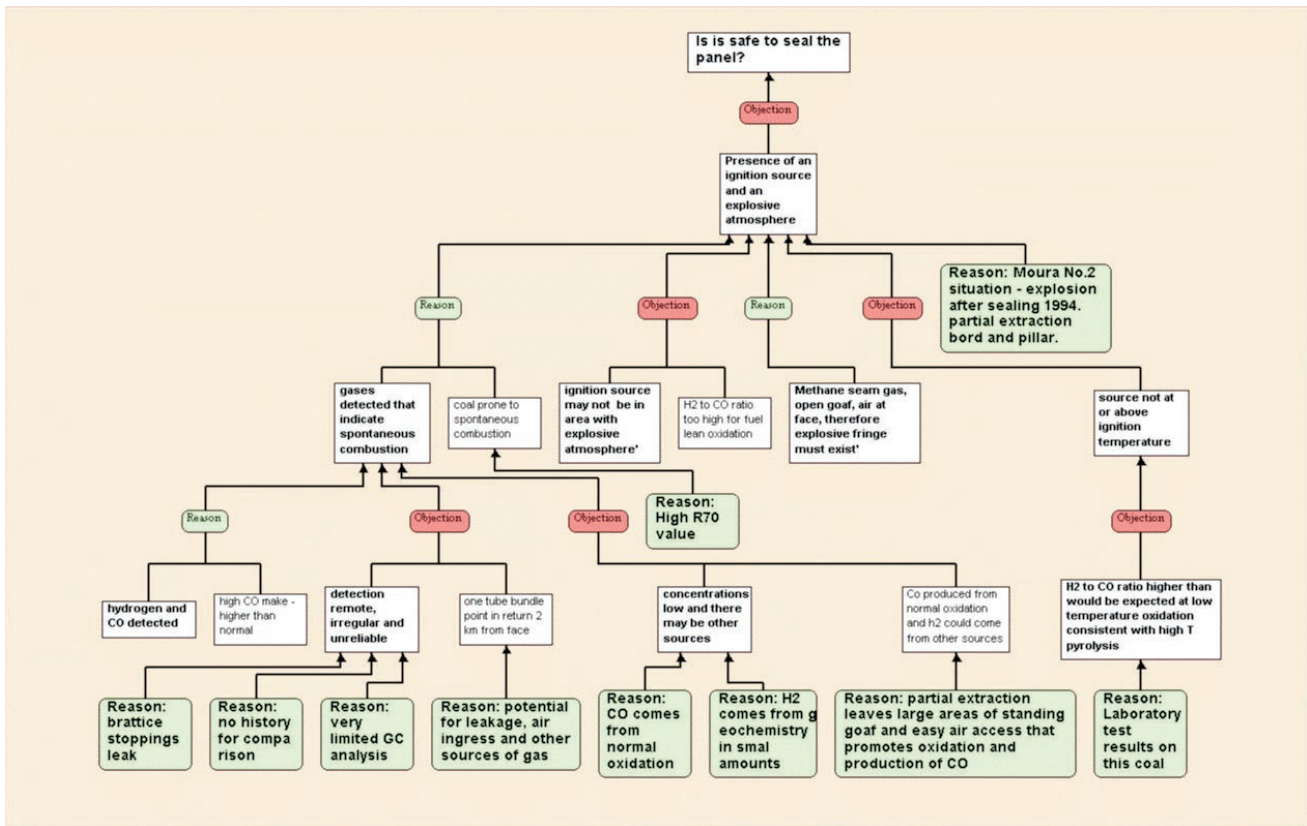


FIG 8 - Reasonable example of decision assistance.

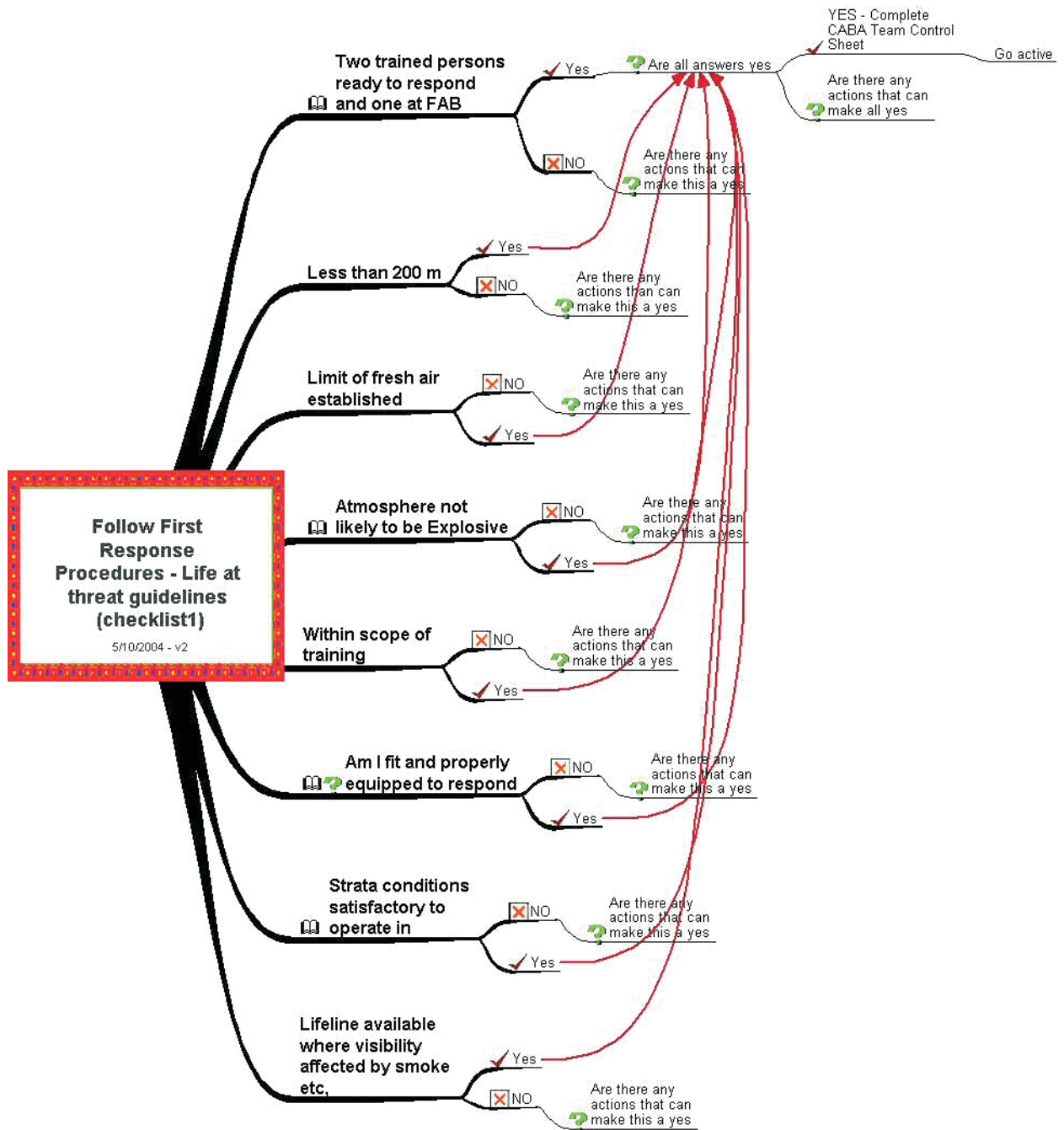


FIG 9 - Mindmap<sup>®</sup> example of decision assistance.

diagrams provide a log of the thought processes; they can be stored for future reference or modified as the situation decrees. It is the intention of the current ACARP project to provide a number of decision-making templates preformed to allow minimal loss of time in a real situation. In addition under the pressures of a real incident, dispassionate logical thought is often not possible so developing rigorous evaluations of situations and thorough risk assessments is unlikely.

Increased use of computers allows sharing of information between a number of locations both on site and anywhere around the world. This in turn facilitates briefings of key groups such as mines rescue or government mine inspectors without disrupting the IMT. Information can also be entered from these areas without disrupting the IMT, which then optimises the decision-making process.

The decision-making process has deliberately been left in the control of the IMT. The electronic devices merely providing aids to improve the quality and the speed of the decision-making process.

### CONCLUSIONS

In general the information display and transfer processes observed during level 1 emergency simulation exercises were found to be inadequate. This was in part due to the fact that many of the systems and roles had not been trialled fully to evaluate their practicality and value. It is imperative that during and incident the incident management team is able to obtain accurate adequate and current information to enable it to function properly.

In the 21<sup>st</sup> century it is appropriate to use 21<sup>st</sup> century techniques to assist in this. The computer-based systems outlined above are examples of how this can be achieved. These systems are examples only and no doubt better systems can be developed, tailored to an individual sites needs. It is imperative that such systems are established during normal mine operation so that in an emergency they can be utilised without any fuss or dislocation of effort. All software outlined above is either freely available in the final report or can be obtained from the Australian Coal Association Research Program via their website, <http://www.acarp.com.au> for a nominal cost or is shareware available for less than \$200.

### ACKNOWLEDGEMENTS

The authors would like to gratefully acknowledge the financial support of ACARP for this work and the active involvement of a number of coal mining industry personnel for their helpful comments, particularly Neil Winkelmann, Bevan Kathage, Bruce Robertson and Ian Kramer.

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