Improving Significant Incident Management in Underground Coal Mines

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Abstract

This paper will outline the findings of the recently completed ACARP funded project looking at improving the investigation and management of significant incidents in underground coal mines particularly as they relate to fires or explosions. Many of the tools developed for this project could also be applied to metalliferous and open cut coal mines.

The genesis for this project was the author's experience in dealing with fires and explosions in underground coal mines over the past fourteen years and participation in the level one emergency response simulation exercises conducted in Queensland. The findings from these exercises, as they relate to incident management, formed the starting point for the project.

The project focussed on the development of computer based tools to assist in the identification and investigation of these incidents. The project has created a program based on a Microsoft Excel® spreadsheet for collecting and displaying mine environment information superimposed on a mine plan. Another Excel® based program developed by Dartbrook Colliery to track decisions and key events is also incorporated into the ACARP project. In addition e-book software has been used to translate mine procedures, advisory notes and trigger and action response plans into electronic documents for ready access on and off site. In addition Pocket computers have been utilised to increase flexibility, speed response and remove mounds of paper.

The paper will demonstrate prototype systems initially developed for the two mines that have participated in the project, Dartbrook and United Collieries.

None of the software developed is proprietary. It is all available either freely or at minimal cost. The host software is all widely available and generally a Microsoft product which most users would be familiar with.

Background

Significant incidents and studies

The author has been involved in investigating and assisting in the management significant incidents at a number of mines including Dartbrook Colliery (1997,1999, 2002), United Colliery (2001), Wallarah Colliery (2001), New Hope Colliery (1989, 1991), North Goonyella Colliery(1997, 1998), Moura No.2 Colliery (1994), Huntly West Colliery NZ (1992), and Ulan Colliery (1991) as well as analysis of older episodes at a wide range of mines stretching back into the 1960's. The majority of these incidents related to spontaneous combustion episodes. In addition more information was obtained during major studies of inertisation at Cook Colliery (1997) and goaf gas behaviour at Moranbah North (1999). The details of these events have all been published previously. The issues raised in these events are consistent with those coming from the level one exercises below. In general they relate to:

- Data acquisition, validation, reporting, and analysis;
- Difficulty in visualising what is happening and therefore why it is happening;
- Collection and reporting of information in one place;
- Briefing of other parties such as inspectorate, check inspectors and mines rescue service;
- Information communication;
- Imperfect documentation and access to this documentation;
- Currency of information;
- Objective decision making;
- Recording the decision making process to allow later review and revision as necessary.

Often small quantities of data, of limited accuracy were used in an attempt to establish the conditions existing in an inaccessible area of an underground coal mine. The prolonged nature of the management of incidents at Dartbrook Colliery particularly has lent itself to the development of mechanisms to improve the management of a number of issues. The author is grateful to Dartbrook Colliery for its permission to share with others some of the techniques developed and utilised by them.

Level one exercises

One of the recommendations of the inquiry into the 1994 Moura No.2 underground coal mine disaster, was that an emergency response exercise be conducted at an underground coal mine each year. The aim of the exercise was to test the mine's internal emergency response system, the Queensland Mines Rescue Service and other external agencies' ability to respond and render assistance to the mine. Five such exercises have been completed. In addition to the 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 level one scenarios were based on historical incidents and were tailored to conditions and situations that had already occurred at the mines, eg roof falls, friction ignitions etc.

The five exercises were: Southern Colliery 27 October 1998, Kenmare Colliery, 7 September 1999, Newlands Colliery, Saturday 25 November 2000, Kestrel Colliery 27 November 2001 and North Goonyella Exercise 4 November 2002

Many valuable lessons have been learnt from these exercises including the move to compressed air breathing apparatus for in seam rescue and response. This paper will focus only on the issues as they relate to incident management. The findings of the exercises have been reported elsewhere (Rowan et al 1998 - 2002).

Issues from level one emergency exercises and significant incidents:

Mine environment monitoring systems

1. Despite the fact that all mines tested had computer based communications systems and gas monitoring systems, much of the communication was done verbally and transmitted via handwritten notes. This lead 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. 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.

3. In most cases, the gas monitoring alarms in control room were submerged in the list of all alarms and not easily distinguished.

Information flow/record keeping

4. Often there was no accurate information flow. This extended beyond gas information and include vehicle and personnel movements and locations. There were no effective recording procedures or logs of actions nor records of decisions with reasons or evidence supporting those decisions.

5. There was often limited or no control over communications into and out of the incident management room. Briefings of Incident Management Team (IMT) personnel were often unstructured.

6. 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.

7. 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.

8. On most occasions important incident management decisions were not made until the mine manager or SSE arrived 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

9. In a number of exercises the Incident control room was poorly resourced, with limited provision of white boards, accurate mine plans, desktop space, communications facilities and security against intrusion.

Decision making

10. All too often there was no record kept of the decision making process.

11. Decision making occurred over too long a time period. There was no sense of urgency, direction or focus – which could be best provided by a clearly stated (and written up) set of Goals, Objectives and Priorities.

12. On more than one occasion there was the development of a Group Think mentality for decision making.

13. Rarely was a formal decision making process established. Little use was made of formal risk assessments in relation to the establishment of mines rescue operational limitations.

14. On at least two occasions, the disjointed flow of people into and out of IMT rooms made it difficult for any risk management assessments to actually reach conclusions.

Duty cards

15. In general the use of duty cards was ineffective. The relevance of duty cards needs to be critically evaluated, as key personnel often did not consult their duty cards at any time during the exercises.

IMT

16. In general there was inadequate provision made for the changeover of the IMT personnel as they became fatigued. Fatigue became a key issue with the IMT as the incident became protracted. The change over of the IMT under these circumstances was never very effective.

17. There was a wide range in the size of the IMT from 2 persons up to 20. There is evidence from the exercises that a group of about 5 persons is most effective, with subordinate groups functioning outside the IMT but reporting back.

These issues lead to the identification of a number of key areas for improvement:

1. Better access to site policies and procedures – both onsite and offsite.
2. Better sharing of information relating to the incident, both on and off site.
3. Objective decision making, including records of process and rationale.
4. Quicker response to incidents.

5. Better focus in IMT – reduction in disruption.
6. Better equipped IMT, to be able to undertake the decision making processes required.
7. Better briefing capabilities to third parties , whether they be relief IMT, mines rescue or other personnel even off site.
8. Improved record keeping.
9. Systematic information flow and analysis.

Developments

A number of these issues have been addressed through an Australian Coal Association Research Program funded project looking at significant incident, investigation, evaluation and analysis. This project has focused on improving the application of electronic technology to assist in the management of significant incidents.

Key tools are:

A. Electronic books – e books

Information sharing can be significantly improved through the use of electronic books 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. Electronic books are very similar to web documents, the key feature is that they operate like paper documents with pages. In addition they are formatted in large size fonts with plenty of white space to enhance their readability. Access is easy via the title page and the table of contents.

An example of an e book as displayed on a Pocket PC is shown in Figure 1 below.

MS Reader is a free program from Microsoft that also acts to convert standard Microsoft Word ® documents into e books at the push of a button. There are a few hidden traps, so the final project report will include a user guide on how best to prepare documents for conversion.

Readerworks is a slightly easier to use and more robust piece of software that does the same job but costs about $ 150 AUD. It also offers a little more flexibility of operation. Both programs are easy to become proficient in.

It is envisaged that the required documents would be accessed via shortcut icons on the user's computer screen.

One of the side benefits of these software is that the e books automatically can be transformed to fit on the pocket pc's.

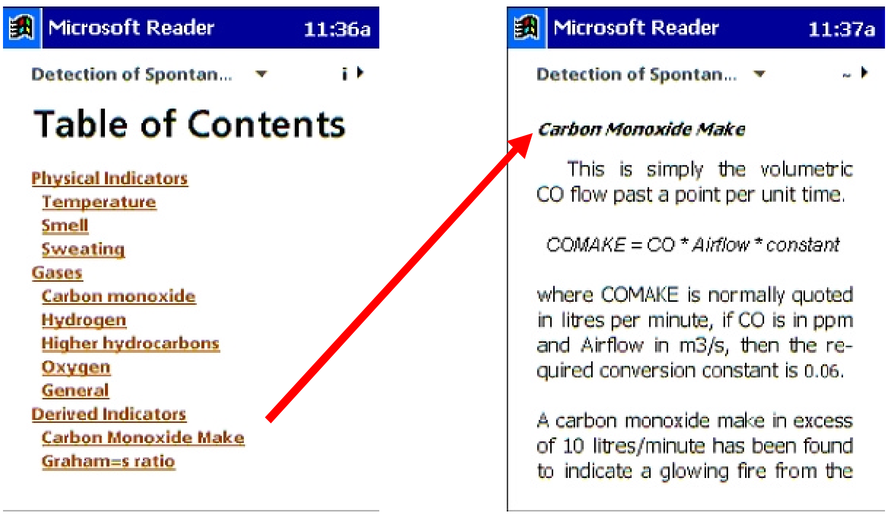


Figure 1. Example of e book screens from a Pocket PC

B. Pocket computers

Personal pocket computers have been utilised in this project to increase the portability of data communication and speed up the incident initiation process. This reduced the delays in responding to incidents. Windows CE compatible devices carry not only the e books but also full internet, email and abridged Microsoft Office software. They are full micro computers running Pentium central processors with many megabytes of memory. This allows for gas interpretation to be done anywhere and the results communicated electronically.

They have their own 56 k modems and can communicate either via Blue tooth technology or infrared technology to other devices including mobile phones.

In an emergency they could:

- carry all the necessary phone numbers and contact details of relevant personnel. The devices can automatically synchronise with contacts databases kept on a computer in Outlook® or similar
- be able to connect to internet to collect latest information and send emails via Outlook® .
- access relevant procedures, duty cards and other documentation to assist in speedy implementation of emergency procedures via e books
- perform calculations on gas concentration data to allow interpretation offsite, using quick data entry as demonstrated in Figure 2 below.

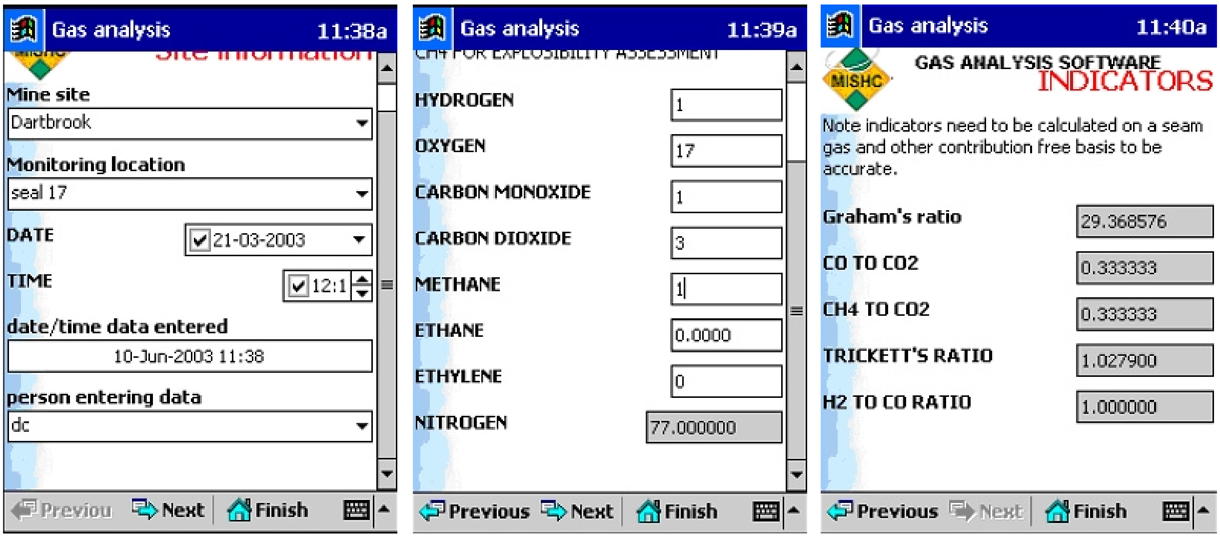


Figure 2. Data entry and analysis screens from Pocket PC Gas Analysis Software

The gas analysis program displayed above was constructed using a front end program called Pocket PC Creations ($ 130 AUD) which uses an MS Access like set of commands to create data entry and processing. The program was constructed in approximately 1 hour and can be modified to include any ratios or other indicators that are considered necessary by the user. The data are stored in files that can be quickly extracted by the host PC when the Pocket PC is synchronised and the data are retrieved via Excel ® allowing more sophisticated analysis and graphical trending to occur. The graphics capabilities of the Pocket PC's are currently being investigated.

C. Generic computer software

In addition to the e books mentioned above, improved information sharing and reduction in disruption of IMT can be obtained through the use of generic computer software that tracks and displays key incident information, and assists in the decision making process by providing a systematic framework to progress the decision making that at the same time keeps a record of the steps taken in making the decision..

Increased use of computers allows sharing of information between a number of locations both on site and indeed 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.

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

Incident decision and event logging software

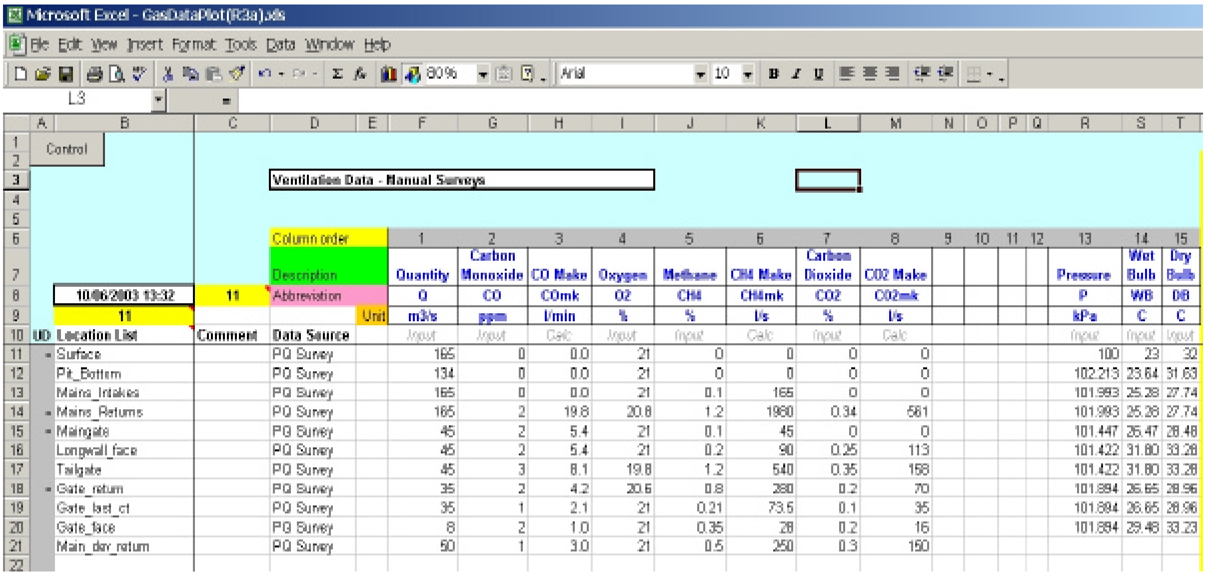
One thing that often is missing from Incident Management Processes is an effective way of logging actions and events, who is responsible and when they are closed out. Dartbrook Colliery have used a simple Excel® spreadsheet utilising the auto-filter function for the columns. Typically the columns used are: date and time, category such as inertisation or drilling, action, who is responsible, complete (Y/N), and comments. This allows quick sorting of the outstanding actions - by those that are not complete, or by category. This also provides a trail of decisions and actions.

Mines are encouraged to develop their own versions that suit their needs. Of course, being a computer file it can be accessed from a range of locations, and emailed etc. This would speed up briefings and allow persons outside the IMT to become aware of the status of an incident without the need to disrupt the IMT or its decision-making processes. The maintenance of the integrity of the IMT would also be enhanced with the following software that allows sharing of other information around a mine site and beyond.

Investigation software

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 Excel ® so that it is not subject to proprietary concerns or huge costs. In addition, as the software is in Excel ®, there should be no barrier to sites will customising the software to their own needs. It can also be used to track the movements of vehicles and persons underground. User guides will be provided as part of the final report to ACARP. Using this software every site has the capability to easily electronically collect and display key information. This information can also be shared offsite readily. These programs could be linked to more sophisticated data analysis packages such as SEGAS PRO, SMARTMATE or HGAS. It is not intended to replace these packages merely to enhance the overall site capabilities for analysis and interpretation.

The data entry to the spreadsheet-based program can be manual or via continuous update per dynamic data exchange facilities available with most PLC run systems. The data entry screen and a typical display screen are outlined in Figures 3 and 4 below. These displays can be tailored to individual needs. Access to the program can then be via the site intranet or on a stand alone PC and the files can be emailed off site for external scrutiny and advice. A user guide will be provided for the package as part of the final report to ACARP. However, the actual program is merely intended to demonstrate what can easily be achieved and it is intended to leave the details to site personnel to create and maintain.



UD	Location List	Comment	Data Source	Quantity (Q, m3/s)	Carbon Monoxide (CO, ppm)	CO Make (COmk, l/min)	Oxygen (O2, %)	Methane (CH4, %)	CH4 Make (CH4mk, l/s)	Carbon Dioxide (CO2, %)	CO2 Make (CO2mk, l/s)	Pressure (P, kPa)	Wet Bulb (WB, C)	Dry Bulb (DB, C)
				Input	Input	Calc	Input	Input	Calc	Input	Calc	Input	Input	Input
-	Surface		PQ Survey	165	0	0.0	21	0	0	0	0	100	23	32
	Pit_Bottom		PQ Survey	134	0	0.0	21	0	0	0	0	102.213	23.64	31.63
	Mains_Intakes		PQ Survey	165	0	0.0	21	0.1	165	0	0	101.993	25.28	27.74
-	Mains_Returns		PQ Survey	165	2	19.8	20.8	1.2	1980	0.34	561	101.993	25.28	27.74
-	Maingate		PQ Survey	45	2	5.4	21	0.1	45	0	0	101.447	26.47	28.48
	Longwall_face		PQ Survey	45	2	5.4	21	0.2	90	0.25	113	101.422	31.80	33.28
	Tailgate		PQ Survey	45	3	8.1	19.8	1.2	540	0.35	158	101.422	31.80	33.28
-	Gate_return		PQ Survey	35	2	4.2	20.6	0.8	280	0.2	70	101.894	26.65	28.96
	Gate_last_ct		PQ Survey	35	1	2.1	21	0.21	73.5	0.1	35	101.894	26.65	28.96
	Gate_face		PQ Survey	8	2	1.0	21	0.35	28	0.2	16	101.894	29.48	33.23
	Main_dev_return		PQ Survey	50	1	3.0	21	0.5	250	0.3	150			

Figure 3. One of the data entry screens from the visualisation software.

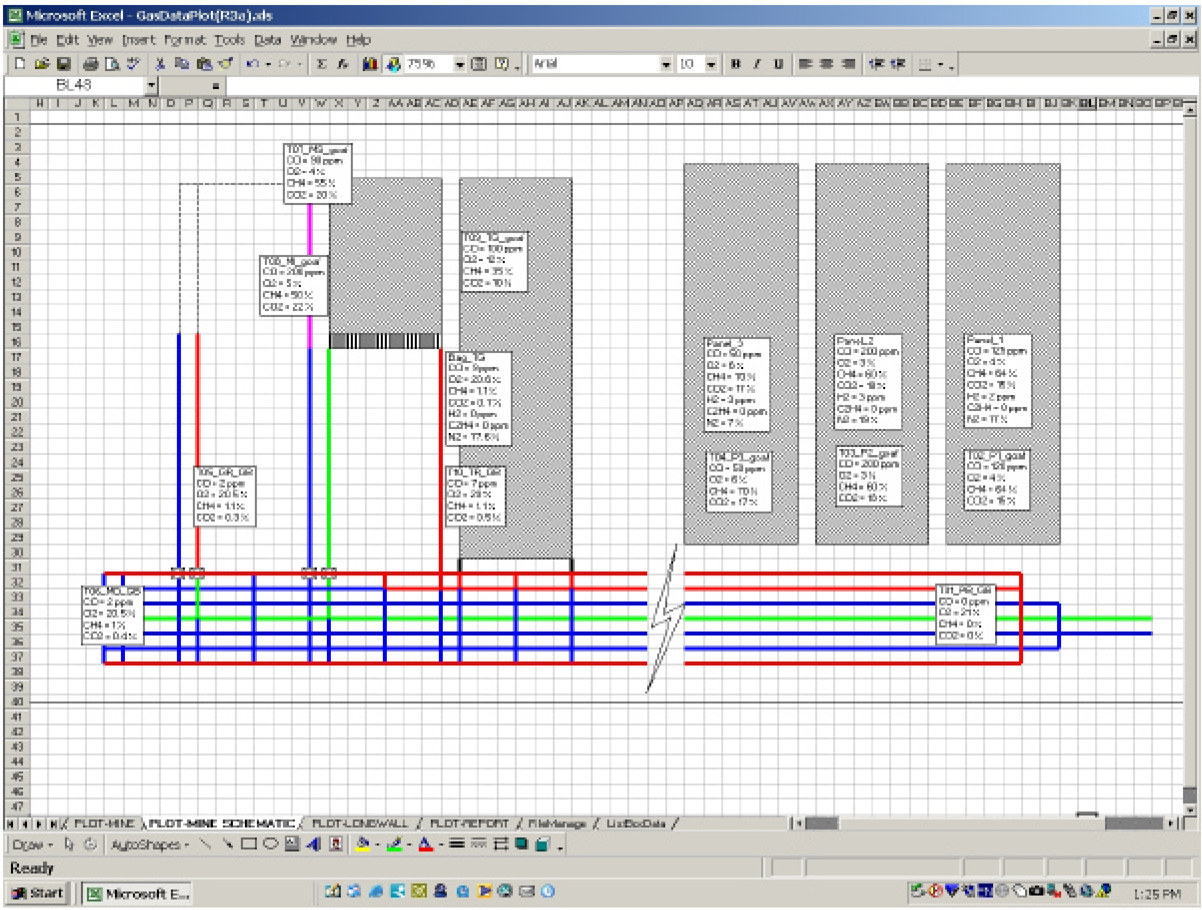


Figure 4. One of the possible data display screens.

The key to the program is a series of macro commands that translate data into graphic boxes that can be displayed on mine plans. This enables better visualisation of incidents. Using the drawing feature in Excel®, other features can be added such as the location of faults or personnel. Figure 4 was entirely created within Excel®. The graphic boxes are fixed in location relative to each other which allows for zooming in and out of the display.

Decision making assistance

A number of free or low cost decision-making and logic tree programs have been trialed to assist in more effective decision making. Decision trees have been developed for a number of scenarios. These will be provided to ACARP as part of the final report and may be used as templates if appropriate. These software track the decisions made and log the rationale behind each decision. Figure 5 shows an example of the simple graphical output from one of these computer programs - REASON!ABLE®.

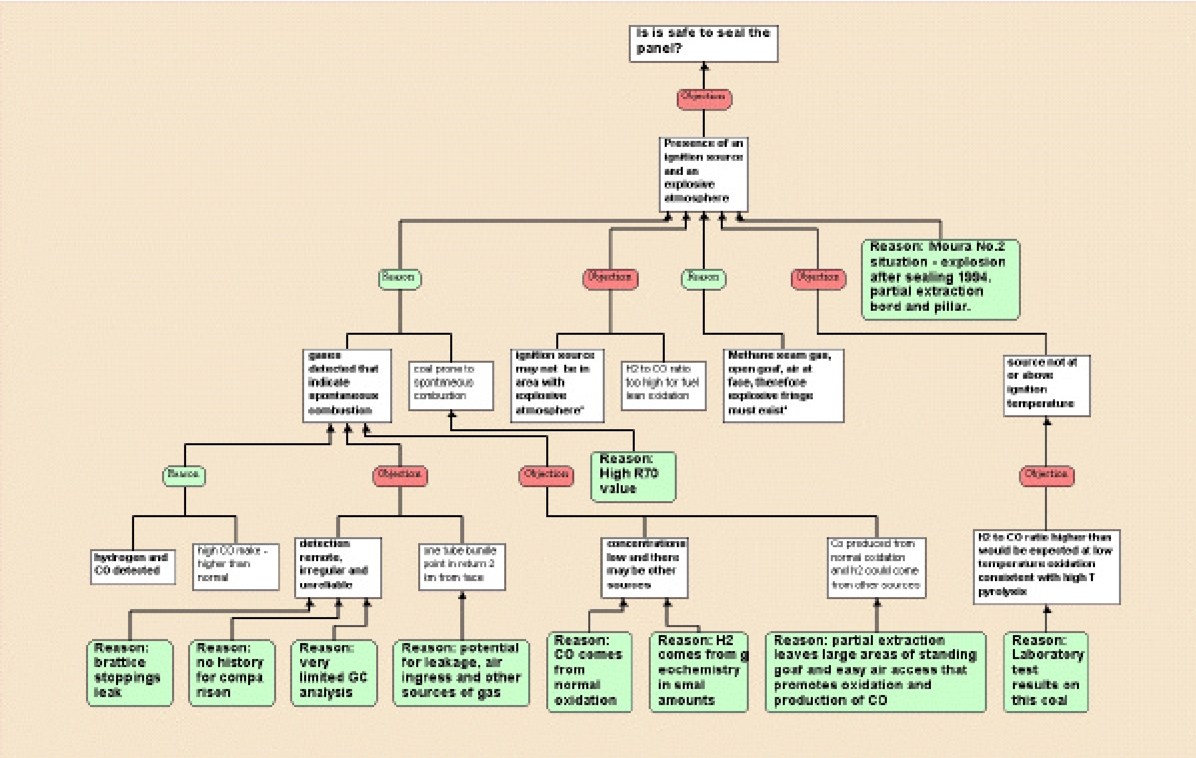


Figure 5. Decision making flowchart example.

This program can then be used in evaluation mode to assist in the decision-making process by documenting the ranking of the reliability and degree of certainty of the decisions as shown in Figure 6. This in turn allows a degree of certainty to be attached to decisions and also areas that need clarification can be quickly identified.

The decision-making process has deliberately been left in the control of the IMT. The electronic devices merely provide aids to improve the quality and the speed of the decision making process. They also provide a record of the process for external review and revision.

It is hoped that for the major risk scenarios at each mine the essential decision trees will be determined in advance. Should the scenario actually eventuate then the tree would only need minor modification and validation of areas of uncertainty before it can be used to assist in the decision making process. Examples of these trees could include the sealing of a longwall panel, a vehicle fire, belt fire, spontaneous combustion in a goaf, or an outburst.

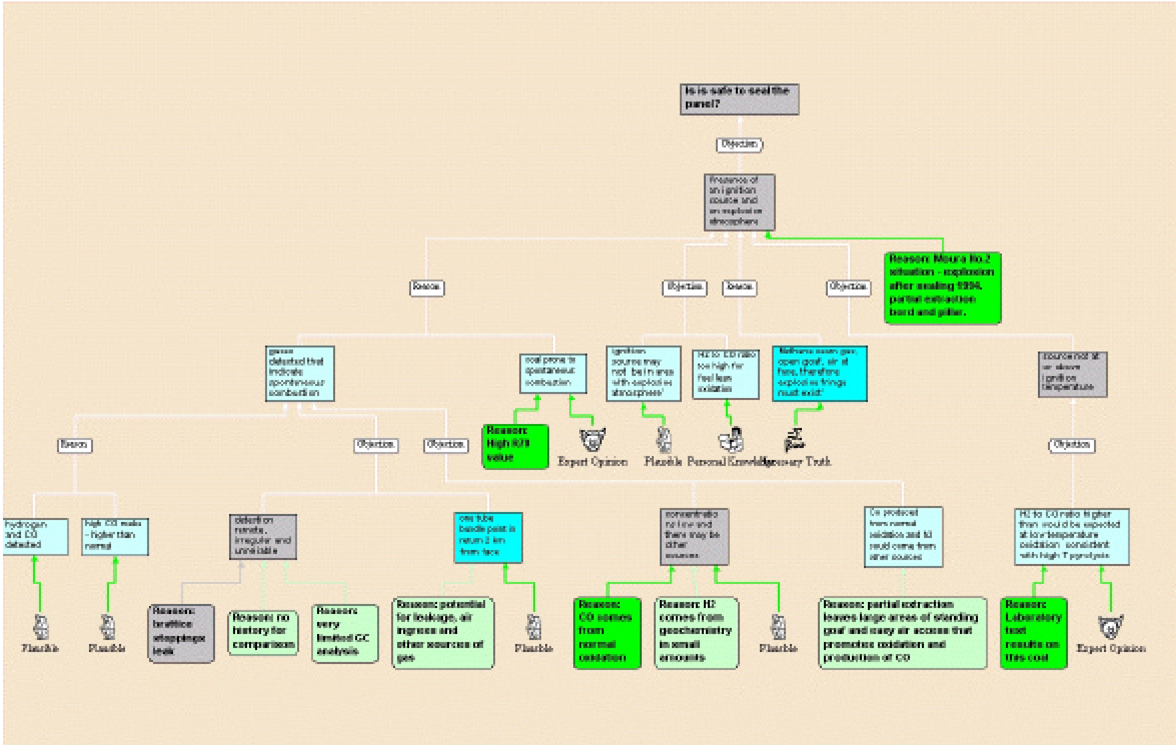


Figure 6. Example of evaluation mode for the REASON!ABLE ® software.

The Future

A logical extension of this project would be to expand the capabilities of the system to record the actions of mines rescue teams and plot their progress during incidents, keeping track of time under supplied air etc. Mines rescue guidelines will be converted to e book format for ease of use. This project extension is the subject of an application for funding to ACARP at present.

Conclusions

This project has demonstrated that we can significantly improve the management of significant incidents by the use of simple computer based programs that remove the need for verbal or paper communications and reduce time lost in collecting and providing information to various parties. The use of Pocket PC computers can increase the portability of information and can significantly reduce the delays in effectively responding to significant incidents. These tools, in their current format, should only be viewed as a starting point for sites to take and develop themselves, as appropriate to their needs. Development requires no specialised computer skills or expensive proprietary software.

The project aimed to demonstrate how this could be achieved but not dictate how it must be done. The responsibility for making decisions resides with the IMT, but hopefully these tools will make their job easier.

One of the key issues with such tools is maintaining familiarity with its use; if it is only used during a significant incident then people will forget how to use it. All the tools outlined above can equally assist in the day operation of the mine and should be used regularly, for example: during routine sealing of a panel.

Acknowledgements

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References:

J Hetherington (1976) Review of an incident at Avon Colliery and dangers associated with fires on machinery underground, Colliery Managers' Association NSW Symposium on Mine Fires, pp 33 – 51.

R J Kinimonth and A E J Fisher (1981) Appin Colliery Belt Drift Fire, The AUSIMM Illawarra Branch, Ignitions, Explosions and Fires in Coal Mines Symposium, pp 17-1..17-8

G Rowan, G Dalliston, M Wood, D Kerr, S Shepherd, D Cliff, I McDonnell, J Oberholzer, M Bird and G Hunt (1998). *Mine Simulated Emergency Evacuation Exercise at Southern Colliery Tuesday 27th October 1998 Industry Report*, Safety and Health Division of the Department of Mines and Energy

G Rowan, D Cliff, G Taylor, N Gow, G Dalliston, R McKenna, R Freeman, B Kathage, J Rowe, B Morrall, S Shephard, M Ryan, K Singer, A Best, T Hemley, N Winkelmann, C Klease, A Monagahn, S Cory, I McDonnell, J Oberholzer, M Bird and G Hunt (1999). *Mine Simulated Emergency Evacuation Exercise at Kenmare Colliery Tuesday 7th September 1999 Industry Report*, Safety and Health Division of the Department of Mines and Energy

G Rowan, D Cliff, G Taylor, M Smith, B Lyne, P Baker, N Kathage, N Gow, J Oberholzer, J Thomas, M Wood, M Bird and G Dalliston (2000). *Mine Simulated Emergency Evacuation Exercise at Newlands Colliery Saturday 25th November 2000 Industry Report*, Safety and Health Division of the Department of Mines and Energy

G Rowan, D Cliff, T Jackson, M Smith, P Baker, M Watkinson, J Marshall, T de Santis, M Bird, W Pendlebury and G Dalliston (2001). *Report on an Emergency Exercise at Kestrel Colliery 27 November 2001*, Safety and Health Division of the Department of Mines and Energy

Rowan G, Dalliston G, Bird M, Baker P, Downs M, McCamley M, Watkinson M, Cliff D, Singer K, Olsen M, Beveridge P, Purse A, Hartley W and Randolph N, (2002). *Report on the Simulated Emergency Exercise held at North Goonyella Coal Mine, Monday 4 November 2002.* Safety and Health Division of the Department of Natural Resources and Mines.