SAFESIM*: Simulating Mine Emergencies

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ABSTRACT

Mine emergency exercises are required by legislation in Queensland to test the readiness of a mine's emergency response system. The effectiveness of such exercises relies heavily on the realism that can be generated both underground and on the surface. One area where realism is very important is in the control room. An authentic environmental monitoring system that duplicates the actual system used by the mine enables monitoring data to be collected and used throughout the exercise. Enabling alarms to sound as they would in a real scenario greatly adds to the atmosphere and tension in the control room and also provides information to those on the surface in the form that they would receive it in a real situation, allowing them the opportunity to determine what is happening underground.

SIMTARS has developed SAFESIM, a software package capable of emulating the environmental monitoring system at most Queensland underground coal mines. To the operator it appears exactly the same as the real system. This enables real time training of environmental monitoring system users and facilitates emergency response simulations, which can be desk top exercises or whole of mine trials. The software package is able to simulate any environment-related situation that can occur at an underground mine.

1.0 INTRODUCTION

A full-scale emergency exercise is conducted by the Queensland Department of Mines and Energy (DME) once per year at a designated underground coal mine. The exercise aims to test the readiness of all emergency resources throughout the State, as well as on the mine site, to respond to an emergency situation at the mine. This fully documented exercise allows areas for improvement to be identified. Conducting an exercise on this scale requires a large amount of planning and coordination and is expensive for both the mine and the DME. In addition to the DME coordinated exercise, all other mines are required to conduct an exercise at least once per year that tests the emergency preparedness of the mine site.

The success of these emergency exercises is heavily dependent on the planning and coordination aspects but is equally dependent on how much the exercise feels like an actual event to those involved. To heighten realism in the underground environment obscured safety glasses or goggles are commonly used to impair the visibility of those escaping and persons whose actions or circumstances would result in their death can be detained underground by auditors so that those on the surface are unaware of their location or status, as would be the situation in an actual event.

On the surface personnel are focussed on providing a timely and appropriate response. The basis of any emergency response is to first gain an understanding of what has happened in order to predict what the environment underground may be like, to assess the likelihood of survivors and the probable locations of any survivors, to assess the possibility for safe entry to the mine in order to rescue missing persons and to determine the course of action required to control the incident and safely recover the mine. A major influence in making judgements on all of these aspects is the information provided from the mine environmental monitoring system. In cases where underground communications are lost this may be the principle influence.

* SAFESIM WAS ENTERED UNDER THE NAME OF MEMSS IN THE INNOVATION AWARDS AT THE 1999 QMISHC.

Consequently simulating the environmental monitoring system of a mine during an emergency exercise strongly affects the realism of the exercise for those involved in the exercise on the surface as well as providing a number of other important benefits. These include:

(a) the control room operator (CRO) experiences the monitoring system responding as it might during an emergency, an experience that would otherwise only be gained during an actual event where lives may be in jeopardy,

(b) the limitations and shortcomings of the environmental monitoring system can be discovered and understood, allowing improvements to be made both to the system and in the training of CRO's,

(c) identifying if information acquired by the mine monitoring system is being used to its full advantage and interpreted properly,

(d) tracking the transfer of information from the mine environmental monitoring system to those involved in the decision-making process to ascertain if information is being lost during the transfer, and,

(e) determining whether information provided by the monitoring system is being verified.

2.0 MOTIVATION AND DEVELOPMENT

Two distinct needs were identified as motivation for creating SAFESIM:

- The first annual emergency response exercise held at Southern Colliery in Central Queensland in 1998 clearly showed that there was a lack of realism in the control room during the incident as data from the site environmental monitoring system was only available on paper, presented by the auditor and not through the actual computer terminals as would be the case in a true emergency.

- CRO's need practice in operating the environmental monitoring system at the mine not just in routine operation but also in undertaking the tasks required during a potentially stressful emergency situation. At present CRO training is carried out through separate training courses which can only address some of the functions required during an emergency incident. For effective training the CRO needs to carry out all the functions required of him/her during an emergency; such as phone contacts, DAC operation, and logging of information as well as accessing the environmental monitoring system computer.

The Southern Colliery exercise clearly indicated that it is only when all emergency response actions are required to be performed that flaws in the system can be exposed and rectified. The exercise also demonstrated the importance of many of the protocols that seem tedious in normal day-to-day operation of the monitoring system. To address these needs, SIMTARS developed a simulator software package which can emulate a mine environmental monitoring system based upon the SIMTARS SAFEGAS system.

The comments and feedback from the committee coordinating the annual emergency exercise, personnel from Southern Colliery and other members of the industry were considered in the development of this simulation software.

3.0 HOW SAFESIM WORKS

Programmers at SIMTARS have written a software package called SAFESIM that basically introduces a data set to the SAFEGAS program just as the information would be presented from a mine environmental monitoring system. The program allows a person, the SAFESIM manager, to influence the data prior to it being presented to SAFEGAS.

As far as the computer operator using the SAFESIM-based SAFEGAS software is concerned it is a real system receiving inputs in real time exactly as their normal system would and reacting to their actions just as their normal system would.

Figure 1 illustrates the how SAFESIM operates. The process starts with a host computer containing a data set from the mine site which can be modified to include a basic scenario such as a belt fire or explosion. This data is then sent to the emulator where the SAFESIM manager can further modify the data in real time to reflect either a change in the incident from the script or due to the actions of mine personnel.

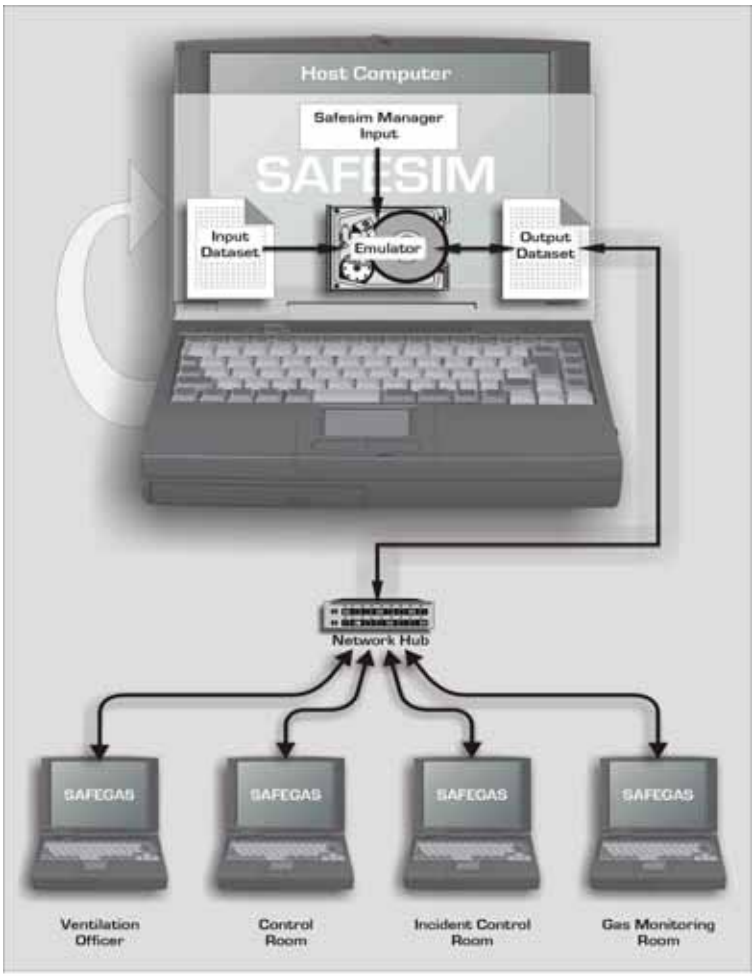

Figure 1
Operational schematic of SAFESIM.

Figure 2 shows the SAFESIM control panel. Using this interface the SAFESIM manager can introduce gas mixtures from a range of sources at variable rates. This interface can in fact be used to create the initial input data file if desired. At present the system relies on the gas mixtures coming from a single location with fixed details on the time taken to arrive at monitoring locations.

The data from SAFESIM is then stored in a database which is accessed by a network of computers emulating the current SAFEGAS system at the mine site. As far as the site operators are concerned they can see no difference between SAFESIM driven system and the normal SAFEGAS system.

A SAFESIM simulation together with SAFEGAS includes the following features:

- The actual mine site plan
- The actual mine alarm settings

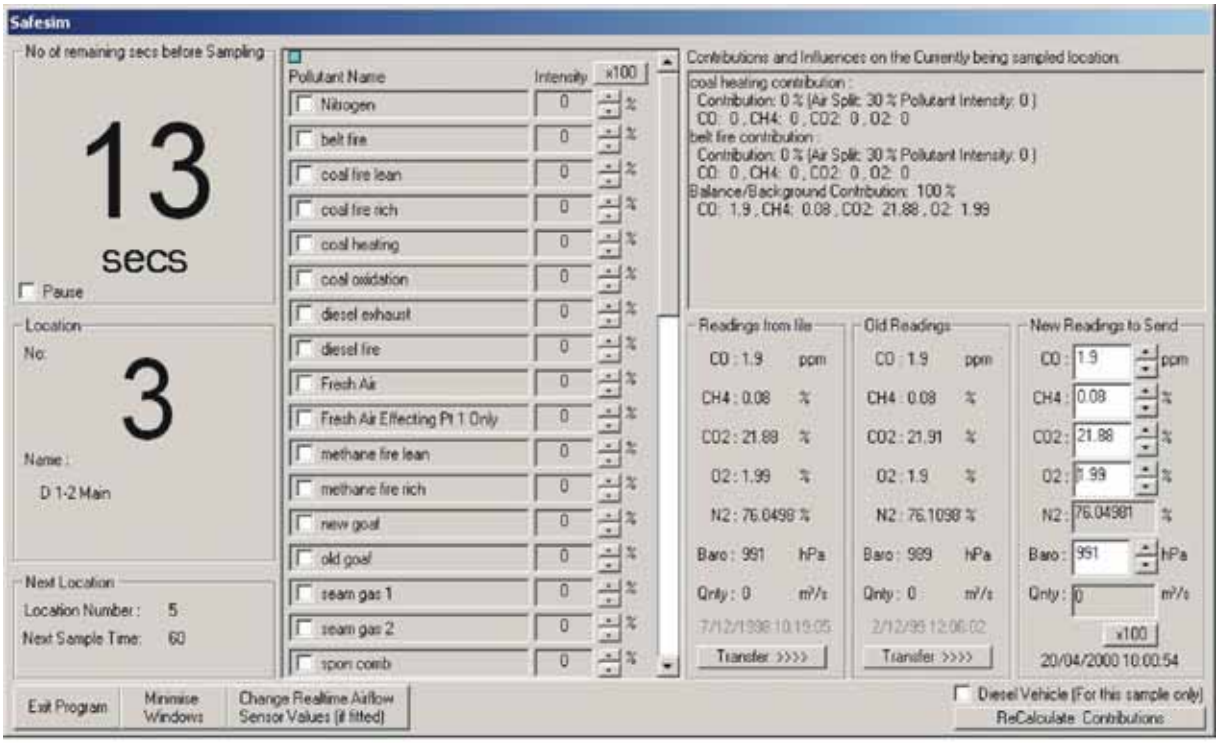

Figure 2
SAFESIM Interface

- The actual mine environmental monitoring system access and acknowledgement protocols
- The actual mine sampling regime for sequencing tubes
- Full SEGAS access for data trending and interpretation of gas data collected
- The ability to modify the data set in case of alterations to the sampling regime or control actions at the mine
- Remote terminals connected via a local area network to provide access to the system at those locations the mine site has SAFEGAS normally operating
- Full data on those gases not available on the environmental monitoring system in case supplementary sampling and analysis by GC is undertaken as part of the exercise
- All parameters logged at the mine site including air velocity, pressure etc can be modified not just the gas concentrations
- Emergency simulations for coal fires, wood fires, methane fires/explosions, diesel emissions, goaf gases, normal oxidation and other user specified pollutants.
- Complete separation from the mine computer system thus protecting the mine operation from any interference and allowing normal operation to continue within the mine. At no time does the simulator override the actual mine environmental monitoring system.

4.0 PERFORMING A SIMULATION

The basic process in setting up SAFESIM to run a simulation for a mine environmental monitoring system is depicted in Figure 3.

One of the first steps taken is establishing a realistic emergency scenario for the mine concerned. This involves consideration of past incidents and history at the mine as well as characteristics of the mine such as seam gas, geology, mining methods and ventilation techniques. It is important that the scenario used is credible to those involved. If this is achieved personnel are more likely to take the exercise seriously. After the exercise, areas for improvement are held in higher regard if people feel that the incident could really occur at the mine.

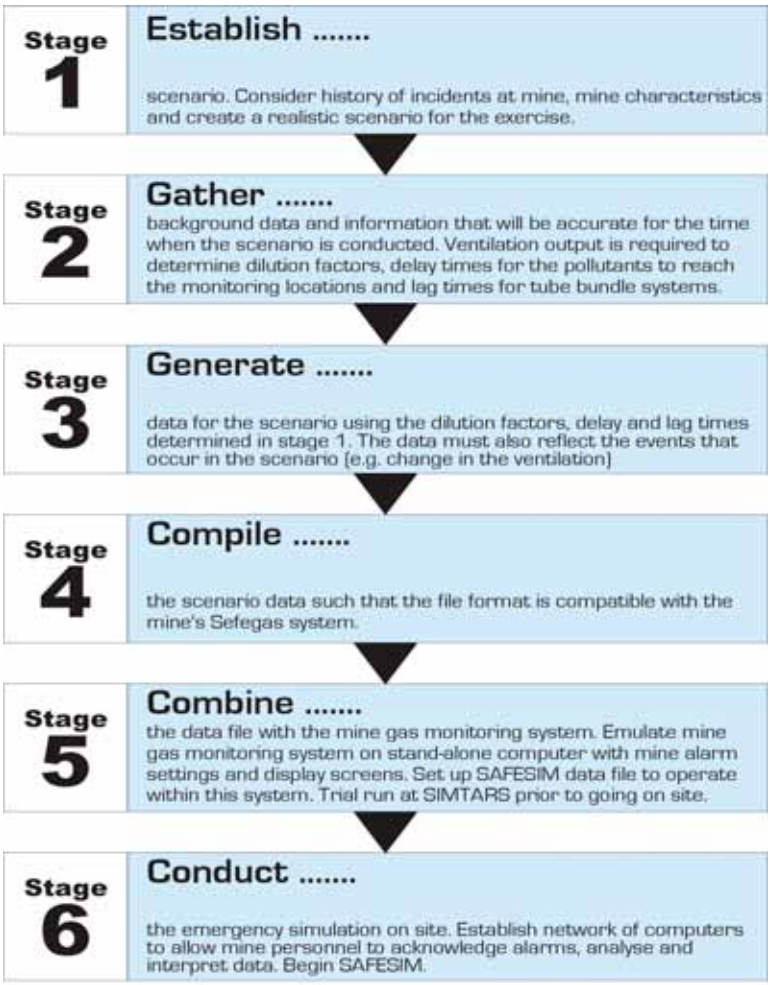

Figure 3
Undertaking of simulation using SAFESIM.

A typical set of data is obtained from the mine environmental monitoring system database and is used as the basis for establishing a data set that contains the environmental data as a result of the scenario established above. Mine plans of the ventilation network together with monitoring locations and recent

ventilation survey data are required. A ventilation network simulation model is also obtained if it is available, otherwise such a network is established using available pressure-quantity survey data. The ventilation arrangement at the time of the scenario is also obtained from the mine and this network is used to provide the necessary information to support the data generation process. The lag times for the tube bundle tubes are also required to ensure that the data reports to the SAFEGAS in the correct sequence and at the right time.

The location of the incident determines the times for pollutants to travel to each of the monitoring locations and dilution of the pollutants that occurs due to mixing of air streams. These values must be entered for each of the monitoring locations when starting SAFESIM so that any changes made by the SAFESIM controller during the incident are seen at the monitoring locations at the appropriate times and at appropriate concentration levels.

The time to prepare a data set for an emergency exercise can be in the order of several days and depends largely on the complexity of the ventilation network, the number of monitoring locations, the scenario being simulated and whether an existing ventilation model is available. This task must be undertaken by a person experienced in ventilation and the interpretation of mine fires and explosions.

A copy of the mine environmental monitoring system is obtained by SIMTARS computer programmers. Using this information the system is set-up to incorporate the data set that has been generated for the exercise. The system includes the mine's alarm settings, alarm acknowledgement and security protocols. The monitoring system is programmed to be the same as it will be at the time of the exercise.

Prior to going to site to undertake a simulation, a test run is conducted to ensure that the data set and monitoring system are compatible. Problems with the system during an exercise must be avoided at all costs.

The system can operate on the mine's own computer system however given the need to protect the environmental monitoring system from any problems no matter how remote, it is not advisable to use the normal mine computer system in case the emulation interferes with the normal environmental monitoring system. Indeed SAFESIM has been designed to operate completely independently of the mine system in order to allow the mine system to continue monitoring the mine throughout the duration of the exercise. Thus the mine environmental monitoring system is not compromised and the safeguards to the mine afforded by the system remain in place.

A network of computers is established for the simulation which represents those computers which would actually be available in a real situation, that is, only those computers that have the mine environmental monitoring system installed and operational. A series of lap top computers are linked to allow the simulation to be controlled by a single person. That person initiates the exercise and then monitors the actions taken which may influence the pre-determined data set. Alterations can be made during the exercise to reflect these influences and maintain the realism of the exercise.

5.0 FUTURE DEVELOPMENT

SIMTARS is currently investigating the extension of SAFESIM to include environmental monitoring systems other than SAFEGAS. This would enable simulations to be undertaken at mines throughout Australia and overseas. The training capability is currently being assessed with respect to including expert system support on interpretation and self paced tutorials with guides and interactive questioning.

The input of multiple dilution and delay times for pollutants reaching the monitoring locations will better reflect the influence of different air streams on a single monitoring location. Currently the system only allows an initial input of dilution factors and delay times which means using SAFESIM for the generation of the data file is very tedious as the data file must be interrupted each time a different dilution factor or delay time for pollutants in reaching the monitoring location takes effect. Data generation to date has been done using a spreadsheet package.

In addition to entering multiple dilution factors and delay times at the initial stages of the simulation the ability to change dilution and delay times for one or more monitoring locations during a simulation would improve the SAFESIM manager's ability to respond to unexpected developments throughout the exercise. This aspect would be especially important where changes were made to the ventilation network during the exercise, or where tube bundle tubes were damaged as a result of a secondary explosion or developing fire.

The ability to input gas mixtures at multiple locations would also be useful. This would require dilution factors and delay times for each monitoring location with respect to the ventilation from the point of origin of the gas mixture. This would complicate the simulation and require that dilution factors and delay times be calculated quickly as the exercise progresses, which is difficult to do with the ventilation modelling package that has been used.

A further improvement that has been identified is the ability to take out a real-time monitor at the SAFESIM manager's discretion. Perhaps a secondary explosion or simply the loss of communications to a number of monitors may be appropriate as the exercise proceeds.

Using SAFESIM in training courses is an obvious short term application and plans are already in place to do this. Emergency exercises where SAFESIM is used are effectively training opportunities for those involved. Networking a number of computers will allow a number of personnel to use a single data source and respond to a situation and interpret the gas data that is available to them at their own pace.

Longer term improvements to SAFESIM that have been identified include:

- Alterations to the ventilation modelling package to output dilution and delay times directly for each different air split in order that input data for SAFESIM is more rapidly available, especially where a number of changes occur on a frequent basis.
- Link a ventilation modelling package with SAFESIM such that output automatically registers with SAFESIM and the data set is updated automatically with any ventilation changes.
- Develop the program as an interactive training package for decision-making in emergency response situations and allow access to this training via the Internet so that persons can undertake the training at their own convenience, yet be able to contact SIMTARS for assistance when necessary.

6.0 CONCLUSIONS

SIMTARS has developed SAFESIM in response to needs identified to improve the realism in the control room as well as the training available to control room operators and other personnel interacting with mine environmental monitoring systems. Efficient information interpretation will reduce the risk of mine personnel being exposed to hazardous situations and facilitate safe, informed and accurate rescue and recovery operations. It is also anticipated that SAFESIM will also allow mine operators to more readily identify areas for improvement in their mine environmental monitoring system and emergency response system.

There is great potential for further development of the package to include more detailed simulations and self-paced training applications and SIMTARS will be committing programming resources to achieve this aim within the next 12 months.