Nexsys™: a real-time risk management system

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Abstract

Monitoring dangers in underground coal mines requires constant surveillance of numerous factors, including data from various sensors and systems, to avert disaster and achieve zero harm in the mining environment. This amount of data can be overwhelming for control room operators, which highlights the need for mine data integration into one concise view for easy interpretation and decision support. This is the role of the Nexsys™ Real-time Risk Management system, initially designed for the underground coal mining industry.

Nexsys™ integrates traditionally incompatible data from a variety of proprietary mining systems, for which it provides real-time analysis and an anomaly detection capability. This brings valuable information to hand in a succinct view to assist in making the best possible decision about what to do in a potentially risky situation. The system, commencing as a CSIRO research project with Australian Coal Association Research Program (ACARP) and Japan Coal Energy Center (JCOAL) funding, is now available as a commercial product through Mining Logic Solutions (MLS).

While Nexsys™ was primarily designed to address the needs of the underground coal mining industry, other potential applications include surface coal mining, metalliferous mining and miscellaneous hazardous worksites, providing the potential to reform safety across these industries.

Introduction

The inherent dangers in underground coal mining are many and are problematic in coal-producing countries worldwide. Fires, explosions, roof falls and flooding are just a few of the life-threatening and costly risks imposed by the mine's structure alone, combined with human factors such as the dangers of using machinery, large trucks and vehicles in general, which are persistently affecting this industry.

The magnitude of the risks involved can be seen through various historical incidents and statistics; approximately 6000 people died in underground coal mines in China in

2002 (Tu, 2007), and more recently, the disaster at the Pike River Coal Mine in November 2010 that killed 29 miners has brought home how volatile an underground coal mine environment is when something does go wrong. That underground conditions can become so serious that rescue teams cannot enter and mines are sealed for years while underground fires continue to burn is indicative of the magnitude of this problem.

It seems straight-forward that many incidents could be predicted or avoided if sufficient data was available to mine personnel describing the mine state before an incident. Studies have shown that in past incidents sufficient data has been available but in overwhelming amounts and in disparate formats, which, if interpreted effectively, could have assisted in avoiding such incidents (Addinell et al., 2005).

It would appear that if incidents can be predicted or even prevented based on the availability of data interpretable into clear and concise mine state information than the solution could be provided by technology. Such technology would have a number of goals.

Superfluous amounts of data about the mine streaming into the control room every second need to be filtered and transformed into concise and straight-forward information for risk analyses and decision support for mine personnel such as control room operators. Risk analyses are often only carried out manually before new work is commenced in a new area of the mine; it would seem that automating this process so that risk assessments could occur more often would greatly improve the safety of the mine.

Where mine processes cannot be automated and mine personnel need to become involved, effective mine communication seems to be an essential element. This has improved in recent years with the evolution of mobile phones and SMS, email, and the development of underground coal mine messaging systems. However, these systems are often disparate from the data analysis that occurs in the mine and a control room operator is generally required to coordinate communication between mine monitoring systems and personnel. When overwhelming amounts of data are available and hard to integrate this can challenge any person’s cognitive abilities.

The Nexsys™ Realtime Risk Management system

CSIRO research early last decade indicated a requirement for improved decision support systems in underground coal mines. It was noted that there was a surplus of data coming from mining systems but a lack of information that was regularly extrapolated. One of the main complains from control room operators was the number of false or unimportant alarms that were flooding the control rooms and diverting operator’s attention away from the major issues.

This research motivated the development of the Nexsys™ Real-Time Risk Management System which aimed at collating various data into a concise view of the abundant mine-wide data for quick, easy and accurate information exchange and decision support, particularly during incidents or in emergency situations.

Real-time critical data monitoring

Nexsys™ gathers data continuously from a variety of mine-based systems which it integrates and monitors using a rules-based engine. This rules engine is capable of triggering various responses (see Figure 1), including triggering alarms and auto-responses like contacting personnel according to the mine's Trigger Action Response Plans (TARPs), which are also made available for display, using a variety of methods dependent on the person's location. These methods include contact via messaging devices (the system is currently integrated with Northern Lights Technologies) when personnel are underground, via email while in the office or via SMS when offsite. The rules engine notifies the control room operator of the state of the mine not only through alarming, but also via the mine risk profile, based on a standard mine risk profile template.

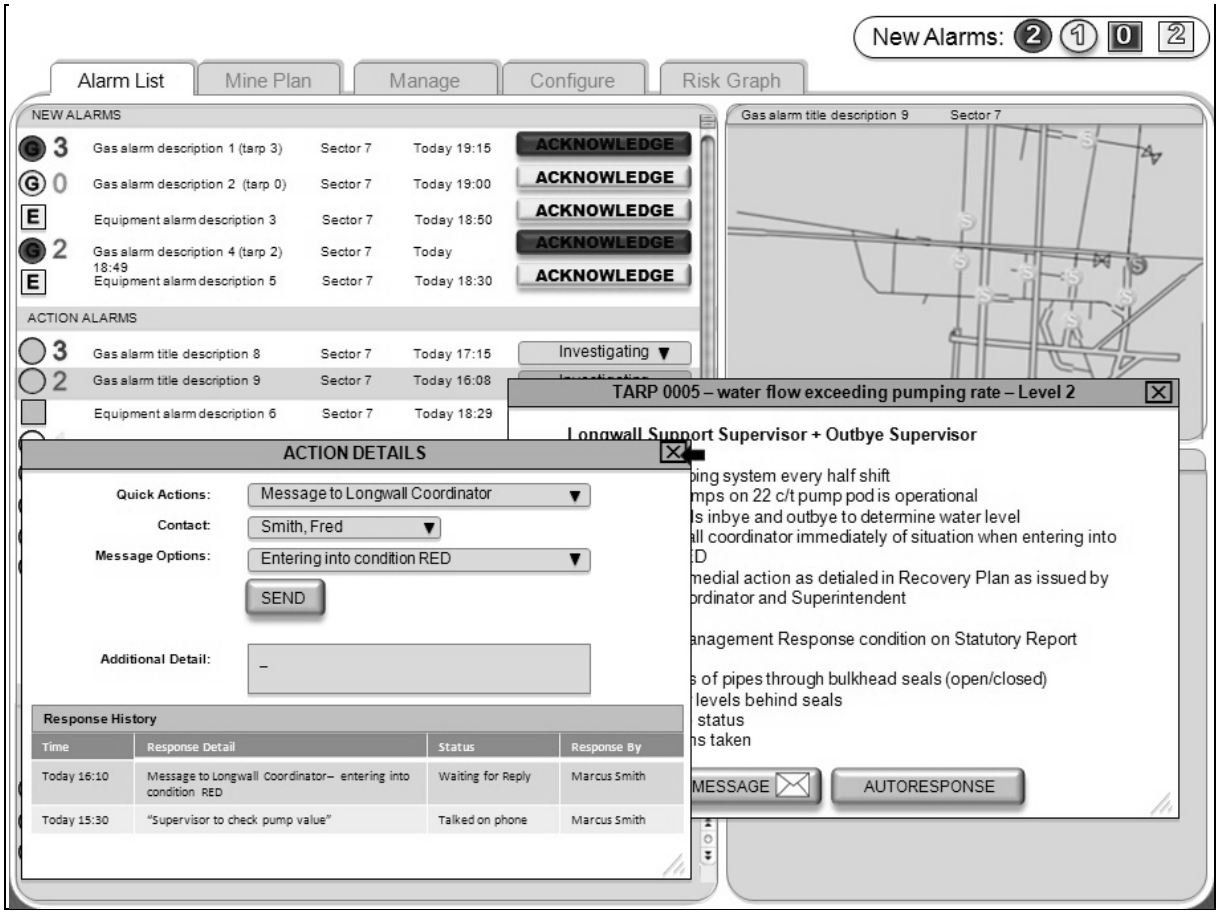

Figure 1. The Nexsys™ Alarms view with TARP and Action details showing.

The Nexsys™ rules engine can also draw information not only from the available data from connected mine systems but also from the Nexsys™ Anomaly Detection module, which is capable of monitoring the mine data, making predictive analyses and detecting anomalous data, which may be indicative of a true alarm (see Figure 2) or a false/unimportant alarm (see Figure 3). If an alarm is triggered by anomalous data, this implies an unexpected mine state and an increased likelihood of a true or emergency alarm. If an alarm is not triggered by anomalous data but, for example, a fixed threshold, this could imply that the mine state was predictable and not

unexpected based on normal mine activity, and hence the alarm is likely to be false or unimportant or may be an artifact of the restricted applicability of fixed alarm thresholds. Fixed alarm thresholds can be problematic, for example, when there is a spike in gas concentrations based on normal mine events, such as a vehicle travelling past a gas sensor. While this may cause gas readings to exceed a fixed threshold, moving thresholds based on the Anomaly Detection module predicted gas concentrations can avoid these false or unimportant alarms that are only indicative of everyday mine activity.

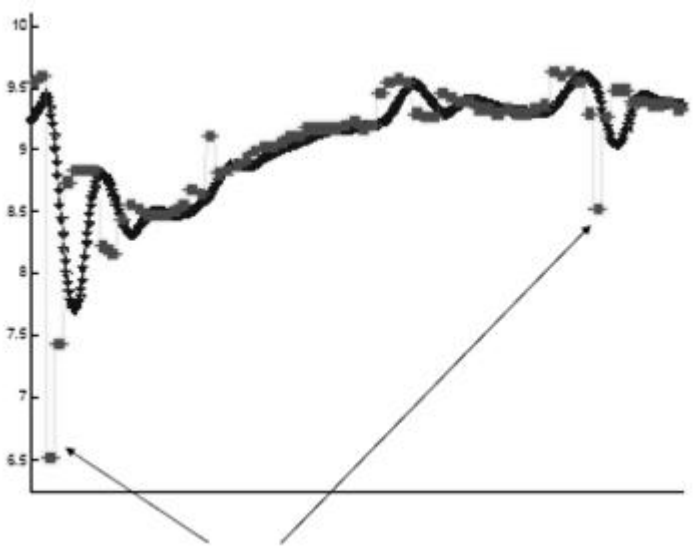

Figure 2. The Nexsys™ Anomaly Detection module predicting True Alarms, triggered by data anomalous to the predicted values.

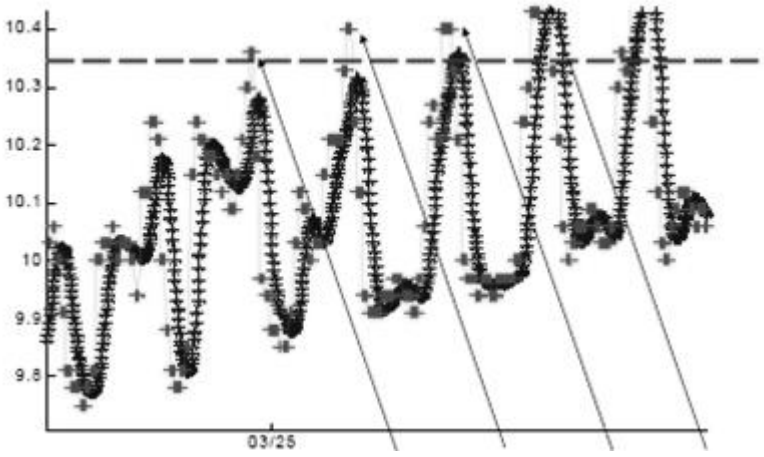

Figure 3. The Nexsys™ Anomaly Detection module predicting False Alarms, demonstrating that while trigger values may exceed a fixed threshold, they are not anomalous from predicted values under normal mine conditions. This analysis was motivated by the occasional insufficiencies of fixed thresholds.

Concise Mine View

Another format via which the Nexsys™ system displays the mine state is its mine plan view (see Figure 4). The system automatically updates to display the latest mine plan available, which it uses as a basis to display mine data spatially.

The system is ultimately configurable as to which systems can be integrated but a standard Nexsys™ installation would typically display the following information in the mine plan view: gas and equipment sensors can be located on the mine plan, with their current state or reading displayed, as drawn from the mine SCADA system, typically Citect, as well as personnel, vehicle and equipment location, as typically drawn from a combination of the HR database (when specific roles of personnel are required) and the Tracking and Messaging System. While Nexsys™ currently integrates with NLT, the system has the potential to connect to any tracking system. In addition, ventilation parameters, video camera footage, entrances, egresses and airflow, all of which can be useful in the case of an incident for example, where the mine needs to be evacuated, can be shown on the mine plan.

Figure 4. The Nexsys™ Mine Plan View showing live camera feeds, gas sensor locations, charted gas trends, and personnel locations.

The Future of Nexsys™

Since the commercialisation of the Nexsys™ Real Time Risk Management system, there have been varying requests for the technology from the mining industry largely due to the 4-dimensional rules engine and personalised interfaces, which allow Nexsys™ to address and solve the many and differing problems encountered at the mine sites. The Nexsys™ system versatility enables a high degree of customisation; industry requirements can be easily matched and range from whole of mine monitoring to specific tasks within the mine:

1**) Whole of Mine Monitoring** has been demonstrated during the final pre-commercial mine trial raising customer confidence in the capability of Nexsys™ to undertake monitoring and decision support for management and operators.

2**) Multiple Mine Monitoring** allows data and information exchange and reporting in real time among a number of company sites and/or directly to the Corporate Office. Data and information flow includes localisation and monitoring of personnel underground as well as production and safety statistics. Any major (red) alarms can be shown in real time to the relevant manager in the corporate office.

3**) Pit to Port Capability** extends the Nexsys™ capability beyond the mining operation and includes a number of Nexsys™ servers linking the pit, the loading and rail systems, and the port infrastructure to a Remote Operations Centre. The Remote Operations Centre, hosting equipment specialists and managers, will enable the use of information from the entire business operation towards increasing business efficiency and safety across the entire supply chain through elimination or reduction of bottlenecks and quick, specialised responses to alarms and breakdowns in real time.

4**) Specific Tasks within the Mine** rely on the Nexsys™ capability to be scaled down to provide support in specific areas that the mine hopes to improve, for example:

a) *Automation of Principle Hazard Management Plans (PHMPs)*, called the Nexsys™ – Control, is an interface located in the Control Room specifically ensuring that safe mining conditions are prevailing within the mine at all times (Figure 5). If these conditions are broken, Nexsys™ – Control will alarm and provide the Control Room Operator with:

- The PHMP that has been activated
- The TARP triggered in response to the alarm (this TARP is presented on the operator's screen)
- Detailed actions to be performed and by whom
- The Communications window, which can send information to other participants in actioning the TARP. Communication can be sent to email or Cap Lamp. If communications are performed verbally, comments can be entered within the communications box
- Acknowledgement (tick) boxes to allow the control room operator to quickly mark off completed tasks. This information is stored in an audit log that records all the information for the alarm for further investigation and auditing.

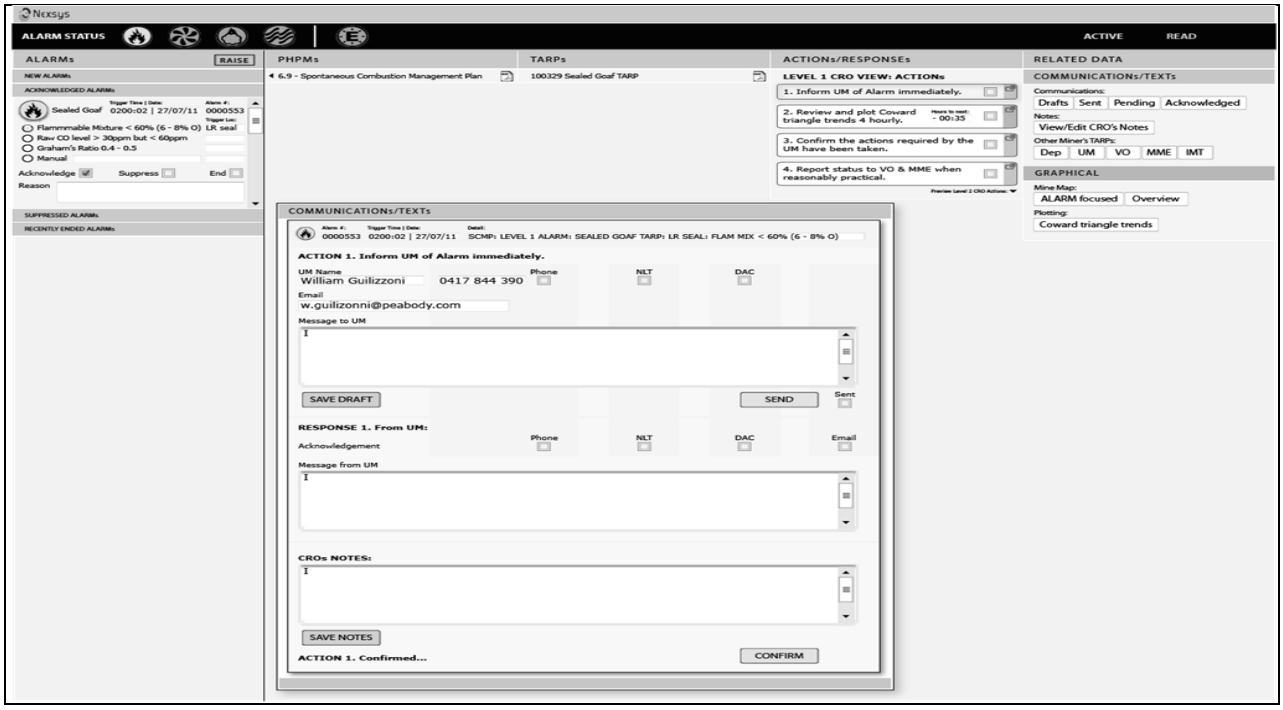

Figure 5. The Nexsys™ - Control Interface: Allows for recording of communications.

b) *Longwall Remote Control* provides a means of Longwall control via an outbye clean room/control station (specially designed rescue chamber) to increase safety at the longwall face by removing miners from the sources of harm. Multiple Longwall control and data acquisition systems are centralized via Nexsys™ and “white noise” filtering is performed. Relevant information is shown on one or a number of screens within the clean room to simulate operating a Longwall manually. Nexsys™ captures data/information from the data sources shown in Figure 6.

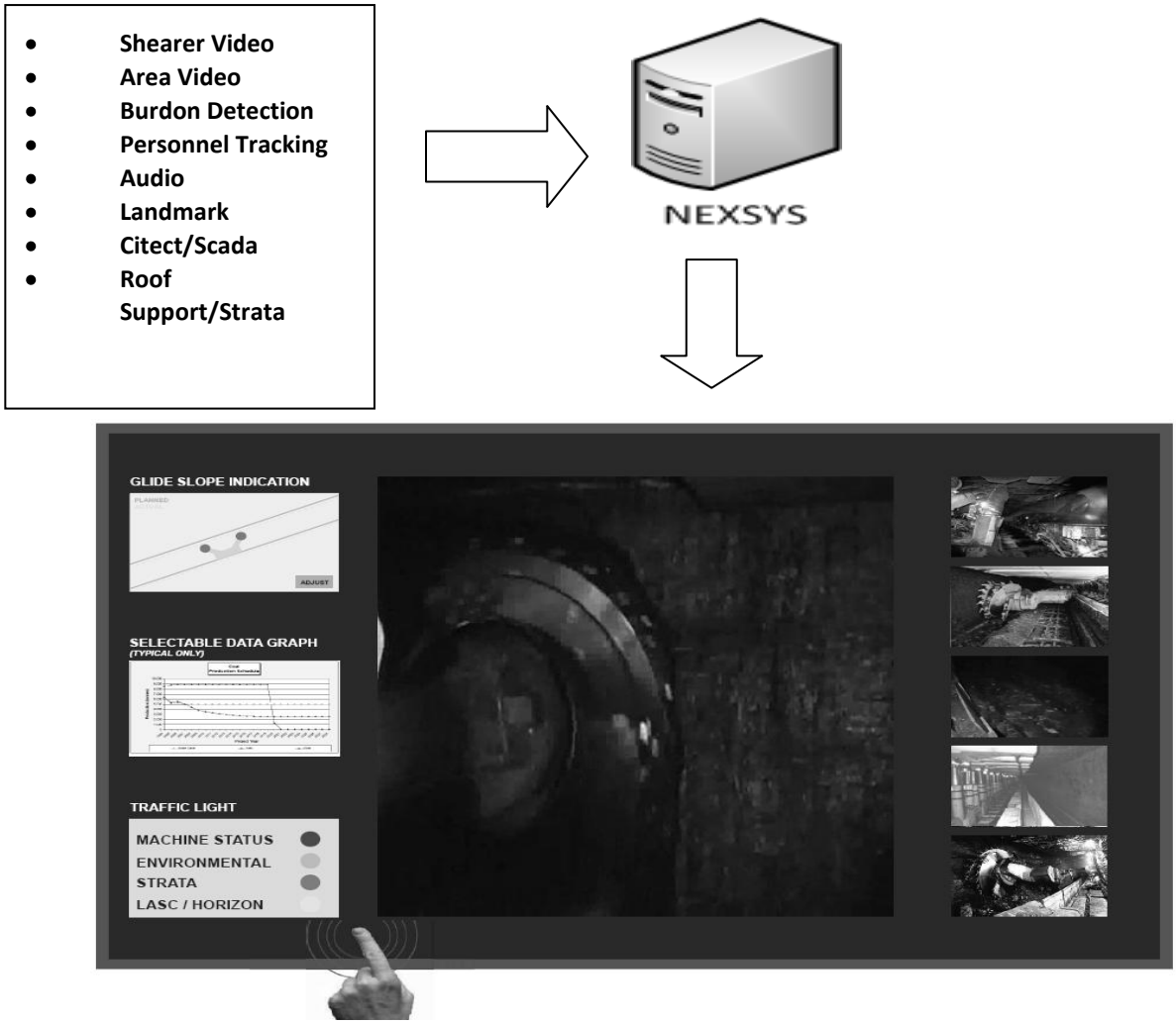

Figure 6. Human Machine Interface Control System: Typically a semi-large touchscreen with interactive pop-ups (example being maingate video appears if personnel detected in that area and shearer potentially scanned).

Conclusions

Nexsys™ capability, flexibility and adaptability delivers a new paradigm towards the communication and safety of industrial operations. Mining Logic Solutions sees Nexsys™ moving into many other domains outside of underground coal mining in the future: interest from manufacturing, military, petroleum and the oil and gas industries indicate Nexsys™ as a way to further advance the use of captured data, information exchange and operator decision support across a wide network of expertise located anywhere in the world.

References

Addinell, S. J., Rowan, G., Matsuyama, S., 2005. Nexsys™ Real Time Risk Management System and Demonstration at Kushiro Coal Mine. Coal and Safety, No. 26, pp. 7-10.

Tu, J., 2007. Safety Challenges in China's Coal Mining Industry. China Brief, Volume VII, Issue 1, pp. 6-8.