Application of Tagging Systems for Personnel and Vehicle Access Control

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ABSTRACT

Controlling the access of equipment, and people, has become more critical over the last few years for improving productivity and to meet safety responsibilities imposed by legislated obligations to have safety management systems. Hence Mine Site Technologies (MST) has spent the last three years completing the development of the tagging system to meet the mining industry's requirements, particularly streamlining access control. The basic tagging system tracks active Tags carried by personnel, or attached to vehicles and equipment, within underground zones.

These Tags are detected (read) by Beacons placed strategically throughout the mine. As a Tag, or Tags, go past a Beacon they are read and the information transmitted back to the main database PC. This allows the current whereabouts of personnel and equipment to be known, as well as the history of their movements.

The objectives of implementing the TRACKER Tagging System at Oaky No 1 Coal Mine were to:

- *maintain a count of personnel inbye a particular point*, and can alarm when a pre-set number is reached (eg the limit imposed by availability of SCSR's, etc);
- *maintain a count of vehicles (and vehicle type) inbye a point*, and can alarm if when a pre-set number is reached (eg when rated diesel units exceeds the limit for the ventilation present in that zone);
- *manage the vehicle fleet*, by keeping track of various vehicles underground better control and dispatch management of the equipment is achieved;
- *keep track of equipment*, knowing the location of equipment (such as forks, baskets, pumps, fans, etc) where last used or stored will minimise the risk of losing gear and assist in keeping inventory to a minimum; and
- *locate personnel in emergency situations*, by placing read Beacons throughout the mine the location of all personnel can be known in real time so that in the event of an emergency, their withdrawal can be monitored.

INTRODUCTION

The release of the TRACKER Tagging System has been timely as controlling the access of equipment, and people, in areas of the mine has become more critical over the last few years. In particular, its application in improving productivity and to meet safety responsibilities imposed by legislated obligations to have safety management systems (the commonly termed 'duty of care' principle).

A review by MST (Internal Market Surveys 2000 and 2002; Allen *et al*, 2002; Einicke, 2003) revealed that none of the tagging systems tried have operated reliably. Because they saw a market opportunity, MST has spent the last three years completing the further development of the TRACKER Tagging System to meet the mines' requirements, particularly streamlining access control.

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THE TAGGING TECHNOLOGY

The system tracks active Tags carried by personnel, or attached to vehicles and equipment, within zones underground. These Tags are basically small radio transmitters that transmit to read Beacons placed strategically throughout the mine.

As a Tag or Tags go past a Beacon they are read and the information transmitted back to the main database PC. This allows the current whereabouts of personnel and equipment to be known, as well as the history of their movements to be maintained.

However, the key to TRACKER's development has been its development as a true system. There are a myriad of 'off-the-shelf' Tags and readers available, but to operate successfully the system must be truly integrated to suit the underground environment. Importantly this is not just obvious physical requirements (water proof, rugged, etc) but the flexibility to integrated simply into a mine's existing infrastructure, as detailed further in the discussion on the read Beacons below.

TRACKER is designed for both coal and metalliferous mines, though the actual application varies between the mines (eg metal mines use TRACKER for blast time safety as well as fleet management).

In more detail, the main system components are as follows.

TRACKER Tags

TRACKER Tags transmit their unique ID on UHF frequency to a range of up to 100 metres in a typical underground roadway (50 m inbye, 50 m outbye). They use a tuneable matched loop antenna printed on the circuit board.

The Tags transmit three key pieces of data:

- unique ID,
- battery status, and
- checksum.

Tags are designed to be carried by personnel, or mounted on vehicles and other equipment. Two versions of Tags are used (see Figures 1 and 2).

The first Tag is a small independent (self contained) unit that may be worn on the belt, or attached to equipment using a custom housing. This Tag contains a 4.5 V battery pack with a lifespan in excess of ten to 12 months. The self contained Tag also has an LED to indicate battery status, the LED has three states:

- off = OK,
- blinking = transition indicating approximately one month left, and
- solid = replace.

Low battery status is recorded and displayed by the TRACKER Tagging System (stored in the database and viewable at the Client/Operator's software).

The second Tag version is incorporated into newer technology cap lamps.

The Tags are currently approved intrinsically safe for coal mine use in Australia, China and the USA.

FIG 1 - Self contained Tag.

FIG 2 - Tags can also be incorporated into the new cap lamp battery packs.

Tracker read Beacons

Beacons receive Tag ID's, transmitted by UHF signal, and then transmit that data back to the PC at central office via RS485 serial protocol. To allow flexibility to fit into a mine's existing communication infrastructure the data links between Beacons and Beacons and the main database PC can be conventional wiring, fibre optic and radio modem links that may all be integrated to carry both up-stream and down-stream data as required. The system can operate over leaky feeder radio systems, but is not recommended as the low data rate of leaky feeder does slow the system response time down and limit the number of Beacons that can be installed.

The Beacon enclosure (see Figure 3) is made of stainless steel and operates from a 12 - 28 VDC supply. TRACKER Beacons can, as a minimum, reliably record ten people, with Tags, moving past in a vehicle at 35 - 40 km/h, and more moving at lesser speeds.

Some key aspects of the beacon's operation include:

- Beacon typically detects Tag signals via a stubby quarter wave monopole coax antenna;

FIG 3 - Read Beacons are placed at strategic locations underground.

- Beacons sensitivity can be manipulated to suit the environment (sometimes a short read range is required to ensure a Tag is not read at two Beacons at one time);
- Beacons operate an on board switch mode supply and require DC >12 to <30 volts for reliable operation;
- power consumption is approximately 800 mW (27 mA at 30 volts/70 mA at 12 volts);
- Beacons have a direct read point option, indicating Tag IDs (and Beacon name) as they are detected; and
- three LED indicators display operational status:
  - flashing red LED represents the *heartbeat* (one flash per second) and indicates the presence of oscillations of the crystal oscillator on the beacon's PCB;
  - flashing yellow LED represents a *Tag read*, indicating that the Beacon has received a signal from a *Tag*; and
  - flashing green LED for *communication* indicates that the beacon's stored data has been transmitted to the central office on its request.

The TRACKER Beacon has two main electronics circuits that can be configured to give a range of applications within the system, these include:

- a simple termination point,
- a branch/split point for system expansion,
- a converter – 232 to 485, 485 to optics, optics back to 485, etc,
- an isolated 485 repeater/booster,
- a read Beacon,
- an isolated stub driver, and
- a Beacon with any of the combinations above.

Tracker software

The main TRACKER software is typically located on a PC in the communications or control room on the surface, with networking to other PC's on the surface and underground as required. At set intervals the TRACKER software sends out a request to each Beacon, asking for its stored list of Tag IDs. After a successful transmit Beacons then have their list cleared and begin to collect the next list of Tags.

The time between polling is set within software, it is typically anywhere between three and 30 seconds, depending on system

configuration. Beacons that see a lot of activity require a faster refresh, where as low activity Beacons need not have their lists cleared so often.

Tag IDs are stored in the TRACKER database, recording which Beacons the Tags have passed, and at what time. The TRACKER software keeps a continually updated record of Tags logged in and out of the system.

Beacon configurations, access limit numbers, zone display text (see next section), etc can all be adjusted from the main PC.

The Open Database (ODBC) compliant TRACKER database allows it to share data with other applications. For example, a future generation of PED software may be able to send a message to all personnel between Beacons 5 and 8 by drawing this data from the TRACKER database, or management tools could draw real time locations of vehicles and personnel to manage these resources.

Zone Display Units

A fourth component to the system used to increase functionality is the Zone Display Unit. Apart from the safety and management uses of the information TRACKER provides, TRACKER can also be interfaced to large display units (see Figure 4) to manage access into certain areas. Key areas of use in coal mines include:

- *Maintain a count of personnel inbye a particular point;* and can alarm when a pre-set number is reached (eg the limit imposed by availability of SCSR's, etc). This is aided by the use of large display units that show a constant count of personnel numbers inbye that point. The limit number for personnel entering a particular zone can be adjusted from the main PC if circumstances change (eg more SCSR's are installed).
- *Maintain a count of vehicles (and vehicle type) inbye a point;* and can alarm if when a pre-set number is reached (eg when rated diesel units exceeds the limit for the ventilation present in that zone). Again, this can be aided by the use of the large display units, which display the diesel unit count and then display '*stop*' when the limit is reached. The limit number of diesel units entering a particular zone can be adjusted from the main PC if circumstances change (eg ventilation volumes are changed into the zone).
- *General vehicle fleet management;* by keeping track of various vehicles underground allows better control and dispatch management of the equipment as outlined by Gauci, 2004. Improved efficiency in this area is often the main cost benefit justification when assessing the use of TRACKER at a mine. The Zone Display Units can be placed at strategic locations to update drivers of transport road conditions (eg used as an automatic block light system), or urgent deployment to another area.

IMPLEMENTATION AT OAKY NO 1 COAL MINE

Xstrata's Oaky No 1 Coal Mine has long been one of the most productive longwall mines in Australia. As such, management at the mine is constantly reviewing technologies and processes to further increase productivity.

Hand in hand with this constant development of productivity has been an emphasis on safety and safety management. In particular, the recent Level 1 emergency exercise at Oaky No 1 highlighted areas where communication and knowing the whereabouts of all personnel during an evacuation can greatly assist the effectiveness of an evacuation and allocation of rescue resources.

With these key drivers, MST is working with Oaky No 1 to implement a tagging system in two stages.

FIG 4 - Zone Display Units can streamline access control to sections of the mine.

Stage 1

The main driver here is cost reduction and production advantages through better management of vehicles and, in particular, implements (such as buckets, forks, pumps, augers, etc). The implementation of a tagging system to control these assets not only gives immediate and quantifiable cost benefits, but provides a deeper understanding of the tagging system's working parameters so its expansion into a full blown safety system is better understood and managed.

Stage 1 involves installing read Beacons at key travel road locations to log the movements of vehicles, and what implements are attached to each vehicle, as they travels around the mine. Each vehicle and implement will be assigned a unique Tag that is then associated with them as they move around the mine. To achieve this 18 Beacons are installed at strategic points as shown on the mine plan in Figure 5.

This layout shown in Figure 5 provides sufficient size zones to effectively track the movement of equipment within key areas underground

Key benefits identified in Stage 1 include:

- Knowing the location of all implements will eliminate, or greatly reduce, the time personnel spend searching for a particular vehicle or implement.
- Better management of contractor's resources on site (what goes in, come out).
- Items like pumps that are move or changed out, are tracked to ensure the correct pump has been moved, and moved to the correct location.
- Access control of vehicles, as each vehicle to be uniquely identified, the system will streamline access control for diesels into ventilation zones, as mentioned in the section on Zone Display Units previously. Each ventilation zone has a limit for diesel horse power depending on the ventilation volumes in that particular zone. As each vehicle type has a rating (tokens), dependent on horsepower, being able to differentiate individual machines ensures the correct horse power count is maintained in each area.

Stage 2

The system is expanded to 35 to 40 Beacons and all personnel that enter the mine are equipped with a Tag. Each Tag is a personal item and the ID is associated with that person only, and is matched with their cap lamp number.

To complement the basic read functions of some Beacons the Zone Display Units used for diesel access control, will also be used for personnel access control. These Zone Display Units provide information locally as it is processed by the main TRACKER PC in the surface control room. The Beacon layout for Stage 2 is shown in Figure 6.

The key drivers for the implementation of Stage 2 include:

- Access control of personnel; similar to the logic behind vehicle access control, personnel access can be controlled in relation to the available long duration SCSR's in the panel

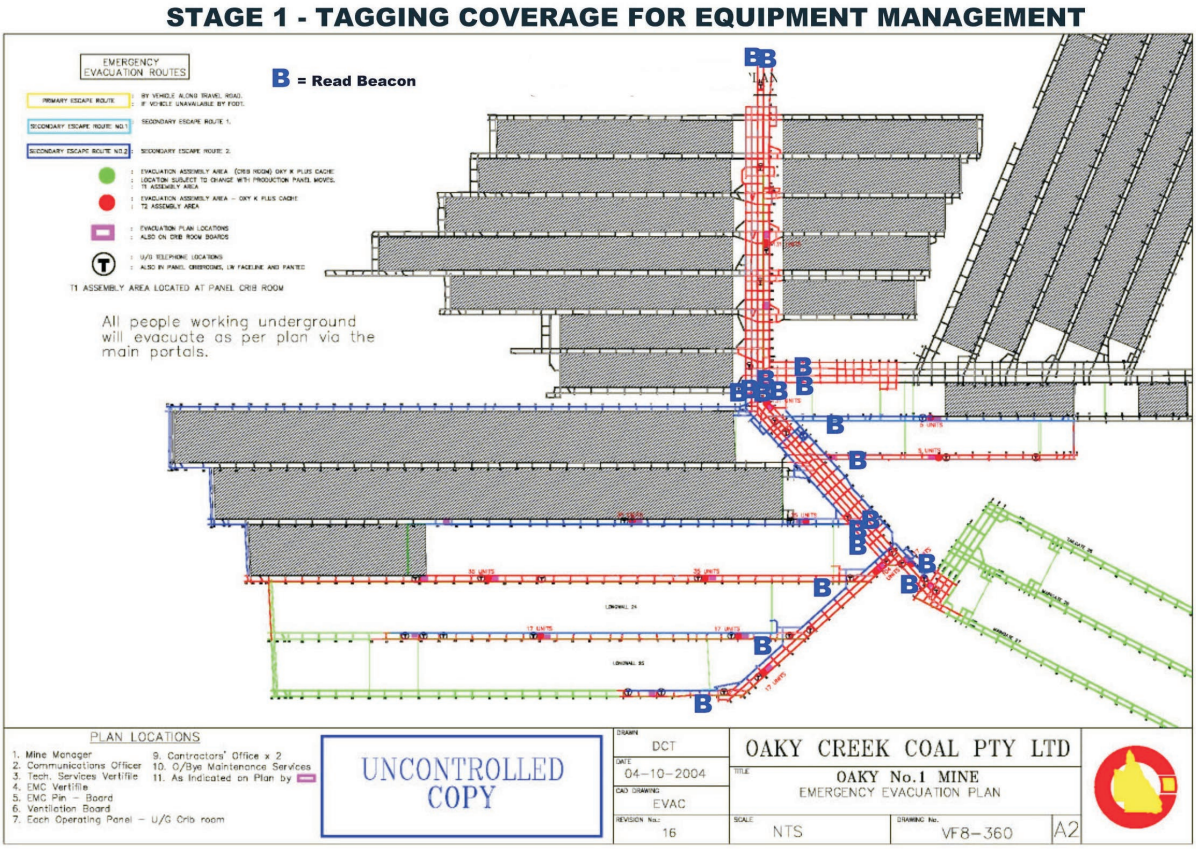

FIG 5 - Stage 1 Beacon locations.

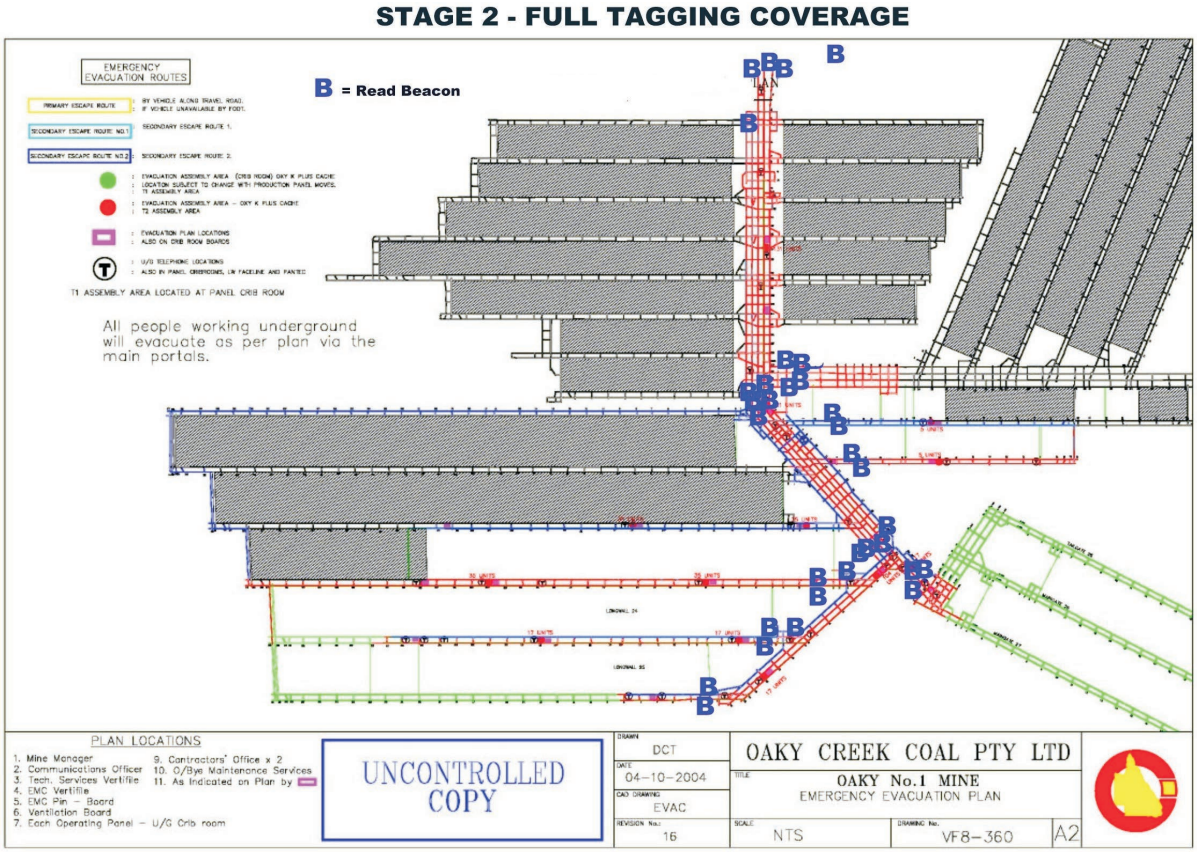

FIG 6 - Stage 2 Beacon locations.

being entered. The same Zone Display Units that already display diesel limit information now also display a count of personnel logged inbye, and alert the person about to enter if they (or them) will exceed the limit for that zone.

- Should an emergency situation arise and an evacuation instigated, the withdrawal of people from the mine can be monitored to ensure all personnel are exiting, or to highlight any area where personnel are not withdrawing.
- During the evacuation, personnel may not be aware of the availability of equipment (eg a PJB) to assist their exit. Knowing the location of a tagged diesel means that personnel withdrawing form a certain area can be alerted to the location of the PJB closest to them.

CONCLUSION

The implementation of the TRACKER Tagging System at Oaky No 1 has provided a powerful management and safety tool at the mine.

However, it is important to note, that it is the integration of the tagging system into the mine's infrastructure and complementation to other management systems that allow its benefits to be optimised.

For example, during an evacuation the tagging system does provide critical information, but it is the ability of the emergency team to react to and use this information that realises the benefits. Hence, for example, communication back to personnel is vital to alert them of correct evacuation routes, or availability of transport, etc. Systems such as telephones, PED pagers, etc work together to ensure this flow of information is fed back to where it needs to be acted on, as emphasised in MSHA reports, 1998 and 2000; MSHA ETS, 2002.

Another example is that the read Beacons are not intrinsically safe, and as such to maintain there operation during an evacuation, where the incident has resulted in a disruption to the ventilation (eg the main fan is off, or one part of the mine has lost stopping, etc) than the ability to monitor gas levels throughout the mine allows power to remain on for some time after an incident to maintain the flow of information as long as possible.

In summary, the implementation of the tagging system at Oaky No 1 gives mine management a powerful tool that provides immediate benefits to the operation. More importantly, the tagging system allows further benefits to be gained from previous investment in a range of technologies (eg communication and gas monitoring systems) by extending the effectiveness and applications of these installed technologies.

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