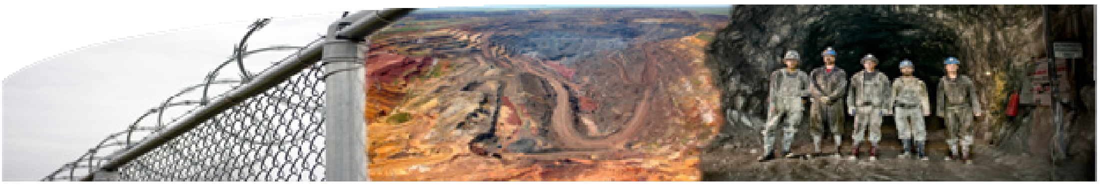
SureWave Technology Ltd
462 Crewe Road | Wheelock | Sandbach | Cheshire | CW11 4QD | UK
+44 (0)1270 757900 | 757669 www.surewavetechnology.co.uk



Report covering Trapped Miner tests December 2011 **Author: Philip Shaw**

Date: 11.01.2012

Report status:V1.0 Summary Version

Contents

Overview of the requirements for detecting Trapped Miners

The death of a miner trapped deep underground after an accident is a tragic event made all the more poignant, when it becomes known after the event. Lives could have been saved had those in charge known at the outset whether or not they were dealing with a rescue or a recovery. Often the approximate location may have been known, but this isn't always the case and feedback on the location is clearly a tremendous advantage where every second counts if lives are to be saved.

Background to the technology and prior tests conducted in mining

Advanced micro-seismic monitoring techniques were designed and developed for use in mines in giving advanced warning of rock outbursts. The inventor, Philip Shaw, has spent over 12 years perfecting this proven technology for use in the security industry and now for detecting trapped miners.

SureWave Technology has recently taken this technology to develop a new and ground breaking portable seismic instrument (Model: TMS2) which has the proven capability to not only to detect trapped miners who have survived an accident, but also to locate them at depths of up to 1500ft and probably beyond within minutes after deployment of the sensors.

In December 2010, the first field trial of SureWave Technology's mine rescue TMS2 system was undertaken at the Blue John Cavern in Derbyshire, UK where at a depth of 80 metres, the stamping of feet was successfully detected in real time, accurately locating an image superimposed upon a Google Map™ of the area.

In a recent test at Federal mine #2 West Virginia in February 2011, a simulated demonstration was independently verified by Professor Heasley Dept of Mining University of West Virginia and involved the simulated test of two "trapped miners" at 230 metres and at 300 meters respectively. Within 61 minutes of setting up the sensors (two shallow boreholes had previously been dug), the TMS2 equipment had detected the minute seismic vibrations of a crib block pounding on the roof of a tunnel at the 230 metre depth and later, the 300 metre depth.

In a second mine test, in August 2011, the system detected the miners signals at around 1000 feet depth, but was unable to locate due to excessive overburden and other issues unrelated to the site or technology. This prompted further work to enable the system to perform in all conditions likely to be present in a typical mine and the need to eliminate the user from having to configure settings on each site.

The tragic events at Gleason mine, South Wales where SureWave were called out to assist the rescue by the UK mine inspectorate and rescue teams, clearly indicated the need for a rapid deployment system with no user input to ensure the rescue teams are proved with the information they need within minutes of deployment on site. SureWave successfully provided this information after 10 minutes of arrival above the mine.

The system is capable of two basic configurations:

Two or more Tri-axis sensors each covering an area of up to 1KM and depths of 500 meters. This system has the capability to give very accurate locations to a few feet. However, to achieve this, at least two sensors must detect the signal and each sensor must be perfectly aligned and level. In an emergency situation, these requirements are considered to be prone to error with potentially disastrous results.

Alternatively, the system can be configured with up to 12 signal axis sensors – 6 being a practical number for mine rescue – enabling rapid coverage over a very large area. Each sensor coving a radius of up to 1km and depths to 500 meters. The need to align and level the sensors is now removed and it’s impossible to give a false direction to rescue teams even if deployed in a hap-hazard manor as may be the case in an emergency.

Access to a working mine was gained to perfect the systems new ability to ‘learn’ the correct settings for any mine. The system was then tested and operated by a mine worker with no input from SureWave staff to ensure its ease of use.

Details of the test

The test was performed over two days 7th December and 9th December 2011. The mine was fully working and the depth was just over 1040 feet.

The system was setup above the mine area in a location where shallow holes for the sensors could be dug.




Figures 1 – 4: Site used above the mine

The image supplied by the mine was enlarged automatically (by SureWave using software included with the TMS2 system) to produce a large scale view of the area covered by the tests. Figure 5 shows the resulting image.

Two teams were used during the tests. Team 1 was deployed in underground work, providing the signal and communications with the surface teams; team 2 was deployed on the surface to observe and operate the TMS2 system.

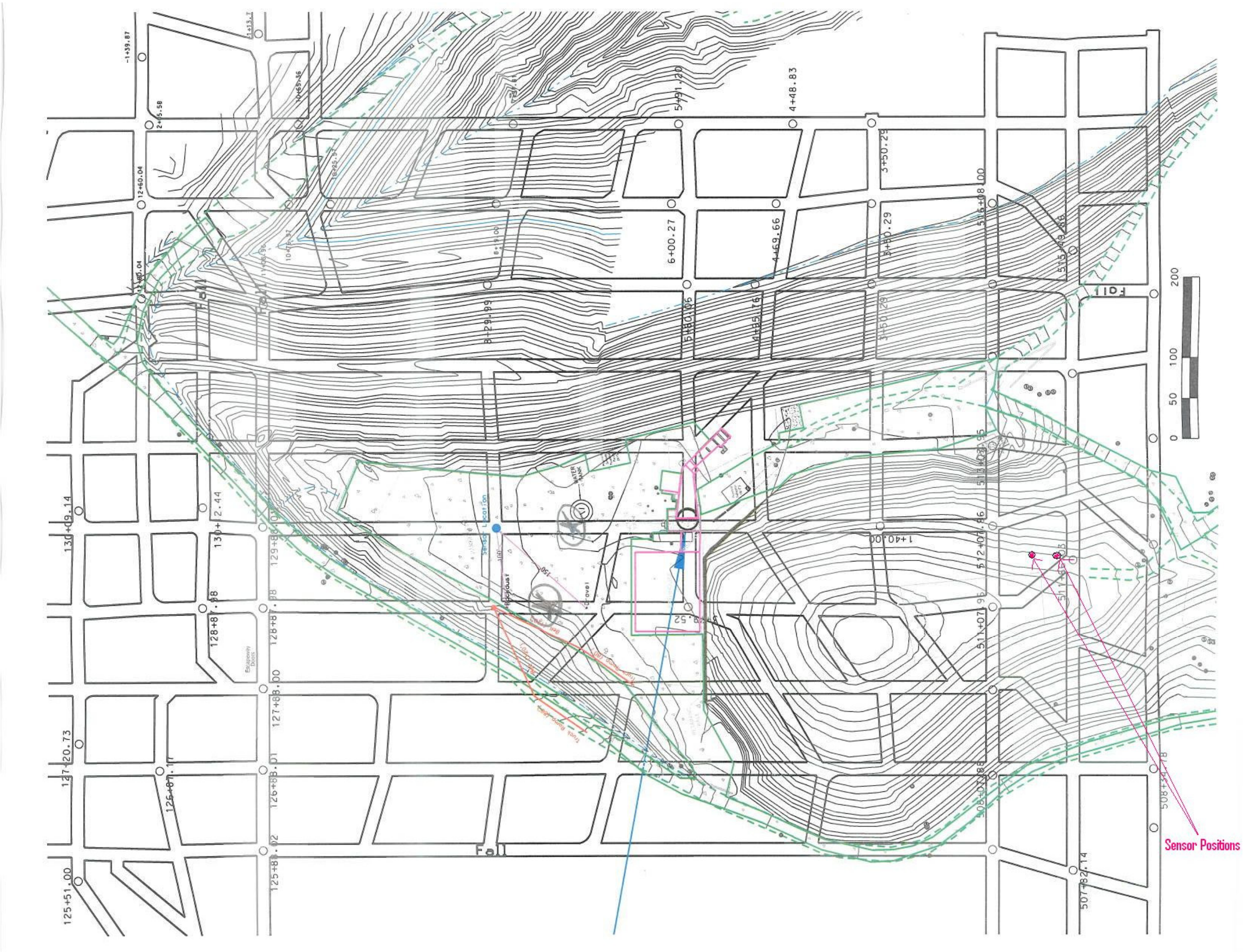


Figure 5: Image of the mine, sensor positions and site layout.

The sensors were placed in shallow holes approximately 30 inches deep. These were sufficient to ensure the base of the sensors was in good contact with the solid hard dense ‘clay’ under the surface soil. Note it had been pre determined that the hole and sensor mounting was critical to obtain distances beyond 500 feet approximately. Two sensors were deployed, single axis TS1 shown below.

Figure 6: TS1 sensor deployed in a typical hole.

The hole can be produced rapidly using a one or two man Auger as shown in figure 7. The diameter of the drill was 9 inches.

Figure 7: Example of a typical two man Auger being used to produce required holes.

The whole deployment can be undertaken rapidly and the system is completely portable suitable for a one man team. In this test, the system was deployed from the rear of a SUV. The system comprises a CPU with touch screen battery pack, sensors and cable reels. Figure 8 shows the setup as used in this test.

Figure 8: TMS2 System in use from a SUV

The procedure used during the tests was for the system to be setup by the mine personnel under the guidance of SureWave for the first day, and independently on the second day.

Once the system was switched on, the user would tap the screen to indicate the location of the sensors using a pre loaded image of the surface above the mine. The locations given are relative to the sensor positions input at this stage. To simply detect the miners, the exact locations are irrelevant and only one sensor can be used if time is of the essence.

The system is supplied complete with a windows program to enable the user to scale or enlarge an area of the image to allow better location and visual interpretation. SureWave used this to enlarge a section of the mine plan to use as the screen image for these tests.

Once the two sensor locations had been input the system was monitoring.

Using the communication link to team 1 underground, events were produced and the system screen observed to determine if the event was detected.

The events were designed to be five strikes at one second intervals, wait a minute and repeat five times. The alternative test pattern was to continually strike for one or two minutes. This second pattern was found to be very tiring for the operators and was used infrequently.

For each event detected, the operator was presented with the view of the seismic waves recorded end then a 'dot' on the image showing the sensor nearest to the event.

The view of the waves allow the operator to clearly see the number of hits detected in a 7 second period as shown in figure 9. This clearly shows 3 strikes of the roof.

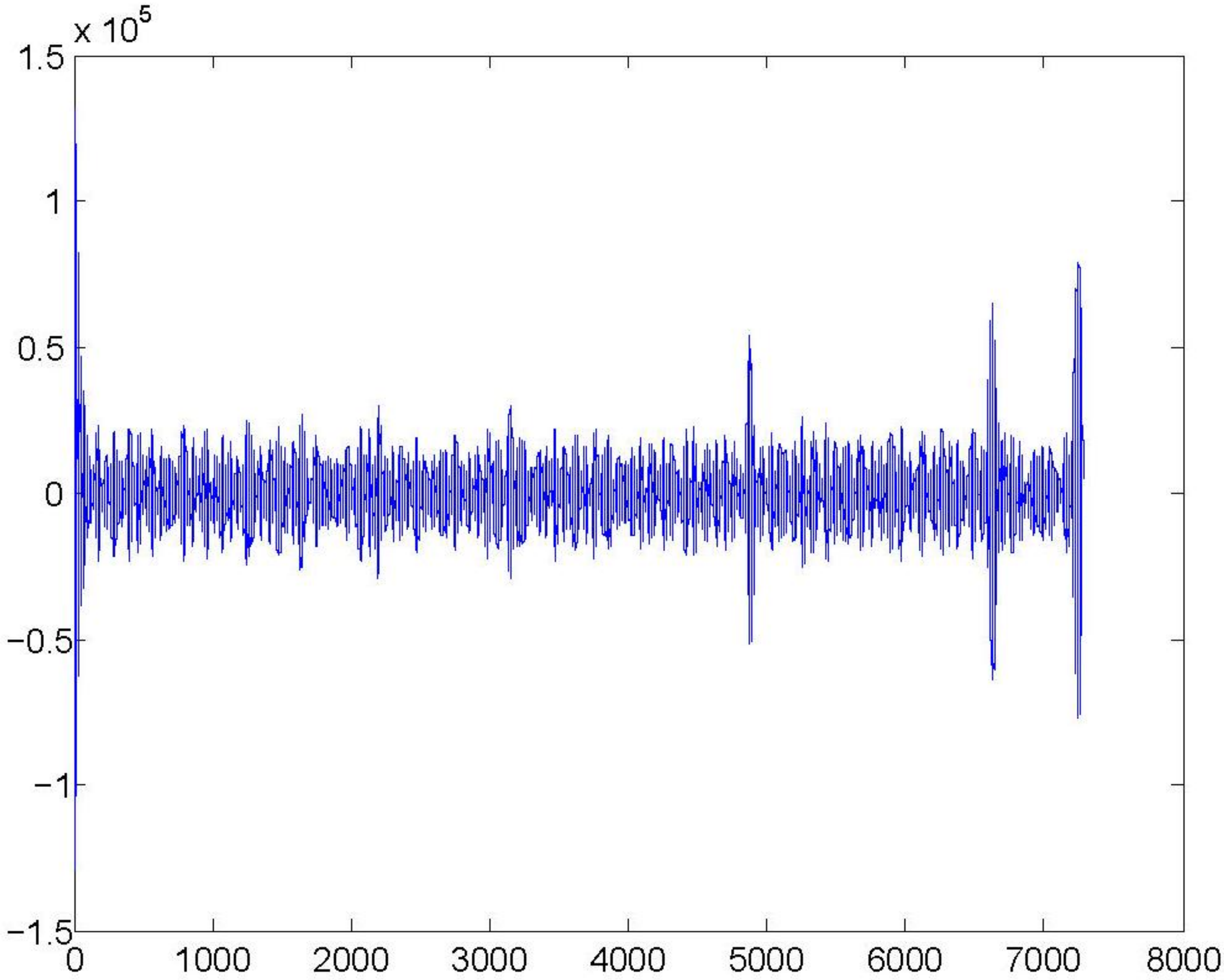


Figure 9: Screen shot showing the recorded waves from the miners at 1040 feet deep, 1500 feet horizontal distance.

By using this system with radio communication to the miner's underground, each event was recorded and confirmed by the screen output.

Once confidence had been established in the system of testing, blind testing was introduced where the system was started and left recording with an event produced at an unknown time. The operator was tasked to say when the system had correctly detected any miner activity. A second test pattern was 5 strikes approximately a second apart once a minute repeated.

The activity was a crib block (a 3 x 4 inch timber of 3 to 4 foot length). This was used to strike either a roof bolt, mine floor or the mine roof. In some areas, the roof consisted of flaking coal and the signal recorded was considerably smaller, but still detected. The mine floor was sufficient up to 500 feet horizontal distance, beyond which only 60% of the strikes were recorded.

The comparison of signal strength between a roof strike and a roof bolt strike was less, but generally the roof was stronger if the condition of the area struck was stable.

The mine was working through out these tests, team 1 underground often inhibited by passing traffic of coal wagons. The background seismic noise was very large from the mine activity (SureWave stated 10,000 times greater than the detected miners signals) coupled with very large mains noise from a nearby sub-station and underground high voltage cables near to a sensor. These signals posed no problems for the technology demonstrated.

The second day on the 10th December 2011, the holes left from the previous tests had filled with water. The issue was that the bottom of the holes had become a deep area of soft mud with 2 feet of standing water above.

In one hole, a stone slab was dropped in and the sensor positioned on this. The slab was unstable and had no or very poor contact with solid material as required for maximum distances to be achieved.

The second sensor was placed in a part Auger drilled / part hand dug shallow hole of insufficient depth (around 24 inches). The depth needs to be sufficient to expose the hard ‘clay’ or ‘sand’ material well below the top soil. A definition of “material that would not support any plant life” was established to describe a suitable hole base.

Time restricted the excavation of more suitable holes on this day.

Results Recorded and Sample Screen outputs

Time	Distance	Event	Strikes Displayed	Result
10:22	Zero	Roof	5	√
10:23	Zero	Bolt	2	√
10:26	500 feet	Roof	5	√
10:27	500 feet	Bolt	4	√
10:37	1000 feet	Roof	3	√
10:40	1000 feet	Bolt	5	√
10:50	1000 feet	Roof	5 *	√
10:51 -10:58	1000 feet	Roof	5 *	√
11:02	1500 feet	Roof	5	√
11:05	1500 feet	Roof	3	√

Table 1: 8th December 2011

*** These events were recorded in a 'Blind Test' window. The system was left recording and detected events were confirmed to team 1 underground as they were displayed on the TMS2 screen.**

Time	Distance	Event	Strikes Displayed	Result
11:34	Zero	Roof	None	N/A
11:36	Zero	Bolt	5	√
11:37	Zero	Roof	5	√
11:45	500 feet	Roof	1 *	√
11:47	500 feet	Roof	3 *	√
11:48	500 feet	Roof	4 *	√
11:55	500 feet	Roof	4	√
11:56	500 feet	Roof	4	√
11:58	500 feet	Bolt	4	√
12:05	500 feet	Bolt	1	√

Table 2: 8th December 2011

*** these events were generated in an area of the mine (left hand direction on Figure 5) that contained significant broken coal and poor strata to the sensors.**

Time	Distance	Event	Strikes Displayed	Result
12:24	Zero	Roof	None	N/A
12:25	Zero	Roof	5	√
12:35	500 feet	Roof	3	√
12:43	1000 feet	Roof *	1	√
12:44	1000 feet	Roof *	0	X
12:45	1000 feet	Roof *	4	√
12:46	1000 feet	Roof *	4	√
12:47	1000 feet	Roof *	3	√
12:48	1000 feet	Roof *	4	√

Table 2: 8th December 2011

*** These events were recorded in a 'Blind Test' window. The system was left recording and detected events were confirmed to team 1 underground as they were displayed on the TMS2 screen. All but one event was recorded.**

Results Recorded and Sample Screen outputs- Cont'

Example of waves shown during the tests:

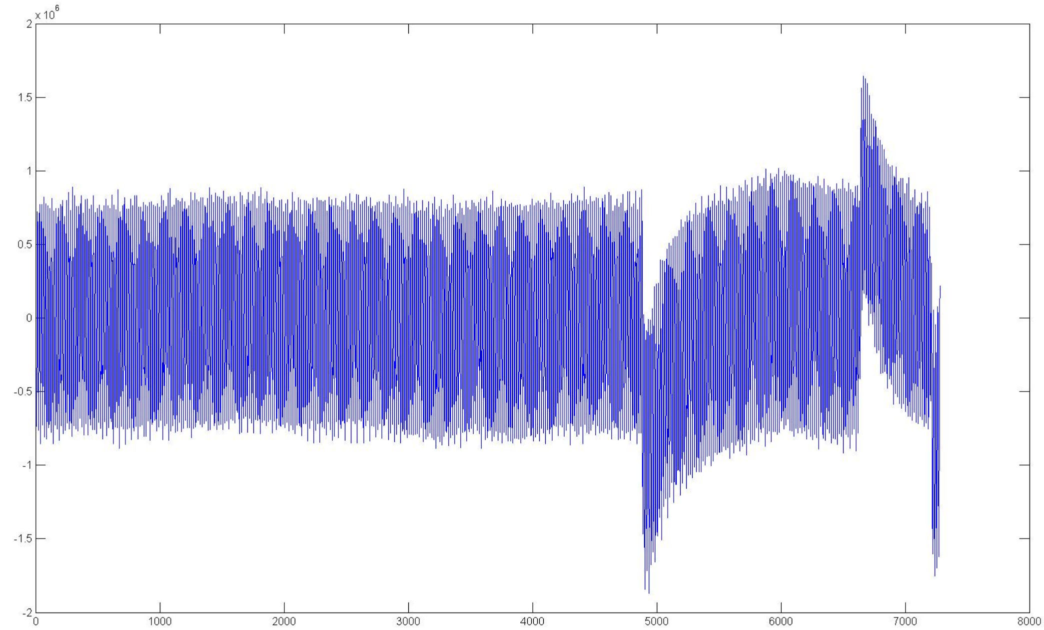


Figure 10: Detected wave 1500 feet from the sensor (depth 1000 feet).

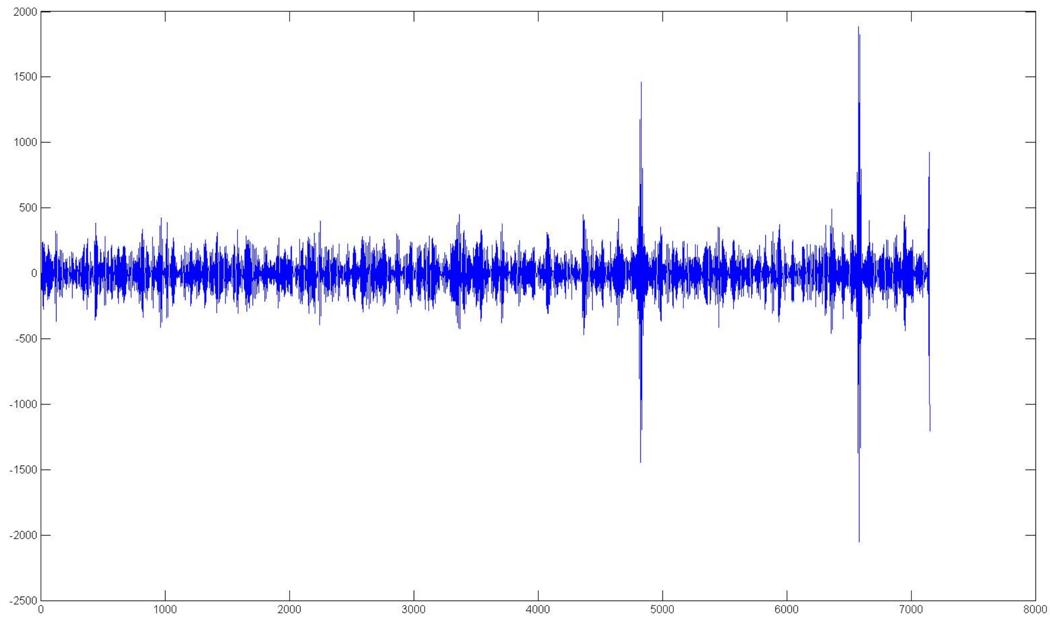


Figure 11: Displayed wave showing number of hits detected.

Conclusion

All events produced from tests conducted on the first day, 8th December 2011 were detected. Although 5 strikes were produced by team 1, simulating a trapped miner, and not all 5 were recorded on every test, it would have been immediately clear that the miner(s) had survived if this were a real emergency situation. The system (TMS2) rapidly demonstrated its ability to determine whether a rescue or recovery was required following an incident.

Compared to previous tests witnessed in February and August, SureWave have incorporated technology to remove the requirement for a user to change sensitivity and other settings depending upon the hole depth and mine conditions. The system was seen and demonstrated to be set up within minutes with the operator tasked to position the sensors in a suitable hole, connect all cables, switch the system on, and tap the screen (if location required) indicating the position of each sensor placed on a mine supplied site image.

Depending on the depth of overburden and depth of mine and horizontal distance required, it was demonstrated that the holes are very important to achieve distances greater than 500 feet. However, using an auger or mechanical digger, suitable holes can be produced easily.

The second day's testing limited to less than 2 hours, still detected the miners despite the holes not meeting normal requirements. It should be noted that throughout these tests, the mine was fully operational producing significant seismic noise often adjacent to the "trapped miner" position. In a real emergency, such seismic activity would be minimal. This would have a significant impact on the requirements for good holes and the visual interpretation of roof strikes would be very easy to discern by a user.

The system, as demonstrated, now automatically detects all seismic activity and automatically configures itself to the most appropriate settings at switch on and every few seconds. This ensures the sensitivity is optimum for whatever conditions are present at each event. This removes any technical requirement on operators.

When multiple sensors were used, it was demonstrated that the system indicates the sensor closest to the event and the user manual gives details on how to use this feature to obtain a location within 50 feet.