Decreasing Post Blast Re-Entry Time with Battery-Powered Wireless Monitoring of Gas and Ground Movement

Abstract

Innovations in mining technologies has created opportunities to significantly improve the efficiency of mining processes. Recently, Newtrax, Conspec, and MDT collaborated at Glencore Kidd Operations to enable battery-powered wireless gas and geotechnical monitoring in active mining areas, with real-time data acquisition to a front end display on surface. This new capability has enabled Glencore Kidd to reduce post-blasting re-entry delays for underground workers, creating a more efficient mining process.

Generally, mines rely on a fixed-time strategy to deal with the post-blast re-entry time. This fixed re-entry delay is determined from previous observations and experiences. For example, if a blast is delayed, then re-entry is delayed as well, no matter what the actual conditions are underground.

Using the simple post-blast re-entry system mentioned above, Glencore Kidd Operations was able to quickly set up various wireless sensors to remotely measure undiluted concentrations of different gasses (CO, SO2) from seismically active work areas, which along with geotechnical data, has allowed ventilation and safety supervisory personnel to remotely determine when atmospheric and seismic conditions may be declared safe for a return to work while minimizing the risks from these hazards to the safety personnel. This has allowed for an operational change of procedures that better mitigates any potential risks post-blast and to prepare more effectively for any potential damage to the ventilation systems which may affect a potential return to work site by the miners at Kidd Operations.

In order to verify the effectiveness of this post-blast re-entry system, this study compares conventional post blast re-entry methodologies with the Conspec/MDT/Newtrax wireless gas and geotechnical monitoring system as implemented at Glencore Kidd Operations to confirm the substantial benefits derived from the implementation of this technology and accompanying post-blast operational procedure changes that have resulted from the adoption of this technology.

Decreasing Post-Blast Re-Entry Time with Battery-Powered Wireless Monitoring of Gas and Ground Movement

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Introduction

Innovation in data acquisition and remote technology developed for the mining industry has allowed time-consuming and risk-inducing procedures previously performed by dangerous physical inspection by mine personnel to be replaced by battery-powered wireless sensors that can relay data all the way to the surface in real-time. This enables faster and better informed decision-making resulting in both significant cost-savings and productivity increase for mine operations.

Glencore's Kidd Operations, the world's deepest base-metal mine below sea level located in Timmins, Ontario, selected Newtrax, Conspec Controls and Mine Design Technologies (MDT) in 2013 to deploy a remote wireless data-acquisition system for real-time monitoring of both atmospheric and geotechnical conditions in underground work areas.

This project began with the implementation of a distributed network of Newtrax battery-powered wireless nodes to connect to the existing MDT SMART instrumentation located in the footwall development within the upper portion of the deep mine, between the 6900 and 7500 Levels, in 2012. Geotechnical instruments, either SMART cables, or SMART multipoint borehole extensometers had also been installed in most of the footwall development intersections as part of a repair program following multiple large seismic events in 2009 and 2011. As such, there were already established points to which Newtrax battery-powered wireless nodes could be attached, creating a network encompassing most of the footwall development throughout the mine. The Newtrax wireless network was subsequently expanded in 2014 to cover all levels down to the 9500 Level.

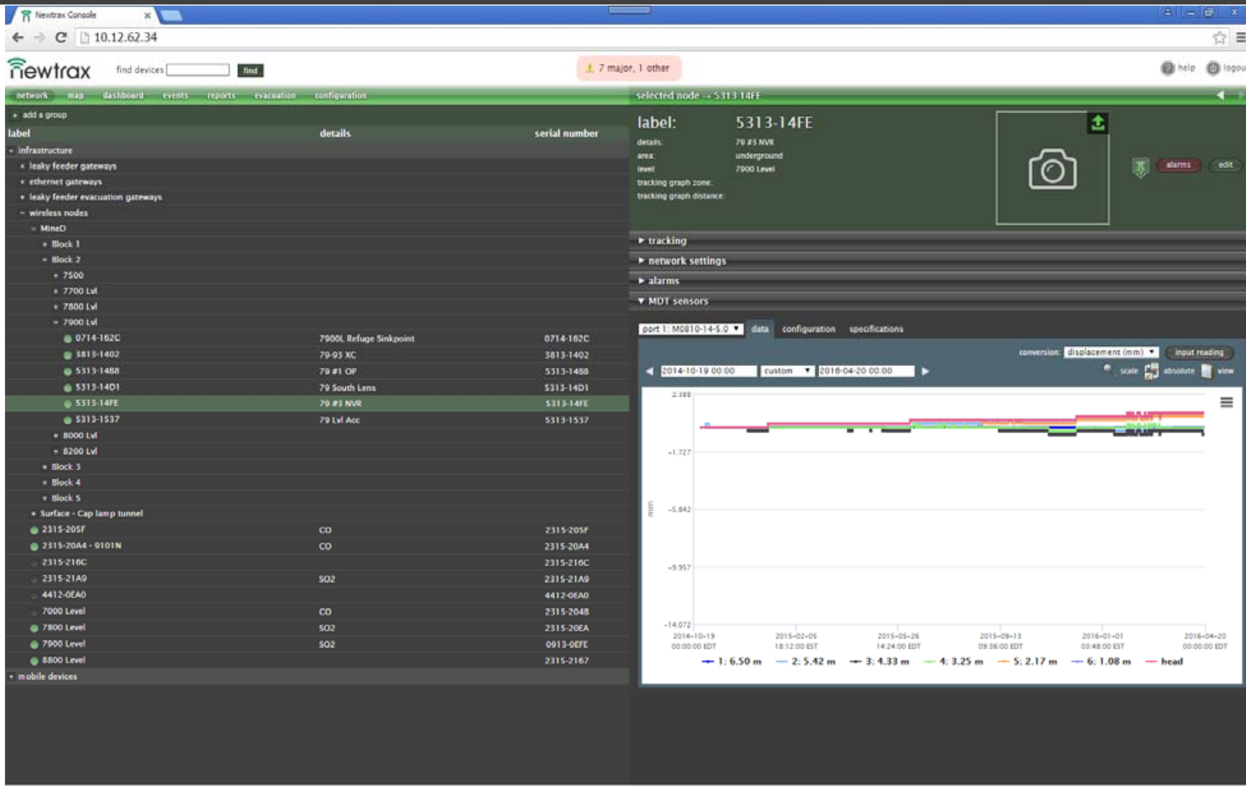

Figure 1: ***Newtrax's central server, showing a network tree on the left side of the image and geotechnical data for an extensometer on the 7900 L, for an 18-month period.***

Once the network had been established, Kidd Operations' engineering staff became aware of other technologies which could be leveraged over the network, including vibrating wire stress cells, gas detection and monitoring equipment.

1-Manual monitoring: Delays and lost productivity

Due to the seismic hazard at depth, mining personnel are often restricted from accessing areas immediately after production blasting due to the elevated risk.

Traditionally, gas monitoring at Kidd Operations was done manually: personnel were sent into the mine to physically detect gas with hand-held monitors. Due to the elevated seismic hazard, this monitoring would typically be delayed by several hours, up to a full 12 hour shift or more. When personnel could finally enter the area, a preliminary inspection would identify any damage to the ventilation ducting or other ventilation infrastructure problems. Further delays could also then be incurred by having to wait until after the initial assessment had been completed to determine whether any of the ventilation infrastructure had in fact been damaged, and to determine what materials needed to be withdrawn from stores and brought to the affected area.

The manual method increased the mine personnel's exposure to the hazard of seismic events triggered by stope production blasting. This was the case during both the initial inspection to determine whether contaminants were present, as well as during any repairs, if the ventilation hazard was significant and needed to be addressed quickly. Until the ventilation was fully restored and the area purged of contaminants, a guard equipped with a gas monitor had to be posted at the entrance to the restricted area to ensure that no personnel crossed the barrier and potentially exposing themselves to the unknown and as yet unquantified gas hazard.

The guard was also potentially placed at risk should a major upset to the ventilation network occur, directing contaminants out of the isolation zone. Moreover, while the guard was preventing other personnel from becoming exposed to the possible gas hazard, he could not perform useful productive work in unaffected areas of the operation. The guarding process, therefore, also resulted in additional production delays due to labour reallocation. For any given blast, up to five employees could be required to guard all entrances to a blast site, or to other levels on which the ventilation system could be impacted. They could also be required to guard for an entire shift. Subsequent repairs to the ventilation network could delay operating personnel from re-entering for another full shift or more due to the need to fully assess the condition of the repaired ventilation infrastructure.

2- Deployment of Strategic Real Time Remote Monitoring onto the Existing Ground Movement Wireless Monitoring Network

Through the deployment of Newtrax-enabled Conspec Smart Head Wireless Carbon Monoxide (CO) Gas Transmitters onto the pre-existing geotechnical distributed Newtrax wireless network. This has enabled Kidd Operations Ventilation personnel to monitor the full change in gas readings from the moment of the blast, through to when each area of the underground workings could be declared safe, thus allowing for an increase in the information available regarding the dissipation of gas levels in the "restricted zones".

Figure 2: ***A Newtrax-Enabled Conspec Smart Head Wireless Carbon Monoxide (CO) Gas Transmitter.***

2a – Remote Monitoring using Wireless Carbon Monoxide Gas Transmitters

Prior to each blast, mine personnel now deploy Newtrax-Enabled Conspec Smart Head Wireless Carbon Monoxide Transmitters in predetermined locations between the blast and the dedicated ventilation exhaust infrastructure. Ideally, they are placed as close to the site of the blast as practical without risking sensor damage due to blasting and to be able to effectively monitor the integrity of the longest possible portion of the fresh air supply ducting.

To allow for a rapid deployment of the necessary sensors, the wireless gas transmitters were mounted on a 0.3 m square section of the No. 6 WWM mine screen. They were also equipped with "hooks" to allow the sensor to be hung from the existing mine support screens at predetermined locations, and were installed towards the end of the shift immediately prior to the blast. The location for the sensors was indicated on mine level plans used to establish the isolation barricade locations, and showing the ventilation infrastructure. The gas monitors would be "turned on" near the end of the shift prior to the blast to preserve batteries, and to confirm that the sensors had acquired the network and were communicating with the surface.

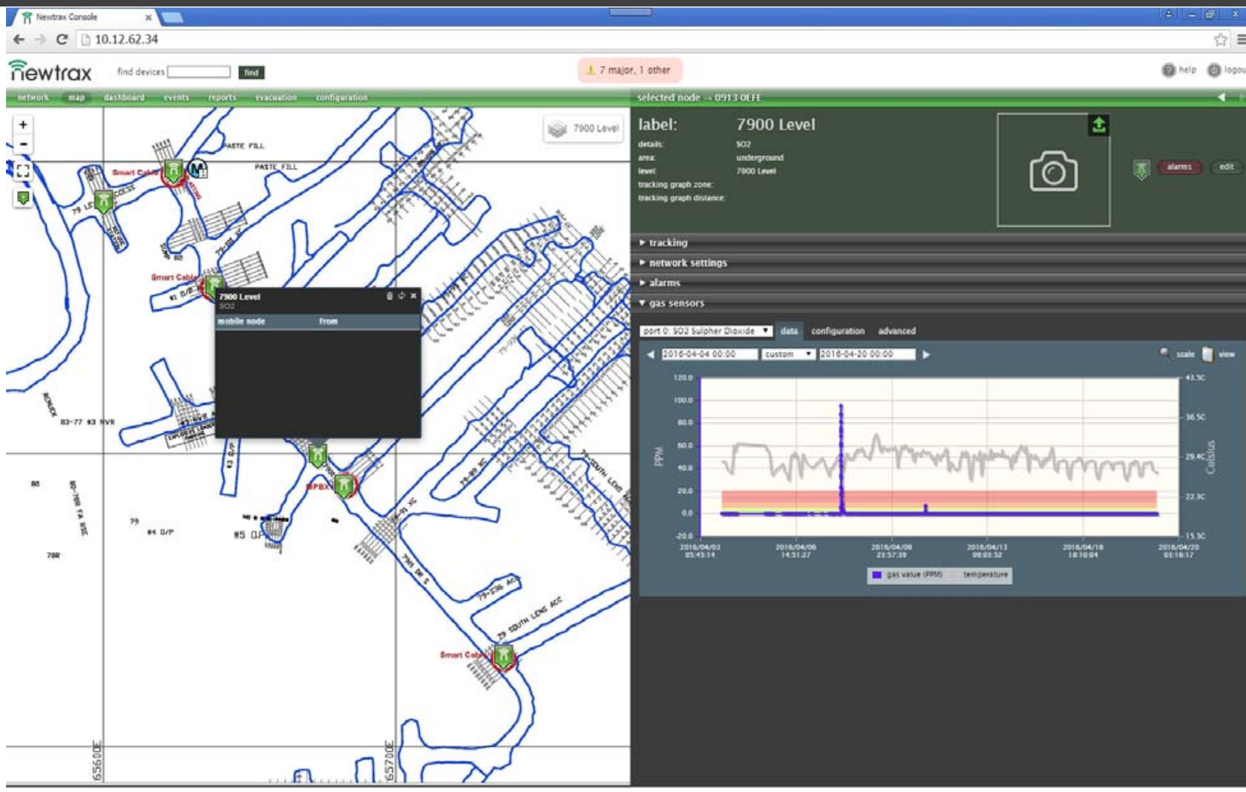

Figure 3: ***Newtrax's Central Server showing a map of 7900 Level on the left, and a steeply rising gas concentration immediately after a blast and subsequent null readings at a rapid rate of decay.***

Once a blast is initiated, the ventilation department supervisor previously assigned after a pre-determined "reduced hazard" time to guard the access points to the blast area with handheld gas monitors and ultimately restore normal ventilation, instead now remotely monitors the status of the ventilation from the time of the blast using the real-time data from the Carbon Monoxide wireless gas transmitters, through a Newtrax Central Server web console from any computer terminal at the operation. By measuring the decay rate of the Carbon Monoxide levels in ppm after a blast, the ventilation department supervisor on duty can assess from a safe location the effectiveness of the ventilation system in clearing all atmospheric contaminants generate by the blast without the need to risk going underground while either atmospheric or seismic conditions may pose a hazard.

If there was an immediate increase in gas concentrations, followed by a steep decay curve, it could be determined that the gas had been flushed from the stope. This meant that there was minimal likelihood that the auxiliary ventilation distribution network has not been damaged. At that point in time, the area only needed to be quickly inspected to confirm that all associated developments had been purged of gas once the seismic risk had abated.

As has been determined though trend analysis of the residual post-blast concentrations of Carbon Monoxide in the atmosphere is that these concentrations are closely aligned to the physical condition of the ventilation ducting and other auxiliary ventilation hardware to clear the atmospheric contaminants.

If the carbon monoxide concentration rises steeply immediately after a blast, then subsequently returns to null readings at a rapid rate of decay, then it has been shown from subsequent field inspections that the ventilation ducting has remained intact all the way to the site of the blast. Thus now, as verified by the field inspections, gas hazard is thus eliminated prior to any personnel being sent underground. At that point in time, only the seismic hazard remains the more significant risk which may be adequately mitigated through the use of barriers (fences) alone, without the continued need for ventilation personnel to monitor for atmospheric contaminants.

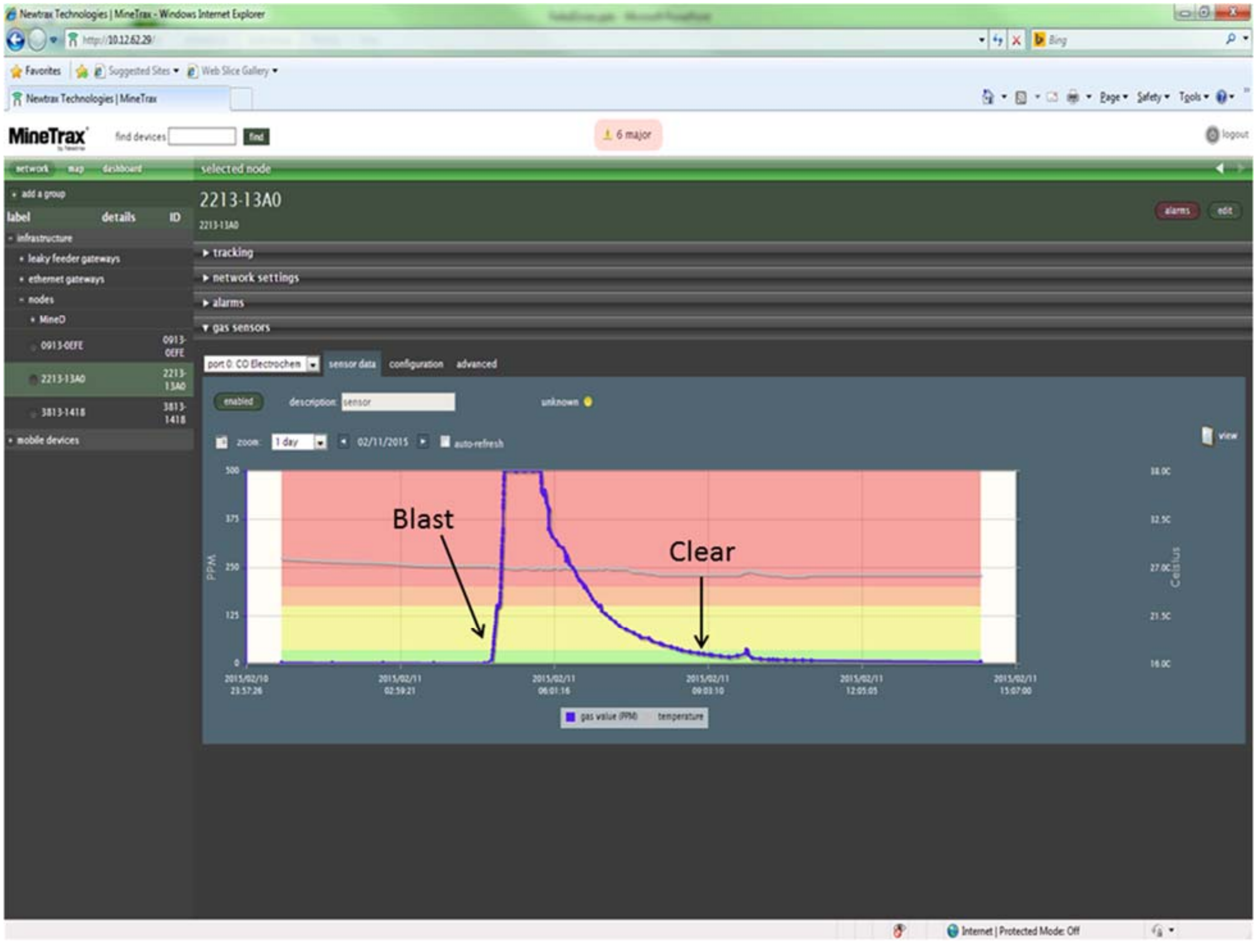

Figure 4: ***The ventilation systems on the level survived the blasting intact and showed that by 9:00 AM the Carbon Monoxide had been cleared to normal background levels, and thus restriction barricades were moved to isolate the continuing seismically area active only. The resulting seismic restriction included the South section of the levels, releasing the Northern part for operations after 9:00 AM, without having to expose mine ventilation safety personnel to confirm the absence of gas.***

If the Newtrax dashboards indicated a poor ramp-up in gas concentration, and a "lingering" peak, then it could be assumed that there was substantial damage to the ventilation infrastructure. The gas checking personnel could then be assigned to obtain sufficient material to repair the entire ventilation distribution tubing, from the auxiliary fan feeding the stope to the actual stope. Once the seismic hazard had abated, the crews could also then immediately begin the process of restoring ventilation. Any delay would be reduced since they would already have the materials required on hand and would know the restrictions in terms of gas concentration where they would be working.

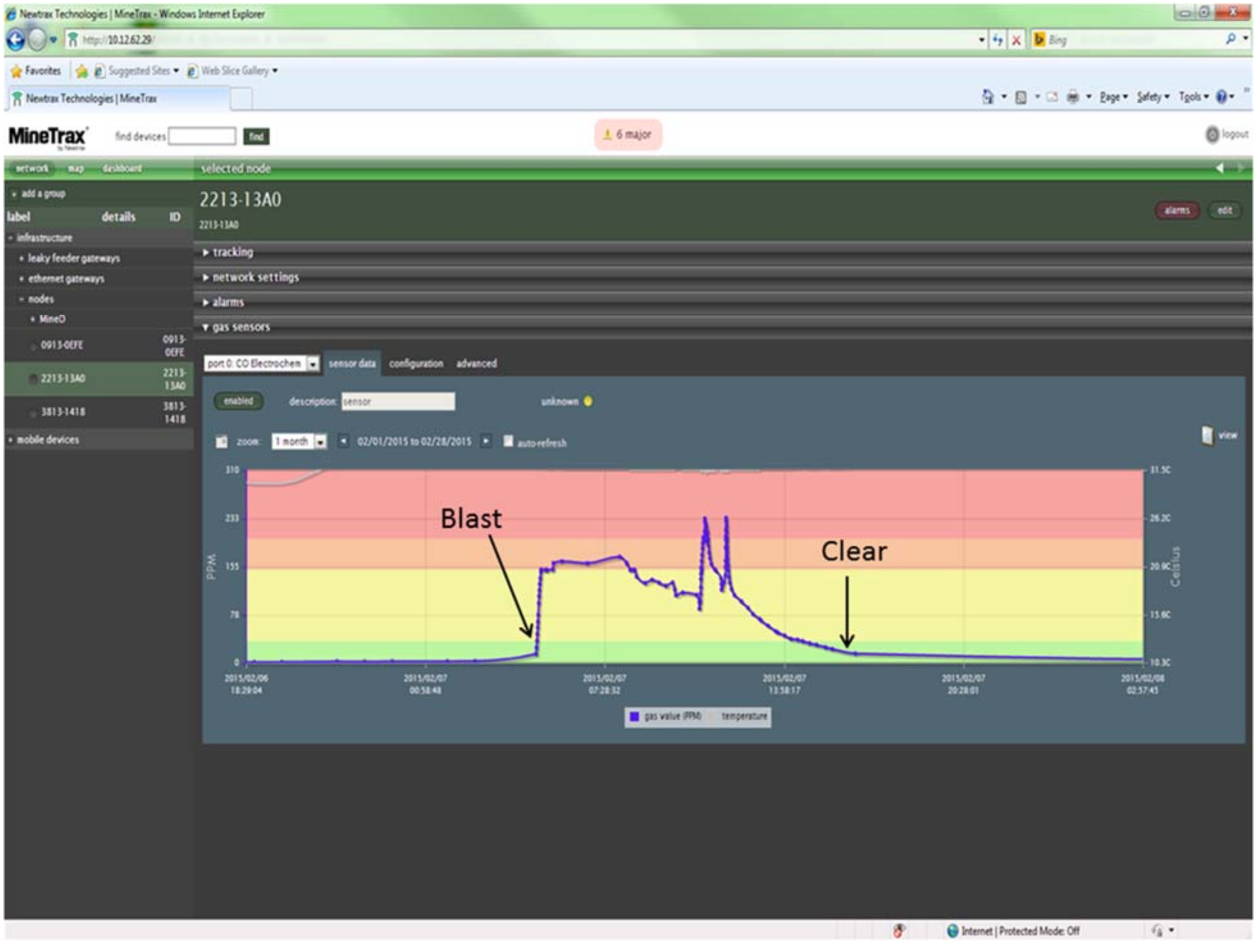

Figure 5: ***the vent did not survive the stope blast, and the gas check team had to wait until 13:00 until the seismic hazard had abated, before being able to re-ventilate the area with gas finally clearing after 15:00 hours. During the 7 hour period from the start of the shift, until the seismic hazard had declined, the gas checking personnel were able to obtain the necessary material and equipment to undertake the repairs, without ever having entered the affected area. The repair and re-ventilation process was completed within 2 hours. If they had been required to survey the damage prior to gathering materials, the delay could have extended into the subsequent night shift.***

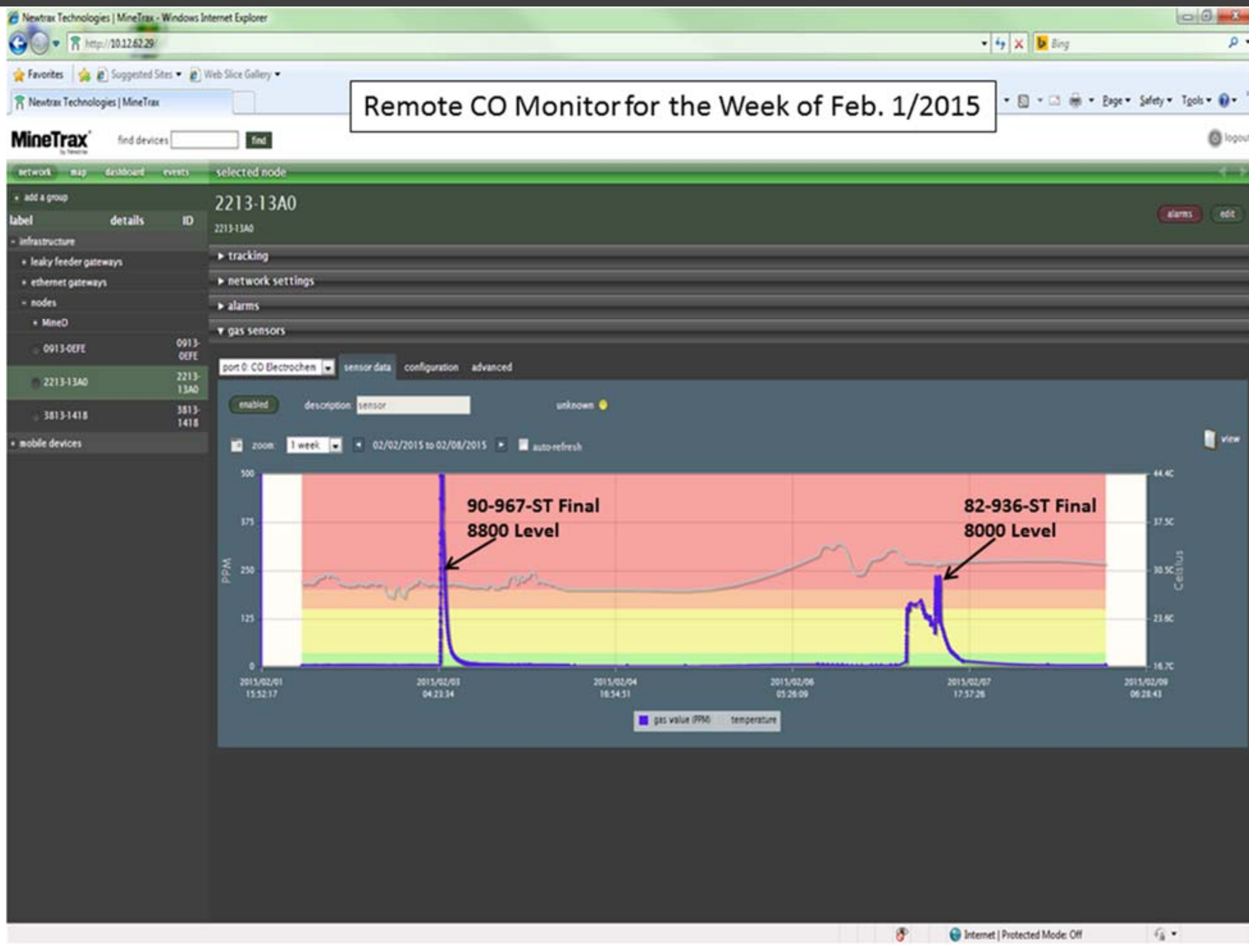

Figure 6: ***This trending graphs allows us to compare two blasts using the Newtrax Web Console. The first shows the Conspec Smart Head Wireless Carbon Monoxide Transmitters deployed on 8800 Level reporting as in Figure 4 a rapid increase in Carbon Monoxide levels to in excess of 500ppm followed by a sharp steady decline to normal background levels which correctly identified no damage from the blast to the ventilation infrastructure on the level. The second shows the Conspec Smart Head Wireless Gas Transmitter having been redeployed to 8000 Level reporting as in Figure 5 an increase at the time of blast of Carbon Monoxide levels to just over 150pm and remaining steady with only a slight reduction in CO levels through the overnight period indicating damaged ventilation ducting preventing the atmospheric contaminants from being cleared. The levels of Carbon Dioxide then again spike as the ventilation ducting is repaired, followed by a rapid steady decrease in the levels of Carbon Dioxide as the repaired ventilation system clears the remaining atmospheric contaminants.***

At the same time, the geotechnical instruments could be polled to check for abnormal displacement or overloading, warning the supervisor about potentially hazardous ground conditions within the affected area to ensure that safety precautions due to seismic risks continue to be observed.

2b. SO2 gas remote monitoring

The Kidd Operation has also experienced spontaneous heating of high sulphide ores, leading to rapid oxidation and the evolution of SO_2 gas. In stopes suspected of having the associated minerology required for the evolution of SO_2 gas, Newtrax-enabled Conspec Smart Head Wireless Sulfur Dioxide Gas Transmitters are deployed on both the overcut and undercut elevations, in the entrance to the crosscut to the stope, prior to any blasting.

If a secondary sulphide detonation occurs during the blast (sulphide dusts spontaneously ignite due to the high temperatures generated during the firing of the explosives), the presence of high levels of SO_2 combined with delayed CO gas decay can indicate that the ventilation ducting has been damaged. Once in normal production mode, if the broken ore, which has a high surface area, begins to oxidize, the gas monitors can immediately detect the presence of SO_2 in low concentrations. This allows modifications to be made to the ventilation system or to the ore recovery rate to mitigate the risk.

To deal with the “hot muck” issue, the undercut is allowed to freely ventilate and upcast through the stope. All auxiliary ventilation systems are also turned off on the overcut, allowing the contaminants to flow freely to the primary exhaust raise. The overcut is isolated by ventilation brattices, creating a dedicated ventilation path from the stope to the primary exhaust raise. The battery-powered wireless SO_2 sensors can remain within this isolated and hostile environment, and allow conditions to be monitored remotely without the need to expose personnel to the risk of acidic and toxic gas. Prior to the ability to do this remote monitoring, teams of personnel equipped with full SCBA protective equipment had to enter the contaminated zone every two hours to monitor both the ventilation flow and the gas concentrations and determine whether conditions were improving or if the oxidation process was accelerating.

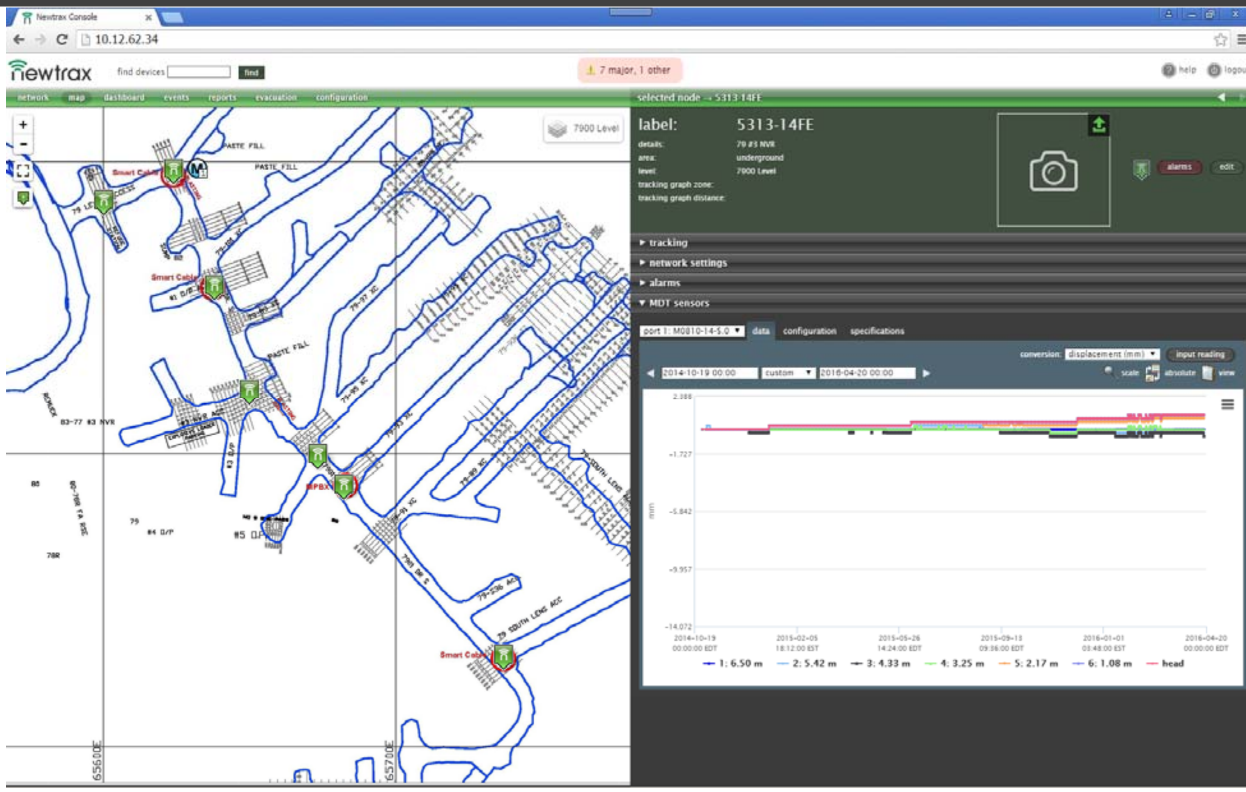

Figure 2: Newtrax's central server, showing a map of the 7900 Level on the left, and geotechnical data for an 18-month period for an extensometer. One of the Conspec gas detectors for SO2 is located in the main footwall development, at roughly the centre of the image.

3. <u>Benefits of the remote monitoring system: Enhanced safety and productivity</u>

The presence of the battery-powered wireless gas sensors in active work areas allows gas concentrations to be determined in real-time and tracked over time, providing key analysis to the ventilation managers of atmospheric conditions without personnel needing to enter a "restricted zone."

Because now through remote atmospheric monitoring, ventilation personnel can without hazard to themselves can determine not only the effectiveness of the ventilation system in clearing atmospheric contaminants from the blast area using the Carbon Monoxide and Sulfur Dioxide Gas Levels readings from the Wireless Gas Transmitters as described above, but also any potential damage of the ventilation ducting and auxiliary ventilation system on the blast level prior to the deployment of personnel underground. This allows mine ventilation inspection and repair personnel to obtain potentially necessary replacement ventilation ducting from an underground storage or warehousing facility while still on their way to the affected area and before they have even inspected it.

Once the seismic hazard has returned to normal levels and ventilation personnel with the appropriate protective gear are allowed to enter the area, they can immediately repair any damage that they encounter because they already have the material and tools with them. Before the use of this continuous Carbon Monoxide and Sulfur Dioxide monitoring during and post blast, this ventilation personnel were unable to determine if there was any damage to the ventilation system until they could be safely deployed underground based on the readings of the handheld gas monitors at the entrance of the level to perform a preliminary inspection, which could only be done following the easing of the seismic hazard restrictions. They would then need to go to the warehouse, located several kilometers away, withdraw the material and then return to the affected area to affect repairs. That delay time for gathering material is now avoided because they are sufficiently informed of the potential for damage to bring supplies with them on their way in.

In addition, knowing that a gas hazard is present, or that the gas has cleared, allows for a better assessment of risk to "other personnel" remote from the actual blast site. Because the gas readings are available in real-time on the surface, appropriate actions can be taken during the "shift change and supervisory line up process" prior to assigning work and workers to an area. By reassigning new tasks and directing workers to new work sites which are unlikely to be impacted by the gas delay, at the start of the shift and before they head underground, an immediate gain in effective working hours for those personnel can be achieved.

4 – Productivity Gains from Remote Atmospheric Monitoring Post-Blast

Because in the time savings as described above in operators being able to safely return to their work areas back to productive use thanks to remote real time monitoring of Carbon Monoxide and Sulfur Dioxide during and post-blast, the productivity gains have been substantial.

As can be seen in the above examples, whether it is through releasing areas for production that is no longer seismically active immediately upon remote confirmation of dissipation of gases to safe levels in these areas, or through the redeployment of miners involved in mucking, drilling and development to other non-affected production areas, productivity has been increased by 5-6 production man hours per shift. As a skilled operator can move approximately 20 buckets of 10 tonnes each from a stope to the pass over this period, increased productivity of on average of 200 tonnes of extraction of rock has been containing on average 3% copper has been measured since implementing the remote post-blast monitoring system when it has been detected that the ventilation system survived the blast intact. At current copper prices, this has resulted in an increase of approximately USD$35,000 in copper yields from the mine in the shift immediately post-blast since they began the utilization of Conspec's Smart Head Wireless Gas Transmitters operating over their Newtrax MineHop wireless network.

Further increases in productivity have been measured through earlier awareness of any potential damage to mine ventilation systems, allowing Kidd mine ventilation personnel to respond in a more efficient manner to repair this damaged infrastructure while simultaneously minimizing the risks to their safety due to the exposure of potentially toxic levels of remaining blasting gases. This has allowed ventilation repair personnel to reduce the time required to conduct inspections and necessary repairs to this ventilation infrastructure, thus allowing areas that have no longer been deemed a seismic risk post-blast to return to productive use 1-2 hours faster than previous post-blast inspection procedures had allowed, ensuring a more productive second shift post-blast. Rough averages on the productivity increases as outlined above measures this increase in productivity due to more efficient repair of ventilation infrastructure after it has been damaged by a blast to be on average between USD$5,000-15,000 in copper yields from the mine during the effected first or second shift.

5 - Conclusion

The battery-powered wireless gas and geotechnical monitoring system installed at Glencore's Kidd Operations in Timmins, Ontario by Newtrax, Conspec Controls and Mine Design Technologies (MDT) has enabled the mine to significantly reduce post-blasting re-entry delays for underground workers and created a more efficient mining process, resulting in substantial financial benefits for the Glencore.