MOSS- “Miner Operated Survey System”

INTRODUCTION

Accuracy and efficiency; two critical elements in the modern mining industry, and both easily lost if mine plans are not followed. With each meter of advance, overbreak, underbreak, and deviation from the designed mine plan, are three key factors that can result in substantial delay in the cycle. As the old aphorism states, the most expensive round is the round you don’t get. “Over-break as well as damaged zone has significant impact on the project cost, construction period, safety and performance of the underground structures,” (Verma, Dwivedi, Roy, Singh, 2016, p. 1).

Problems with the Current Underground Surveying Process

Underground Surveyors are skilled mining professionals with significant training and experience in their field. Surveying a newly blasted round can take time, as surveyors are required to perform a tope (topographic survey) of the round to determine as-built conditions vs original design.

The current underground surveying process requires the surveyor’s time to install grade plugs in the wall and smoke marks in the back to mark line and grade at planned distances and intervals. Development must wait for surveyors to complete this process, which can take days depending on the size of the mine, and the surveyor’s workload. During this time, if development continues, it typically does so with improper drift control. Development using outdated plugs or following one of the walls often results in incorrect line and grade, with the drift deviating to an incorrect location.

When development follows correct procedure and waits for proper set up by the surveyor, the individual miner is still required to mark up the round factoring grade, centerline and the crank line prior to a new round being blasted. This can take a miner anywhere from forty-five minutes to an hour depending on their experience and field conditions, further slowing down cycle time.

Another issue commonly encountered beyond the surveying procedure is that there is no way for the miner to know how much overbreak and underbreak they have with each round. This information would allow for all necessary adjustments for the following round. “Studies show that most mines are looking at an overbreak of 20 or more percent.” (Lalonde, 2016).

What if it were possible to solve both issues with one person in control of one user-friendly device?

WHAT IS MOSS?

Overview

The Miner Operated Survey System is user-friendly underground surveying software that integrates mine design specifications and drawings when completing mark ups for the round, and provides real time information to miners, engineers, and geologists. MOSS allows for face mark ups to be performed by a single operator and is proven to help reduce overbreak by an average of 10% as well as providing accurate line and grade markups for every round.

Advantages

The MOSS software supports a wide range of Leica robotic total stations, including the state-of-the-art MS60 Multi Station. Rather than have a surveyor go underground after each freshly blasted round, MOSS completes the survey pick up during the mark up process performed by the miner. This provides surveyors with more time to focus on quality assurance of the control points being used for production drilling and blasting, and with no requirement to perform layout and pickup tasks, can greatly decrease the time required to cycle a round.

Additionally, mine plans are updated with every MOSS mark up is completed, meaning plans remain current on a daily, or even shift-by-shift basis. Further, depending on the available infrastructure underground, any new data picked up by the miner can be sent straight to surface in real time once the miner saves their work, or uploaded at the end of their shift. Updated drawings are instantly accessible on the network for surveyors, engineers, and geologists to review.

Information that surface workers can see on a real time or shift by shift basis includes:

- Overbreak
- Underbreak
- Deviation from mine design
- Topes
- Drill hole patterns
- Hold offs on uneven faces

Components of MOSS

The complete MOSS system is easy to set up and requires only a few components to function properly. The components are designed to be rugged and durable for the underground environment.

MOSS Contains the Following Components:

- Robotic Total Station
- Tablet Computer
- Tripod
- Mini Prisms

Figure 1. MOSS Components: As shown above, the tablet is contained in a durable hard-shell cover that which provides additional protection against drops while making it more portable.

How MOSS Works

The Set Up

Step 1 in the MOSS mark up process is to set up the tripod in the center of the drift, 5 to 10 meters from the face. It is important to consider the location of the two back sights; the angle between backsights should be between 20 and 160 degrees. Once the tripod is set up, the miner mounts the robotic total station and tablet. After turning on the total station, the miner ensures it is leveled and connects the tablet to total station via a Bluetooth or WLAN connection.

Good Practice – creates accurate resections

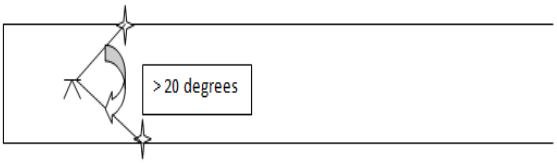

Figure 2. Ideal set up angle

Poor Practice – creates poor resection accuracy

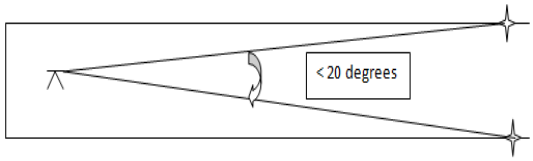

Figure 3. Angle less then 20°

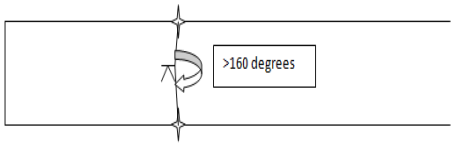

Figure 4. Angle greater then 160°

Step 2 is to insert two Leica Mini Prisms into the 3/8” sleeves, which are in turn inserted into two separate stations on the wall.

Below are images showing the process of installing a new station. (Figure 4)

Figure 5. New station inhalation process

With Steps 1 and 2 complete, the miner begins using MOSS and its features to mark up the face.

Solution Features

Face Profile

The face profile is the first step in the MOSS process, which helps determine the overbreak and underbreak percentages. This beneficial feature allows the miner to see the profile on the tablet, while the percentages help calculate how they will blast their next round to make up for any discrepancies.

“Because the surveys are done per round, per shift, the miners take a lot more ownership of their work. There’s more pride involved. At the end of a shift, they can say ‘I was under five per cent overbreak.’ Because MOSS gives you a visual picture, they know what the round looks like.” (Lalonde, 2016)

Below is a photo showing what the overbreak/underbreak profile will look like after the face profile is complete (Figure 5)

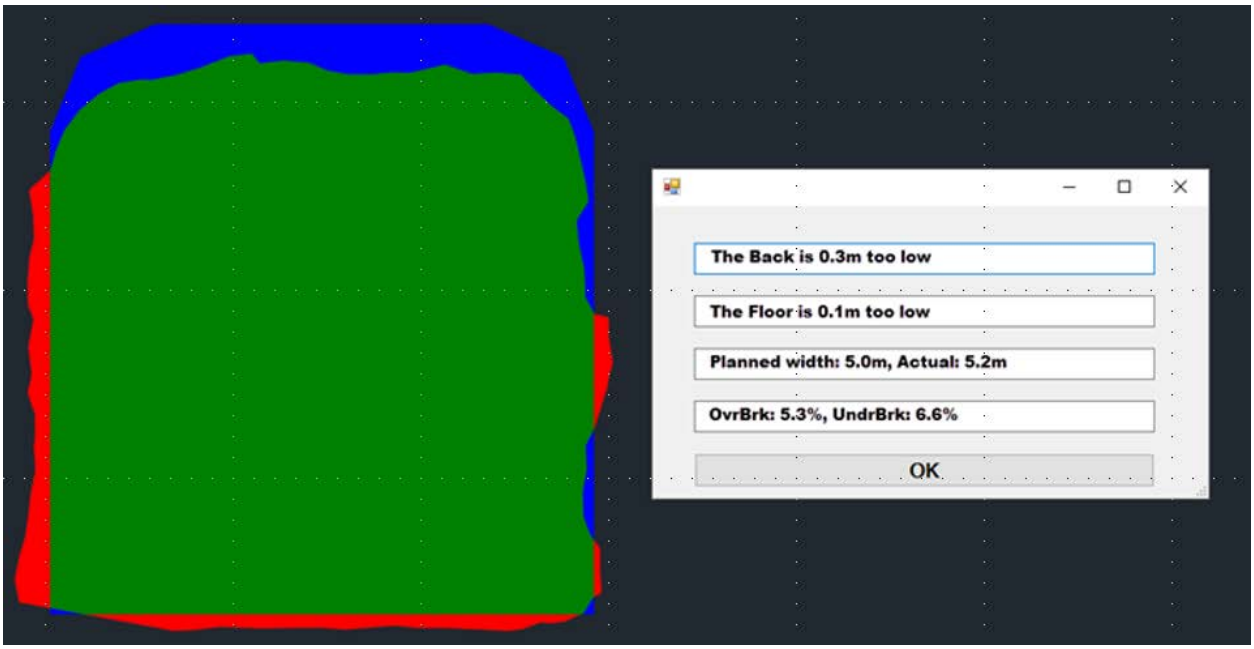

Figure 6. Overbreak/underbreak percentages

Centerline Mark Up

Next in the process is the centerline mark up. The robotic total station projects a laser on the centerline of the face from any offset from the floor or the back based on the mine standards or drift conditions. Once the laser has projected the centerline, the miner marks it with a paint can.

Below is a photo showing the centerline marked on the face. (Figure 6)

Figure 7. Centerline marked on face

Crankline Mark Up

Crankline mark up is the next step the MOSS helps complete. The robotic total station projects a laser on either the back or the floor, depending on the mine standards or drift conditions. Providing a choice of back or floor is a popular due to the possibility of water or muck being of the floor, in which case the miner marks up the crankline on the back. Once the total station projects the laser, the miner follows it with a paint can creating a perfectly positioned crankline.

The MOSS also eliminates the hanging and alignment of plumb bobs, resulting in significant time savings.

Below is a photo showing the crankline being marked up on the back using a paint pole. (Figure 7)

Figure 8. Crankline being marked on back

Gradeline Mark Up

While using the MOSS to mark Gradeline is when the MOSS completes the topographic survey normally completed by the surveyor, which will show the miner in real time what their round looks like in comparison to the design.

MOSS projects a laser on the centerline and traces the gradeline starting on the left side of the drift. It stops projecting at 90° to the total station. The process is then repeated for the right side of the face and wall. This gradeline also provides the proper height for screen installation. The miner simply follows the laser with a paint can to mark up the gradeline.

Below is an image showing the gradeline marked up. (Figure 8)

Figure 9. Gradeline being marked up

Face Markup

MOSS is used to show where all drill holes will be located on the face, and creates the most efficient drill hole layout specific to the size of the drift, and rock type.

The total station projects a laser onto the face in the location of each drill hole, and remains in each location for a desired length of time predetermined by the operator. (If the miner misses marking up a hole with the paint can, they can go back as many as five holes.) After hole markup is complete, MOSS generates a visual hole mark up drawing on the tablet, show which holes have been marked up, and which have not, allowing for adjustment and correction.

Below is an image showing the face markup drawing on the tablet. (Figure 10)

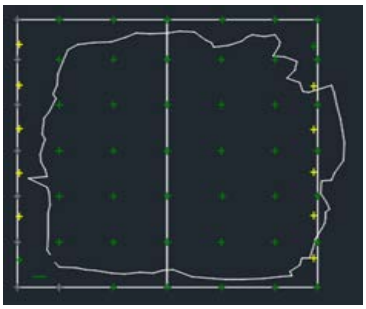

Figure 10. Face Markup shown on tablet

Using MOSS to complete a face markup results in significant time savings compared to the traditional method of using a measuring tape.

Additional Features

Topes

MOSS can perform topes in any location. These topes can be completed by the miner during the process of marking up a new face, or by a survey crew who needs to tope an existing heading or drift.

While it is not traditional for topes to be performed with every new round taken, MOSS makes it both possible, and beneficial; safety is increased and stress alleviated at year end as workers are not left scrambling to do takeoffs at every face. Planned work is safer work.

As with a ll data collected with MOSS, topes are updated on the network at the end of every shift.

Below is a photo of tope lines for each heading pick up performed. (Figure 11)

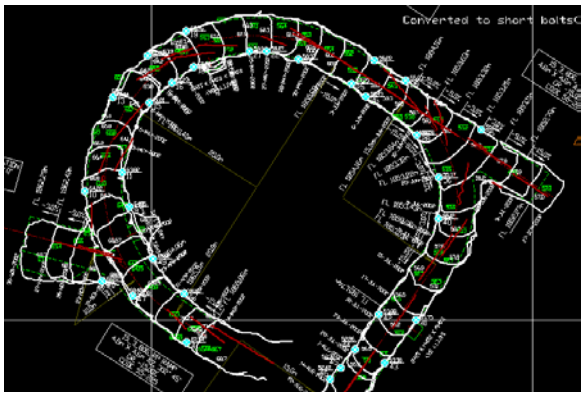

Figure 11. Topes of each heading

Track Mode

Track Mode is a useful feature in MOSS that allows miners to locate objects. For example, if the miner is required to create a safety bay in a drift, they can use Track Mode to locate the opening. Once in Track Mode, the total station projects a laser and provides a live view on the tablet of where the laser is pointed which moves with the instrument. Horizontal and vertical measurements are displayed in respect to where the total station is locked onto, such as the centerline. Track Mode increases efficiency by facilitating tasks such as creating a re-mucks or a safety bays.

Other features of Track Mode include:

- Tracing drift profiles
- Tracing ore outlines and geological structures
- Locating designs (slashes, diamond drill holes, centerline)

Below is a photo showing what track mode looks like. (Figure 12)

Figure 12. Track Mode

CMS – Cavity Monitor Survey

A key safety feature of MOSS is the ability to perform Cavity Monitor Surveys (CMS). MOSS can perform these surveys remotely, eliminating the risk of injury or death to workers from falling ground.

The total station is placed onto a remote-controlled robot that can be operated wirelessly. The cavity monitor survey function on MOSS can be used in dangerous areas such as an open stope, shaft, voids, ore passes, or any other dangerous cavity locations. The CMS function provides the operator with point cloud data, providing thousands of different points to show the exact dimensions of the surveyed cavity. This information is useful for ground control, Engineering, Surveying, and Geology.

Below is a table illustration the Feature/Benefit/Value of MOSS. (Table 1)

Feature	Benefit	Value
Real-time comparisons between Design and Actual Drill Blast	Significant Reduction in Ober-break & Under-break	Reduces costs associated with mucking & hauling, slashing
Setting of Line and Grade	Real-time Surveying performed by the Drill Crew	No need to wait for the surveyor, improves cycle times and increases productivity
Diamond Drill Holes	All Diamond Drill Holes are searched and identified during the markup	Saves time, improves accuracy
Face Scanning & Photos	Geology photos are mapped directly onto the rock face. All installed ground control is documented.	Improves the flow of critical information and provides records for auditing
Cavity Monitoring	Robotic Total Station can be used for Cavity Monitoring Surveys	Lowers required capital investments
3D Solids	All surveys can be swept together in CAD to create 3D solids for month end reports	Timelier & accurate metrics for month end reconciliation and financials
One-man operation	Increased efficiency	Reduce manpower costs and increase safety (fewer people in the development
Construction layout	Stakeout critical construction points/grade lines/ offsets	Improved workflow, estimating schedule timeline more efficiently
Includes AutoCAD OEM License	Streamlines customer software maintenance	Eliminates need to subscribe under Autodesk's new licensing model

Table 1. Feature/Benefit/Value

Longhole Markup

The MOSS vastly simplifies the markup process for Longhole, eliminating the need for a surveyor to mark rings onto the drift walls, then having drillers line drills up on the marks and measure dip and azimuth using conventional methods. (Methods at times resulting in overbreak of as much as 80% in some stopes.) With MOSS, drillers mark up their own ring layout, collar locations, and precisely track and line up their drill steel.

Design for ring layouts is easily imported from any CAD based planning software. Once setup, MOSS tracks prisms mounted to the top and bottom of the drill steel, and measures how they must be displaced to line up the drill steel to the correct dip and azimuth. The offset at the toe of hole is calculated in real-time with the driller adjusting the drill steel until the error is within tolerance. This is repeated on each hole on each ring.

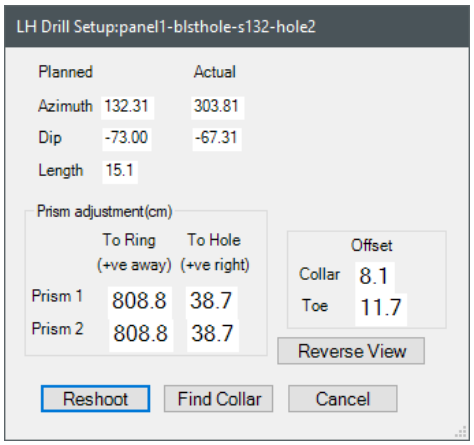

Figure 13. Longhole Drill Setup

Return on Investment

"The return on investment is within 82 metres of development. The cost savings are huge. We're not talking thousands. We're talking millions." (Lalonde, 2016)

An investment in MOSS pays for itself in short order. Mines that have purchased and switched to MOSS have already realized millions of dollars in efficiencies, substantial savings that have a positive impact on any mining operation.

Below is a table showing Business Case data at Goldcorp's Hoyle Pond Mine in Timmins, Ontario. (Table 2).

Case 4: Purchase MOSS System				
Overbreak data collected daily per heading Ensures that 4 surveyors can survey both undergrounds, one Chief Surveyor oversees both Mines. Surveyors can help with Vent Readings. Enables geological mapping at the face with tablets.				
Category	**Quatity**	**Price**	**Ut hrs**	**Total**
Labour	4	$107,00	1	$428,000
UPC Costs	3	$70	520	$109,200
Survey Equipment Maintenance	10	$3,000	1	$30,000
MS60 Purchase	10	$106,689	0.016666667	$17,781
Total	N/A	N/A	N/A	$584,981

Delta to Case 1				$38,781 107.1%
Initial Investment				$1,066,889
Yearly Opex Costs				$567,200
Assumed OE2 Savings from Overbreak reduction				$1,360,00
Yearly Cost/Benefit for this Case				$792,800
NPV (6%) over 3 years				$2,481,782
NPV (6%) over 7 years				$5,526,394
Payback (Years)				0.7

Table 2. Hoyle Pond ROI

As demonstrated above, since switching exclusively to MOSS at Hoyle Pond, after 3 years the NPV is $2,481,782. In this case, the pay back of switching to MOSS occurs in 0.7 years, a quick turnaround on ROI by any measure.

For every percentage overbreak that is decreased using MOSS, there is an estimated $100,000 to $200,000 in savings. From Hoyle's data this is $113,000 per % overbreak.

CONCLUSION

Today's modern mining industry is safer, more efficient, and more cost effective, due in large part to innovation and the adoption of new technologies. MOSS checks off all these categories. MOSS speeds up cycle time by providing the ability for one miner to perform tasks previously completed only by the survey crew. And MOSS eliminates the serious hazard of workers being exposed to open cavities with its cavity monitor survey feature.

"MOSS positively impacts professionalism and worker satisfaction." (Lalonde, 2016)

Worker satisfaction is quickly becoming a major deciding factor in the purchase of new technology. These benefits are felt by everyone, and not only have a positive impact on the bottom line, but also on worker morale and engagement. MOSS is already proving itself with workers who enjoy using the system because it makes their lives safer, easier and decreases cycle time, which means more rounds. And we know what more rounds means.

With MOSS proven to save mining companies millions of dollars with a very quick return on investment, it has attracted serious interest, with many mining companies looking forward to its beneficial impact on their own mining operations.

MOSS is the future for surveying in the mining industry and the obvious choice for surveying technology.