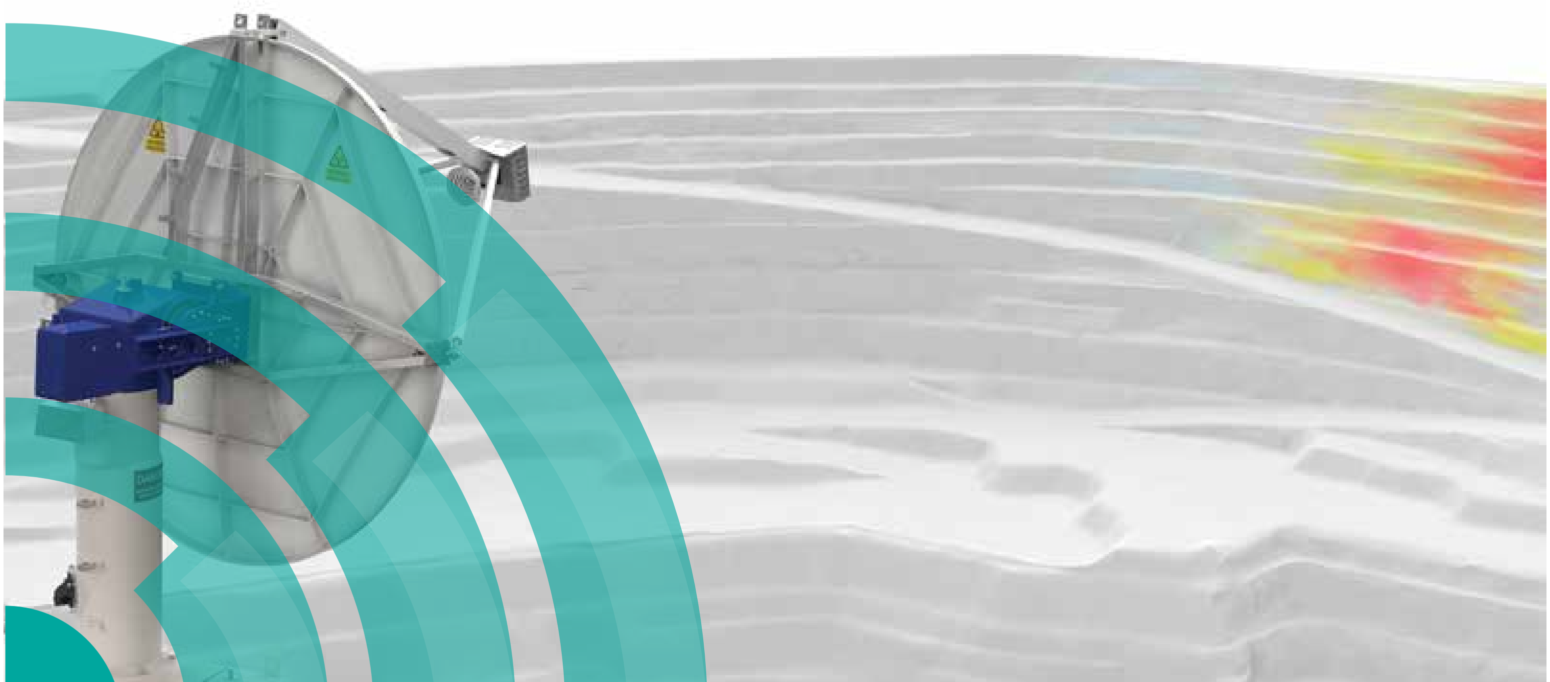
REUTECH
MINING



Newsletter
Quarter 1

In this issue

A message from Reutech Mining

At Reutech Mining we believe that an uncompromising commitment to innovation is the cornerstone of great product design. This philosophy, drives our desire to produce accurate and reliable products, which ultimately provide customers with increased safety and productivity. Over the past year, we've been on a mission to challenge the status quo because the industry doesn't require more solutions, it requires smarter solutions. The end result is reflected in our latest software release – ScatterX.

ScatterX is the reason that there is nothing quite like the MSR. Because we engineered both the hardware and the software, everything is designed to work together seamlessly. It brings together cutting edge radar hardware and innovative software to offer a game changing slope monitoring radar capable of performing both strategic monitoring tasks as well as tactical monitoring tasks.

ScatterX is capabable of running on all MSR systems currently deployed, which means that even our very first systems will remain at the cutting edge of radar technology. We are very excited about ScatterX and we look forward to how it will help you in meeting your business goals.

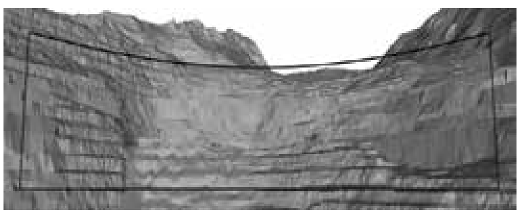
Jan de Beer

ScatterX

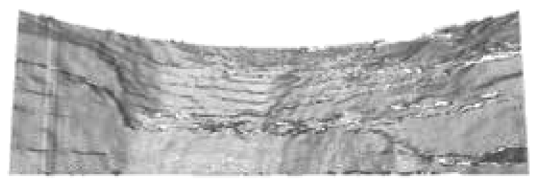
Innovative software inspired by the industry

High resolution data in 3 dimensions

ScatterX relies on advanced proprietary processing techniques that dramatically improve the amount of information recoverable from inside a single beam. Whereas previously a single data point in range was reported for each scan point, up to 30 points within a single beam are now reported on and displayed.



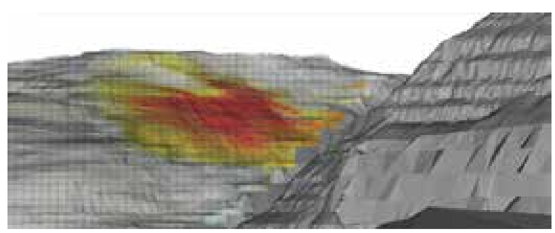
Digital Terrain Model Generated Using a Laser Scanner



3-Dimensional Point Cloud Generated using the MSR Powered by ScatterX

Faster scan speeds over broad areas

The ability to extract multiple points at each elevation position means less elevation positions need to be visited, allowing the radar to scan up to three times faster, without compromising processing time. A new multi-threaded software architecture combined with optimised data file compression structures provides updated radar data immediately after every scan.



High resolution true 3 -Dimensional MSR synthetic map generated at 3200m

Improved atmospherics without a known-stable

The MSR no longer requires known-stable regions as it relies on advanced atmospheric correction algorithms to compensate for the effect of the atmosphere on radar data. The increase in resolution combined with shorter scan times allow for better correction of atmospheric effects, yielding a cleaner and more accurate representation of slope surface displacement.

Going the extra mile

MSR Modular Series increase operating distance from 2500m to 4000m

Building on the innovative MSR Standard Series hardware platform, the MSR Modular Series offers all of the same benefits. The building blocks of the MSR Modular Series take flexibility to a whole new level, providing a highly customisable solution. The Radar Module forms the foundation of the solution and can be supplied with electrical power to provide real-time data at operating distances of up to 4000 meters.

With a maximum scan speed of 40° per second, the MSR Modular Series covers broad areas in only a few minutes. The advanced parallel computing architecture processes data while actively scanning. Lossless data compression algorithms combined with high speed wireless communication hardware provides instant remote access. This means that slope movement information and alarms are immediately available. Anywhere. In real time.

Intended to evolve with operational and budgetary requirements, the MSR Modular Series allows for optional Battery, Generator and Solar Modules, all with a variety of mounting options. Life-cycle costs are greatly reduced; with a new integrated power management system that drastically reduces the service intervals.

Operating Distance	 MSR060 30 m to 600 m	 MSR120 30 m to 1200 m	 MSR250 30 m to 2500 m	 MSR400 30 m to 4000 m
Power Supply	220 V @ 50 Hz 110 V @ 60 Hz External	 Battery	 Generator	 Solar
Deployment	 Fixed	 Trailer	 Vehicle	
Operating System	Powered by ScatterX			

Project focus

Tracking rapid developing instabilities

The MSR was recently deployed as both a strategic and a tactical monitoring tool for the early detection and subsequent critical monitoring of a rapidly developing rock fall. The MSR plays a crucial role in the mine's integrated monitoring system, alongside other methods such as an Automatic Total Station system, ground water monitoring and visual inspection.

The MSR was set up to scan a broad area, as per Figure 1, characterised by known geological faults but which had historically displayed no apparent movement.

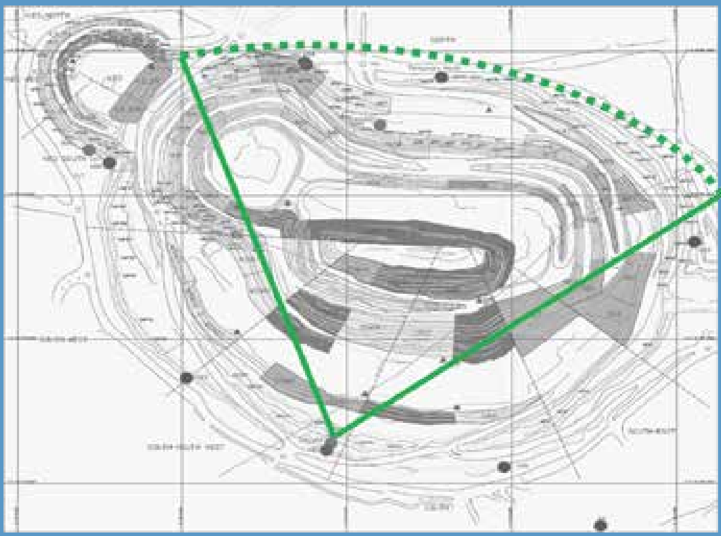


Figure 1 - MSR Scanning a Broad Area

The mine experienced a severe rain event where more than 30 mm of precipitation was measured over a 2 hour time period. This resulted in a 160,000 ton failure which rapidly developed over a 3 hour period from initial onset. The dual level user defined alarms where configured for both relative range and average velocity as indicated in Table 2 and provided sufficient warning for the successful evacuation of the mine.

Table 2 - MSR Dual Level Alarm Configuration

Alarm Type	Geotechnical Alarm	Critical Alarm
Relative range (mm)	8 mm	12 mm
Average velocity (mm/h)	4 mm/h	5 mm/h

The MSR's ability to track rapidly developing instabilities, even in adverse weather conditions, was a key contributing factor to preventing damage to equipment and loss of life on site. It identified a hazard that was initially unknown to the mine and then proceeded to successfully track and provide alarms based on the measured data.

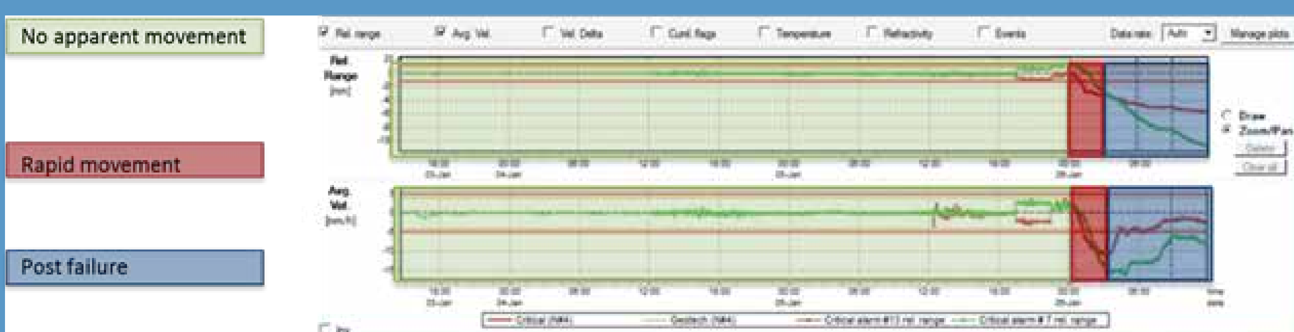


Figure 2 - MSR Tracking an Instability that Rapidly Developed in a 3 Hour Time Period

Geotechnical consultancy services

DOWL joins Reutech's global team of authorised geotechnical consulting partners

Reutech Mining's global team of authorized consulting partners provide clients with an independent third party service that specifically focuses on geotechnical support services. DOWL is the latest addition to this growing team of partners providing both once off MSR site integration services as well as ongoing geotechnical support services.

DOWL'S mining experts specialize in geotechnical engineering, tailings and heap leach, civil infrastructure, pre-feasibility/feasibility studies, and stability monitoring support. Their engineers provide assistance in evaluating slope conditions and monitoring needs, provide in-depth knowledge regarding monitoring with radar and other technologies, and provide geotechnical and geologic support.

MSR Site Integration

Geotechnical and geological assessments
Determination of failure trigger modes
Identification of environmental considerations
Identification of monitoring areas of interest
Developing alarm thresholds
Optimizing radar configurations
Developing communication/response protocols
Developing monitoring documentation

Ongoing MSR Monitoring

Interpretation of radar data
Movement identification
Predictive analysis of slope movement
Geotechnical and geologic assessments
Evaluating alarm thresholds
Optimizing radar configurations
Routine reporting recommendations
Updates to monitoring documentation

Read more about DOWL's experience with MSR technology in *Project Focus: MSR Plays Pivotal Role During Construction at Tailings Management Facility.*

Project focus:

MSR plays pivotal role during construction at tailings management facility

Introduction

Geotechnical instrumentation monitoring of soil slopes often involves hourly, daily, or weekly data collection intervals to track gradual stress changes or deformation. This is driven through an understanding of potential failure modes as well as the availability of personnel and resources to collect the data. Collected data is often reviewed and evaluated monthly or quarterly to track performance and evaluate trends.

In situations where a soil slope is more susceptible to sudden “brittle” failures and a corresponding event is anticipated to have more subtle precursors, it becomes particularly necessary to re-evaluate this approach, especially in environments where site access or construction activities are required adjacent to or within areas with sensitive stability.

Near real-time monitoring incorporates a substantial reduction in data collection intervals, yielding a more comprehensive data set, allowing early warning of slope failure. Each point of collected data provides a snapshot of performance, and as the time between is decreased, the likelihood of missing or overlooking a subtle precursor event is reduced. Understanding the geomechanical behavior of a soil slope provides a significant benefit to overall project safety and long-term performance, as well as in the determination of ongoing maintenance requirements.

Facility Description

The Deilmann Tailings Management Facility (DTMF) at Cameco’s Key Lake Operation (KLO) in northern Saskatchewan was an open pit uranium mine that was converted to a tailings management facility. This facility has been the repository for tailings since 1996. The west wall is comprised of approximately 70 m of glacial outwash sand, generally consisting of interlayered clean sands of various sizes with some silty layers, overlying sandstone bedrock.

A zone of variable thickness consisting of gravel and cobble-sized material, typically mixed with sand or in a sand matrix, was encountered just above the outwash/sandstone contact. In order to provide a water cover for the placed tailings, pit dewatering activities were reduced and flooding of the DTMF began in 1998. Saturation of the outwash sand resulted in pit slope sloughing in mid-2001, which was an ongoing issue until water elevations were stabilised in 2008 through the careful management of dewatering wells around the perimeter of the DTMF. The failure mechanism was identified as structural collapse of the loose outwash sands upon re- saturation, followed by flow liquefaction. A slope remediation design was developed to stabilise the pit wall, based on geotechnical analysis, incorporating slope excavation from established safety setbacks behind the pit crest.

Figure 1 - Existing Outwash Sand Slope

Subsequently, a geotechnical instrumentation monitoring program was developed and implemented for use prior to, during, and after slope remediation construction activities to track the performance of the DTMF slopes and provide early warning of slope instability. Slope remediation activities began on the DTMF west wall in the spring of 2012 and were successfully completed ahead of schedule in the fall of 2013.

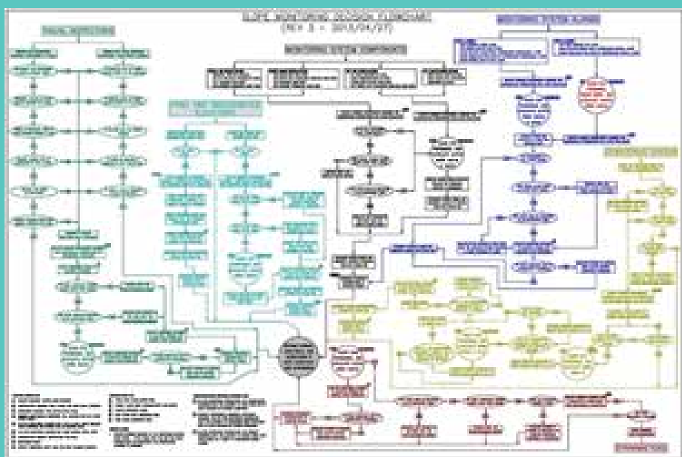


Figure 2 - Slope Monitoring Decision Flowchart and Instrumentation Layout

Selected Monitoring System

Due to the unstable nature and inaccessibility of the pit wall slopes, coupled with the goal of a near real-time data collection and analysis interval, it was not feasible to utilise conventional methods of slope movement monitoring, such as survey prisms and inclinometers. Selected instrumentation included groundwater level transducers installed in monitoring wells behind the slope crest, numerous vibrating wire piezometers (VWPs) near the toe of the slope, and two ground-based movement and survey radar system (MSRs).

The composite monitoring system worked within the defined site limitations and was configured to provide primary monitoring of both pore water pressure and physical slope deformation, using near real-time monitoring methods. The system also incorporated automated alarms at pre-determined thresholds to provide early warning to operations and construction personnel. A plan view of the DTMF monitoring system instrumentation that was implemented is presented in Figure 2.

Movement and Surveying Radar units

Two separate ground-based MSRs were installed on opposite sides of the DTMF facility to provide full and overlapping coverage of the entire west wall slope. As mentioned earlier , the original slope face area was estimated at nearly 104 000 square meters. The approximate scan distances for the MSRs ranged from 700 meters to 1300 meters, resulting in a data point spacing or coverage interval ranging from 3 meters to less than 6 meters. This type of point spacing and corresponding slope coverage would realistically have been unachievable through conventional slope surveying methods. Data collected by the MSRs included total slope movement, as well as a calculated rate of movement. Scan and data return rates were within an approximate range of 1 to 4 minutes, depending on the size and distance of the area being scanned. Figure 3 presents example data obtained through the on-site monitoring system during the 2013 construction season.

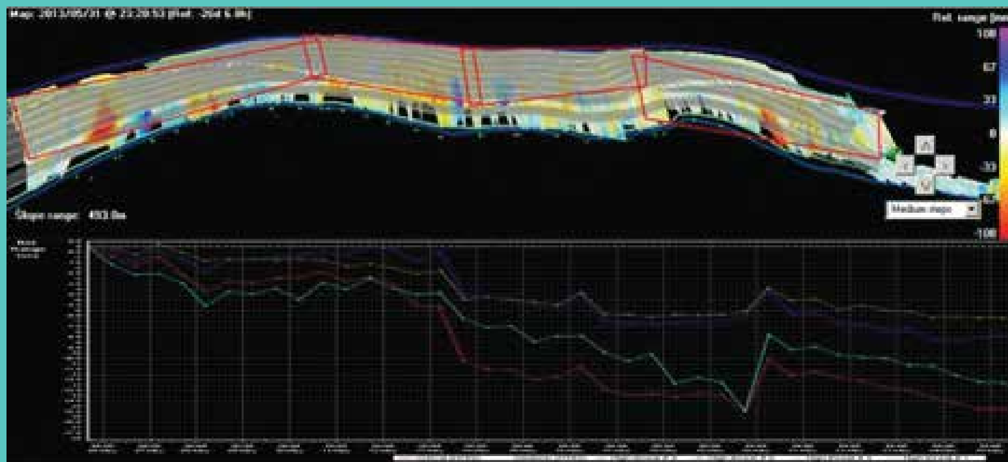


Figure 3 - Example Relative Range Data

The MSR units were able to measure both relative range (total movement, mm) and cumulative rate (rate of movement, mm/hr). During construction, it was observed that the surfaces of the west wall slopes were susceptible to surficial sediment transport due to environmental impacts such as wind and rain.

Snow accumulation and deterioration also had an impact on the representation of the slope face during early spring and late fall. As these influencing factors only occurred on the surface of the slopes, it was not necessarily a geotechnical stability concern, but did create challenges when monitoring slope movement at the face.

Based on observed data, as well as recommendations from other mines using similar units, it was determined that developing thresholds for the cumulative rate of slope movement was a more appropriate means of evaluating slope performance. This allowed for the monitoring team to filter out many of the ongoing environmental impacts affecting only the surface of the slope, while also evaluating movement associated with larger potential failures. This method provided an adequate solution to dealing with surficial changes in the slopes, as they occurred very slowly and could be filtered out using the cumulative rate thresholds.

Based on a large amount of sample data collected prior to and during the construction seasons, it was determined that cumulative rate threshold levels of 7 mm/hr and 10 mm/hr should be applied within the on-site automated alert systems. The threshold value of 7 mm/hr was assigned a "Geotechnical" designation and signified a lower level of movement warranting the attention of the Resident Geotechnical Engineer.

The threshold value of 10 mm/hr was assigned a "Critical" designation and signified a higher level of movement that could potentially correlate with an impending failure, requiring immediate evacuation of the DTMF in-pit work areas. These threshold values were assessed throughout the duration of construction to confirm their adequacy as additional experience was gained.

Figure 4 - Remediated Outwash Sand Slope with Rock Buttress

Conclusion

Near real-time monitoring is warranted in scenarios where active construction is required to take place adjacent to sensitive slopes or structures. As available technologies continue to develop and progress, the ability to identify and diagnose failure events improves and becomes a useful tool for geotechnical professionals and mining operations. The monitoring system and culture of safety implemented for this project were essential to its successful completion, without incident and well ahead of schedule.

This article is an excerpt from Geotechnical Instrumentation and Monitoring for Pit Slope Stabilization and Remediation as first published in the proceedings of the 18th international conference on tailings and mine waste. Keystone, Colorado, USA, October 5-8, 2014 by T. Meyer and D.Hrubes (DOWL HKM) and C. Salewich (Cameco Corporation).