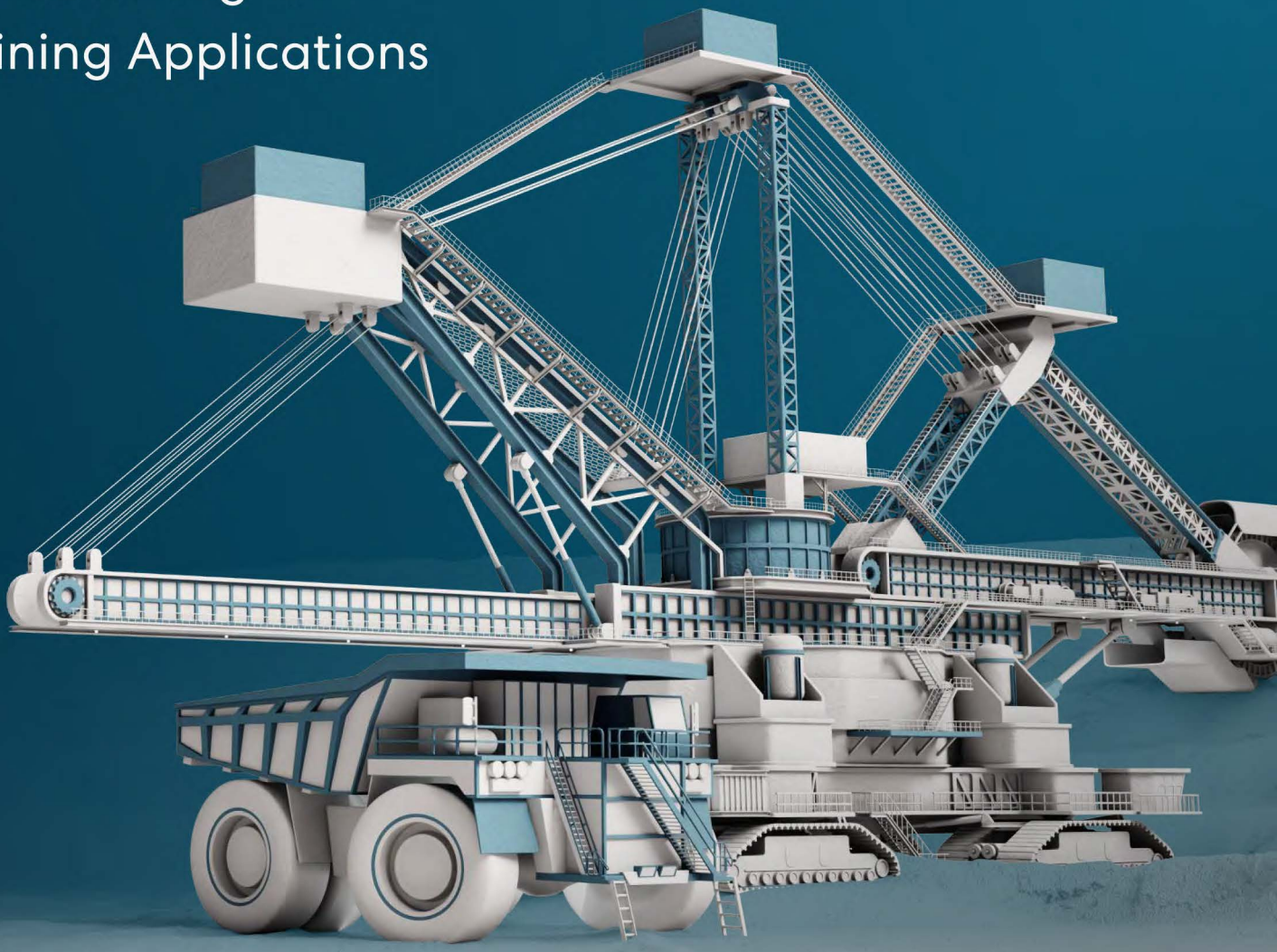
WHITEPAPER

Light at the End of the Tunnel

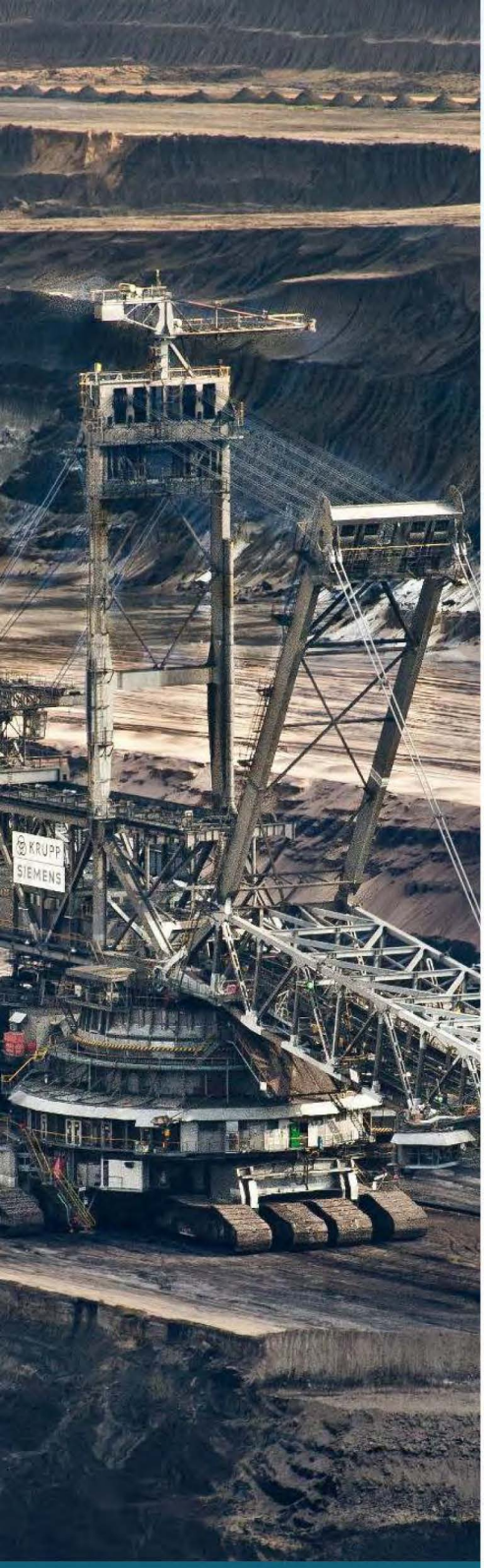
3D Scanning for Mining Applications



Dx Geomagic Design X

Cx Geomagic Control X

OQTON



Driven deeper into the ground by rising demand for valuable minerals, **the mining industry** is always looking for ways to **streamline processes** and better understand complex environments.

New 3D scanning technologies are opening the door to faster and more accurate data capture of mining sites above and below ground, as well as the infrastructure, processing systems, materials and equipment involved.

These technologies are transforming how the mining industry plans its work, manages and monitors ongoing operations, detects hazards, protects workers and ensures profitability.

In this whitepaper, we take a closer look at the **impact of 3D scanning in mining**, including an overview of the technology, popular applications, unique advantages, and where the future of 3D scanning may lead.

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Introduction

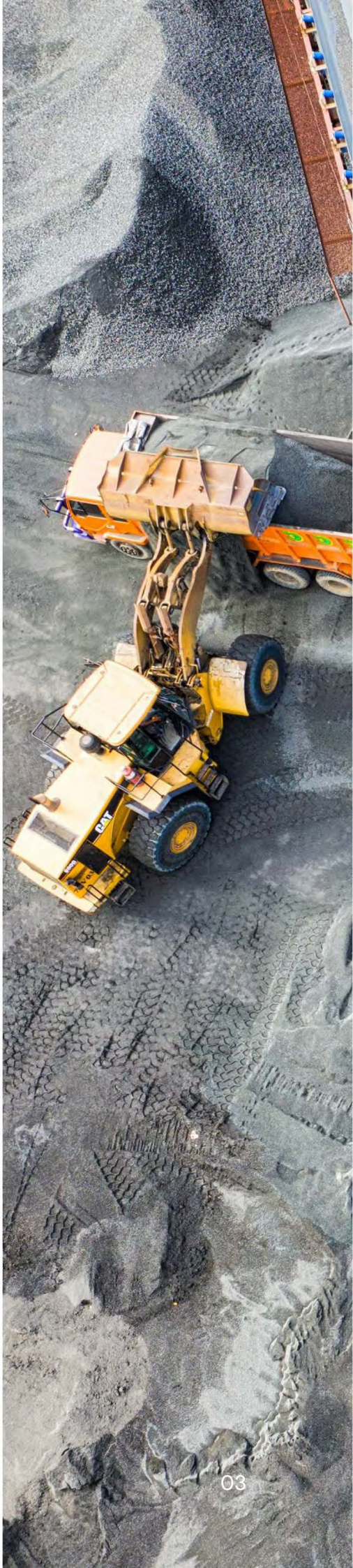
The mining industry thrives on information: where to find critical mineral resources, how to extract them, the precise location, size and orientation of tunnels and shafts, the position of support structures, the condition of equipment, the safety of the crew, and the efficiency of the entire process.

One of the most important sources of information in mining is 3D scanning. Faster and higher resolution than many traditional surveying methods, 3D scanning technology is transforming how modern mining operations monitor the site, manage assets, assess the environment and much more.

What makes 3D scanning so powerful in the mining industry is that it directly addresses many of the key challenges of mineral extraction. It makes underground mapping easier, which is important because underground surveying is such a difficult task given the inherent space restrictions and safety concerns.

It also allows mining companies to complete mapping tasks in sites that may involve unique hazards or a greater overall risk profile. The speed of 3D scanning compared to previous technology also helps minimize equipment downtime to maximize operational efficiency during production and meet aggressive timelines for very complex construction projects.

In this whitepaper, we will provide an overview of 3D scanning technologies and explore how they are applied in the mining industry, the benefits they can deliver and what mining companies can expect from the future of 3D scanning.



Understanding 3D Scanning

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In general, 3D scanning refers to the process of capturing a physical subject in order to represent its geometry accurately in a digital environment. Importantly for the mining industry, the physical subject can be an entire environment.

Just like a camera captures a flat, 2D image, a 3D scanner captures the height, width and depth of all the objects within an environment. 3D scanning typically acquires millions of data points that mining companies can use in a variety of ways. But the most important applications by far are the surveying of mining locations and maintenance of heavy equipment.

Traditional surveying techniques were well known for being accurate but slow. In the mining industry, where speed and efficiency are critical for complex projects, the pace of surveying has been a longstanding issue.

For this reason, 3D scanning has quickly replaced the traditional approach with a faster method that does not compromise data accuracy. In fact, 3D scanning can create a highly precise digital map of a mine feature within the space of a few minutes.

Because 3D scanning is faster and can be carried out without interrupting ongoing work, it can be performed repeatedly throughout a mining operation to give stakeholders fresh, relevant information about the mine and everything in it. This aspect of 3D scanning is becoming increasingly important as mining companies pursue minerals deeper in the ground that raise new risks.

While it is true there are contact-based 3D scanning methods, 3D scanning typically implies non-contact technology, which is vital in a large, complex mining operation.
With non-contact 3D scanning, the measurements are collected, and the information is contained within a set of data points (point cloud or mesh representation) in a three-axis world coordinate system. These data sets can then be manipulated in a myriad of tools depending on the use case, such as CAD, CAM, CFD, FEA, inspection and parametric reverse engineering.

Overall, 3D scanning offers three capabilities that make it an excellent fit for the mining industry:

1. **Fast, large-scale data collection** of complete environments for point-in-time analysis.
2. **Capture of large mining equipment**, machinery, components and systems, for ongoing maintenance.
3. **Non-contact data collection** for equipment or material documentation.


Image courtesy of GoMeasure3D

Because production efficiency is such an important metric, mining companies must pay very close attention to the status and performance of all systems and vehicles involved in the extraction process. The non-contact nature and flexibility of 3D scanning enables mining companies to do more than just map complex underground environments. It gives mining companies the ability to:

- Measure complex parts
- Create a complete digital model of parts and components
- Capture as-built assemblies to detect real-world differences from original designs
- Rebuild and repair broken components

This last benefit has two elements. The ability to create a digital 3D model allows mining companies to better understand broken components, so they can repair as necessary instead of waiting for replacements that may have long lead times. They can also reverse engineer and rebuild components that are old enough to no longer have replacements in the supply chain.

In addition, 3D scanning gives mining companies an efficient way to inspect components, large assemblies and complete environments, including payloads and stockpiles. Analyzing all of these components helps mining companies to monitor operational performance and detect issues before they cause more serious breakdowns.

Given all of these potential uses in mining, it is important to understand the options available for 3D scanning technologies. These include:

TERRESTRIAL LIDAR 3D SCANNING

Terrestrial LIDAR scanning (TLS) acquires the x, y and z coordinates of terrain by emitting laser pulses and measuring the distance from the scanner to the target using the time it takes for the pulse to return to the emitter, given the speed of light in air is a constant. TLS provides high point density and accuracy for monitoring changes in mining operations, specifically for assessing the progress of underground mining as well as stability, deformation and convergence.

AIRBORNE 3D LASER SCANNING

Airborne laser scanning involves capturing 3D data of large areas, including open pit mines. It collects high-resolution data quickly and accurately, providing millions of data points per square kilometer to create a digital model of the terrain. It involves three components, an inertial measurement unit that gives the precise orientation of the scanner, GPS to determine the precise location of the scanner, and the scanner itself mounted in an aircraft or drone.

PORTABLE LASER SCANNING

Portable laser scanners are extremely useful in challenging mining environments. These handheld laser scanners are lightweight, compact and easy to use. They can also be mounted on mobile platforms for greater control.

PHOTOGRAMMETRY

Digital cameras can be used to provide high-resolution imagery. These digital photos can then be transformed into highly precise point clouds and 3D models via photogrammetry software, which recreates a 3D model by processing photographic digital images.

Applications in the mining industry

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Overall, 3D scanning is transforming how the mining industry conducts site planning and design, equipment maintenance and inspection, stability analysis, mapping and surveying, and environmental monitoring.

Let's dig a little deeper into the most useful applications of 3D scanning in the mining industry.

Surveying and mapping

As mentioned earlier, surveying is the most critical application of 3D scanning in mining. Creating precise maps of underground areas is one of the most challenging and complex types of surveying. With the proper equipment, mining companies can maintain a very high level of accuracy while dramatically simplifying and accelerating how this work is accomplished. By creating detailed maps and models of mining sites, 3D scanners help mining companies better understand the terrain and take appropriate measures with respect to both safety and efficiency. Specific applications include:

1

Shaft inspection

To ensure worker safety, mining laws commonly require that companies inspect mine shafts regularly. Every new 3D scan is then compared to a previous scan to detect potential issues, such as cracks in lining and misalignment of pipelines and other equipment, as well as identify and calling attention to any and all changes.

2

Shotcrete application

Shotcrete, or sprayed concrete, is projected at high speeds onto vertical or overhead surfaces to stabilize them. In these instances, it is very important to measure the thickness of the shotcrete as this indicates its strength. 3D scanning can help mining companies understand the characteristics of the surface in order to apply the correct amount of shotcrete, as well as measure the thickness accurately without requiring operators to take these measurements using destructive techniques like drilling.

3

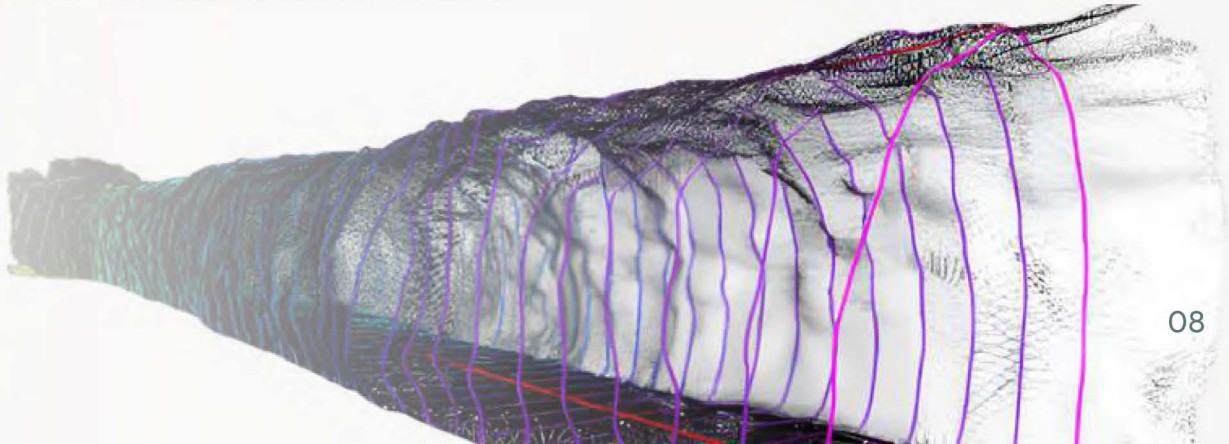
Convergence analysis

Convergence analysis uses regular scans of underground mines to inspect the rock and document any changes. This helps mining companies understand rock behavior, identify potential problems like fractured rock or deformations in tunnels, and take action if conditions become unsafe. 3D scanning makes this process faster and more accurate.

4

Production progress mapping

Mining companies need to keep close tabs on the progress of the entire operation. 3D scanning helps collect data from various sites throughout the mine so that progress can be compared to the original plan. The differences highlighted by this type of mapping helps mining companies make more informed operational decisions.



Volumetric load scanning

This application of 3D scanning has revolutionized how mining companies weigh the payloads of ore trucks and assess the volume of stockpiles. Previously, this work was done manually, either with static scales or by on-site specialists who estimated the size and volume of stockpiles.

Volumetric scanning technology uses a 3D scanner and imaging software to perform these tasks automatically. Trucks move beneath a suspended scanner and the payload of the truck is measured and recorded. This allows mining companies to generate more accurate load data faster, which improves operational efficiency, increases the accuracy of inventory tracking, and assists with both compliance and cost control, both of which depend on precise data about how much material the operation is moving in, around, and off the site.

Spatial data visualization

Spatial data refers to the information about the position of an object in a geographic coordinate system. In mining, spatial data visualization enables more efficient design of new mining operations. Detailed 3D models of mines include moveable, rotatable objects and spatial depth that helps planning teams understand the environment with greater precision and make more accurate decisions in less time.

Spatial data visualization coupled with immersive virtual reality (VR) allow mining teams to test equipment virtually with no risk, then use this analysis to deploy equipment more effectively and efficiently. In addition, augmented reality (AR) overlays a digital 3D image over an actual environment, creating opportunities to accelerate and improve training programs for equipment maintenance and other vital activities.

Asset management

The mapping and inspection techniques enabled by 3D scanning can be applied to mining equipment and infrastructure as well. The concept is the same, with regular, repeated scans delivering important insights about the condition of equipment and maintenance schedules as well as detecting potential issues earlier so they can be resolved before there is any impact on the mine's productivity.

Wear analysis

Wear analysis is a critical operation in mining. For SAG mills, AG mills, ball mills, both primary and secondary jaw crushers, and other earthmoving equipment like dozer blades and bucket teeth, wear analysis validates feeds and speeds for specific types and sizes of rocks and also helps mining companies plan to replace parts as they wear down.

Replacing worn parts in these systems can be somewhat time-consuming, and every day a mine is offline the company is losing money. Powered by 3D scanning technology, wear analysis can be done quickly and accurately to help teams develop efficient maintenance plans, maximize the lifespan of wear parts and avoid the risk of unplanned and expensive downtime.

Benefits of 3D Scanning Technology

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In the mining industry, information is a critical resource.
The latest 3D scanning technology delivers all kinds of information to mining companies in more effective ways. The advantages of 3D scanning over previous manual approaches are numerous.

Efficiency

With 3D scanning, mining companies are now able to acquire accurate information about virtually every part of the physical operation faster. Without a great deal of special expertise, the mining company can map tunnel profiles, stockpile volumes, pits and caves in minutes - up to 10 times faster than before. In addition, the digital data set can be accessed and analyzed later without the need to go back into the mine. Faster scanning also means fewer interruptions and less overall downtime for the mine.

For example, one of the most time-consuming aspects of surveying is sectioning, the process of providing a 'slice' of a tunnel at a specific position. It involves setting up a total station instrument within the space and rotating it to capture the required measurements, which can take time. More importantly, it requires that section of the mine to be shut down.
By comparison, 3D scanning can acquire the same data in minutes and individual sections can be extracted later from the scan data. Surveyors are able to produce thousands of sections from a set of 3D scan data in the same time it would have taken to produce just a few sections manually.

Accuracy

3D scanning technologies capture millions of data points about mine locations and mining equipment, creating a highly precise 3D model of the environment or devices rather than a series of discrete points. These 3D data sets also improve accuracy in terms of the actual state of the mine, its structures, systems and equipment as opposed to the original models or plans.

Accurate 3D scans can be used as a reference for future surveys of the mine to highlight important changes that occur over time. Similarly, an accurate 3D model of the tunnel or shaft will help mining companies when upgrades or modifications need to be made due to slight deviations from the design model.

Flexibility

Unlike traditional manual surveying methods, 3D scanning technologies provide a much more flexible range of applications. Scanners can be used by the mining team or attached to a drone, trolley, or even a robot to access virtually any space, regardless of its risks. 3D scanning also works in underground environments where GPS is not an option.

Continuity

A big advantage of 3D scanning data is that it can be accessed by many different off-site teams to gain valuable insights about operations quickly. When stored in the cloud and made available through collaborative platforms, this data can help rock engineering teams identify rock deformation and areas that may become unstable. Geology teams can examine the structure of specific areas before applying shotcrete to ensure the correct thickness is applied. Ventilation teams can use computational fluid dynamics (CFD) to analyze airflow and understand how proposed changes may affect it.

Safety

One of the most important ways that 3D scanning is transforming mining operations is its impact on worker safety. Its speed helps minimize the amount of time workers spend in areas with more risks or more dangerous conditions.

The amount of data captured reduces the need for repeat visits. It also eliminates the need to put an operator in harm's way for the riskiest surveying assignments, which can potentially be done by drone, robot or some other vehicle with the operator safely above ground. 3D scans of mining areas and equipment also makes it much easier for mining companies to recognize problem areas, instabilities and other risks and take appropriate action.

The Future of 3D Scanning

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The goals of new mining technology are often the same: improve the efficiency of the operation and the safety of the workers involved.

As we have seen, 3D scanning technology provides multiple ways to accomplish both of these goals. The future should continue along this path as 3D scanning systems gain the ability to capture even more data in even less time.

Today, 3D scanning can provide real-time insights into the efficiency of mining processes and the structural integrity of the mine itself. As the software used to analyze 3D scan data, such as Geomagic from Oqton, continues to become more powerful, mining companies can expect to gain an even more accurate picture of operations that fuels insights into planning, process efficiency, payload management and more.

The mining industry will also likely continue to pursue the objectives of Industry 4.0, also known as the Industrial Internet of Things (IIoT). Imagine a vast network of sensors feeding real-time information to a 3D model built from scanned data — and updating that model as new data is delivered related to seismic activity, rock movement, ventilation, equipment wear and virtually any other variable that can be monitored. In this future state, sensors can combine with powerful analytical tools to help predict problems with infrastructure and equipment before they actually occur.

The future of mining will also certainly continue to innovate around spatial data visualization. Driven by data from 3D scanning, these VR and AR environments could make it possible to build and deconstruct entire mines digitally, exploring various extraction plans and other "what if" scenarios with zero risk to the environment.

Information is incredibly powerful in mining. Companies that start equipping themselves to capture as much data as possible and analyze with as many different tools as possible will be well positioned to improve efficiency, profitability and safety and build a competitive advantage out of millions of points of 3D scanned data.

Have questions? Speak with one of our experts!

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