HOKUYO USA

THE IMPACT OF ROBOTS ON

Mining Industry

HOKUYO USA

2019 Van Buren Ave., Suite A,
Indian Trail, NC 28079

CONTACT

704-882-3844
info@hokuyo-usa.com

Sensing the Future.

Introduction

The rise of autonomous robots in the mining industry shows how effective robots can be in environments that often pose a danger to human lives.

Mines are dangerous places. For years human labor was the only solution for inspection, excavation, mining, and transportation of goods.

In the US alone, the year 2019 noted 27 fatalities and over 3900 non-fatal injuries.

If we consider data from other underdeveloped countries lacking the necessary technologies, the global average grows significantly.

Autonomous robots are valuable propositions to replace human lives from hazardous areas in mining while maintaining similar or even better efficiency. Equipped with robust and accurate sensors, these intelligent machines are becoming capable of assisting miners in inspecting the site, assisting them in excavation, and even detecting gases and minerals.

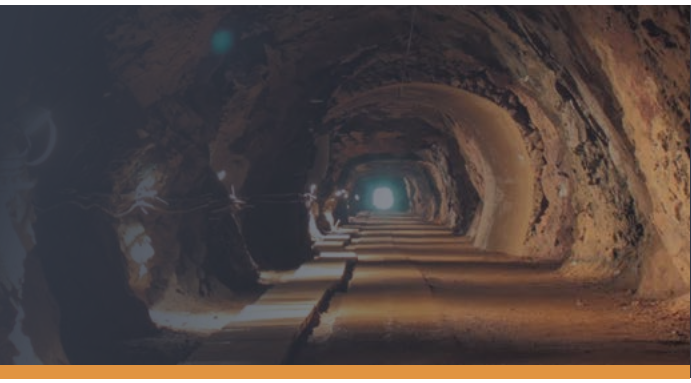
This whitepaper examines the current state of the mining industry and presents a brief overview of how autonomous robots can provide a better, safer, and efficient working environment for the mining industry. The paper also sheds light on the potential applications of these robots in mining operations.

› The Dangers within Mines

Mines are deep excavated areas within the earth, usually made to extract minerals. Most materials and resources we use to power the world, like coal, iron, copper, and gold, come beneath the earth's surface. By digging deep into the earth's surface, we can uncover these valuable minerals.

However, mines are not a safe place by any means.

Miners are often exposed to dangers that can be life-threatening. Some of these risks include:



Explosive Gases

Resources like coal are made from decaying natural matter. Coal mines always present the risk of methane gas formation. While mining, methane gases can escape from the rock layers, a process called methane liberation. Methane is a highly flammable gas that can readily ignite even with a small electrical spark or flame. Explosions in coal mines often happen due to methane liberation or coal dust.

Poisonous Gases

Mines often have poor ventilation. Hence, gases like carbon monoxide can remain trapped within these quarries. Since carbon monoxide is tasteless and odorless, miners may not sense the gas directly. Breathing this poisonous gas causes serious health hazards and can even lead to death.

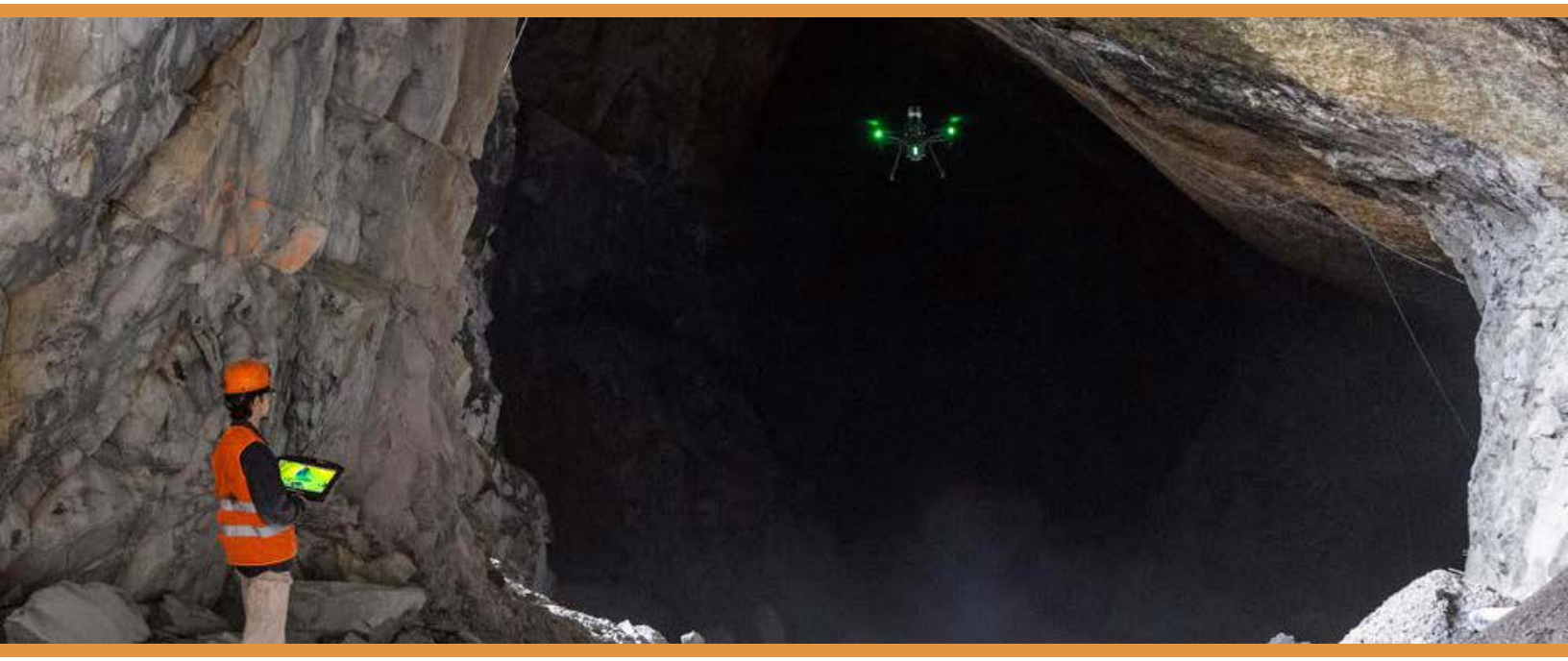
Our UGM-50LXP is the most robust LiDAR in the mining industry.

Slippery Surface

Excavations often pose a danger of creating undesirable ground movements and damaging the existing surface. Due to the presence of mud and water, these underground surfaces often become slippery and may lead to worker injuries. As a matter of fact, slips, trips, and falls (STFs) are the second-largest contributor to non-fatal injuries in the US mining industry.

Cave-Ins / Collapses

Cave-ins or collapses in mines occur when the mine frames fail to hold the mine structure, leading to a series of catastrophic events. For example, a collapse may produce powerful air blasts that fly debris around. In addition, falling rocks may block the tunnel, hurt miners, and release toxic or explosive gases.



Mine Inspections:

A Hazardous Job Still Left for Humans

It is crucial to get an understanding of mines to realize the importance of bringing autonomous robots into this industry.

Inspecting a mine is the first order of business before anyone can access it.
Currently, human workers carry out mine inspections either for new mining sites or abandoned ones.

Inspecting New Mines

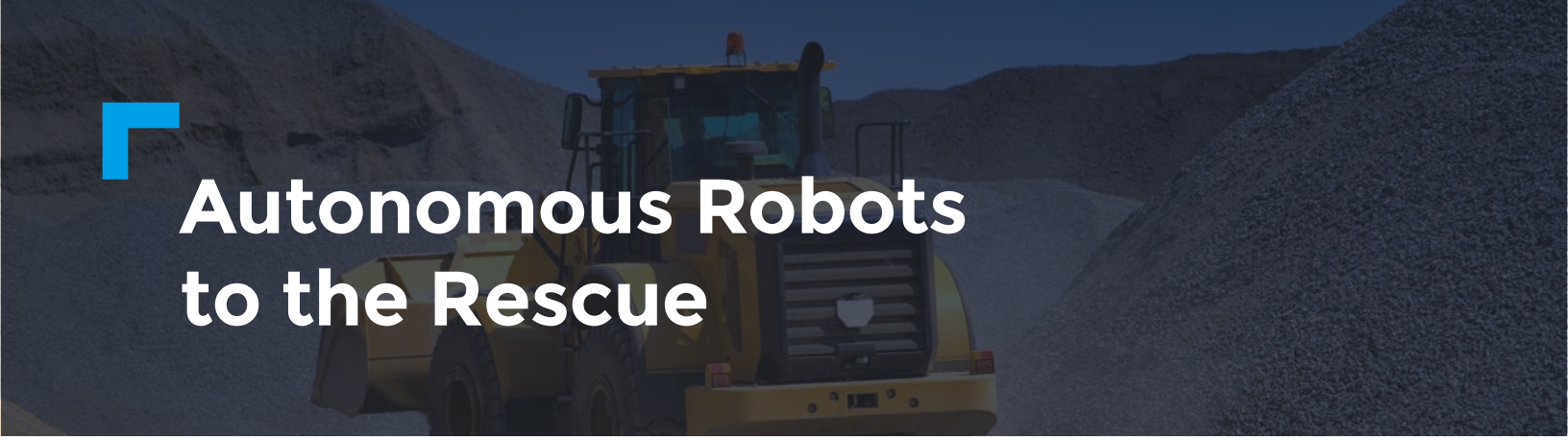
A newly excavated mine needs to be inspected to understand its conditions and whether it has the expected mineral or not.

Unfortunately, we still lack the technology to map the location minerals within a mine with pinpoint accuracy. Therefore, inspections are carried out to see the mine structure and identify areas within the mine where minerals exist. The inspection also includes several physical tests to identify if the site is fit for workers.

Revisiting Abandoned Mines

The risks associated with abandoned mines are plenty. These mines can damage the surrounding environment, causing the collapse of large areas, subsidence, and pollution. Closing these dismissed mines is necessary to avoid potential environmental risk, which is why these fields are often revisited to prepare closure plans.

Oftentimes, abandoned mines that need a revisit would have flooded from the underground water sources, making the inspection process much tedious and hazardous.



Autonomous Robots to the Rescue

Autonomous robots in mines

reduce human effort or human participation

that goes into checking the feasibility of mines.

These robots, built for outdoor purposes, offer several benefits when used for mine exploration, extraction, handling, and other mining processes. Some of the key advantages of these autonomous robots include:

Remote Operation

The robots are easy to control from a remote location. A vworker may not necessarily be required to be physically present at the site to maneuver the robot inside a mining site.

Detecting Hazards Efficiently

Although we humans possess advanced sensory organs, our senses may not detect certain elements easily. Carbon monoxide gas is one such example, which is odorless and tasteless and is deadly to human life. Contrary to human workers, autonomous robots can be fitted with specialized sensors to detect poisonous gases or chemicals within the mines and can remain fully operational in such adverse environments.

Unaffected by Fatigue

What makes robots superior to humans is that they never get tired and can continue their programmed tasks as long as there is a sufficient power supply. They can essentially work all day long and provide valuable insights into the structure and layout of the mine, enabling higher efficiencies in mining operations.

Unaffected by Lack of Oxygen

Mines often have spots where there is a lack of oxygen availability. A mine that goes deeper into the earth's surface will not have enough oxygen available. Further, such mines also lack ventilation, creating a hazardous environment for human workers.

When the atmospheric concentration of oxygen drops below 19.5%, it will start affecting the human body, both physically and psychologically.

For instance, an accident occurred in Alabama on November 23, 2009, where a foreman and a miner were tasked to inspect a mine. During their descent, they noticed the increasingly humid nature of the mine, accompanied by heat.

The oxygen levels in the atmosphere were also on the decline. The two men then decided to halt their inspection and return due to fatigue.

However, they were unable to make it. **A search party later found one of them severely injured and the other person dead.**

Can Withstand Adverse Conditions

One of the many risks that a mine poses is flooding. A mine undergoes flooding when it is no longer in use as the dewatering systems are no longer operational to carry out the water seeping in from the rock formations. This poses a serious challenge when the mine is revisited.

The entire mine requires to be dewatered. As a result, the surfaces become slick, making it harder for mine inspection teams to traverse. Robots are highly effective in such situations as they can be fitted with threaded tracks that offer superior grip over such surfaces. They also remain unaffected by heat or humid conditions inside the mine.

How Autonomous Robots Work in Mines

Autonomous robots carry out the complex tasks of mapping and scanning the mining site using sensors, especially LiDAR, which stands for

Light Detection and Ranging.

LiDAR sensors use pulsating laser beams to map out the surroundings. The robots can further carry cameras to relay images in real-time to the user. Other sensors such as oxygen level sensors and toxic level sensors gauge whether the mining area is safe for human workers to enter.

Combining the data recorded from these sensors and imaging cameras, it is possible to get a 360-degree view of the mining area.

The UXM-30LAH-EWA is an outdoor-rated 2D LiDAR sensor

offering obstacle detection, area profiling and localization capabilities for all types of mining equipment and vehicles.

- **Equipped with an Ethernet interface**
- **Measures data in a 190° field-of-view up to 80 meters**
- **Has an integrated multi-echo feature**

The URM-40LC-EWT is an outdoor-rated 2D LiDAR sensor

offering obstacle detection, area profiling and localization capabilities for all types of mining equipment and vehicles.

- **Equipped with an Ethernet interface**
- **Measures data in a 270° field-of-view up to 40 meters**
- **With IP67 protection and multi-echo integration**

The UXM-30LAH-EHA is an outdoor-rated 2D LiDAR sensor

offering obstacle detection, area profiling and localization capabilities for all types of mining equipment and vehicles.

- **Equipped with an Ethernet interface**
- **Measures data in a 190° field-of-view up to 80 meters**
- **Offers reliable detection of dark colored objects with no effect on scanning performance due to dust, condensation or scratches on the hard-coated lens**

Potential Applications of Autonomous Robots in Mining

Autonomous robots are not only useful in inspection and mapping.

There are other potential applications of integrating robotics in mining operations to make them more efficient and safe. A few areas where these robots can bring a significant change include:

› Search and Rescue Missions

In the event of an accident or a mine collapse, the first few hours are critical and can mean the difference between life and death. Instead of risking more human lives, rescue teams can quickly deploy robots equipped with gas sensors and cameras to locate the trapped miners. With the aid of thermal imaging sensors, these robots can operate efficiently even in low light conditions.

› Tunnel Mapping

Abandoned mines can have tunnel systems not mapped correctly. Autonomous robots can help map out such areas without risking human lives. Using thermal imaging cameras and acoustic sensors, these robots can detect any potential risks before performing site closure operations.

Autonomous Haulage

Robotics can also aid in automating the movement of heavy-duty vehicles used to carry materials from the mine. Instead of drivers risking their lives, these heavy vehicles utilize geolocation and route mapping techniques to perform the monotonous task of to and fro movement from the mines. Long-wall miners are one such example of modern-day mining.

Autonomous Excavation

Developments are already underway to utilize robotics technologies to automate the excavation process. The objective is to replace humans with robots to perform hazardous and tedious operations.

Geological Sampling

Robots can also become useful in collecting productive rock or ore samples from the mines to determine the material composition and quality through.

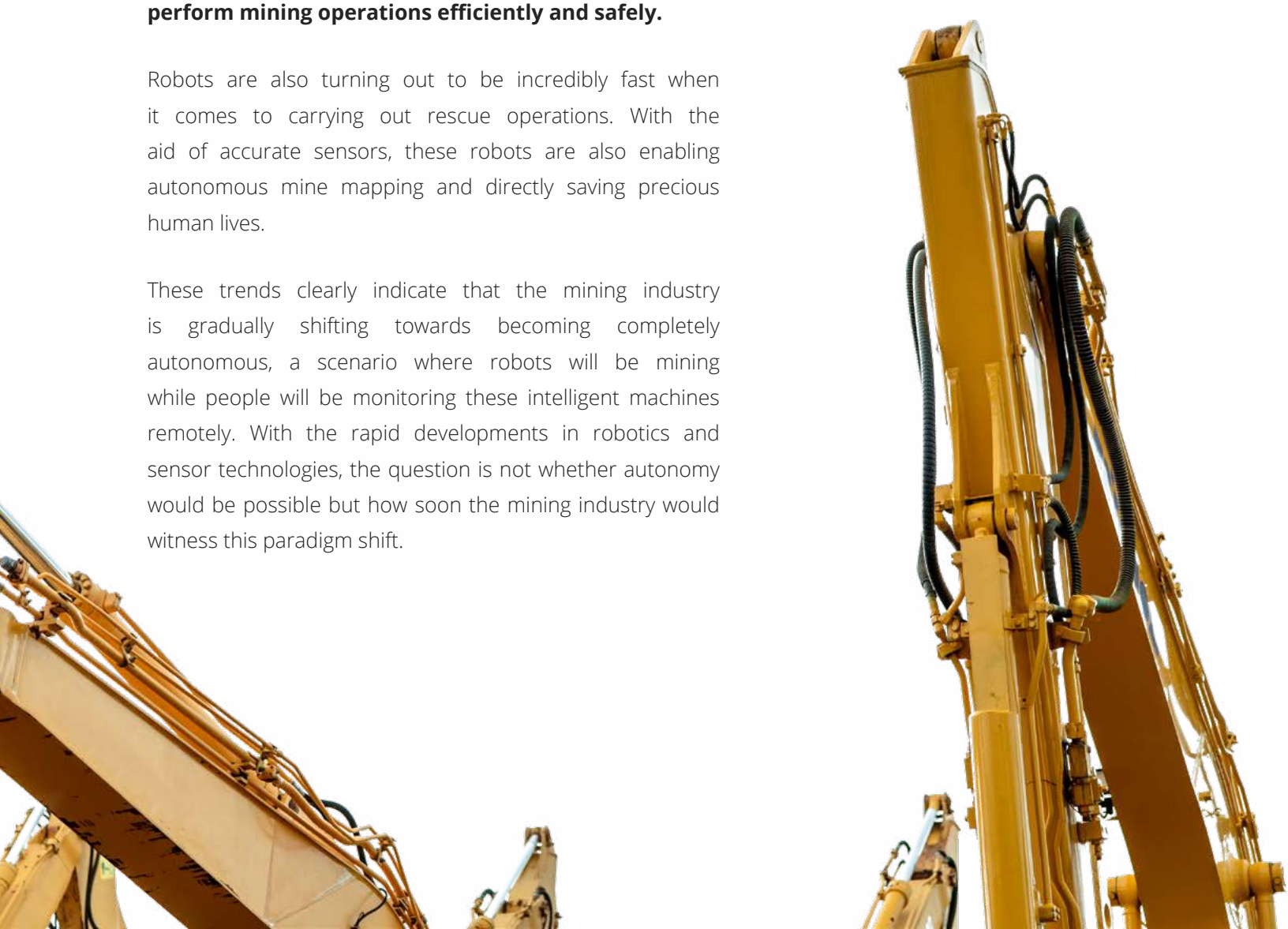
The Future of Mining is Autonomous

As robotics continues to improve, the mining industry will increasingly widen its use of automation over the coming years.

With the autonomous capabilities that robots possess today, miners and mining companies are able to perform mining operations efficiently and safely.

Robots are also turning out to be incredibly fast when it comes to carrying out rescue operations. With the aid of accurate sensors, these robots are also enabling autonomous mine mapping and directly saving precious human lives.

These trends clearly indicate that the mining industry is gradually shifting towards becoming completely autonomous, a scenario where robots will be mining while people will be monitoring these intelligent machines remotely. With the rapid developments in robotics and sensor technologies, the question is not whether autonomy would be possible but how soon the mining industry would witness this paradigm shift.



Sources

https://new.abb.com/mining/mineoptimize/systems-solutions/mining-automation/mining-robots-move-people-away-from-unsafe-areas-and-towards-the-autonomous-mine-vision

https://www.sciencedirect.com/science/article/pii/S1474667017604841

https://www.technologyreview.com/2016/12/28/154859/mining-24-hours-a-day-with-robots/

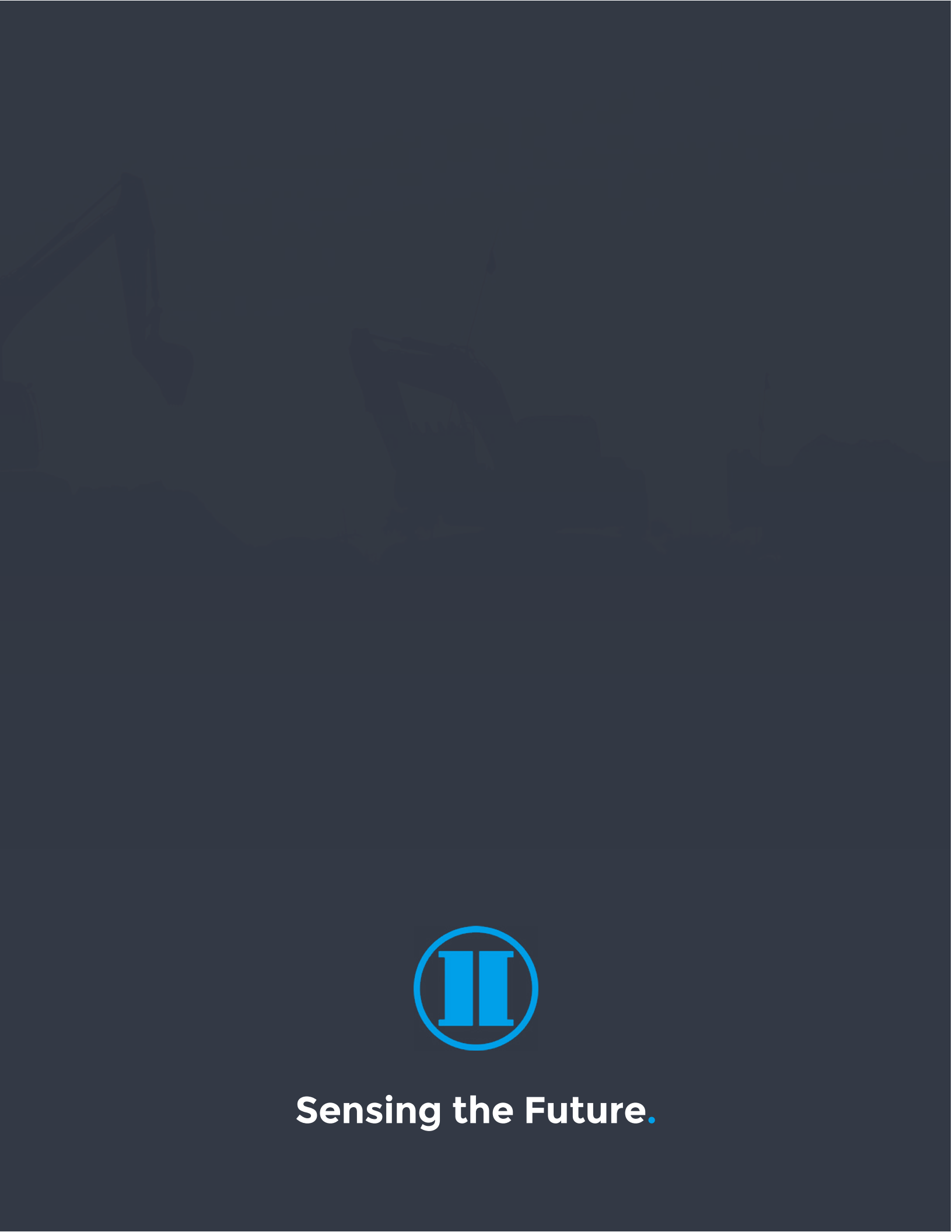
https://www.miningmonthly.com/partners/partner-content/1379768/rise-of-the-robots

https://eos.org/features/underground-robots-how-robotics-is-changing-the-mining-industry

https://www.mdpi.com/2076-3417/10/20/7221/pdf

https://www.miningmagazine.com/innovation/news/1387411/taking-step-into-the-robotic-future

https://www.dmp.wa.gov.au/Documents/Safety/MSH_COP_SafeMobileAutonomousMiningWA.pdf



Sensing the Future.