ICL Boulby

Modern Mine Surveying Techniques to Control Inrush Hazards

By

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Introduction

Polyhalite mining involves the extraction of a unique evaporite mineral composed primarily of potassium, calcium, magnesium and sulphate. Found in sedimentary rock formations, polyhalite is a valuable fertiliser due to its nutrient-rich composition (ICL UK, 2025). Unlike traditional potash mining, which focuses on potassium chloride, polyhalite mining offers an eco-friendly alternative as it is naturally low in chloride content, reducing environmental impact. (BGS, 1999; ICL Boulby, 2023)

The process typically begins with extensive geological surveys to identify viable deposits, often located deep underground. Located on the North Yorkshire coastline, Boulby Mine is home to one of the world's largest known polyhalite deposits (ICL UK, 2025), which is actively mined to supply agricultural markets globally. Advanced techniques, such as underground tunnelling and modern machinery, enables efficient extraction while minimising disturbance to surrounding ecosystems. (ICL Boulby, 2023; STFC, n.d.)

Polyhalite mining is paving the way for sustainable agricultural practices. It's applications in enhancing soil health and crop yields is gaining popularity among farmers worldwide. However, challenges such as accessibility to deep reserves and the cost of extraction, highlights the need for innovation in mining technology.

Importance of surveying in mining operations

Surveying plays a crucial role in mining operations by ensuring safety, efficiency and accuracy throughout the entire mining process. From the initial exploration phase to post-mining land rehabilitation, surveying techniques provide the foundation for informed decision-making and sustainable practices. (GIM International, 2025) (GIM International, 2018)

During exploration, precise surveying is essential for helping locate and evaluate mineral deposits via planning after exploration drilling has been carried out. Advanced surveying tools and technologies such as GPS and remote sensing, help identify resource-rich areas and determine the feasibility of mining projects. This reduces unnecessary excavation, minimising environmental impact and operational costs. (GIM International, 2018)

In active mining, surveying maintains safety by mapping underground and surface features, detecting structural changes such as smaller pillars and ensuring the stability of excavation areas. Accurate surveys assist in designing and monitoring mining infrastructure, such as tunnels shafts and access roads; contributing to the seamless flow of operations. (Quora, 2025)

Moreover, surveying supports efficient resource extraction by tracking the volume and location of extracted material. It helps prevent wasting resource, ensuring that operations remain cost-effective and environmentally responsible. Post-mining, surveying is pivotal for tonnage reconciliation and accurately updating mine plans, such as contours, lease plans and 1-1000 Plans. Surveying serves as the backbone of modern mining operations fostering safety, precision and environmental management across every stage.

Objectives of the paper

The paper focuses on exploring and analysing advanced surveying methods tailored for polyhalite mining operations. It aims to highlight the integration of cutting-edge technologies, such as modern theodolites, drones and laser scanning to enhance precision, efficiency and safety in mining operations. Additionally, the paper discusses the challenges of managing inrush hazards specific to polyhalite mining and proposes innovative solutions to address them, ensuring sustainable resource extraction.

Background

History of mining surveying techniques

Mining surveying techniques in the UK have evolved significantly over centuries, reflecting advancements in technology and the growing complexity of mining operations. Very early methods were basic, relying on basic tools such as compasses and chains to measure distances and angles. These techniques were often imprecise, due to iron tools and ore deposits interfering with compass readings.

The Industrial Revolution in the 18th/19th century marks a turning point, as mining became a cornerstone of Britain's economy. The introduction of precision tools, such as Jesse Ramsden's theodolite in 1787, further enhanced the accuracy of surveys as it allowed for accurate measurements of vertical angles and improved mapping of underground mines.

By the late 20^{th} and early 21^{st} century, technological advancements brought about the use of electronic distance measurement devices and lidar scanning technology. These innovations enabled surveyors to create detailed three-dimensional models of mining sites, improving safety and efficiency. Today, modern techniques incorporate Geographic Information Systems (GIS) and remote sensing, ensuring precise data collection and analysis for sustainable mining practices.

This progression highlights the UK's pivotal role in shaping the field of mining surveying, combining tradition with innovation to meet the demands of an expanding industry; especially when we consider the courses available through established education institutions such as Cambourne School of Mines (CSM) which was established in 1888. They first began offering HNC's and ONC's in relation to mining in the 1960's, allowing for a combination of theoretical and practical learning due to CSM having King Edwards Mine at their disposal.

Unique challenges in polyhalite mining

Polyhalite mining presents a range of unique challenges due to the mineral's specific characteristics and the environments in which it is typically found. Some of the key difficulties:

1. **Depth of Seam Deposits**: Polyhalite is located deep underground, requiring extensive and costly shaft mining operations. For instance, Boulby Mine, in North Yorkshire, involves mining at depths of over 1,400 metres, which demands advanced engineering and safety measures. (ICL Boulby, 2023; STFC, n.d.)
2. **Geological Complexity**: The extraction process can be complicated by the surrounding rock formations. Ensuring the stability of mine shafts and tunnels is critical to prevent collapses, which adds to the technical and financial challenges.
3. **Environmental Concerns**: Mining in sensitive areas, such as beneath national parks, requires careful planning to minimise surface disruption, such as subsidence and ecological impact.
4. **Market Uncertainty**: Polyhalite is a relatively new fertiliser product with its market still developing. Convincing agricultural sectors of its benefits over traditional fertilisers, like potash, requires significant investment in marketing and education.
5. **Economic Viability**: The high costs associated with developing polyhalite mines, including infrastructure and technology, can pose financial risks. Securing funding and maintaining investor confidence are ongoing challenges for mining companies.
6. **Processing and Transportation**: Once extracted, polyhalite requires processing to meet agricultural standards. Transporting the mineral from remote mining locations to global markets also involves logistical hurdles such as train infrastructure or road transportation.

These challenges highlight the need for innovative solutions and sustainable practices to ensure the successful development and sustainability of polyhalite mining projects.

Modern surveying techniques

Modern methods truly exemplify the cutting-edge integration of technology in mine surveying.

Remote Sensing: Drones allow for the collection of data over vast and often inaccessible areas. They provide high-resolution visuals which are useful in mapping terrain, monitoring environmental changes and disaster response.

3D Laser Scanning: This technique is invaluable for underground mapping as it offers high precision and detail. It captures spatial data in the form of point clouds, helping to create accurate models of subterranean structures or landscapes.

GPS Technology: Revolutionising surveying, GPS ensures pinpoint accuracy in location tracking and is widely used for mapping, navigation and even integrating with autonomous systems. (GIM International, 2018)

Geophysical Methods: Seismic surveys utilize waves to investigate subsurface properties, aiding in resource exploration, construction planning and archaeological studies.

Information Collaboration: By combining data from multiple sources (e.g., lidar data and point clouds), surveyors achieve a comprehensive view, enhancing decision-making, precision and accuracy.

Inrush Hazards

What is an inrush?

In mining, an inrush refers to the sudden and uncontrolled flow of water, gas or loose material into underground workings. This phenomenon poses a significant hazard, as it can lead to flooding, suffocation, or structural instability within the mine. (UK Government, 2025) (Legislation.gov.uk, 2014; HSE, 2011)

To mitigate the risk of inrushes, mining operations implement strict safety measures through geological surveys, controlled excavation techniques and the construction of barriers to prevent unexpected inflows. British mining regulations, such as the **Mines Precautions Against Inrushes Regulations 1979 (PAIR),** outline specific protocols to safeguard workers and infrastructure against such incidents. (UK Government , 2025) (Legislation.gov.uk, 1979)

Controlling the Hazard of Inrush

Why is it important to manage inrushes?

Managing inrush hazards is critical to ensuring the safety and sustainability of mining operations. Uncontrolled inrushes can lead to:

Loss of Life: Sudden flooding or gas explosions can endanger miners and result in fatalities.

Environmental Damage: Inrushes can contaminate surrounding ecosystems, particularly if the influx contains harmful substances.

Economic Consequences: Damage to infrastructure, equipment and delays in production can lead to substantial financial losses.

Regulatory Compliance: Proper management of inrush hazards is essential to meet legal requirements and avoid penalties.

Proactive measures: Geological surveys, monitoring systems and robust emergency plans are essential to mitigate these risks.

Events shaping inrush legislation and regulations

Historically, inrush incidents have led to significant changes in mining legislation and practices.

Some notable tragedies include:

The Knockshinnoch Disaster (1950, Scotland):

The Knockshinnoch disaster was a mining tragedy that occurred on 7 September 1950 in New Cumnock, Ayrshire, Scotland. Heavy rainfall had saturated the ground, causing a waterlogged field to collapse into the workings of Knockshinnoch Castle Colliery. This resulted in an inrush of peat and slurry into the mine, trapping 129 miners underground. (HMSO, 1951; NMRS, n.d.)

Rescue efforts were heroic and involved digging through unstable ground to reach the trapped men. Over the course of three days, 116 miners were successfully rescued, but tragically, 13 lost their lives. The disaster highlighted the dangers faced by miners and the importance of safety measures in the industry. As a result in advancements in mine safety protocols, including better surveying and monitoring techniques. (New Cumnock History, 2025)

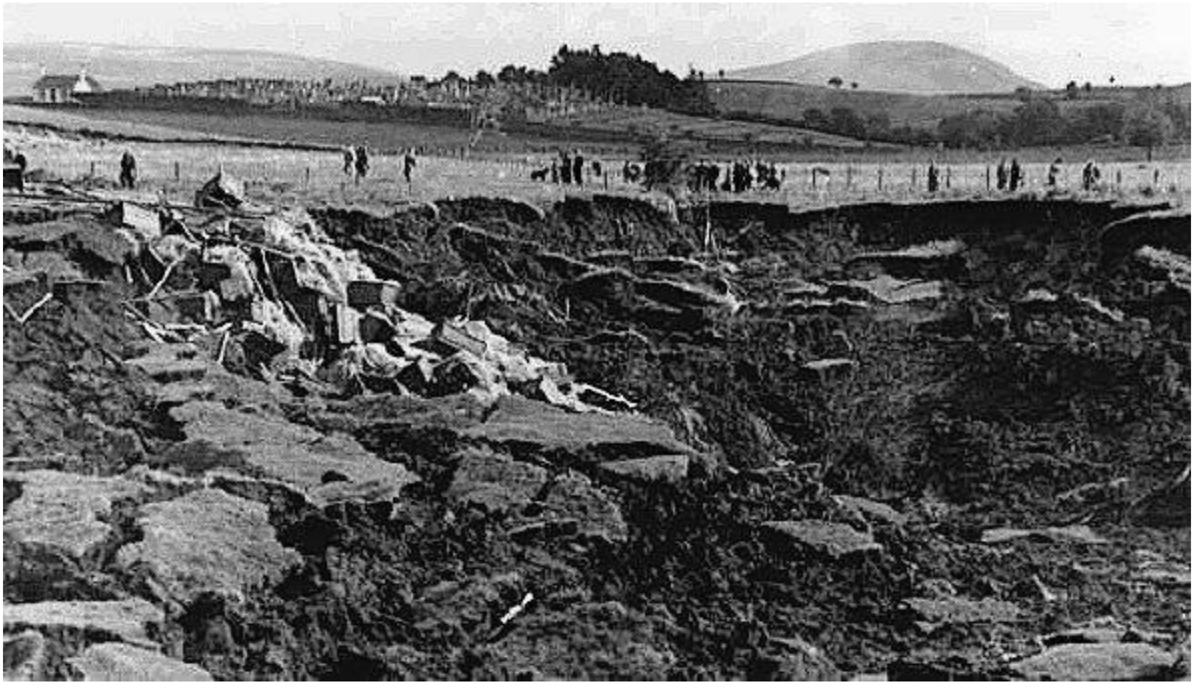


Figure 1

The Aberfan Disaster (1966, Wales):

The Aberfan disaster was a tragic event that occurred on 21 October 1966 in the Welsh village of Aberfan, near Merthyr Tydfil. A colliery spoil tip, which was a mound of mining waste, collapsed after heavy rainfall causing it to become unstable. This resulted in a devastating landslide of slurry that engulfed parts of the village, including Pantglas Junior School. (Tribunal of Inquiry, 1967; Legislation.gov.uk, 1969)

The disaster claimed the lives of 144 people, of whom 116 were children. The National Coal Board (NCB), responsible for the spoil tip, was found to have ignored warnings about its instability. Despite this, the organisation or any members of the organisation did not face prosecution.

The tragedy left a lasting impact on the community and led to changes in mining regulations, including the introduction of the Mines and Quarries (Tips) Act 1969. The Aberfan Disaster Memorial Fund was established to support the victims' families and the community; however, the event remains a poignant reminder of the importance of safety and accountability. (Nation CYMRU, 2025)

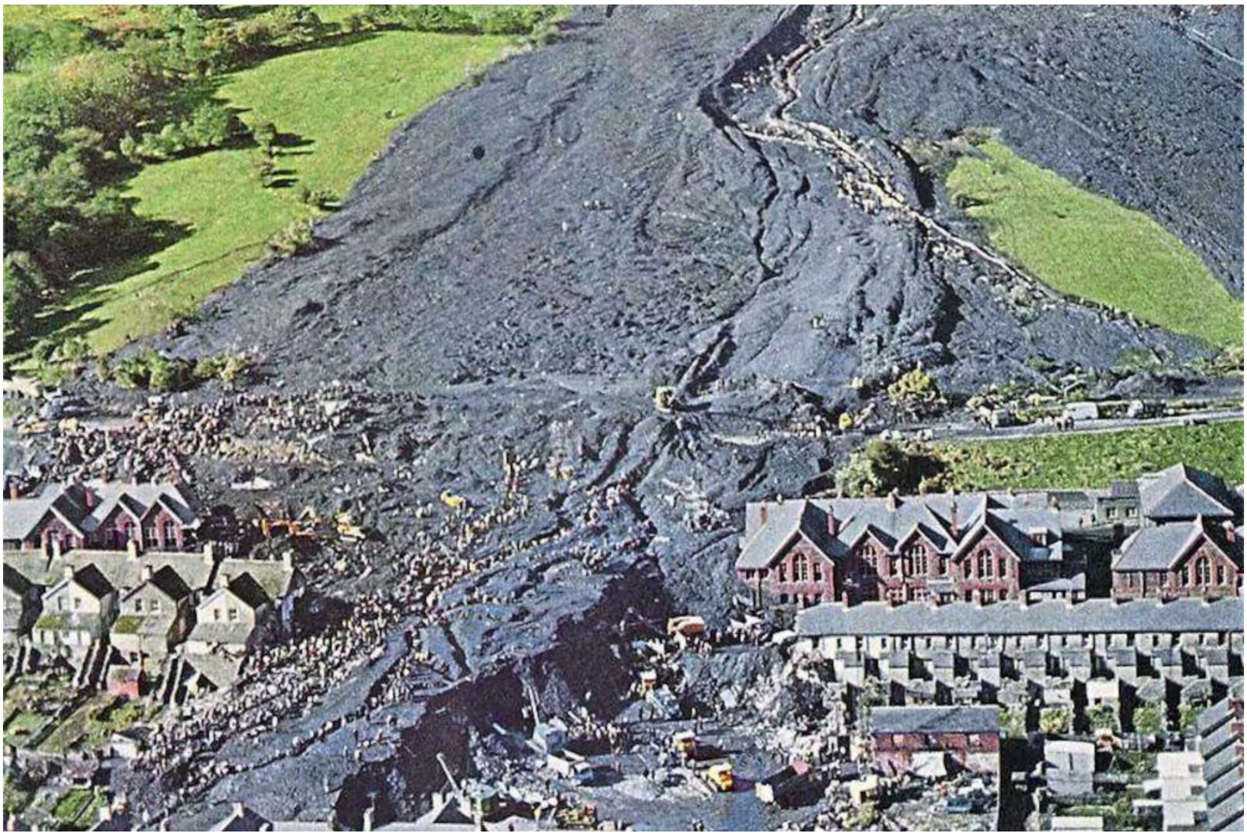


Figure 2

Lofthouse (1973, Lofthouse):

On 21st March 1973, 7 men were killed after the coalface was excavated too close to a flooded 19th century mineshaft. There was a sudden inrush of 3 million imperial gallons (14,000 cubic metres) of water which trapped 7 miners underground. (HMSO, 1973; NMRS, n.d.)

The location of the flooded 19th century shaft, known as the Haigh Moor Bull Pit (No.7) Low Laithes, was known to the national coal board (NCB). However, it was sunk deeper than the mines lease agreement allowed. British Geological Survey records indicated that the flooded shaft did descend to the same depth, which was also found in the shaft sinkers logs, however, the NCB had already exhausted all directly accessible means of information. (Northern Mine Reasearch Society, 2025)

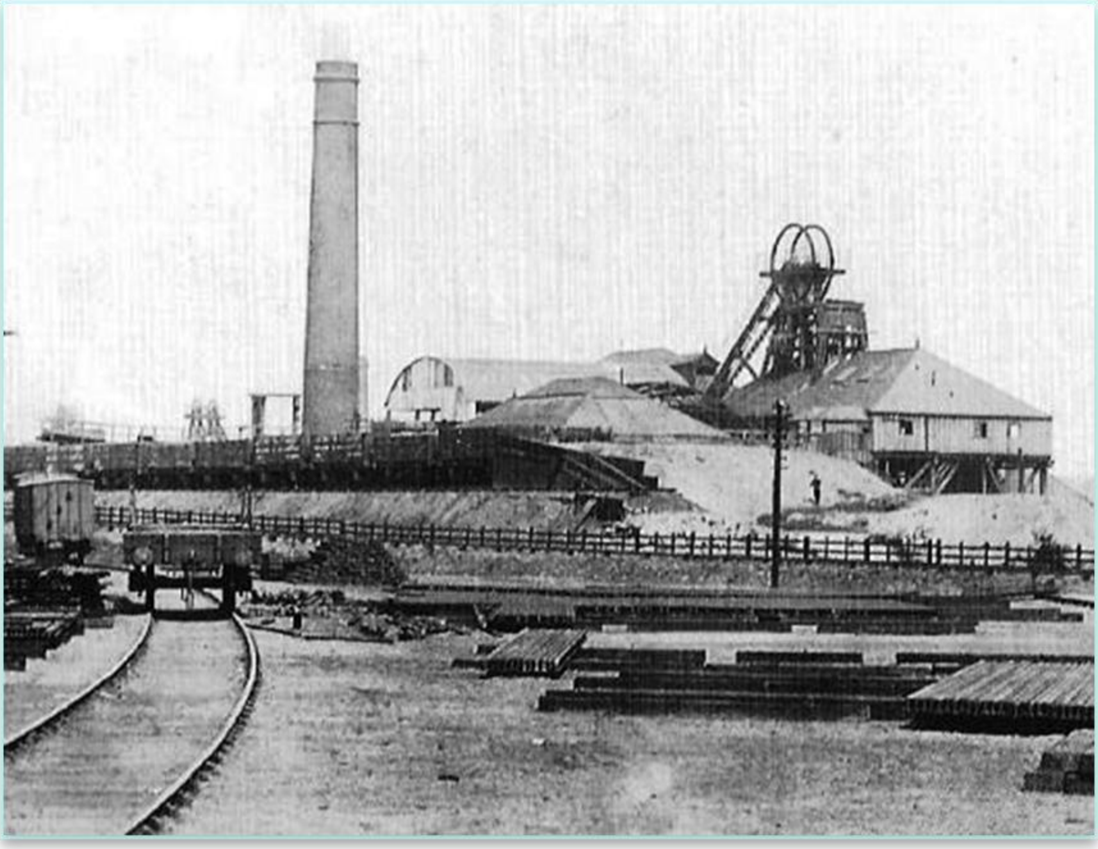


Figure 3

These tragedies underline the importance of proactive measures in managing inrush hazards, shaping both national and international mining regulations. Modern legislation often mandates detailed geological assessments, barrier installations and continuous monitoring systems to prevent such occurrences.

Effective control measures of inrush include:

Comprehensive Geological Surveys: Pre-mining surveys identify potential inrush hazards, such as aquifers, faults, gas pockets and boreholes that could be filled with water or gas. These surveys help to determine risk management strategies.

Barrier Pillars: Installing robust barrier pillars prevents the uncontrolled flow of water or material into active mining areas.

Drainage Systems: Implementing advanced drainage solutions, such as pumps and sealed drainage channels, effectively diverts water away from vulnerable zones.

Monitoring Technology: Continuous monitoring using sensors, pressure gauges and seismic equipment detect early warning signs of inrush events enabling prompt action.

Emergency Protocols: Developing comprehensive emergency plans, alongside training programmes for workers, ensures correct and safe responses in the event of an inrush.

Recent developments in inrush regulations reflect the ongoing evolution of mining safety standards, with a focus on proactive measures and technological integration. Here are some notable updates:

Modernised Regulatory Framework

The Mines Regulations 2014 replaced outdated laws with a single standard setting framework. This approach prioritises risk management and hazard control, including inrush prevention.

Enhanced Precautionary Measures

Updated guidance emphasises the importance of maintaining accurate and up-to-date plans of underground workings. These plans must include detailed information about potentially hazardous areas, such as, proximity to disused workings or water-bearing strata. (HSE, 2011)

Mandatory Risk Assessment

Mine operators are now required to conduct comprehensive risk assessments for areas identified as potentially hazardous. These assessments must include schemes to prevent inrushes, which are to be submitted to the Health and Safety Executive (HSE) for approval.

Technological Integration

The adoption of advanced monitoring systems, such as IoT sensors and real-time data collection, is increasingly encouraged. These technologies help detect early signs of inrush hazards and improve response times.

Focus on Emergency Preparedness

Regulations now stress the importance of robust emergency protocols and training programmes to ensure swift and effective responses to inrush incidents.

These developments highlight the shift towards a more proactive and technology-driven approach to managing inrush risks.

Case Studies

Polyhalite mining operations utilising modern surveying techniques.

ICL Boulby Mine, North Yorkshire: Known as the world's first and only polyhalite mine, uses advanced geophysical methods and exploration drilling to identify mineral-rich areas and ensure sustainable extraction. (ICL Boulby, 2023; STFC, n.d.)

These operations showcase the innovative use of modern surveying techniques to enhance efficiency and sustainability in polyhalite mining.

Our risks of inrush

We have old long holes from exploration drilling that are under pressure from water and gas.

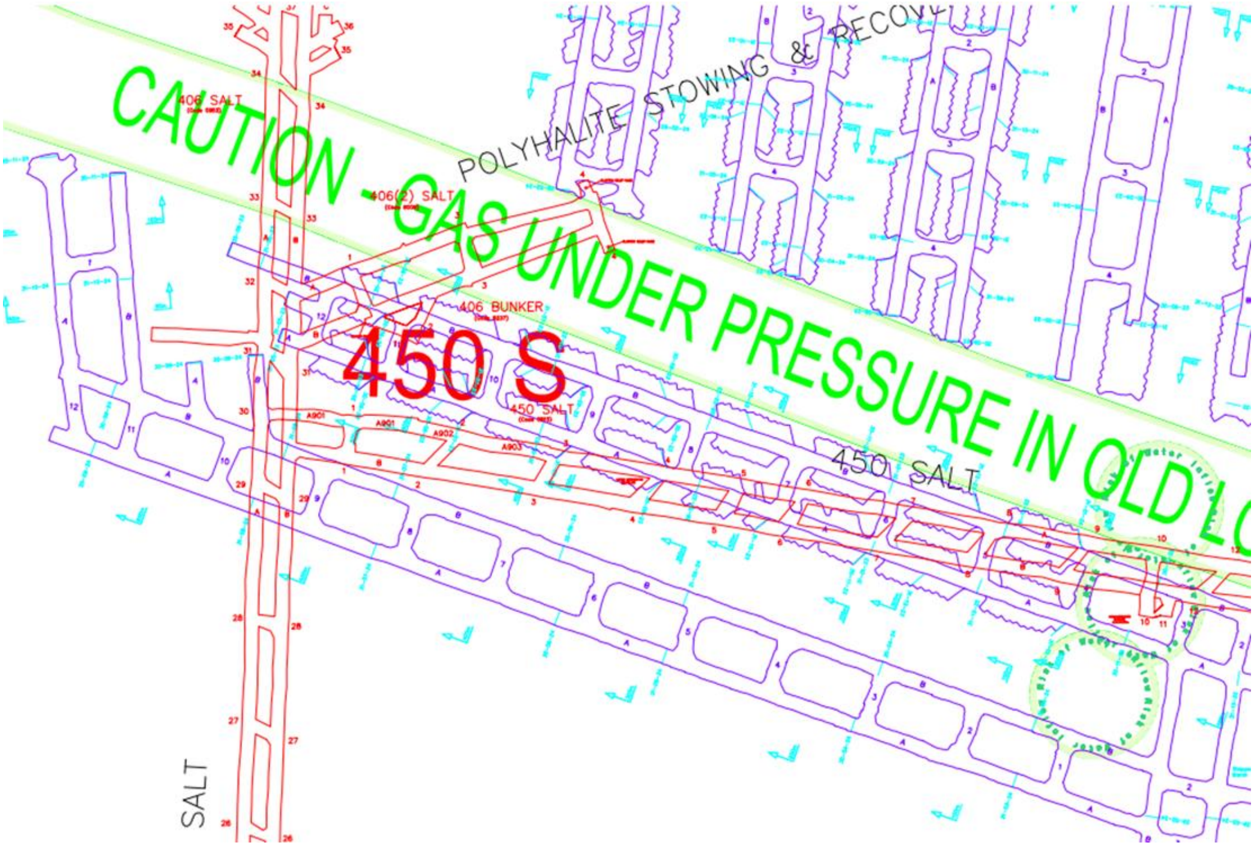


Figure 4

We also plot legacy workings that have water present. This means we can avoid any long holes or legacy workings if we are mining within a precautionary zone.

Mining methods

We mine in a herringbone retreat method. Which essentially is driving two roads, a belt and an access road with crosscuts on specific centres based on the geotechnical and geological assessment. Once advanced to full distance, we begin retreating taking herringbone stubs in a sequence whilst also milling the floor which is all based on geological assessment.

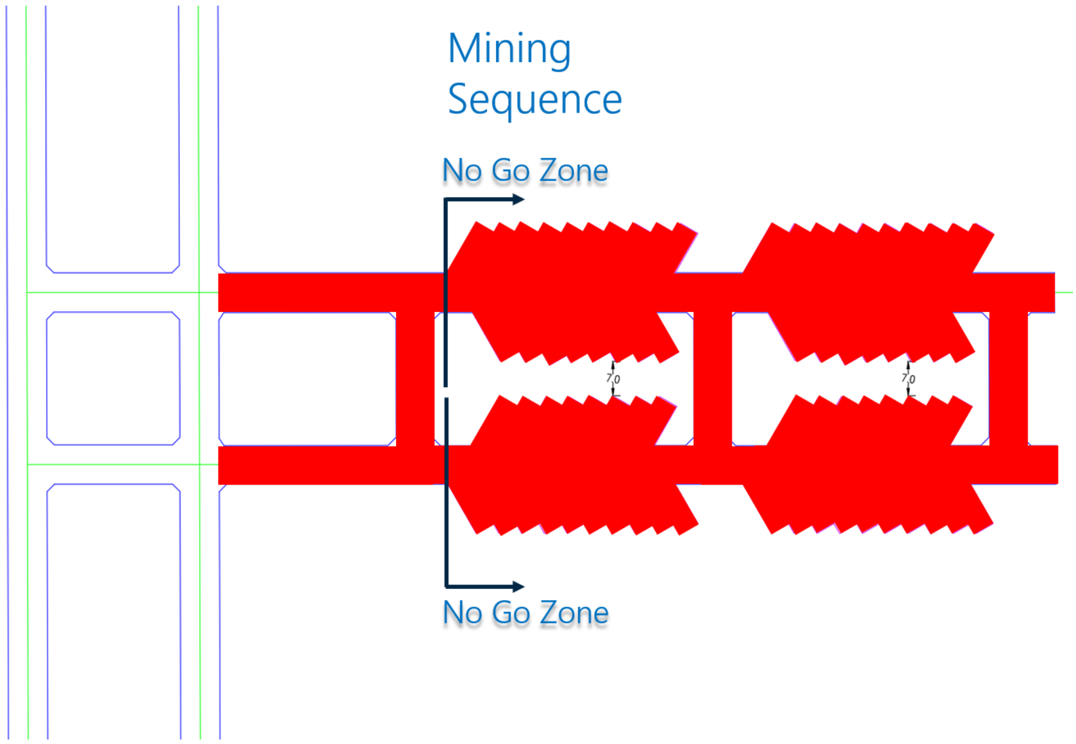


Figure 5

With our method of mining, we are creating an unsupported goaf (inaccessible open areas). This means we cannot access the mined area, which from a surveyors perspective, creates difficulty. This difficulty is due to the inability to accurately measure and record the tonnage reconciled and to update plans accurately. In relation to what was earlier discussed, inrush can occur when plans are not updated correctly and accurately.

This issue required a modern solution. Normally, our measurement process for mined headings is:

- Assess
- Measure
- Reconcile

Problem statement

With current technology deployed in our department, this meant we could not measure and reconcile retreat headings. Due to the advanced retreat system, we cannot access workings to the remaining material, therefore, we cannot guarantee what has been mined is in accordance with the design. This is safety critical, as if we cannot prove regional stability, we will not be able to satisfy the legal requirements to measure the workings.

Project scope

Where? - Boulby mine retreat headings.

Why? - It is a statutory requirement to measure the excavation and plot it accurately on the mine plans.

In Scope - Precise and accurate plans of the retreats will be produced which will allow ICL to utilise the orebody more efficiently and keep within legal constraints.

Out of Scope - Anything not pertaining to the measurement of districts and creation of statutory mine plans in retreat headings

SMART Objectives

- Specific – Retreat headings will now be able to be measured rather than estimated.
- Measurable - New technology will allow 3D representations of previously unmeasurable areas.
- Action – Measuring the workings and processing the data.
- Realistic – The tech is now available to achieve this.
- Timetabled – 6 - 12 months.

Research and development

Boston Dynamics' Spot the Dog is a highly agile quadruped robot designed for a variety of applications, including industrial inspection, security and research. One of its key features is LiDAR (Light Detection and Ranging), which enhances its ability to perceive and navigate complex environments. (Boston Dynamics, 2025) (Boston Dynamics, 2025; Boston Dynamics, 2023)

Capabilities with LiDAR (Flyability, 2023b)

Spot can be equipped with LiDAR sensors to create high-resolution 3D maps of its surroundings. This allows it to:

- Autonomously navigate through indoor and outdoor environments, avoiding obstacles with precision.
- Perform site inspections, collecting detailed spatial data.
- Enhance safety by detecting hazards in environments that may be dangerous for humans to access, plus, preventing humans to ever enter dangerous areas.
- Supports research and development, particularly in fields like radiation mapping and environmental monitoring.

Spot's modular design enables users to integrate additional sensors and payloads, making it a versatile tool for various industries. Its ability to operate autonomously or via remote control ensures adaptability across different applications. (Interesting Engineering, 2025)

However, we found that we have steps in milled roadways of anything from 1-3 metres in height which would mean spot is unable to traverse such challenging and obscure terrain. This ultimately meant we couldn't measure mined workings and update plans accordingly to fulfil our statutory requirements.

Flyability Elios 3 Drone

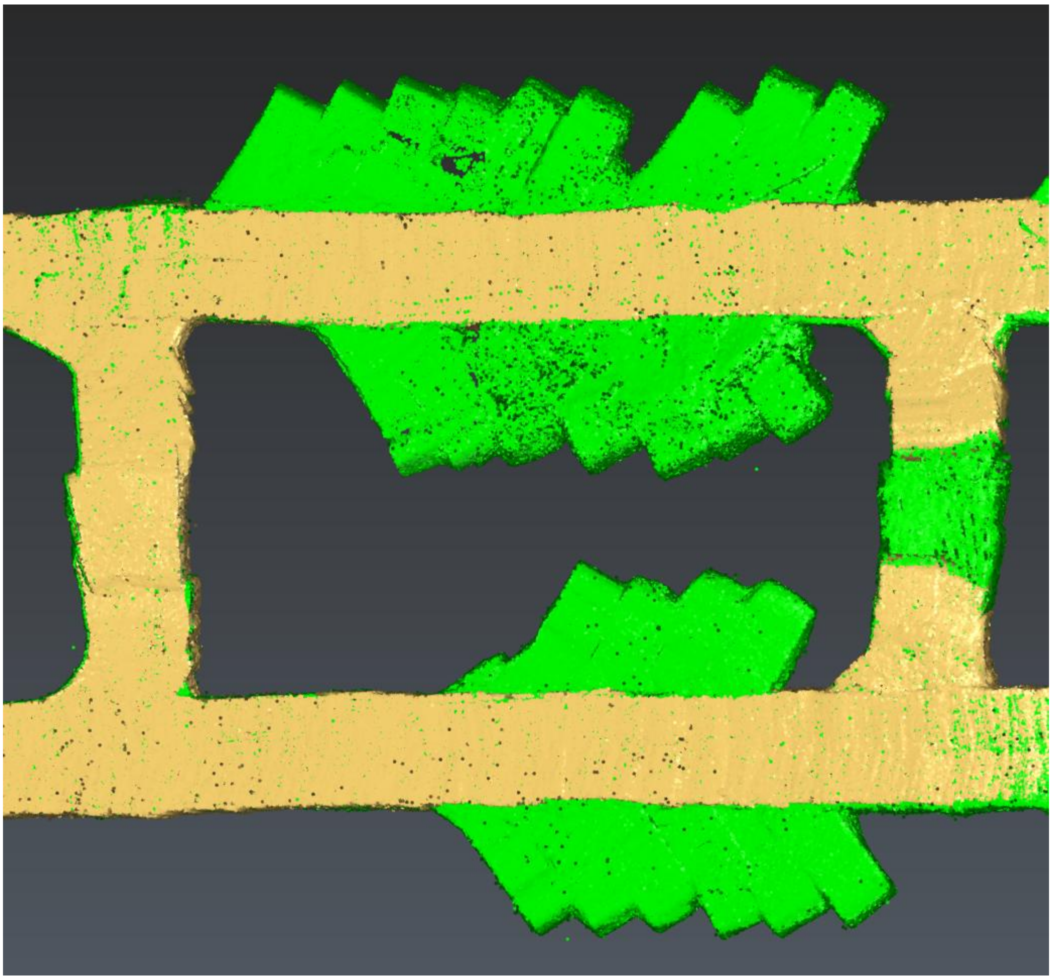
The Flyability Elios 3 is an advanced indoor drone designed for confined space inspections and 3D mapping. It is equipped with LiDAR technology, allowing it to generate high-resolution point cloud maps, in real time, while in flight. (Flyability, 2025) (Flyability, 2023a)

Capabilities with LiDAR (Flyability, 2023b)

- **Collision-Tolerant Design**: The Elios 3 is built to navigate tight and hazardous environments, making it ideal for industrial inspections.
- **SLAM-Based Stabilisation**: Utilising Simultaneous Localisation and Mapping (SLAM), the drone maintains exceptional stability, even in challenging conditions.
- **Real-Time 3D Mapping**: The embedded Ouster OS0-32 LiDAR sensor enables the drone to create detailed survey-grade 3D models, improving situational awareness.
- **Modular Payload System**: Users can customise the drone with additional sensors to suit specific inspection needs.
- **Industry 4.0 Integration**: Elios 3 supports digital transformation by streamlining data collection.

We then trialled the drone at Boulby of which we had training on how to operate it safely and efficiently. We got examples of data from scanned headings. (Flyability, 2025)

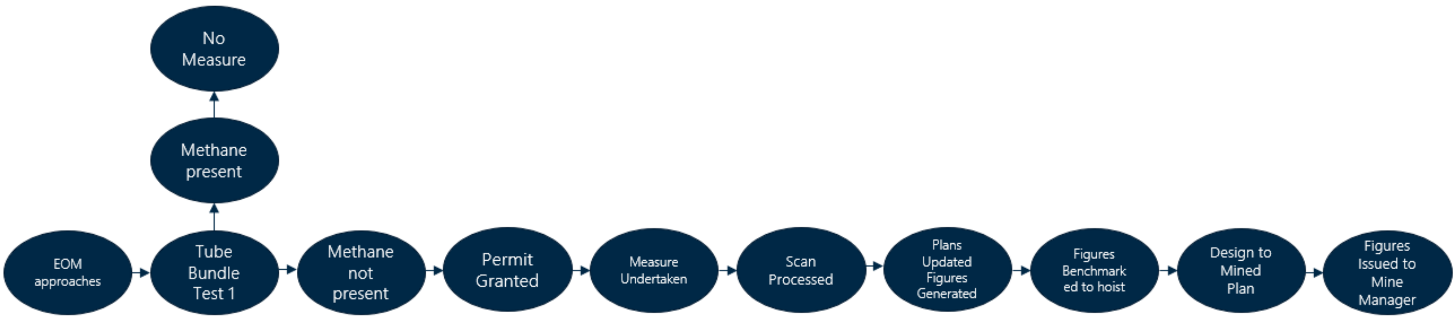
- Compared to previous measures for accuracy
- Precision of scanner
- Checking
- Global VS Local SLAM



(ICL UK, 2025)

The green point cloud portrays the drone scan, and the yellow is a handheld lidar scanner from the advanced roadways measured months prior to it being retreated. A process was required for deploying the drone as part of Boulby's surveying equipment, such as (ICL UK, 2025):

- Ventilation/Gas Testing Headings
- Post Processing Software Workflow
- Second Drone
- Updated Scanner on drones



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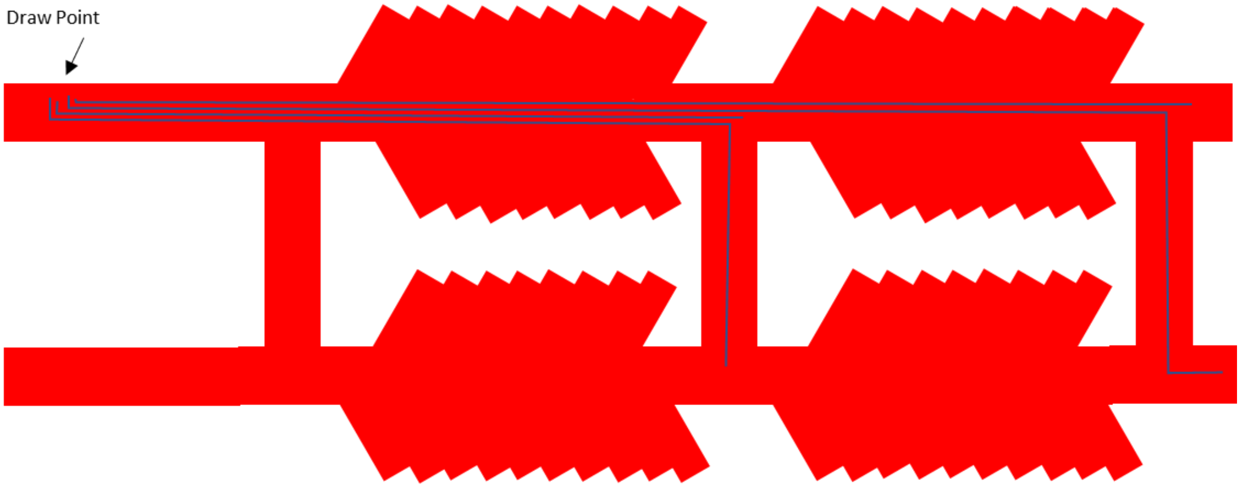
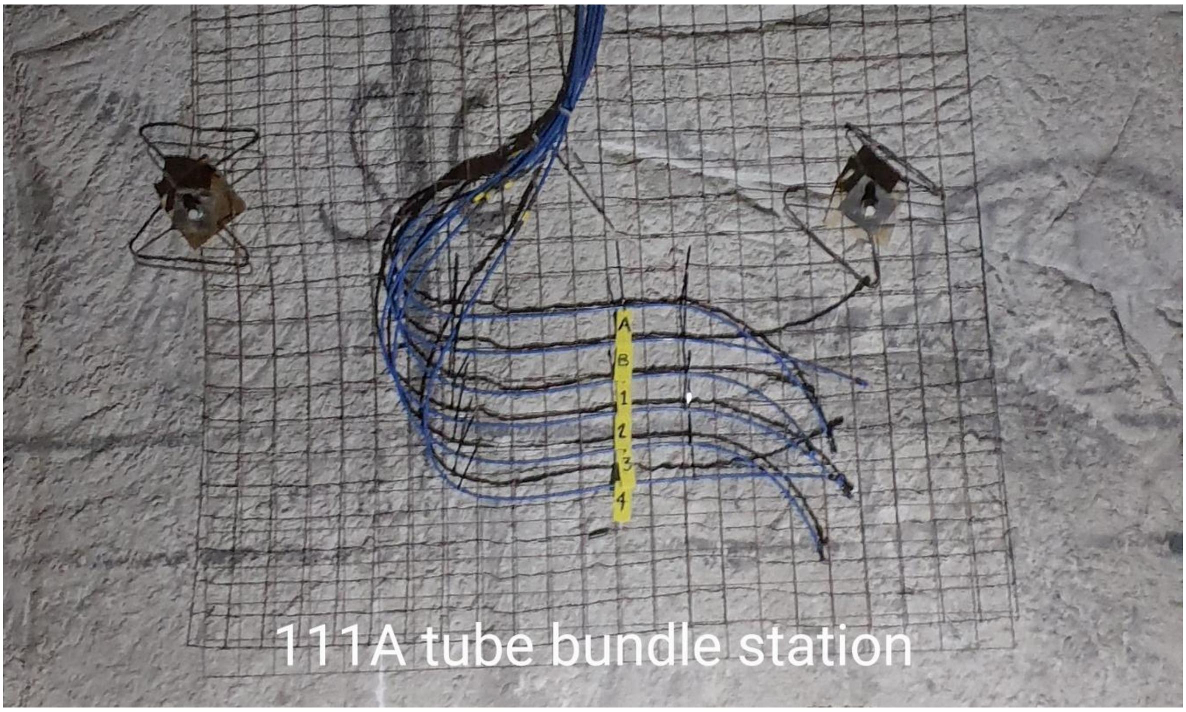
The process map for our end-of-month (EOM) assessments outlines the installation of tube bundles. These ran from the face and across each crosscut, extending back to the draw point. This enables the use of pumps to extract air samples from the goaf and direct them outbye for gas analysis. These sampling procedures commence up to a week before flight operations and are repeated immediately prior to flight. If gas levels are deemed unsafe for flight, additional testing and analysis is conducted until we are instructed it is safe to fly.



(ICL UK, 2025)

Once safety is confirmed and a permit is granted, measurements of the retreat heading are undertaken. Following the flight, scan data is processed to update plans and calculate tonnage figures. These figures are then compared against hoisted data to identify discrepancies or operational concerns. A comparative analysis of planned versus mined layouts is conducted to evaluate adherence to the mine design and to determine whether mineral extraction levels are within acceptable parameters. Below is the tube bundle measuring area:



(ICL UK, 2025)

Louis Robson flying the drone in a retreat heading, a section where the floor has been milled out.

(ICL UK, 2025)

Lessons learned and best practices.

As with all new projects, certain initial challenges must be addressed. As previously discussed, a key aspect of our investigation involved developing an accurate method for measuring gas levels in retreat headings. Following our assessment, tube bundles emerged as the most suitable solution, as they facilitate testing prior to the deployment of drones into the workings. This ensures that safe operational limits are established before flight.

Regarding LiDAR scanning, we determined that optimal coverage for pointcloud data was achieved by flying around the perimeter of the herringbones before traversing back through the centre of the goaf. To maintain data quality and minimise the impact of airborne dust, we sought to operate within the upper third of the goaf, thereby reducing exposure to dust accumulation on the floor. As a result, flights were consistently conducted in environments free from significant dust presence, ensuring the integrity of our dataset remained uncompromised.

Challenges and limitations

Deploying an Elios 3 drone underground at Boulby Mine presents many challenges and limitations that must be carefully considered to ensure successful operation in such a complex environment.

One of the primary challenges is navigational precision. Underground spaces like mine workings at Boulby Mine often have irregular geometry, some unstable surfaces and unpredictable obstacles such as gas, making it difficult for the drone to maintain steady flight and avoid collisions. While the Elios 3 is designed for confined spaces, the mine's conditions may push its manoeuvrability to its limits, especially when exploring areas that are structurally compromised or with anything hanging from the roof such as torn steel mesh.

Signal interference and communication difficulties also pose a significant limitation. The dense rock formations and extensive underground networks can weaken radio signals and reduce connectivity, which lead to disruptions in data transmission and remote-control responsiveness. This issue may require strategic placement of signal boosters in some applications or potentially use of autonomous flight capabilities to ensure that critical information is successfully captured.

Additionally, the lighting and imaging constraints underground can affect the drone's ability to accurately map inaccessible areas. Even with advanced visual and LiDAR capabilities, dust, humidity and poor visibility conditions may compromise the quality of the gathered data, leading to inaccuracies that must be accounted for during analysis.

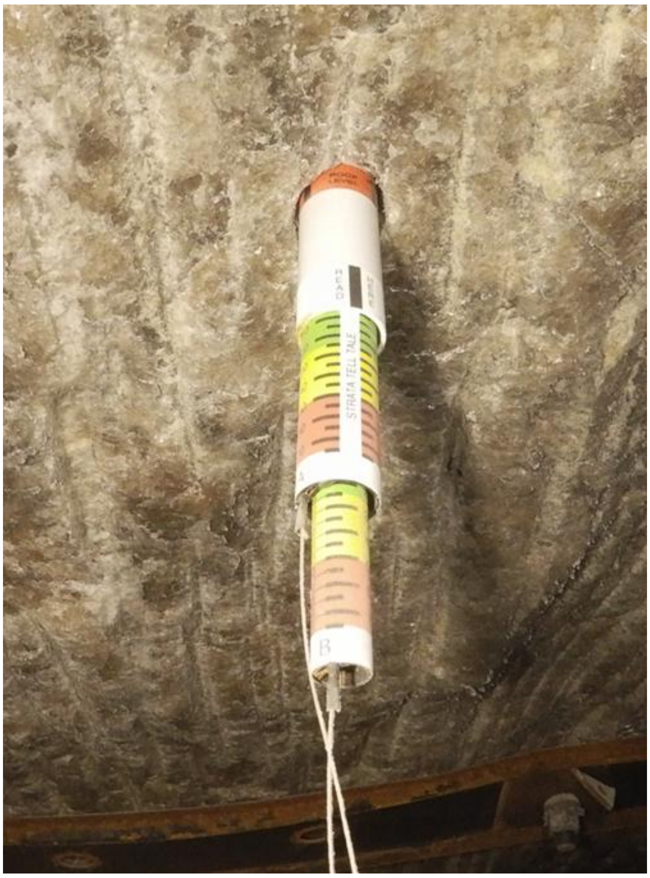
Battery life is another operational limitation due to the batteries used only having a 9-minute power capability. Extended flight durations are often required to explore large sections of the mine, yet underground missions can be highly energy-intensive due to the need for continuous stabilisation and sensor operation. Efficient mission planning and battery management strategies are necessary to maximise coverage without prematurely exhausting power.

Lastly, safety and regulatory considerations must be carefully addressed. Operating a drone in an active or historical mine carries potential risk; with the main risk being exposing the drone to any high level of explosive gas. Therefore, implementing tube bundle gas testing systems ensures the headings are clear and free from gas prior to any flights.

While the Elios 3 drone provides an innovative solution for inspecting inaccessible underground areas, overcoming these challenges requires a lot of thought and testing in its active application before deploying it fully into the workforce.

Enhancing ground control monitoring through drone-based inspections in underground mining

Beyond its primary inspection capabilities, the drone has proven invaluable for accessing areas that are otherwise unreachable within the underground environment. One notable application involves the close-range observation of telltales installed in the roof to monitor ground movement. By capturing high-resolution images during flight, we were able to assess displacement accurately, enabling the Rock Engineering team to maintain systematic records of ground behaviour over time.



ICL UK (2025)

In sections where the roof conditions have deteriorated, the drone was deployed to conduct targeted inspections directly beneath the affected zones. This approach allowed us to identify structural concerns, such as fissures and notable delamination; all without placing personnel at risk. The ability to carry out these assessments remotely has significantly improved both the safety and efficiency of our ground control procedures.

Future Trends

Advanced mine surveying technologies and methods

Mining industries are undergoing a significant transformation, driven by advancements in technology and the necessity to increase efficiency, safety and environmental sustainability. Surveying plays a critical role in mining, ensuring accurate mapping, resource management and operational planning. Below are some key trends shaping the future of mine surveying (McClure Vision, 2025): (GIM International, 2018; RICS, 2025)

Integration of Unmanned Aerial Vehicles (UAVs)

Unmanned Aerial Vehicles, commonly known as drones, are revolutionising mine surveying. Equipped with high-resolution cameras and LiDAR sensors, drones can capture detailed aerial images and 3D models of mining sites. Their ability to survey hazardous or inaccessible areas enhances safety while reducing costs and time.

Adoption of Autonomous and Remote Sensing Technology

Autonomous systems, including robotic total stations and remote sensors, are becoming prevalent in surveying. These technologies can operate in challenging environments, delivering accurate data without requiring human presence in dangerous locations.

Enhanced Real-Time Monitoring and Data Sharing

The rise of Internet of Things (IoT) devices facilitates real-time monitoring of mining sites. IoT sensors can collect and transmit data, which is then integrated into centralised systems for better decision-making. Cloud-based platforms also enhance data sharing and collaboration among teams.

Virtual Reality (VR) and Augmented Reality (AR)

VR and AR technologies are gaining traction in mining enabling immersive visualisation of survey data. These tools allow stakeholders to interact with 3D models and gain deeper insights into site conditions, improving planning and training processes.

Focus on Sustainable Practices

Environmental considerations are increasingly influencing mine surveying methods. Renewable energy-powered survey equipment, alongside technologies that minimise land disruption, are emerging to align with sustainability goals.

Conclusion

The implementation of the Elios 3 drone at Boulby Mine has been a significant step forward in enhancing underground surveying capabilities. By utilising advanced mapping technology, this project has successfully measured and assessed inaccessible areas, providing vital insights into the mine's structure and safety conditions. The drone's ability to navigate complex environments without risking human presence has reinforced efficiency, accuracy and operational safety.

This initiative underscores the growing role of innovative technology in modern mining, demonstrating how unmanned aerial systems can revolutionise underground exploration. The valuable data gathered not only supports ongoing operations but also contributes to future planning and risk mitigation strategies. As mining continues to evolve, the integration of cutting-edge solutions like Elios 3 will remain essential in overcoming industry challenges and ensuring sustainable safe practices for years to come.

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