emesent

USE CASE

MAPPING VERTICAL INFRASTRUCTURE

HOVERMAP IN UNDERGROUND MINES

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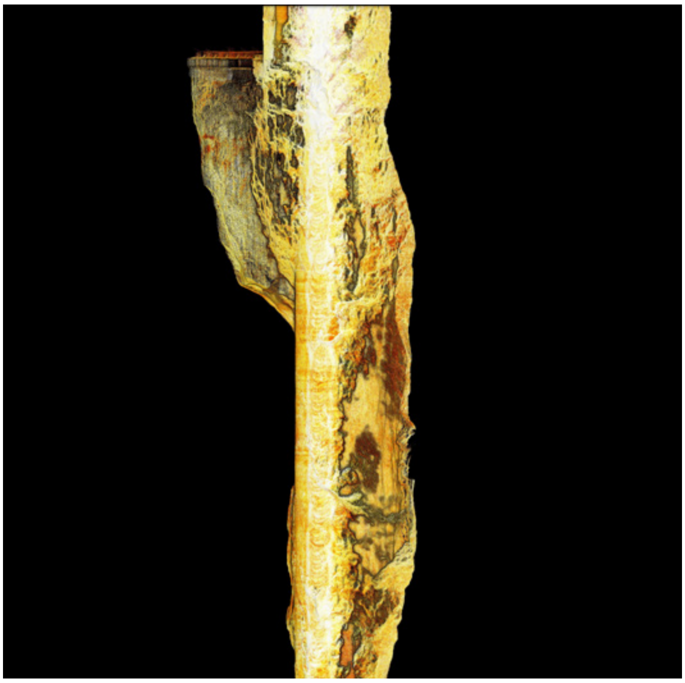
INTRODUCTION

Deep and high-stress conditions make mining inherently high-risk environments for personnel, equipment, and infrastructure. Laser scanners are used to capture data in vertical infrastructure so that mining and geotechnical engineers can understand the effect of mining-induced and tectonic stresses on orepasses, raises and vents to maintain safe and efficient operations.

However, the data collection process for inaccessible infrastructure can be hazardous, time-consuming, and has the potential to delay production.

Hovermap reduces these risks by removing personnel from hazardous areas and minimizing the time taken to map inaccessible vertical voids. When drone-mounted, Hovermap enables autonomous flight and collision avoidance capability to produce shadowless, high resolution scans of underground voids. Or it can be attached to a tether and lowered into voids too narrow to fly. Mining or geotechnical engineers can quickly and safely inspect orepasses, raises or vents with minimal disruption to production.

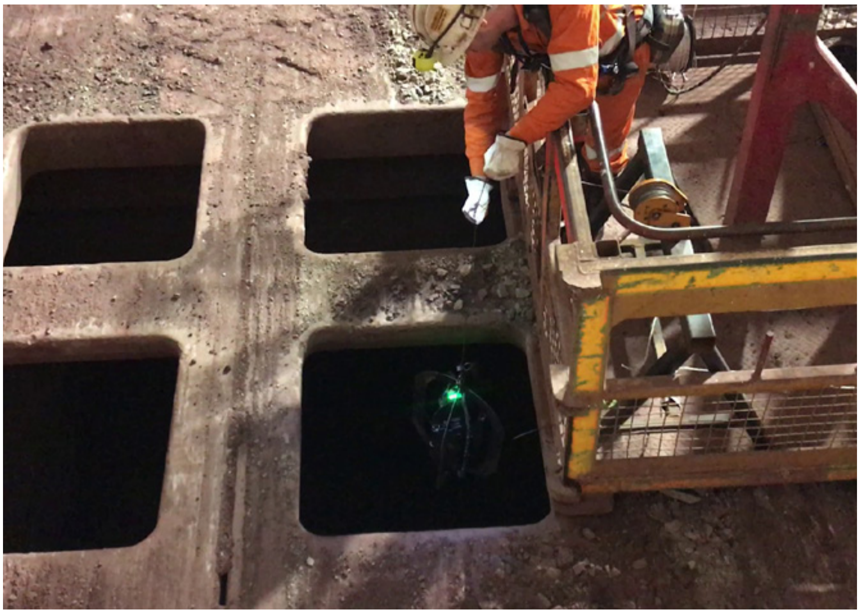


"We lowered Hovermap down orepasses, flew the drone into drawpoints and even scanned our shaft and ramps by fixing the scanner to one of our vehicles. The visualization delivered exceeded all our expectations. The data captured in one orepass saved us significant time and effort by confirming it was irreparable. That saved us millions."

Alex Holder, Group Planning and Projects Lead, Petra Diamonds

DATA CAPTURE METHODS FOR VERTICAL INFRASTRUCTURE

Hovermap enables low-cost, rapid data acquisition suited to development, monitoring and management of excavations. Where there is sufficient width, Hovermap's autonomous flight capabilities can capture data. Other options are to lower Hovermap attached to a hoist, a protective cage or a motorized buggy, with the cage or buggy being well suited to orepass and vent rise inspections. The resulting data can be used for a range of applications, the detection of failure mechanisms, inspection of condition, blockages or hang-ups, and back analysis comparison of as-designed versus as-built.



CAGE DATA CAPTURE

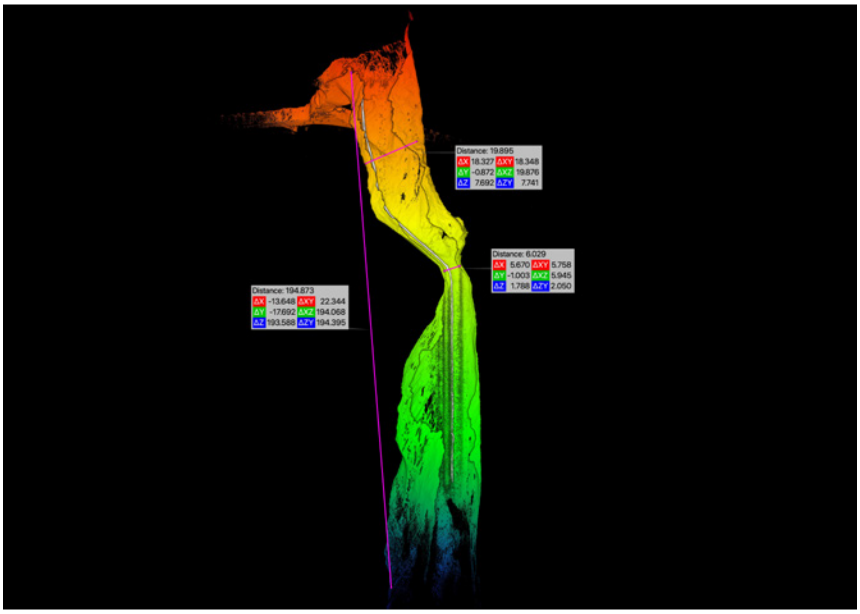
With grizzlies (800x800 mm) at the top of the orepasses preventing flights, Hovermap was lowered in a protective steel cage, designed to reduce damage from debris, water and vibrations. To better understand the condition of its orepass system, BHP's Olympic Dam scanned 35 fingerpasses by lowering Hovermap in a cage. The data was processed, georeferenced and surveyed-in during the 3-day monitoring program.

Cage-based data capture is also suited to scanning raises, which extend for hundreds of meters and can be too deep to fly.

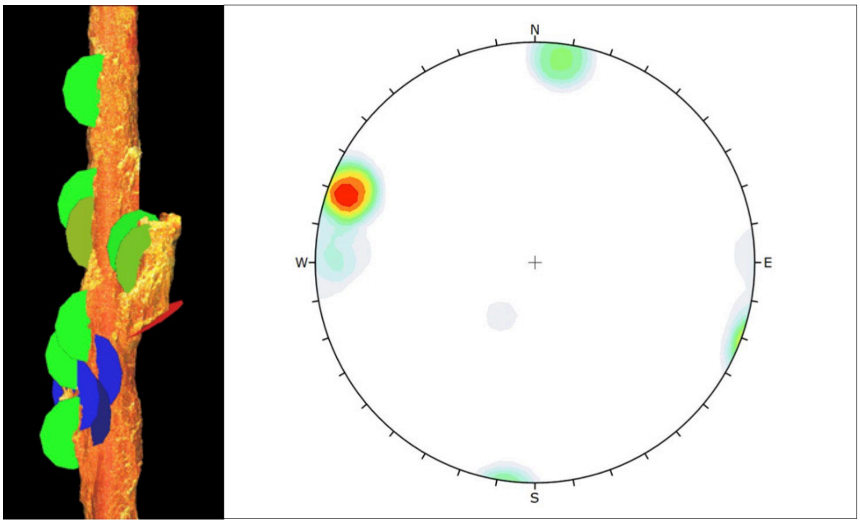
FLIGHT DATA CAPTURE

This ore pass was scanned by Hovermap-enabled autonomous drone flight. The drone operator, safe under supported ground, set a height waypoint at 200 m below the original position.

Hovermap planned its own flight path, descending about 150 m (165 yd) into the orepass in a beyond line-of-sight flight to achieve the objective while avoiding obstacles. The point cloud is colorized by elevation.



IDENTIFICATION OF FAILURE MECHANISMS



STRUCTURAL

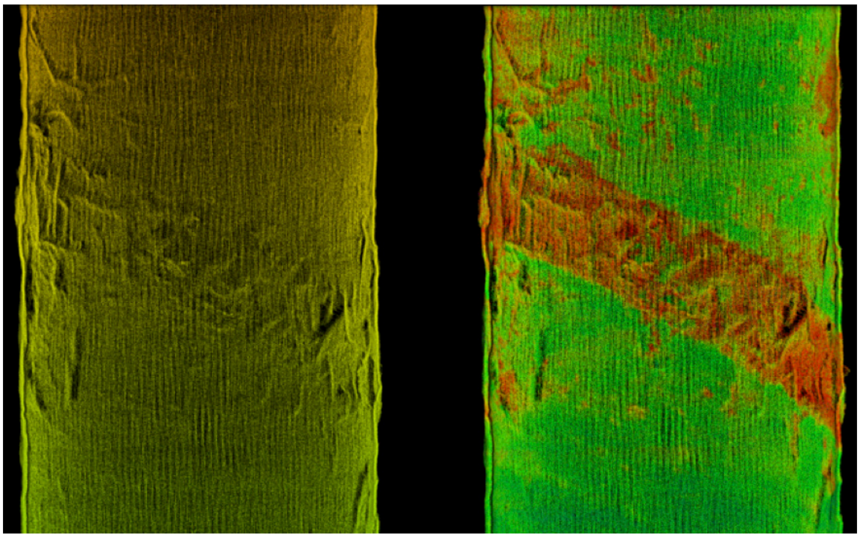
Analysis of this data set, captured with Hovermap lowered in a protective cage, shows the structures responsible for generating fall out in the orepass, visualized as planes and in a stereonet. Mapping the structures causing the existing failure helps identify the potential for more significant failure and informs back analysis to improve future designs.

STRESS

Stress-induced damage is easily identified in Hovermap data. Typically this is observed as buckling and stress-induced spalling (or dog earing) perpendicular to the principal stress direction. Observational data obtained from Hovermap provides significant benefit to understanding rock mass response. Additional information can be obtained relating to the depth of breakout.

The cost of scanning a raisebore is typically less than the cost of a single stress measurement and could be an important validation of geotechnical conditions at a mine site. Simple numerical modelling can be used to validate if the area is under the influence of surrounding excavations. With the addition of rock testing from an investigation borehole and the depth of the stress breakout, more detailed back analysis of magnitudes could be explored.

CONDITION INSPECTIONS

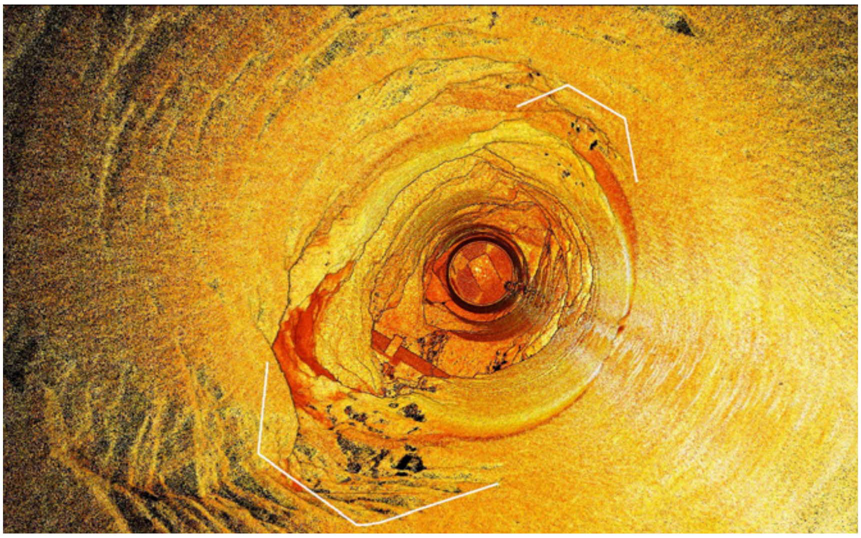


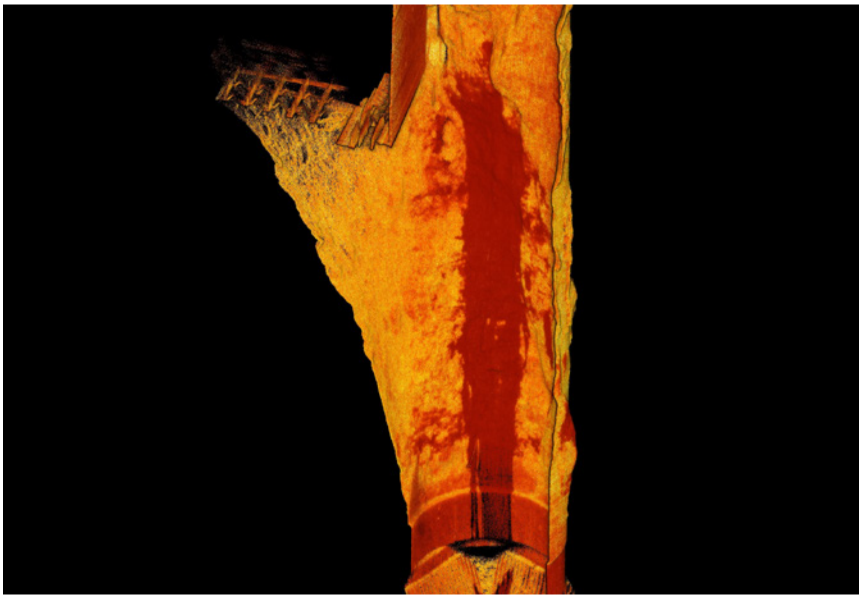
GEOLOGICAL FEATURES

The LiDAR attribute reflectance intensity can help identify geological features in voids, like this feature in an orepass. With red indicating a lower intensity return, it is easy to identify a feature that could be a change of lithological unit, such as an intrusive sill. The increased rock damage in the area may necessitate further geotechnical investigation to determine the cause of the geological feature, if it requires remediation, and how future raises will perform when intersecting this feature.

CONDITION MONITORING

From the visualization of the point cloud data, colored by reflectance intensity, the orepass shows clear signs of deterioration. This may be partially attributed to stress-induced damage, but also to wear resulting from use as a pass. Using comparative scans for condition monitoring allows for the location and volume of deterioration to be monitored over time. Using multiple scans allows for the rate of change to be measured and triggers put in place for understanding the service life of the pass, the need for remediation or whether the orepass is operable for another year.

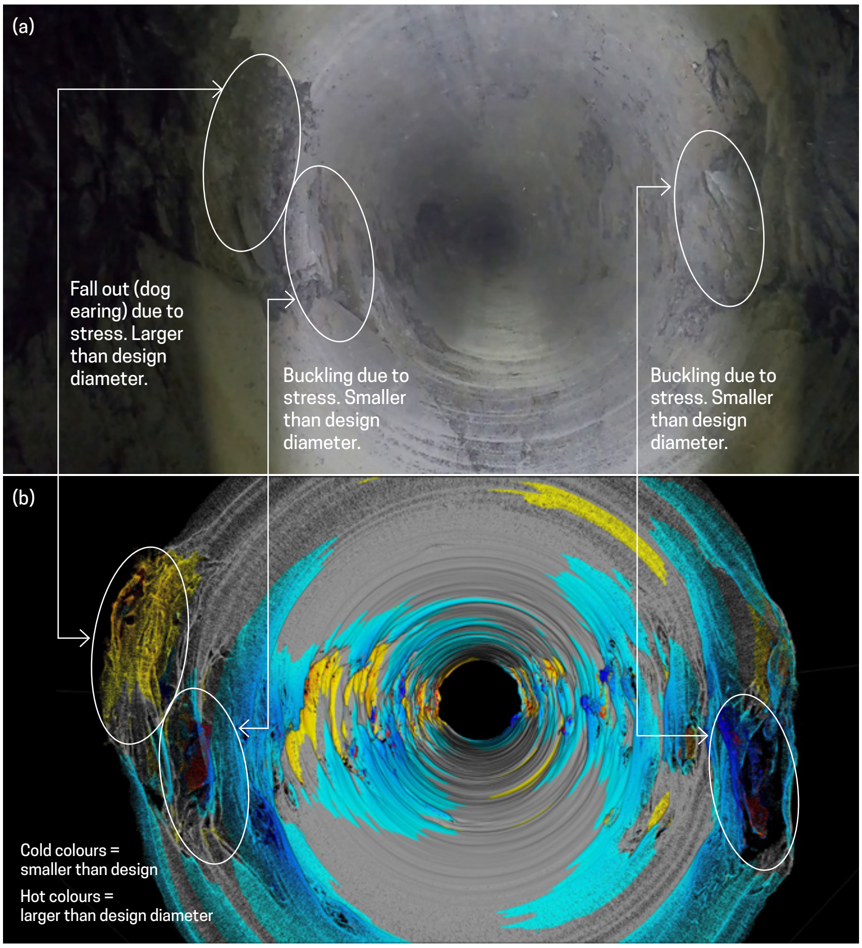




WATER INGRESS

Water inflow can be recognized with a point cloud colorized by intensity. Here, the wet rock shows as a darker, lower intensity area, and water pooling, in the built section, is black where there were no LiDAR returns. Water inflow appears to come from a structure but has not resulted in significant deterioration of the rock mass and there is no significant fall out. Identifying water inflow is relevant where the rock mass may deteriorate under the presence of water, as well as understanding if water ingress is the cause of fall out. Reliable identification of the source and extent of water can assist in forecasting performance of future vertical excavations.

RAISEBORE PERFORMANCE



BACK ANALYSIS OF RAISEBORE AGAINST DESIGN

A raise scan, colorized by intensity (b), shows areas of failure correlated with images from a video camera (a). The raisebore, scanned immediately after reaming, shows stress damage already present in the shaft. The raise image (a) shows areas of significant damage. The LiDAR scan highlights the stress-induced distortion causing a reduction in raise diameter adjacent to areas of fall out. Hot colors show where the excavation is 50 mm (2 in) larger than design dimensions and cold colors are 50 mm smaller.

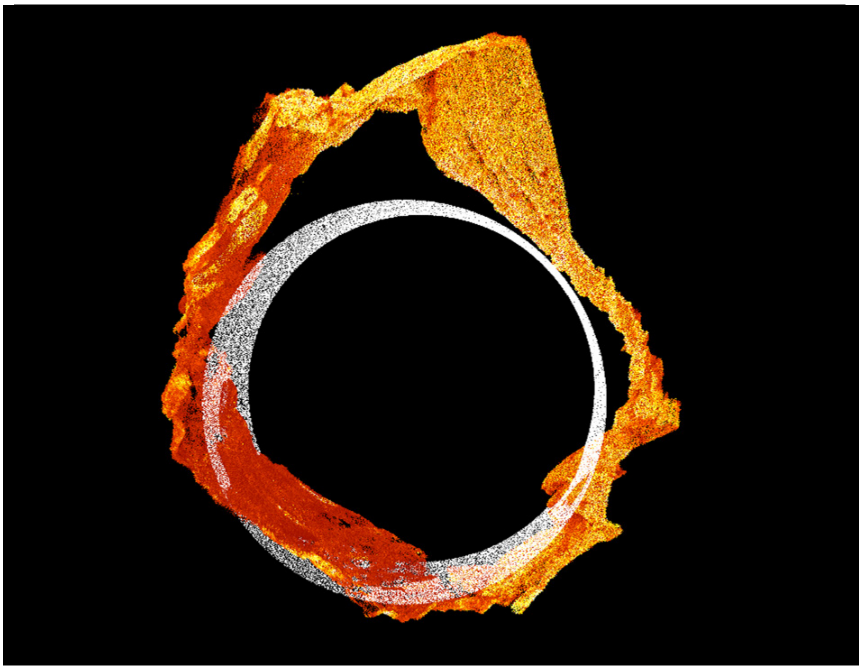
"Hovermap provides our clients with a level of data about their vertical excavations that wasn't previously possible. This allows them to make more informed decisions."

Peter Evans, Director, MINELiDAR

CONDITION MONITORING

This scanned vent raise section shows white points representing the original excavation design overlaid with LiDAR intensity points showing the current condition of the asset. Note the deviation of the excavation from the original design position as well as the potential for further instability within the excavation due to wedges forming. Repeat scanning of a raise allows for the detection of changes over time.

Scanning immediately after reaming establishes a condition baseline and, when combined with routine data capture, allows for the validation of empirical assessments of raisebore design, improves forecasting of stability for future raises, and provides detailed asset management data of critical infrastructure.



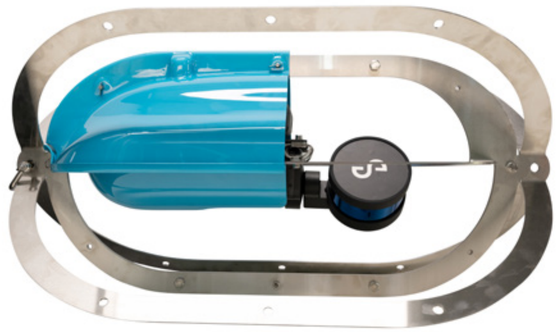
HOVERMAP

Hovermap, a versatile LiDAR scanning solution, makes mapping of inaccessible areas safe, easy and fast.

Designed as a drone payload, Hovermap combines advanced collision avoidance and autonomous flight technologies to safely and quickly map hazardous, inaccessible, GPS-denied environments.

Easily mounted on drone, vehicle, winch or backpack, Hovermap data capture is adaptable for any development, production or infrastructure environment.

» Versatile: fly, drive, walk, tether—multi-application mapping
» GPS-denied flight—unaffected by GPS loss
» SLAM[1] based mapping—precision mobile LiDAR scans without GPS
» Tap-to-Fly autonomy—autonomous flight beyond line-of-sight and communication range into inaccessible excavations
» 360° field of view—shadowless, uniform-density point cloud data



The Hovermap cage provides a complete shaft scanning solution ready to be winched. The stainless steel frame is specially designed to slide smoothly, avoid snags and deliver great scans in vertical shafts and raises.

IMPROVED SAFETY

Keep personnel away from edges, confined spaces or heights. Fly Hovermap beyond line-of-sight and capture critical data to assess the condition of assets and improve decision-making.

PRODUCTIVITY & EFFICIENCY

Quickly and safely map inaccessible areas and assets with minimal disruption to operations. Fly, walk, drive or tether Hovermap to capture data where and when you need it.

GREATER INSIGHTS

Hovermap's accurate, high resolution point clouds deliver greater confidence in analytical and modeling outputs and improve decision-making.

COST & TIME SAVING

Hovermap pilots can fly an entire mission from take-off to landing using a tablet, with minimal training. Imaging complex assets, which normally takes hours using traditional survey techniques, takes only a few minutes with Hovermap.

1. Simultaneous localization and mapping

Emesent would like acknowledge the following contributions: use case and point clouds from Peter Evans at MINELiDAR and point clouds from Dwyka Mining Services.

MINELiDAR DWYKA MINING SERVICES

www.emesent.com

Version 1