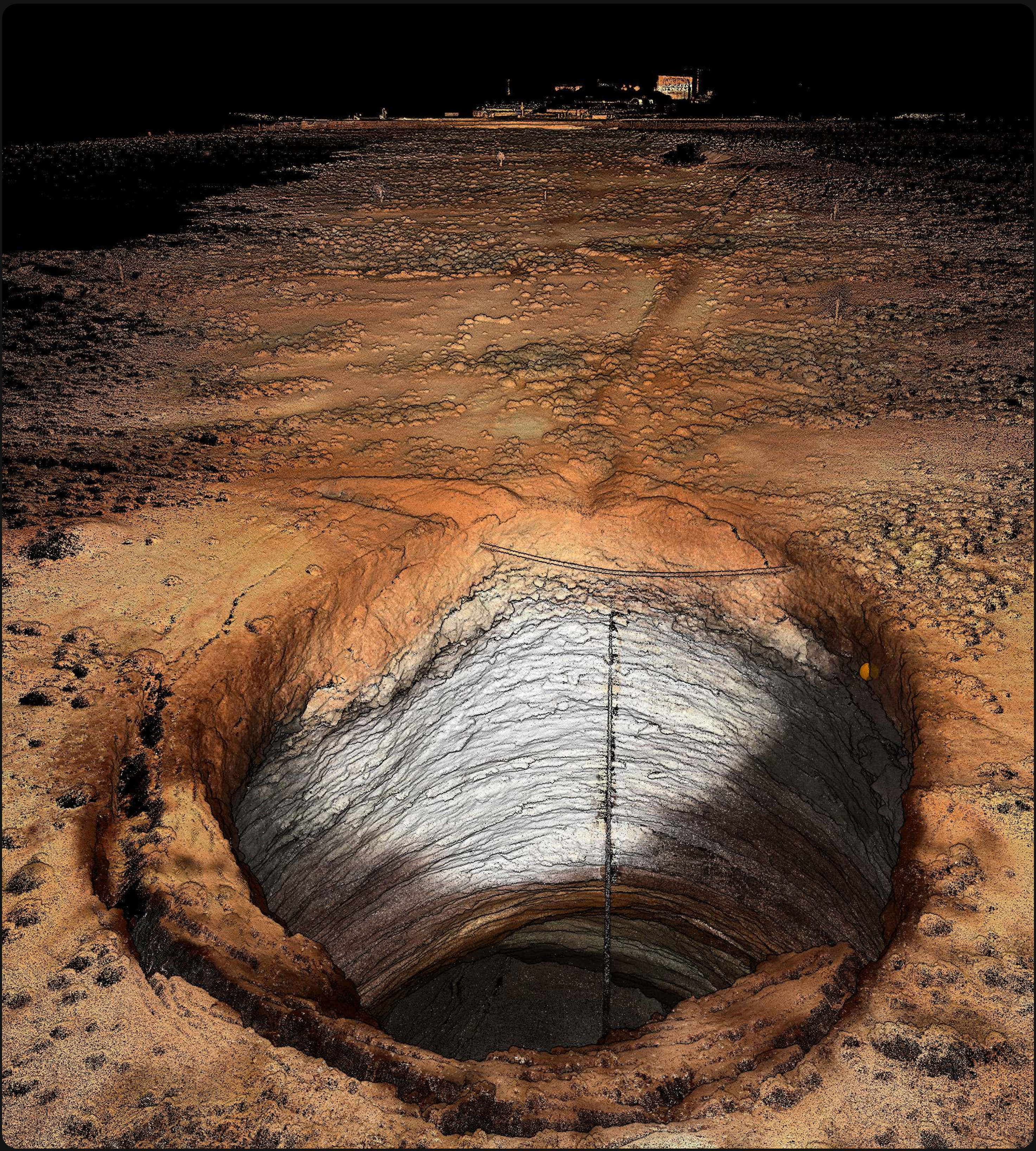
Case Study

Mining

Topic

Mapping the Carrapateena mega cave autonomously: How Emesent Hovermap conquered the inaccessible

emesent



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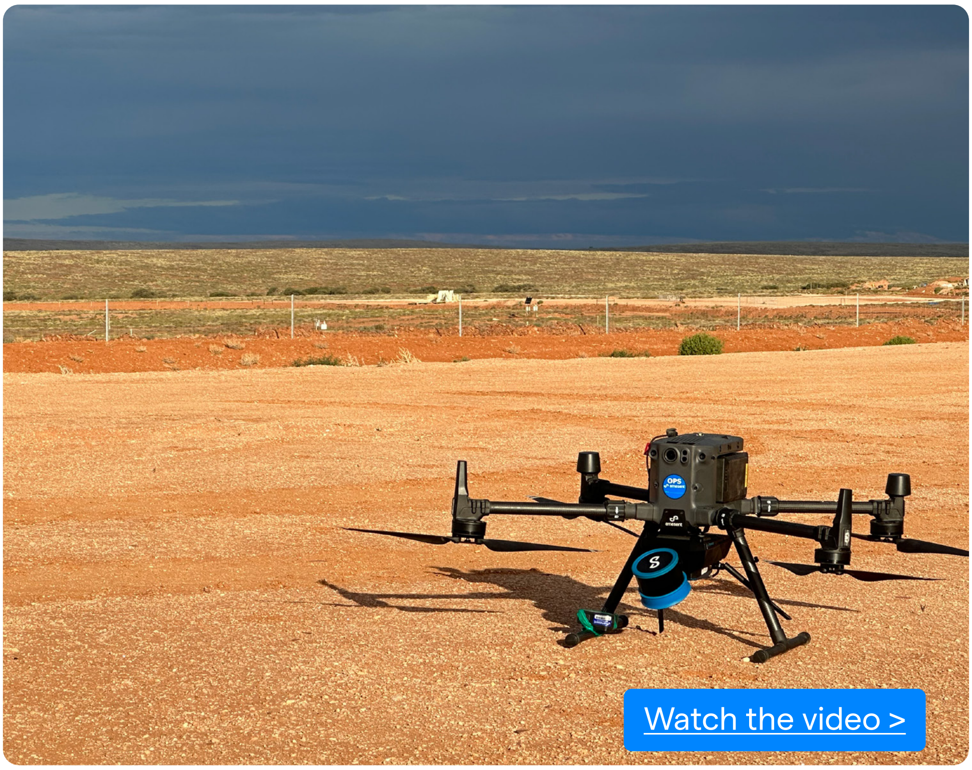
Mapping the Carrapateena mega cave autonomously



Key Outcomes

Autonomous capability uniquely enabled critical data capture otherwise not possible

Ensured continuity of underground production, preventing potential production losses

Enabled safe data capture without risking personnel

Ability to conduct ongoing monitoring to detect anomalies early, ensuring safety of personnel and operations

Background

The Carrapateena mine in South Australia is one of the largest copper reserves in Australia — and the world — with an annual production rate of approximately 4.25 million tonnes. Initially acquired by OZ Minerals in 2011, the mine became part of BHP in 2023. The ore at Carrapateena is extracted using the sublevel caving mining technique, suitable for large orebodies with a steep dip, tabular or massive deposits, and continuation at depth.

This method involves developing sublevels within the orebody at regular vertical intervals. As mining progresses downward, each new level collapses into the mine opening. This results in surface subsidence, creating sinkholes as the ground above the orebody subsides.

The need for regular monitoring

While sublevel caving is an efficient and economical mining method, it requires regular monitoring of the surface subsidence and the cave formed to ensure: 1) safety of personnel underground and on the surface; 2) stability of mine and operations and continuity of production; and 3) validation of geotechnical models and optimisation of drill and blast.

In the case of Carrapateena, a 5m diameter hole appeared at the surface in 2023. As the hole continued to grow substantially over the next few months, as per the sub level caving method, monthly scanning became even more critical in order to assess its width and depth.

It was also crucial to assess both the overburden and the elevation of the muck pile meticulously to guarantee that they remained within safe thresholds, minimizing the risk of triggering an air pressure blast from a wall collapse, which would have catastrophic consequences to personnel and equipment. This data was essential to enable the geotechnical team to ensure that there was not an air gap (void) forming between the cave muckpile and the sublevels. If such a void or air gap was identified, all mining operations and production underground would immediately cease.

The challenge

The project faced significant difficulties due to the mandatory 200-meter exclusion zone around the mega cave as well as its size, which prevented close proximity for direct observation. Traditional methods such as terrestrial LiDAR, CMS, and COW systems were impractical. Standard drones and manned helicopters were inadequate, as they could only capture the cave's opening, not its full depth and width. Nor was it possible to manually fly most drones from over 200 meters away, especially without a line of sight, communication link or GPS once the drone descended into the cave. A LiDAR payload slung from a manned helicopter was even considered, but judged unsuitable.

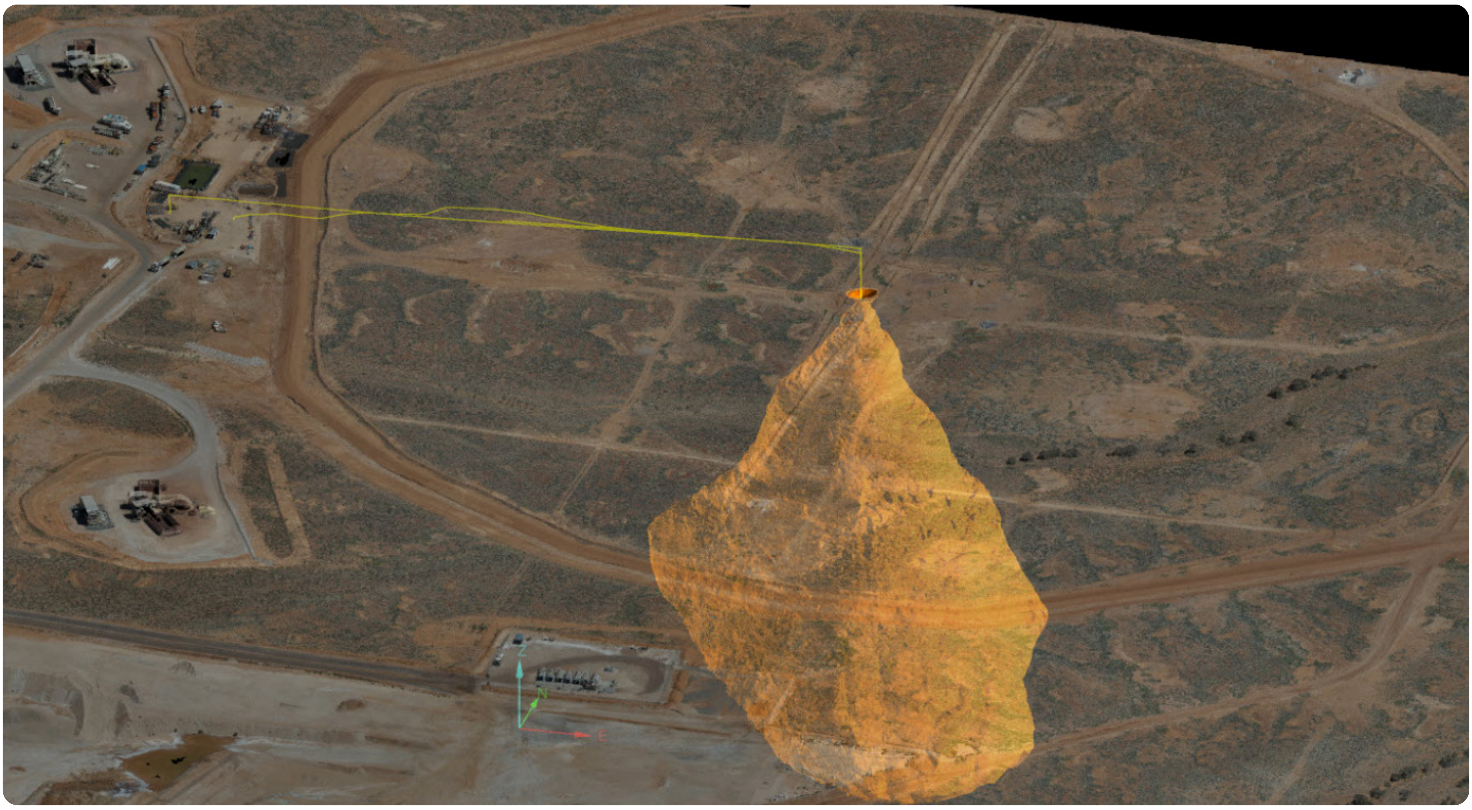
A solution was required that would allow surveying of the cave from a considerable distance, while at the same time ensuring the capture of precise and detailed information. The answer? A drone with a LiDAR payload and camera that could be launched from outside the exclusion zone, navigate to the cave's opening, autonomously descend into the cave, and perform accurate scans without GPS or communication range.

Carrapateena turned to Emesent and their autonomous Hovermap drone system, which was uniquely capable of this mission.

The requirements

Carrapateena required a 3D scan of the mega cave to measure its depth, width, shape, and the slope of the muck pile at the bottom. Additionally, images of the cave, particularly the bottom, were desired to provide further insights for the geotechnical team. It was also important to establish a monitoring program with a system and guidelines that enabled the team to easily capture the scans on a monthly basis for:

1. Cave Analysis: Measuring the width, depth, and shape of the mega cave, including its opening at the surface.
2. Muck Pile Assessment: Evaluating the slope and shape of the muck pile at the cave bottom.
3. Comparison with Geotechnical Model: Contrasting the scan data with the geotechnical model and ore mined from sublevels to detect abnormalities like air gaps or voids forming between the muck pile and sublevels.
4. Optimization of Mining Operations: Assessing the slope and shape of the muck pile to adjust drill and blast operations for ore extraction, ensuring even rock/load distribution aligned with the design model.



MEGA CAVE POINT CLOUD AND DRONE TRAJECTORY FROM A PREVIOUS AUTONOMOUS HOVERMAP SCAN, OVERLAID ON AN AERIAL IMAGE OF THE AREA, HIGHLIGHTING THE CAVE'S SIZE AND THE EXCLUSION ZONE.

Technology used:

Hardware Components:

- Hovermap ST-X payload with a 300m range LiDAR
- DJI M300 drone platform
- Drone controller and Samsung tablet
- Emesent Long Range Radio module
- GoPro camera

Software and Functionalities:

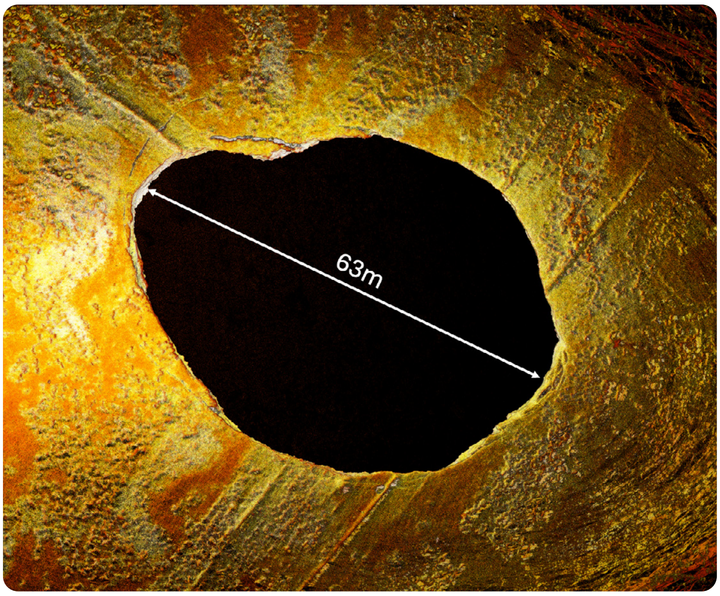
- Emesent Cortex, enabling autonomous flight beyond line of sight and advanced obstacle avoidance when flying in pilot assist mode
- Commander App for live streaming point clouds and tap-to-fly real-time operation
- Aura desktop software for post-processing, data visualization, and deliverable preparation

The approach

1. Takeoff: The drone was launched from a safe distance 300 meters away from the mega cave opening.
2. Approach: It was flown towards the opening in Hovermap in Pilot Assist mode, while Hovermap's Long Range Radio maintained the communications link, enabling live monitoring of the point cloud and camera feed.
3. Descent: Upon detecting the cave opening, the drone was commanded to autonomously descend 70 meters into the cave.
4. Autonomous Operation: The drone continued its mission autonomously after losing communication and line of sight.
5. Completion: The drone ascended after a few minutes, updating the live 3D map on the tablet.
6. Return: Once the scan was deemed complete, the drone was commanded to return home autonomously.

The scan took just 15 minutes to complete. After landing, the operator and mine engineers analyzed the live 3D model on the tablet and processed the data in Emesent Aura to enhance the accuracy and density of the scan. A 3D model was created within 25 minutes, ready for visualization and measurement, determining the size, width, depth, shape, and muck pile slope of the mega cave. The data was delivered to the geotech engineers for further analysis and integration into their systems and models.

In total, from arrival at the site, it took less than 20 minutes to acquire an initial low-resolution scan and less than an hour to obtain the high-resolution 3D model and size of the mega cave.



The deliverables

The mission proved a great success, providing Carrapateena with all the data they required to better understand and monitor the mega cave, including:

- An accurate and complete 3D point cloud of the mega cave
- An initial report with screenshots of the cave and its dimensions
- GoPro video and images of the cave

Additionally, a simple *Scan The Mega Cave* procedure was established for the mine crew to follow in order to perform monthly scans and monitor the cave ongoing.

Key findings

- The Carrapateena mega cave was larger than anticipated, with a maximum width of approximately 187 meters and a depth of 255 meters.
- The cave's opening had a diameter of about 63 meters, extending approximately 40 meters down before widening.
- Two long wires, each approximately 6 meters long, were found hanging at the edge of the opening which were likely old pipes or wires from the surface. These posed a risk of oscillation and potential collision with the drone during future missions.
- A subsequent scan showed that the size of the cave breakthrough opening relative to the size of the top of the muckpile had significantly increased in size, greatly reducing the airblast risk.

Summary

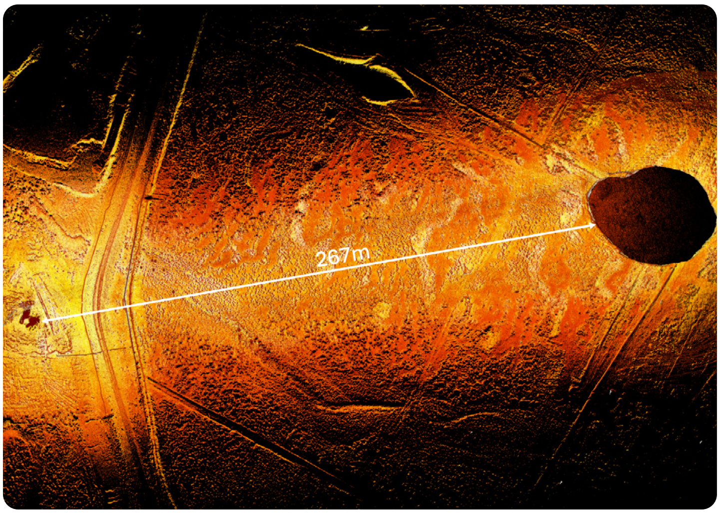
This project demonstrates the potential and utility of autonomous systems for performing dangerous and repetitive tasks, significantly impacting the mining industry. In this instance, the data provided by Hovermap ensured the continuity of underground production, preventing potential production losses amounting to tens of millions of dollars. Furthermore, the data was captured safely, without risking personnel, and ongoing monitoring will detect anomalies early, ensuring the safety of both underground personnel and operations.

The mission highlights Hovermap's unique ability to capture critical data in inaccessible and challenging areas, which would otherwise be impossible to scan. Hovermap's key capabilities — SLAM LiDAR mapping and autonomous flight in GPS-denied environments — were crucial to success.

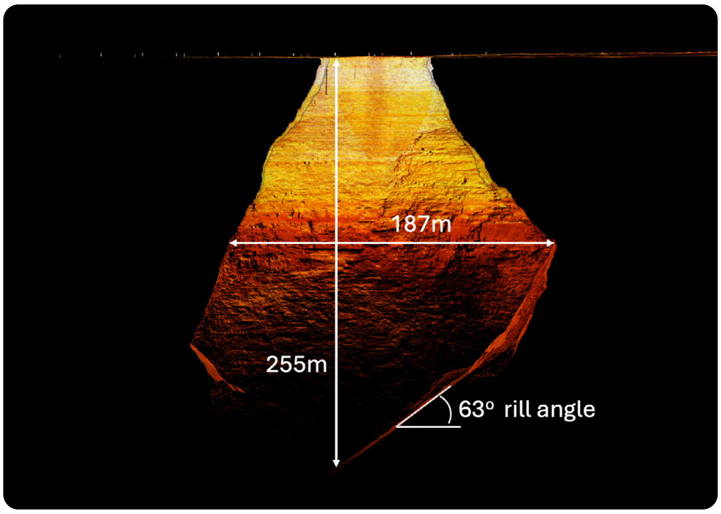
Watch the video >

> "The ability to regularly survey the Carrapateena mega cave marks an important de-risking event for ongoing operations and enables mine planning to be safely optimized for production. It is testament to the advanced autonomous capabilities of Hovermap that we were able to capture critical data for decision making that otherwise would simply not have been possible."

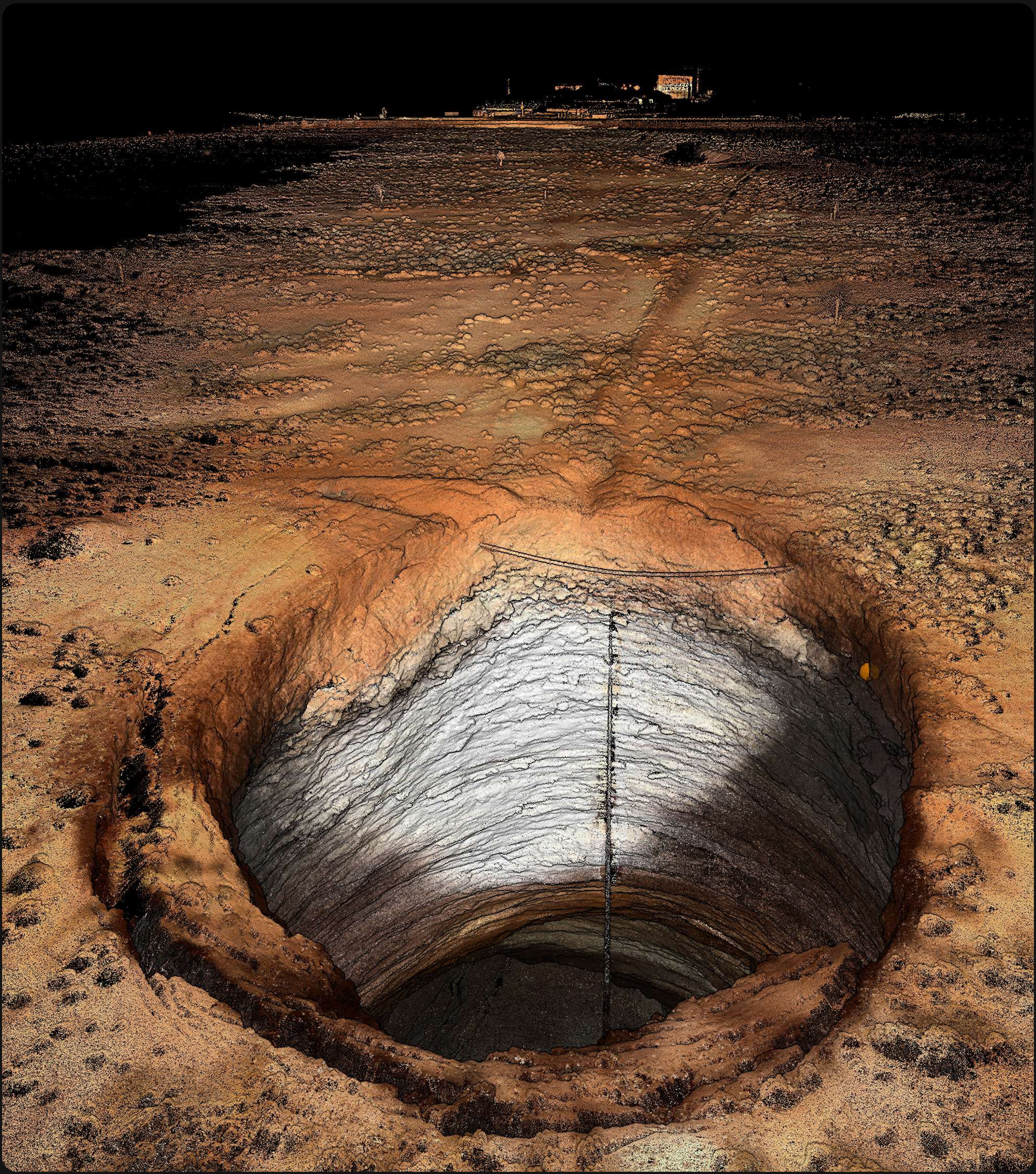
— Richard Cheung, Digital Robotics & Automation Architect, BHP



TOP-DOWN VIEW OF THE MEGA CAVE POINT CLOUD, HIGHLIGHTING THE DRONE LAUNCH LOCATION AND THE CAVE'S OPENING.



CROSS-SECTION OF THE MEGA CAVE POINT CLOUD, SHOWCASING ITS DEPTH, WIDTH, AND THE SLOPE OF THE MUCK PILE



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About Emesent

Emesent is a world leader in robot autonomy, LiDAR mapping, and data analytics, founded after a decade of cutting-edge research at the Robotics and Autonomous Systems arm of the Commonwealth Scientific and Industrial Research Organisation (CSIRO). As well as being well established in a number of industry sectors, we collaborate with customers and partners to explore new possibilities and innovate novel proof of concepts.

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