UAV aerial photography is increasingly used in mines because it captures information without putting someone in harm's way.

**Neville Judd, Hexagon Mining, Canada, and Benjamin Federmann, Hexagon Mining, Germany,**
demonstrate the advantages of deploying drones in mine surveying.

# AN AERIAL ADVANTAGE

Imagine a mine where every day, planning software automatically tasks a fleet of drones – completely autonomously – to collect high-resolution coordinate scans, imagery and other remote sensing of the entire mine. Data from highwalls, stockpiles, waste dumps, tailings dams, blasting and plants is collected by the same software and converted into information for quicker, smarter decision-making.

This scenario describes a future that will soon be reality. Drones, otherwise known as unmanned aerial vehicle systems (UAV or UAS), are already having a profound effect on mining. The regulatory process is catching up with the technology, and by 2022, the international drone market is expected to be worth US$21.23 billion,[1] growing at a rate of about 20% annually.

There have long been many places in a mine where foot traffic is not allowed or is ill-advised: near the crests and toes of highwalls, under operating machinery, on stockpiles and muck piles, near blasts, etc. Under these circumstances, obtaining measurements with a surveying rod, total station or GNSS is problematic. UAV photography and remote sensing allow us to capture all that information without putting someone in harm's way. However, people, utilities, equipment and public airspace must be protected from UAVs, with the tradeoff being strict safety regulations and pilot training. That tradeoff and the amount of data that can be acquired through UAV technology make it more than justifiable and more than worthwhile.

Hexagon Mining is one of the companies making progress in the application of UAVs in mining. Better blast optimisation, improved safety, faster surveying, and construction of the most comprehensive and continuous project datasets are just some of the advantages of this technology.

## UAV development

Aerial photogrammetry has been around for as long as the airplane. For mining though, a manned aircraft was too expensive and too inconvenient for regular airborne photogrammetry. Unmanned aircraft systems (UAS) are a natural fit for mining and the advent of the lithium polymer battery has transformed the development of airborne photogrammetry.

Electric motors now safely discharge at a very high rate to be able to carry a small aircraft with a payload such as a camera. This technology facilitates the capture of data in near real time from areas that would otherwise be inaccessible or unsafe for staff. Whether it is for blast fragmentation, stockpile volumes or any other mine-related activity, data can be captured quickly and safely.

## Surveying capabilities

Leica Geosystems' subsidiary, Aibotix, is at the forefront of pushing photogrammetry's boundaries with its core product, the Aibot X6. The Aibot X6 is an autonomously flying hexacopter, specifically designed for demanding tasks in surveying, mining and industrial inspection. Equipped with a high level of artificial intelligence, this UAV reaches almost any target and can independently create high-resolution images and videos. It offers the possibility to adapt varying kinds of sensors, such as hyper-spectral and multi-spectral sensors, infrared and thermal sensors and sensors for other industry-specific missions.

Surveying of the future is dynamic and flexible. Data captured by the commercial UAV and the software solutions of Aibotix and Hexagon allow mines to generate orthophotos, 3D models and high-density point clouds with great accuracy. The flight planning software Aibotix AiProFlight makes it simple to obtain all the parameters essential for proficient photogrammetry. The drone's ability to hover and take photos at any angle makes it ideally suited to stockpile and muck-pile monitoring and analysis, plus rock mass characterisation, and plant, equipment and highwall inspections.

For larger-scale aerial surveys, Leica recently added the long-range capabilities of the RF-70 fixed wing UAV. It can fly up to one hour at higher speeds, allowing it to survey one square mile (640 acres) per flight. This UAV is more than capable of surveying the entire pit, tailings impoundments, waste dumps and leach pads.

With all the flight planning and data capture features of the drone, the newer RF-70 UAV provides mines with the tools they need to quickly and easily map their entire mine. The addition of terrestrial laser scanners completes the surveying picture, inside and out. The digital mine of the future will need all of these remote surveying sensors along with automated control and processing software to create complete digital project models.

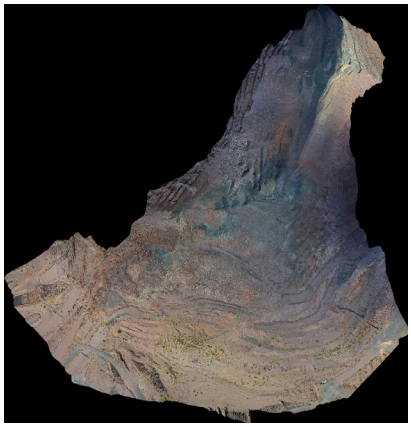
## Mine planning software

Hexagon's mine planning software, MineSight, is well equipped to handle point clouds. Its point-cloud data type features a high level of detail rendering

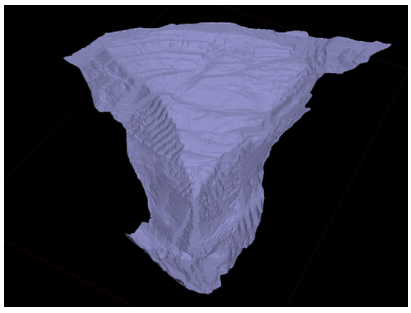
Autonomously flying hexacopters, such as the Aibot X6, are pushing the boundaries of photogrammetry.[2]

The Aibot X6 is specifically designed for demanding tasks in surveying, mining and industrial inspection.

capability, akin to a gaming rendering. The software is capable of displaying billions of points at a time, averaging out points in the pixels with level detail rendering, saving computer memory, while displaying high-resolution images. MineSight's Point Cloud Mesher turns large data sets into topographic surfaces, tunnels, drifts and stopes, and any other solids and surfaces available from point clouds. It allows mines to quickly go from field capture to usable data for optimisation. The tool removes errors and noise from the data to ensure clean surfaces are available for downstream processes. The colour-point cloud can be displayed over the optimised surface to allow feature extraction and geologic interpretation.



Orthophoto generated by the Aibot X6.



3D mine model structure generated by the Aibot X6.

## Blasting and comminution

The crushing and grinding of ores accounts for a significant portion of the energy costs at any mine. Comminution is estimated to represent 2% of the world's electrical power consumption, according to the US Department of Energy. Consequently, blast fragmentation has an important downstream effect with implications for total comminution energy, as well as extraction, recovery and, ultimately, profit. Mills need efficient grinding for proper processing. Efficient crushing requires well-blasted material. Poor blast fragmentation of ore material can wipe millions of dollars from the value of a mine.

Aerial photogrammetry and point-cloud technology have an important role to play in improving blast optimisation. Open-face surveys can be used to detect areas of critical minimum burden that could cause dangerous flyrock. Analysis of the face geology can be used for rock mass characterisation, including initial block size distributions. Videos taken by UAVs from a safe, eagle-eye perspective are fast becoming popular to evaluate the success of blasts. After blasting, UAV data can reveal blast material movement, delineations between ore and waste, and allow fragmentation analysis. All of this allows mines to quickly learn more about their geology and their blasting performance, driving the site toward better knowledge of its material and better blasting practices.

## Geology and geotech

From a geological and a geotechnical perspective, there are numerous opportunities to extract mineralogical and lithological data, as well as structural and geomorphological data, shapes, etc. There are also numerous possibilities for automation to be introduced to the UAV point-cloud loop. More interpretation, more usable data for analysis for future designs, and reconciliation are among those possibilities. One post-blast scenario could be having the program automatically delineate a polygon for ore location, waste location or at least best-guess based on the imagery. Hyper-spectral imagery could also be undertaken where spectral signatures are established for different rock types that have been previously coded.

UAVs remove the risk from collecting data in areas such as highwalls, stockpiles, waste dumps and tailings dams.

## UAVs and surveying in the field

UAVs are making a significant difference to the speed and safety of surveying, particularly in areas with hazardous terrain.

Landslides and earthquakes are common near the Porgera Valley gold mine, located 2200 – 2700 m above sea level in the highlands of Papua New Guinea. So when Australian company, Benchmark Survey & Design, was contracted to map spill grounds around the secluded mine, the Northern Queensland firm, specialising in topographic site surveys, knew it needed to find a new method of surveying. The Porgera mine survey

team assigned the company to capture data so it could environmentally monitor the dump sites of the spill generated by the mine. With only five days available to map and with accuracy a priority, it was decided a survey by air would be the safest and quickest survey method. The company turned to Spatial Technologies, an Australian firm with more than 20 years of experience in GIS, to provide a UAV pilot.

Spatial Technologies has been using the Aibotix Aibot X6 UAV to collect data in various environments for more than two years. It had two sites to capture around the mine, Anjolek at 380 ha. and Anawe at 250 ha. Pilot, Anton van Wyk, faced several challenges in planning his route. Much of the terrain is only accessible by helicopter, which was available for just one out of the five days. Fog in the mornings and rain in the afternoon were added complications, leaving only a few hours each day to survey.

Van Wyk's plan hinged upon the durability and dependability of the UAV.

"The Aibot X6 provided better results than the Porgera mine survey team expected, even in such rough terrain," said Wayne Storey from Benchmark Survey & Design. "Though the mine survey team had someone prior fly this mission, the team didn't receive the expert mapping and processing of the data the Aibot X6 delivered with its more advanced sensors."

With 32 total flights at about 10 min. each, Spatial Technologies collected 9100 orthophotos at a 5 cm ground sampling distance. While Benchmark Survey & Design only need sub-metre accuracy for the project, Spatial Technologies was actually able to supply 10 – 20 cm accuracy with strategically placed controls in conjunction with the RTK on the Aibot X6. The entire project was processed in about 96 hours to provide visual documentation of volume changes in the spill grounds.

Combing the orthophotos from the Aibot X6 with older data and point clouds of the site created by laser scanning technology, engineers and environmentalists on the project were able to go beyond just volume calculations. Together with the many forms of data collected, they can now see visible proof of vegetation changes and conduct slope analyses.

As the dangerous terrain evokes risky conditions for surveyors, measurements were previously being taken few and far between. With the safer and quicker UAV survey, the mine survey team can now monitor more regularly to manage issues sooner and rectify problems before they become major concerns.

"Aerial surveys with the Aibot X6 can not only be done quicker than traditional methods, but with the advanced sensors it can carry, we can gain the same, if not better, accuracy, as well," said van Wyk. "Since surveyors don't have to enter risky areas to set up instruments, the UAV also makes our jobs safer."

## The future

In the future, UAVs will be able to fly longer, farther and carry heavier and different types of sensors. A fleet of aircraft – multi-rotor, fixed-wing, or more likely a combination of the two – will be autonomously dispatched each day from mine planning software to collect necessary data before landing and downloading that data onto the cloud and into the office for extraction, analysis, rapid decision-making and optimisation. WC

## References


1. UAV Drones Market-Global Forecast to 2022, ADS Reports, (October, 2016).
2. Images courtesy of © Aibotix GmbH.