AUTOMATED DRONE APPLICATIONS IN MINING
AN AIROBOTICS CONCEPT PAPER
User selects a pre-planned, scheduled or on-demand mission, designed to scan areas throughout the site.

Data collected from the Optimus drone is processed into final digital elevation models and other file types.

Drone harvests data along flight paths.

User receives analyzed data that supports critical operations.
In recent years the mining industry has been confronted with the challenge of low commodity prices, forcing companies to look for new ways to increase efficiency, improve safety and streamline operations. Companies cannot afford poorly planned haul roads that cause vehicle damage and malfunctions, nor ore misclassification that leads to sub-optimal blending. In order to rectify these issues, frequent oversight and maximizing the use of data is imperative. Many mining companies are investing immense resources in technological solutions that provide greater data collection and analysis. This data has enabled companies to monitor what is happening on-site and generate insights that can improve results, cut costs and advance capital flexibility for growth opportunities.

UAVs are becoming an integral tool in this data collection cycle, gathering essential information and replacing hazardous manual and ground-based inspections, while drastically reducing the time and manpower required to do so. The benefits of this data collection are numerous and range from enabling early detection of damage and incidents to allowing experts to spend more of their valuable time analyzing rather than collecting data. These benefits translate to cost savings both directly (e.g. reduced conventional surveying costs) and indirectly (e.g. less damage costs from quicker detection of a fire). Read more about these benefits at the end of this paper.

However, different drone ownership models have varying advantages and disadvantages. Contracted, piloted drone service models do not allow for a permanent presence, which is necessary in order to have frequent data collection that can lead to actionable insights. In-house drone programs require dedicated operators that are extremely costly, may still have delays in response time, and ultimately do not enable the consistency and speed of a fully-automated system. Additionally, with drone technology constantly improving, ownership of the asset in-house can often be a liability.

A fully-automated UAV system streamlines operations and offers immediate access to aerial data without the need to load and transport the drone or depend on a service provider. Management of drone flight and capture is complex, and what is actually desired is insights. With a fully automated and self-operated drone platform, mining companies can receive the data they require for various functions across the mine, without the operational complexity and overhead.

To reconcile the amounts of ore, waste, and overburden generated by mining operations, sites utilize surveying technologies which yield 3D models profiling each stockpile. Ground-based surveying methods, including GPS, total stations, and laser scanners, have been the industry standard for generating digital 3D stockpile models, the cornerstone of stockpile management. These methods, however, are slow and often require surveyors to scale hazardous slopes to collect data. Drones - using photogrammetry or LiDAR - are significantly more accurate, efficient, and prevent endangerment of personnel. The updated 3D surface models provide recurring snapshots of changes in the life of the stockpile. For mine operators, this data plugs directly into any mining or GIS software suite for further analysis and evaluation.

**STOCKPILE MANAGEMENT WITH AUTOMATED DRONES:**

- **Blending**
  Assist in the calculation of blended piles by tracking quantity of ore grades mixed.

- **Accounting & reconciliation**
  Reconcile accurate stockpile volume for productivity benchmarking and financial reporting.

- **Archive layered stockpiles**
  Define placement and profile of historical stockpile grades and archive ore grades across the life of the stockpile to reduce misclassification.

- **Inform processing design**
  Accurately model each stockpile for improved feeding of the material for processing and mineral extraction. Ensure greater confidence of material attributes when processing the stockpiles.
The amount of information known about a mining site is inversely related to the risk of unforeseen events. Thus, with better quality and more up-to-date geotechnical data, productivity and safety can be increased, all the way from the exploration phase to mine rehabilitation.

GEOTECHNICAL MODELING WITH AUTOMATED DRONES:

Pit monitoring
Use precise information about grade, area, lines, and volume through 3D terrain models to monitor infrastructure such as haul roads, ramps, and benches.

Slope management
Use more detailed geotechnical data to improve slope stability, which can result in greater safety and savings from reduced slope failures.

Haul road optimization
Assist in optimal road design, planning, construction, and improvement.

Industrial inspections involve the use of ladders, ropes and rigs to scale infrastructure. In addition to being risky for inspectors, the process requires machinery to be shut down, resulting in significant financial implications. Drones offer inspectors a way to view difficult-to-access areas - both as part of routine patrols and impromptu - giving them a safer, more cost-efficient way of gaining greater insight into critical processes. Sensors can range from cameras for visual inspection to thermal, IR, and laser spectrometers for leak detection.

EQUIPMENT INSPECTION WITH AUTOMATED DRONES:

- **Pipes, lines & conveyor belt systems**: Identify damage and needed repairs across long distances of pipelines (e.g. slurry, mud, water) or conveyor systems.
- **Stability**: Drones can ensure ground and materials holding up elevated pipelines are stable and not at risk of collapse.
- **Cracking & leak detection**: Thermal / Visual IR sensors on a drone can be used to detect voids in pipe walls to catch problems before they occur.
- **Processing infrastructure**: Inspect comminution and processing facilities for corrosion, infrastructural integrity and overheating of equipment without shutting down operations or putting people in dangerous situations.
Drilling, blasting, and extraction of ore, waste, and overburden can account for 30 – 40% of operational costs at an open pit mine. For ore processing, blasting is the initial and most cost-effective opportunity for comminution – also known as rock fragmentation – in many mining processes. In addition, the blasting process is directly involved in segmenting high-grade ore, sent for further processing, from waste, which is redirected to waste stockpiles.

BENCHMARKING AND IMPROVING THE BLAST PROCESS:

- **Manage blast performance, volumes, swell factor & more**
  - Receive the pre and post-blast digital elevation model (DEM) of an area that digitally defines the bench and muck pile profiles, yielding data to utilize for drill planning and improvement. Additionally, view blast in slow motion to see detailed blast behavior.

- **Blast exclusion clearance & shotfirer inspection**
  - Efficiently clear the exclusion zone to ensure all personnel and equipment are a safe distance from the explosion, and conduct an aerial shotfirer inspection to make sure it is safe to return.

- **Rock fragmentation analysis**
  - Receive near real-time measurement of particle size distribution of muck piles, benchmarking blast performance and informing downstream comminution processes of particle size profile.

In addition to monitoring the structural integrity of haul roads, the process of transporting material from the blast area presents many opportunities for improvement in surface mining operations. Each stage of the process, from loading to transit through haul road networks, has deep implications on operational expense and efficiency.

HAULING OPTIMIZATION WITH AUTOMATED DRONES:

- **Optimize fleets**
  - Provide current 3D models to engineers and planners which can be used to improve fleet fuel consumption. Use damage and traffic flow data to inform most optimal maintenance scheduling.

- **Damage identification**
  - Identify road damage features using images, video, or surface models to prevent future incidents and eliminate the need of personnel to physically enter the haul road network.

- **Emergency oversight**
  - View streaming footage of incidents, including tire overheating and unresponsive driver, to support decision making.

- **Minimize personnel in dangerous areas**
  - Reduce risk of injury by using aerial data instead of manned-inspection for incident response.
Project oversight is an important task across various operations and throughout the lifecycle of a mine. Aerial data enables a project owner to remotely monitor and manage in real-time the progress of an operation as well as identify cause of damage and produce reports.

PROJECT OVERSIGHT WITH AUTOMATED DRONES:

**Business information management**
Ensure work is progressing to plan, and quickly modify plans, budgeting, or contractor management if necessary.

**Reporting**
Demonstrate compliance through reliable, visual data.

**Insurance, claims & verification**
Easily determine causes of damage, location of objects (e.g. pipes, cables) or what actions took place by using images from the various stages of the process.

TAILINGS DAMS

Tailings dams and deposits are difficult to manage because they often contain toxic materials and are in a semi-solid phase. Aerial data can help ensure the strength of these dams and reduce risk of dam failure, which can be disastrous from a human life, cost and environmental perspective.

TAILINGS DAMS WITH AUTOMATED DRONES:

- **Slope & gradient**
  Frequent, general oversight of slope and gradient can assist with analyzing the dam’s shape.

- **Tailings moisture level**
  Identify surface cracking from evaporation to calculate tailings moisture and potential impact on dam wall.

- **Identify erosion**
  Locate beginnings of erosion in external tailings dam wall.
Airobotics has developed a pilotless drone solution, the first of its kind in the global market. Airobotics provides an end-to-end, fully automatic solution for collecting aerial data and gaining invaluable insights. The industrial grade platform is available on-site and on-demand, enabling industrial facilities to access premium aerial data in a faster, safer, more efficient way.

Airobotics is headquartered in Israel and was founded by Ran Krauss and Meir Kliner in 2014. The team at Airobotics fuses expertise in aerospace hardware design, robust electronic systems, leading software engineering, and years of experience in commercial drone operations.

Airobotics is the first company in the world certified to perform fully automated commercial drone flights without a human pilot. In April 2017, Airobotics was awarded an Edison Award for its automated industrial drone system.

Industrial operations face constant safety and security threats, which require real-time response solutions that provide rapid, precise and reliable situational awareness. Drones offer security officers and emergency responders a professional tool for collecting unlimited aerial data and providing live visibility into security threats and emergency situations.

**SECURITY & EMERGENCY RESPONSE WITH AUTOMATED DRONES:**

- **Bushfire detection**: Aerially locate bushfires across a vast area, before they are able to spread and cause significant damage.
- **Security**: Monitor perimeter security with predefined, scheduled patrols, deter detected intruders, track a potential threat's movements, and analyze data in real-time all while removing personnel from dangerous situations.
- **Search & rescue operations**: Determine the location of missing or injured personnel on-demand, faster and more effectively.
- **Community relations**: Alert local communities to incidents faster and ensure areas are adequately cleared before and during potentially harmful fires, leaks or spills.
- **Incident identification**: Detect incidents such as spontaneous combustion in stockpiles through the analysis of aerial thermal data.
- **Reporting**: Verify details of incidents by collecting visual data, which can easily be used for claims, etc.

**BATTERY & PAYLOAD MODULES**

- Carries a 1kg mission-specific payload, swappable design for multi-functionality

**CERTIFICATIONS**

- ISO 9001:2015 certified, authorized by CASA, FAA & CAAI, member of AUVSI & Austmine

**SAFETY**

- Geofencing, emergency parachute, ‘return home’, GPS redundancy, strobe light & siren deterrence

**STORAGE**

- Airbase holds up to 5 payloads and 10 rechargeable batteries

**DURABLE, INDUSTRIAL DESIGN**

- Mine-spec, rugged-exterior Airbase and large, carbon fiber drone that flies for 30 minutes

**FULL AUTOMATION**

- Automatic launch to land using commercial-grade autopilot and controllers

**ELEME$$T$$-RESISTANT**

- Sustains winds up to 20 knots, water and dust ingress protection IP43, operating temperature 0-50°C

**ROBOTIC**

- Robotic swapping of payloads and batteries enables multi-purpose applications
Reduce the time surveyors and other personnel spend manually inspecting mud lines, pipelines, stockpiles, tailings dams, pits and blast areas.

Minimize the hours spent on potentially dangerous manned ground security.

Curtail the cost of purchasing, installing and maintaining equipment such as drones, cameras, sensors, and CCTVs.

Under a service model, reduce legal and administrative costs of training pilots, maintaining licenses, and obtaining regional aviation certifications and UAV insurance.

Minimize the risk and enormous cost of infrastructural failure of pits, roads and tailings dams through better planning and more frequent risk based inspections.

Decrease ore misclassification errors, including errors occurring during the process of blending.

Reduce the risk of human error in manual flight of UAVs, which can result in data inaccuracies and physical harm.

Alert the community of potentially harmful incidents early on.

Minimize the endangerment of personnel and greatly reduce the risk of injury or death.

Minimize the use of excess blast material by improving the placement of drill-holes as well as the overall blasting process.

Reduce fuel cost by replacing ground-based vehicle inspections with aerial inspections.

Reduce time spent locating equipment, producing reports, verifying progress, and managing contractors.

By tracking progress, adjust budget as necessary and avoid costs of improper planning.

Maintain bookkeeping accuracy and update asset quantities on balance sheet using stockpile aerial measurement data.

Detect fire, combustion, leaks, spills, and other incidents early to minimize the extent of damage and cost of clean up.

Detect issues such as cracks, corrosion, and overheating early to inform predictive maintenance, rather than incurring the cost of full replacement and expensive failures.

Free up time of costly experts to analyze data rather than collect it.

Minimize environmental damage, potential fines and/or brand reputation impairment.

Minimize equipment use & damage

Reduce the risk of digging and hauling equipment being damaged by potholes and other road impairments that could have been identified and fixed.

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