

An aerial photograph of a large-scale mining operation. A massive conveyor system, supported by a complex metal lattice structure, extends across a wide, excavated area of earth. At the end of the conveyor is a large, white industrial processing plant with various structures and equipment on top. The surrounding terrain is dark and appears to be a deep pit or a large-scale excavation site. The sky is a deep blue, and the overall scene is one of intense industrial activity.

**dji** ENTERPRISE

# IMPLEMENTING AN AUTOMATED MINING WORKFLOW USING DJI DOCK

How to guide for successfully integrating  
the DJI Dock into your mining operations.

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## EXECUTIVE SUMMARY

This white paper outlines the process of implementing an automated mining workflow by leveraging the DJI Dock and flight control software (DJI Flighthub 2).

This paper will first introduce the key features of the DJI Dock, before diving into why utilising drones and a Docked drone enhanced mining. In section 3, the setup process of the Dock operations is described. Section 4 then goes into the automated processing workflow and finally, section 5 reviews the commercial applications, with two case studies being presented.

Mining in Australia is big business, with mining sites scattered all over Australia, with the majority of inland mines being situated in Western Australia. Being quite remote, travel times and staffing of drone pilots can pose problems. See figure 1 below for the layout of operational mines in Australia in 2024. Globally, mining hasn't slowed down, and is still growing, recording revenues in excess of US\$3 trillion in 2023.

Key objectives include reducing manual drone operation, increasing inspection frequency, and enabling rapid decision-making and wider distribution of data through real-time visual data sharing and automated reporting. The workflow combines remote mission planning, automatic and scheduled drone deployment, instant data syncing, cloud based project management and automated processing to monitor and review milestones.

The integration of DJI's Dock system with automated drones and existing photogrammetry software offers mining operations a streamlined approach to data capture and reporting. This synergy enables rapid decision-making through automated reporting, enhancing operational efficiency and safety, even in challenging environments and with minimal human intervention.

By implementing an automated mining workflow using the DJI Dock, mining operations can achieve a great increase in productivity when compared to traditional drones, further enhancing drone operations within mining operations.

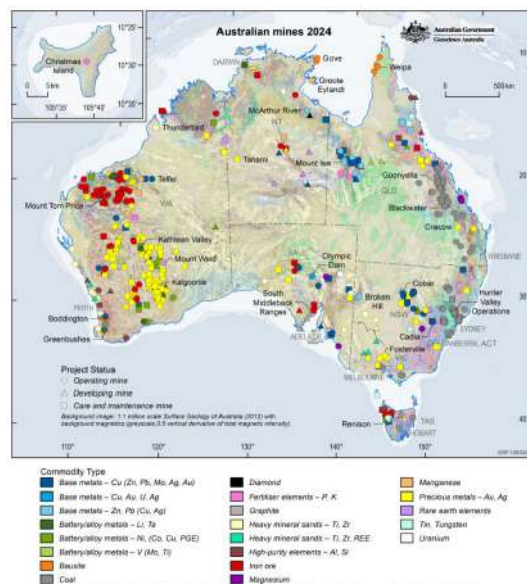


Figure1: Map of mines in Australia in 2024  
(Source: [Geoscience Australia](https://www.geoscience.gov.au/)).

# 1.0 INTRODUCTION TO THE DJI DOCK



DJI has developed the DJI Dock to revolutionize automatic drone operations. This innovative solution is designed to enhance efficiency, reduce operational costs, and expand the use of drones across industries such as mining, infrastructure inspection, agriculture, and public safety.



Figure2: DJI Dock3

The DJI Dock serves as a fully automated deployment and charging station, allowing drones to operate independently without human intervention. This ensures frequent data capture, seamless integration with intelligence-driven analytics and uninterrupted workflow automation.

### EVOLUTION OF DJI DOCK: FROM DOCK 1 TO DOCK 3

#### DJI Dock 1

Introduced as DJI's first-generation Drone-in-a-box solution, Dock 1 was designed to support the M30 series, enabling remote deployment and automated operations.

It laid the groundwork for BVLOS (Beyond Visual Line of Sight) missions, allowing drones to launch, perform tasks, and return automatically.

However, its size, weight, and infrastructure requirements made deployment more challenging. Limiting its adoption for industries needing high mobility.

#### DJI Dock 2

The DJI Dock 2 addressed key limitations of the first-generation system by introducing a more compact, lightweight, and mobile-friendly design.

Designed to work with M3D (Mavic 3 Enterprise Dock version), it offered improved weather resistance, easier setup, and faster deployment.

With enhanced integration into cloud-based management platforms, the Dock 2 was a significant step toward large-scale remote drone operations.

### **DJI Dock 3**

The most advanced version to date, the DJI Dock 3 was built to support the M4D (Matrice 4 Dock version), a next-generation industrial drone optimized for fully automatic operations.

It brings significant improvements in battery life, payload capacity, and intelligence-powered data analysis, allowing users to automate more complex and longer-duration missions.

The DJI Dock 3 is positioned as a scalable solution for industries such as mining, energy, telecommunications, agriculture, and public safety, where high-frequency drone operations are required without the need for an on-site pilot.

## **1.1 WHY DJI BUILT THE DOCK**

Drones have become an essential tool in the mining industry, providing efficient, cost-effective, and safer methods for data collection, monitoring, and site management. When combined with Onboard Intelligence, drones offer even greater capabilities, such as real-time analysis, predictive maintenance, and automation of critical processes. The DJI Dock was created to address the limitations of traditional drone operations, enabling businesses and organizations to automate drone missions with minimal human intervention.

The primary reasons for building the DJI Dock include:

### **1.1.1 Expand Drone Market Size**

By introducing an automated docking system, DJI aims to make drone operations more scalable and

accessible to industries that require continuous and reliable aerial data. Traditional drone operations often involve manual take-off, landing, and battery changes, limiting their efficiency in large-scale applications. The DJI Dock eliminates these constraints by enabling round-the-clock operations.

The integration of Onboard Intelligence in drones is transforming the mining industry by enhancing efficiency, safety, and data accuracy. They are used for site surveying, safety monitoring, environmental compliance, equipment inspection, and stockpile management. Intelligence-powered drones automate data collection and analysis, enabling predictive maintenance, real-time hazard detection, and automatic operations. These technologies help mining companies optimize resources, reduce operational costs, and minimize human exposure to hazardous environments. Additionally, intelligence-powered drone can improve environmental monitoring by tracking air quality, water contamination, and land reclamation. By streamlining workflows and providing real-time insights, intelligence-powered drones are revolutionizing modern mining operations, making them more efficient, cost-effective, and sustainable.

### **1.1.1 Frequent Data Capture**

Industries such as mining, construction, and agriculture rely on consistent, real-time data for decision-making. The DJI Dock supports scheduled and on-demand drone deployments, ensuring that data is captured frequently and consistently. This is especially beneficial for applications like stockpile measurements, site monitoring, and equipment inspections, where real-time data is crucial for optimizing productivity throughout the entire project.

## 1.2 WHERE DOES THE DOCK FIT IN THE CURRENT PRODUCT LINE-UP?

### 1.2.1 Comparison with M400/350 RTK

The DJI Dock is positioned as a highly specialized addition to DJI's enterprise product lineup. While models like the M400 and M350 RTK are widely used for professional operations, they still require human intervention for battery swaps and mission planning. The DJI Dock is designed for full autonomy, making it a game-changer for industries that demand continuous aerial monitoring.



Figure3: DJI Matrice 350 with H30 series gimbal

Feature	DJI Dock	M400 RTK / M350 RTK
Autonomy	Fully automatic, no human intervention	Requires manual operation for takeoff, landing, and battery changes
Deployment	Fixed location, optimized for long-term monitoring	Can be deployed anywhere but needs a pilot
Use Case	Continuous, scheduled & on demand missions	On-demand missions requiring manual control
Charging	Automatic charging in the dock	Requires manual battery swap
Industries	Mining, construction, infrastructure, agriculture, search and rescue, law enforcement	Inspection, surveying, search & rescue, law enforcement

Table 1: Table comparing the features of the DJI Dock solution against standalone/traditional drones

The DJI Dock does not replace the M400/M350 RTK, but complements it. Organizations that require both manual flexibility and automated operations can deploy a combination of both solutions for maximum efficiency.

### 1.2.2 Comparison with M3E/T and M4E/T

Compared to the M3E/T and M4E/T, the Dock series can be seen as the automated versions of these aircraft. The Dock 2 and Dock 3 aircraft are named M3D/TD and M4D/TD. The “D” stands for Dock in these cases. Compared to the normal versions of M3 and M4, the Dock version of the aircraft has a redesigned body structure and a strong IP rating, which can meet all-weather operations.



Figure4: DJI Matrice 4

Feature	DJI Dock	Mavic 3 Enterprise Series and Matrice 4 Series
Autonomy	Fully automatic, no human intervention	Requires manual operation for takeoff, landing, and battery changes
Deployment	Fixed location, optimized for long-term monitoring	Can be deployed anywhere but needs a pilot
IP Rating	IP54 to IP56	No IP rating
Payload	Same	Same
Use case	Scenarios that require automation	Scenarios that do not require automated operation and focus on portability

Table 2: Table comparing the features of the DJI Dock against the traditional drone equivalent, the Mavic 3 and Matrice 4 series. For those that still prefer the flexibility of standalone drone deployment, the Matrice 4D and Matrice 4TD are both operable without the Dock. Allowing for IP55 operations whilst still having the convenience of a standalone drone.

## 1.3 DRONE OPTIONS

### 1.3.1 Survey Drone (M3D, M4D)



Figure5: DJI Matrice 4D

The **M3D** and **M4D** models offer superior stability, extended flight durations, and seamless integration with DJI's mapping software, making them ideal for professional mining surveys.

#### Key Features:

- **High-Resolution Imaging:** Equipped with advanced cameras, survey drones capture detailed aerial images for precise mine mapping and planning.
- **Mechanical Shutter:** Eliminates the rolling shutter effect, ensuring accurate image capture for volumetric measurements.
- **RTK (Real-Time Kinematics) Compatibility:** Enhances positioning accuracy down to 1cm for precise pit and stockpile measurements.
- **Automated Flight Paths:** Pre-programmed flight routes allow for efficient, repeatable survey operations with minimal manual input.

#### Applications:

- **Mine Site Mapping:** Enables accurate 3D modeling of mining sites for planning and operational efficiency.
- **Stockpile Volume Calculation:** Provides precise measurements of extracted material to improve inventory management.
- **Drill & Blast Planning:** Assists in mapping terrain and calculating the most efficient drilling patterns.
- **Environmental Impact Assessment:** Supports monitoring of land use, vegetation loss, and compliance with environmental regulations.

### 1.3.2 Thermal Drone (M30TD, M3TD, M4TD)



Figure6: DJI Matrice 4TD

The **M30TD**, **M3TD**, and **M4TD** drones offer advanced thermal imaging capabilities, allowing mining companies to improve operational safety and efficiency.

#### Key Features:

- **Thermal & Visual Sensors:** Equipped with dual-camera systems to provide both visible and infrared imaging for detecting heat anomalies.
- **Real-Time Heat Detection:** Enables operators to identify overheating equipment or spontaneous combustion risks in stockpiles.
- **Intelligence-Assisted Object Recognition:** Enhances monitoring of critical assets such as conveyors, machinery, and storage areas.
- **Weather Resistance:** Built to operate in challenging environments, including dust, high winds, and extreme temperatures.

#### Applications:

- **Equipment Inspection & Maintenance:** Detects overheating in machinery, conveyors, and electrical systems to prevent costly failures.
- **Underground & Open-Pit Monitoring:** Assists in identifying ground subsidence, rockfall risks, and unstable slopes.
- **Worker Safety & Hazard Detection:** Enhances safety protocols by identifying hot zones, gas leaks, and hazardous areas in real time.
- **Tailings & Waste Management:** Monitors tailings dams and waste storage areas to detect leaks or structural weaknesses.

# 2.0 AUTOMATION IN MINING



## 2.1 GROWING TREND OF AUTOMATION AND AUTONOMOUS SYSTEMS IN MINING

Globally, mining is a massive and growing industry, recording revenues in excess of US\$3 trillion in 2023.

### 2.1.1 Market Growth and Adoption

The global mining automation market has been experiencing substantial growth. Valued at approximately USD 4.90 billion in 2022, it is projected to expand at a compound annual growth rate (CAGR) of 7.3% from 2023 to 2030. This growth is driven by the rapid advancement in technologies such as On-board Intelligence and robotics, leading to increased adoption of automation solutions to boost production efficiency and

### 2.1.2 Technological Advancements

Automation technologies are revolutionising mining operations, leading to greater efficiency, safety, and sustainability. The integration of Onboard Intelligence Internet of Things (IoT), and robotics has enabled the development of automatic vehicles, drilling systems, and real-time data monitoring, transforming traditional mining practices.

### 2.1.3 Case Studies of Automation Implementation

#### **Rio Tinto's Mine of the Future Initiative:**

Since 2008, Rio Tinto has been operating automatic mining equipment in Australia's Pilbara region, managed remotely from a control centre in Perth. This initiative has improved productivity and fleet utilisation, with the automatic fleet hauling over 1 billion tonnes of ore and waste since 2008.

#### **Fortescue Metals Group:**

In a landmark deal, Fortescue partnered with Liebherr to convert two-thirds of its mining fleet to zero-emission battery technology, including 360 automatic electric trucks. This move underscores the industry's commitment to sustainable and automated operations.

## 2.2 WHY AUTOMATE DATA WITH DJI DOCK?

In a mining context where data drives decisions, the speed and reliability of data capture are paramount. Traditional drone workflows, while effective, are limited by human scheduling, weather windows, and site access constraints. DJI Dock offers a paradigm shift—automatic, pre-programmed drone flights that can operate daily, or even multiple times a day, without a pilot on-site. This consistency enables faster insights into operational areas such as ore movement, pit progression, equipment conformance, and environmental compliance. By automating these workflows, mining teams gain near real-time visibility into site conditions while reducing personnel exposure, minimising delays, and enabling better planning and reporting across departments.

### 2.2.1 Enhanced Efficiency and Cost Reduction

Automating data capture with the DJI Dock minimises manual data collection efforts, leading to increased operational efficiency and productivity.

The on-site DJI Dock hardware remains in a ready state at all times, enabling an off-site pilot to initiate a drone flight with minimal delay. By eliminating the need for an on-site pilot, significant time is saved by not needing to travel to & from the mission area, set up & pack up the drone, and avoiding the common operational delays that are experienced by an on-site pilot (such as delays associated with traffic or equipment interactions, blasting, etc).

While aviation regulations still require a pilot to remotely monitor operations performed with drone-in-a-box hardware (for the necessary pre-flight safety checks and radio communications with air traffic), minimal time is required beyond the actual drone flight time.

A conventional drone mission conducted by an on-site pilot may typically involve 10-30 minutes of flight time but occupy up to 1 hour of the pilots' time once travel and other common delays are factored in. The same mission performed remotely with the DJI Dock often takes less than half that time. In Australia, RocketDNA is performing up to 50 flight hours per month with a single DJI Dock

during daylight hours alone for its mining customers. This represents approximately 150-200 individual drone flights, with remote pilots performing up to 8 flight hours in a single shift.

Further efficiencies can be achieved by automating certain data workflows. All data captured by the DJI Dock is automatically uploaded to the cloud (either to a US-based DJI FlightHub2 server, or other designated server) as soon as the drone returns to the Dock at the end of a mission. Once uploaded, processes such as photogrammetry processing to generate digital surface models can be automated, which significantly reduces delays in data handling.

### 2.2.2 Indicative Time Comparison for Post-Blast Survey (Conventional drone versus DJI Dock)

Activity	Conventional VLOS Operation (on-site pilot)	DJI Dock Operation (Remote Operations Centre (ROC))
Prepare drone equipment	5 min	N/A
Travel to the mission area	15 min	N/A
Drone set-up & pre-flight checks	5 min	3 min
Perform drone flight	5 min	5 min
Drone pack-up	2 min	N/A
Return travel from the mission area	15 min	N/A
Copy captured imagery from drone SD card to local PC or server	5 min	25 min (includes data upload and automated photogrammetry processing)
Perform photogrammetry processing	20 min	
<b>Total Capture &amp; Processing Time</b>	<b>1.2 hrs</b>	<b>0.5 hrs</b>

Table 3: Comparison of the time required to capture and process a post-blast photogrammetry survey (based on actual data obtained from a RocketDNA Ltd customer in Western Australia)

With the increased operational efficiencies that remote operations with the DJI Dock provides, comes a significant overall reduction in the cost of capturing and processing drone data. This cost benefit is realised through:

- Reduced labour cost associated with the drone data capture & processing (by eliminating inefficiencies such as travel time & drone set-up/pack-up that is associated with conventional drone operations, and automating data workflows);
- A reduction in the drone hardware requirements for the site - one DJI Dock can typically capture significantly more data than a conventional drone;
- Reduced equipment maintenance & repair costs due to:
  - a permanently installed system that does not require frequent equipment set-up & pack-up (which can lead to manual handling damage or improper set-up)
  - a robust drone design with minimal moving parts and an IP55 rating
  - a reduction in the number of drones required on-site
  - take-off and landing from the Dock minimises the drones' exposure to dust and reduces the likelihood of landing damage.
  - Improved environmental and system monitoring is achieved through the DJI FlightHub 2 software.
  - a controlled, comfortable operating environment for the pilot in a remote operating centre significantly reduces pilot error.



Figure7: DJI Dock in a dusty environment

Aside from direct savings in drone data capture and processing, the ability to increase the frequency and timeliness of the data capture, processing & analysis enables further cost savings for the operation through:

#### **The early detection of non-conformances**

For example, open pit operations can automate daily capture, processing & analysis of aerial data for open pit conformance-to-design reporting, enabling early detection of mining non-conformance. This then allows actions to be taken to minimise long-term impacts such as ore loss, pit wall instability and inefficient haulage.

Similarly, the DJI Dock allows for frequent imagery & video capture of critical fixed plant assets at a mine for condition monitoring, allowing for maintenance or repairs to be performed prior to failures occurring. This saves significant costs that are often associated with failures. An example of this is automated condition monitoring of conveyor belt idlers. A global supplier of conveyor systems to the mining industry is already using Onboard Intelligence to analyse thermal imagery captured by the DJI Dock and identify idlers that are nearing end of life based on idler temperature. This minimises costly damage that may be caused by a failed idler (such as belt damage or fire) and labour cost associated with traditional inspection methods.

### **The ability for more roles to be performed off-site**

Many mining operations around the world are in remote regions, where the workforce operates on a fly-in-fly-out (FIFO) basis, resulting in significant costs associated with travel & accommodating the workforce at the site.

By implementing technology that allows traditionally site-based roles to be performed at least partially off site, there can be a significant reduction in FIFO costs. The introduction of the DJI Dock at some open pit mining operations has allowed for a reduction in the time that drill & blast engineers, geotechnical engineers and technical consultants are required to be on the mine site.

Automated pre- and post-blast photogrammetry surveys, on-demand panoramic imagery of drill patterns, and live & recorded video of blasts provide off-site drill & blast engineers with more up-to-date spatial and visual data than they have historically had access to even when working on site, allowing them to perform their design and analytical tasks remotely.

Geotechnical engineers and consultants based in capital cities or even internationally now have timely access to high quality data that is captured to their specifications. This includes high-resolution 3D models of pit walls generated from close-up oblique imagery (for mapping and analysis of rock structure, back-analysis of wall slips, and conformance-to-design reporting) and panoramic imagery & video of key areas of interest. Geotechnical inspections can be captured on a scheduled or on-demand basis.

### **2.2.3 Consistency in Data Quality & Timing**

The mining industry has become increasingly reliant on drone data over the past decade. Many operations rely on capturing and processing drone data in a timely manner for production, technical, envi-

ronmental and other reporting requirements. Achieving consistency in the timing of this data can be challenging due to limited drone pilots available at the site, not having dedicated drone pilots (many mines utilise surveyors to perform the drone operations), and having multiple and competing priorities for data capture. Often the data that is required for quantitative production reporting (such as ore stockpile surveys) takes precedence over data that is required for quality and compliance reporting. There may also be operational factors that delay the pilot from capturing the data (e.g. blasting activity that prevents the pilot from accessing the mission area). Inconsistent or delayed data capture can delay decision-making and result in sub-optimal mine performance.

Additionally, with mine sites utilising multiple drones and drone pilots, there are often variances in the parameters that are applied to mission planning and data processing. This affects the consistency of data quality and increases the likelihood of delays or errors in reporting and decision-making.

By having a permanently installed flight-ready drone system like the DJI Dock on site, the data capture missions can be scheduled independently of site personnel and many of the potential operational delays are eliminated. Further, the transfer, processing & analysis of the data can be fully automated which leads to improved consistency in the timing & quality of reporting.



Figure8: Mission scheduling in FH2

## 2.2.4 Improved Safety

Mine sites are inherently hazardous, with operations involving large mobile machinery, open voids, blasting activities, geotechnical hazards, hazardous substances and much more. The desire to remove people from hazardous areas on a mine site has been one of the key drivers of autonomy in the mining industry.

Conventional, visual-line-of-site drone operations that are typically performed in mining operations today require a drone pilot to be situated within or very close to the drone mission area. This will often result in the need for the pilot to drive into the busy operational areas where they are exposed to multiple hazards.

With the DJI Dock being remotely monitored by a pilot situated in an off-site remote operating centre, the risk of harm to the pilot from on-site hazards is eliminated.

A company in Australia has been deploying the DJI Dock for mining customers in Australia and Africa since the original Dock was introduced in 2023. In all these deployments there has been a rapid adoption of the technology for applications that did not previously rely on drone data. Many of these applications have led to further removal of personnel from hazardous areas. Examples include:

- Scheduled geotechnical inspection missions that previously involved geotechnical engineers inspecting the rock faces on foot within the active mine;
- Frequent (daily or twice-daily) inspection of tailings and hyper-saline pipelines for leakage which would traditionally involve a person driving along the pipeline in a light vehicle;
- Post-blast inspections within open pit mines to perform checks for misfires or other hazards which previously would have involved a person walking

over the blasted material and being exposed to uneven ground and cavities in the muck pile;

- Scheduled environmental inspections at locations on the extremities on the mine site which removes the need for a person to travel and work in a remote location and often is harsh conditions such as the extreme summer heat of Australia's Pilbara region;

- Numerous on-demand requests from mining operations teams for real-time or near real-time vision (live video stream or panoramic imagery) to assist with short-term planning matters without needing to enter the active mining or plant areas.

On several mine sites the company has also been able to successfully demonstrate the use of the DJI Dock as an effective tool in emergency response scenarios. With the ability to launch the drone at very short notice and easily share live-streamed video, the emergency response team is able to obtain valuable situational awareness well before the response team arrives at the site.

Remotely piloted operations also allow for air and ground risks associated with the drone operation to be more effectively managed. Distractions and environmental conditions on a mine site (such as extreme hot/cold weather, dust, noise, insects, sun glare on the remote controller screen, etc) can make it very difficult for an on-site drone pilot to effectively identify and respond to hazards such as people on the ground, drone system warnings and other air traffic. Aviation regulators typically require that remote operations are performed from a suitably equipped location that is free of distractions (a 'sterile cockpit' environment) with all relevant information (including flight control software, live camera views, real-time & forecast weather and air traffic) clearly displayed on screens that are visible to the pilot. This allows the pilot to perform thorough checks for a broad range of hazards at all times during a flight and are able to respond immediately.

### 2.2.5 Improved Utilisation of Skilled Personnel

Mines commonly utilise skilled personnel at the site such as surveyors and engineers to perform drone operations and the associated post-flight data processing. These personnel, however, are often in short supply in the industry, leading to higher workloads and high costs associated with their employment. Performing drone operations often becomes a lower priority than other tasks they need to perform which can make it difficult for broad use of drone data across the operation.

By removing the need for on-site drone piloting, these personnel can dedicate their effort and skills to the critical data analysis and reporting that is needed from them. The more efficient remotely piloted solution is then able to be utilised to capture data on a consistent basis for a broader range of applications.

## 2.3 SPECIFIC APPLICATIONS AND PROBLEMS WHICH THE DJI DOCK CAN DIRECTLY ASSIST WITH

### 2.3.1 Automated Volumetric Measurement

One of the most common applications for drones in the mining industry for over a decade has been volumetric measurement (including quantification of ore stockpile inventory and excavated material from open pit mines), involving the use of one or more software packages to perform a photogrammetry process to generate a digital terrain model from the captured imagery, digitise boundaries for the volumetric reporting, and apply various algorithms to compute the required volume (such as a simple pile volume, or cut & fill volumes between defined surfaces).

By removing the need for a pilot to manually handle the drone data (i.e. remove the drone SD card and manually transfer the data to a PC/server), automated systems like the DJI Dock enable many pro-

cesses, including volumetric reporting, to be automated. Data can be uploaded directly from the Dock to a third-party software cloud server (via API integration), allowing for automated photogrammetry processing and volumetric measurement to be performed (using either pre-defined reporting boundaries, or intelligence-generated boundaries for stockpiles). This automation allows key volumetric reporting to be performed with increased frequency and consistency.

One example of automated volumetric measurement and reporting is at an open pit gold mining operation in Australia where a DJI Dock is used for reporting the volumetric change in the active mining locations over the past 24 hours. The captured imagery is automatically uploaded to a cloud server and API integration with Strayos software then enables automated photogrammetric and volumetric reporting processes to be performed, resulting in the generation of a daily PDF report containing volumetric information and coloured (heat map) imagery to illustrate where material has been placed or removed.

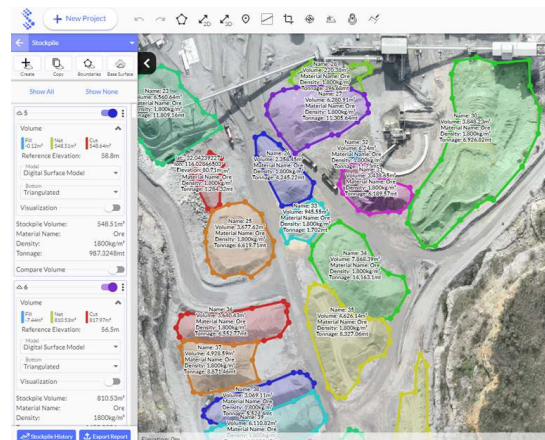


Figure9: Stockpile annotation

### 2.3.2 Bulk Earthworks projects

Mines often have the need to perform major bulk earthworks projects that are typically managed and operated independently from the mine production operations. Examples include the construction or expansion of tailings storage facility (TSF) embankments, mine site remediation works (including profiling of waste rock dumps and other landforms in preparation for revegetation), road construction, drainage & site preparation earthworks associated with mine site pre-construction.

The surveying requirements associated with these types of projects are generally outside the scope of the mine surveyors and instead rely on the earthworks contractors to provide their own surveying capability. The number of surveyors involved is generally limited and they are required to perform multiple tasks including pick-ups, set-outs, management of machine control systems, monthly reporting of material movements for the contractors' claim, and producing as-built plans. On smaller projects, a surveyor may only be on site intermittently to provide basic pick-up and set-out services. Due to these resource limitations, obtaining high quality aerial survey data for these projects on a frequent basis can be quite challenging.

By automating aerial surveying in bulk earthworks projects with the DJI Dock, aerial data can be obtained at high frequency (multiple surveys each day), providing significant benefits to the project, including:

- Early identification of non-conformances (enabling timely rectification).
- The ability to demonstrate conformance to design at all stages of the works (providing quality assurance and minimising the likelihood of contractual disputes).
- Tracking material movements consistently throughout the month rather than just end-of-

month, providing clarity for all parties on progress of the works and accrued costs.

- Up-to-date visibility of the site works for all stakeholders, including off-site management, technical staff and consultants. By capturing and scheduling high-resolution, on-demand 360° imagery and video (recorded and live stream), which can be easily accessed via a web platform in real time or near-real time. Making it ideal for visualising progress and enabling safety and technical inspections to be performed remotely.
- Enabling the project surveyor(s) to dedicate more of their time to analysing the captured data and producing the necessary reporting.

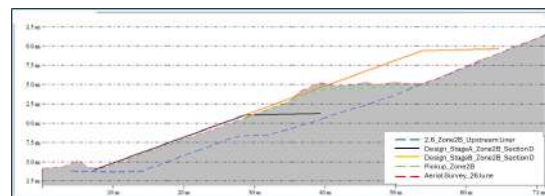


Figure10: Screenshot of conformance reporting with aerial data

### 2.3.3 Mine Conformance Reporting

Excavating open pit mines to design requirements is crucial in maintaining pit stability, maximising ore recovery and minimising the dilution of ore with waste rock.

The early identification of non-conformances by frequently capturing aerial survey data of active mining areas enables engineers to implement timely design changes that can minimise the long-term impact of a non-conformance.

Current users of the DJI Dock in the Australian mining industry are performing aerial surveys of open pits for conformance reporting far more frequently than they were previously with conventional visual-line-of-site(VLOS) drone operations. These surveys are typically requested by geotechnical engineers

on a scheduled basis and involve the capture of oblique imagery of the pit walls to generate high-resolution 3D models that are assessed against the mine design. The processing of the captured imagery to produce the models is often automated, and the analysis and conformance reporting is conducted by geotechnical engineers using mining software packages or, increasingly, automated using AI tools in software such as Strayos.

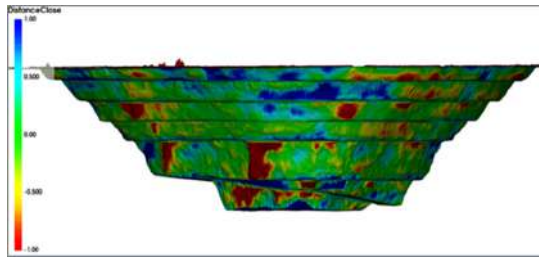


Figure11: Heatmap comparison

### 2.3.4 Efficient Post-blast Workflows

In hard-rock open pit mining operations, aerial data is being increasingly used to assist in determining the performance of each blast (to enable continual blast optimisation), and for predicting the movement of ore during the blast which allows for improved digging & haulage decision-making.

For the prediction of ore movement to be of value to the mine production teams, the data must be captured and processed in a very short timeframe so that digging of the muck pile can commence very soon after the blast. One of the key bottlenecks in this process to date has been the timely capture and processing of the data. Conventional VLOS drone operations require a drone pilot to travel to and from the pit area to perform the drone flight, then manually retrieve the data from the drone before processing can commence.

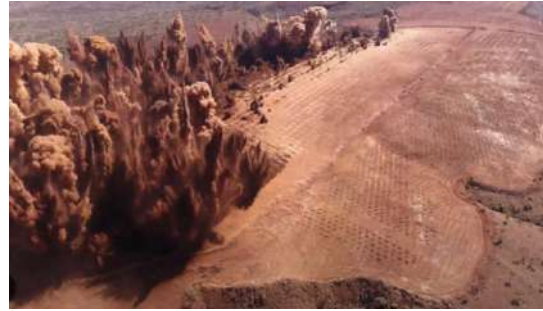


Figure12: Blast operation

The introduction of DJI Dock technology now enables both the delay between the blast and the drone flight, and the data handling time to be dramatically reduced. The remote pilot can be airborne immediately after (or in some circumstances, prior to) the blast, so that the survey flight commences as soon as the dust from the blast has cleared. Immediately upon landing back in the Dock after the survey flight is complete, the data transfer commences automatically. In many cases, the customers are enabling automated photogrammetry processing workflows to further minimise the time taken to generate the surface model, which is then used in third-party software for the ore movement prediction. Refer to Table 3 for an example of the time saving that is being achieved by one mine in Western Australia.

In addition to the survey mission for the blast performance & ore movement analysis, the drone can also perform an efficient post-blast safety inspection – capturing video (recorded and/or live-stream) to identify potential misfires or other hazards prior to digging operations commencing. This can remove the need for on-foot inspections, where personnel are exposed to potential cavities in the muck pile.



Figure13: Fragmentation analysis

### 2.3.5 Automated Asset & Pipeline Inspections

Regular inspections of assets, including fixed infrastructure and mobile equipment, are essential for proactive maintenance planning, reducing unexpected downtime and extending equipment lifespan.

Asset inspections have typically been performed by people conducting visual inspection or using various hand-held sensors. These in-person inspections come with several issues including a safety risk (with inspections often performed at height or in hazardous locations), limited data collection, availability of suitably qualified on-site personnel to perform the inspection, and delays in translating inspection data into useful report formats that can trigger a maintenance event.

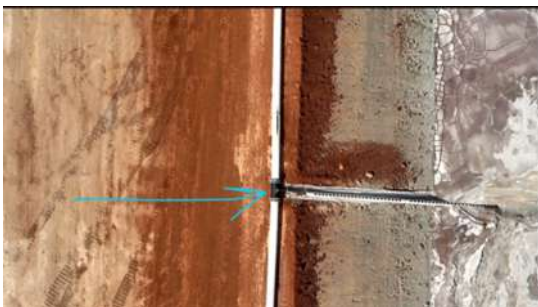


Figure14: Mining pipeline

The DJI Dock can be applied to a broad range of asset inspection tasks in the mining industry through the capture of high-resolution RGB and thermal imagery & video. Not only does this technology remove the need for a person to perform the inspection in person, but it allows for automated analysis by using Onboard Intelligence to trigger alerts in real time or near-real time. Examples of where the DJI Dock is currently being used for asset inspection in mining include:

- Inspection of surface pipelines that have the potential to cause environmental harm if a failure occurs (such as tailings pipelines and hyper-saline water pipelines), with the ability to automate leak detection via live streamed video.
- Automated conveyor belt idler condition monitoring using RGB and thermal imagery captured simultaneously and applying Onboard Intelligence for identification of the idlers in the imagery and reporting on idler temperature. This enables idlers that are nearing end of life (and therefore producing more heat due to worn bearings) to be identified and replaced prior to failure.

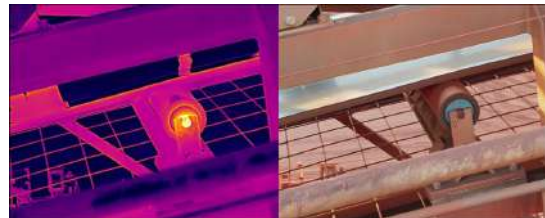


Figure15: Conveyor monitoring with thermal and RGB

### 2.3.6 Automated Safety Monitoring and Hazard Detection

The DJI Dock can be utilised to continuously monitor hazardous and high-risk areas on mine sites without requiring personnel to enter unsafe environments. Equipped with RGB, thermal, and zoom sensors, the drone system can be programmed to conduct regular inspections of critical locations such as tip heads, haul roads, active faces, and inactive pit voids.

In geotechnical applications, drones can capture high-resolution oblique imagery of pit walls to assist in the early detection of slope instability or rockfall hazards. This enables geotechnical engineers to perform structural assessments remotely, reducing exposure while increasing inspection frequency. Additionally, automated patrols can identify physical changes in safety-critical zones—such as berm degradation or haul road deterioration, ensuring hazards are addressed before incidents occur. The ability to detect environmental changes or unauthorised personnel entry near blast zones further enhances overall operational safety.



Figure16: Berm height analysis

### 2.3.7 Automated Environmental Compliance

Environmental monitoring is a regulatory necessity across all mining operations. The DJI Dock allows environmental teams to schedule regular drone missions to assess dust generation, surface water run-off, sedimentation control, and tailings pipeline integrity. Utilising drone imagery and elevation data, sites can monitor the effectiveness of installed environmental controls such as sediment basins, weirs, and bunds, particularly after rainfall events. Vegetation clearance and land disturbance areas can be mapped before and after activities to ensure compliance with clearing permits and rehabilitation obligations.

In sensitive areas, thermal sensors can be deployed for fauna monitoring, especially where threatened species may be present. This enables mining companies to collect high-frequency environmental data with minimal disruption, improving regulatory reporting and enabling proactive compliance management.

### 2.3.8 Emergency Response

When an incident occurs on-site, whether it's a landslide, equipment fire, chemical spill, or missing personnel, the DJI Dock provides rapid situational awareness. With the ability to launch a drone within minutes of an alert, remote pilots can stream live video from the incident area directly to emergency management teams. This real-time aerial perspective allows responders to assess the scale of the incident, identify safe access routes, and monitor evolving conditions without endangering personnel. In scenarios involving hazardous materials or unstable terrain, the drone acts as the first responder, gathering critical intelligence before emergency crews are deployed. Multiple payload types, including thermal, zoom, speakers and spotlights, further enhance the system's utility for night operations, hotspot detection, and locating individuals in low-visibility environments.



Figure 17: Example of personnel identified in an emergency response drill

### 2.3.9 Infrastructure Development

The DJI Dock can be utilized during the planning and execution of infrastructure development projects on mine sites. By capturing accurate and repeatable topographical data, the drone enables survey-grade terrain models to be produced for the design and construction of access roads, drainage systems, ac-

commodation facilities, and plant expansions. Regular flights can track construction progress, verify conformance to design, and provide visual documentation for contractor oversight. This frequent aerial perspective ensures that key stakeholders, including remote project managers and consultants, can assess development stages in near real time.



Figure 18: Dock 2 in use at a mining site

# 3.0 SETTING UP YOUR INTEGRATED DJI DOCK ENVIRONMENT



Implementing an integrated DJI Dock environment within mining operations necessitates meticulous planning and adherence to various technical, regulatory, and operational considerations.

This section provides a comprehensive guide to establishing such an environment, encompassing initial considerations, infrastructure requirements, and maintenance protocols. Although this section specifies examples from Australia, much of it can apply globally. Ensure that consultation with local guidelines is done prior to implementing this procedure.

### 3.1. INITIAL CONSIDERATIONS

There was a time when Beyond Visual Line of Sight (BVLOS) operations represented the height of complexity in drone operations. However, the introduction of drone-in-a-box systems hasn't just added to this complexity—it has exponentially increased it. These systems require seamless integration of automated launch, recovery, remote monitoring, and advanced risk management, demanding an entirely new level of operational oversight and regulatory consideration.

#### 3.1.1 Regulations & Approvals Personnel Training & Licensing

To legally operate BVLOS drones in Australia, pilots must meet stringent licensing requirements set by the Civil Aviation Safety Authority (CASA). This includes obtaining a Remote Pilot License (RePL), an appropriate Aeronautical Radio qualification and either BVLOS OCTA or an Instrument Rating Examination (IREX) certification. The Instrument Rating Examination (IREX) is a CASA-administered theoretical exam designed for pilots seeking an instrument rating in crewed aviation. However, it is also an accepted qualification for Beyond Visual Line of Sight (BVLOS) drone operations in Australia. The IREX assesses a pilot's knowledge of instrument flight rules (IFR), navigation, meteorology, air law, and operational procedures in controlled and uncontrolled airspace. The BVLOS OCTA (Outside Controlled Airspace) qualification is a CASA-endorsed certification that allows remote pilots to conduct Beyond Visual Line of Sight (BVLOS) operations in uncontrolled airspace. It involves completing an approved exam that covers airspace management, risk assessment,

emergency procedures, human factors, and regulatory compliance.

Unlike the IREX (Instrument Rating Examination), which is designed for crewed aviation, BVLOS OCTA is tailored specifically for remotely piloted aircraft and does not require extensive crewed aviation knowledge. These qualifications ensure that pilots have the necessary expertise in airspace management, emergency procedures, and risk assessment to safely conduct remote BVLOS operations.

The introduction of drone-in-a-box (DIAB) systems, however, has significantly expanded the demands on personnel training. Unlike conventional BVLOS operations, where a pilot actively controls the aircraft, DIAB systems rely on automated deployment, remote supervision, and advanced fail-safe protocols. As a result, personnel overseeing remote operations must be trained not only in traditional BVLOS competencies, but also in system diagnostics, remote intervention protocols, and managing higher levels of automation. Each pilot must meet a minimum number of supervised hours before being allowed to operate a drone from a Remote Operation Centre.



Figure19: DJI Dock 3 DIAB solution

To address these challenges, organisations must integrate specialised training into their operational frameworks. In addition to standard regulatory qualifications, DIAB operators should undergo advanced Human Factors and Crew Resource Management (HF/CRM) training, adapted from ICAO’s CRM principles in crewed aviation, to enhance decision-making, situational awareness, and crisis management when overseeing semi-automatic operations. Furthermore, structured emergency response training, with an emphasis on remote system recovery and incident escalation, is essential to ensure operators can effectively respond to unexpected failures or anomalies.

### 3.1.2 ReOC workflow for compliant operations

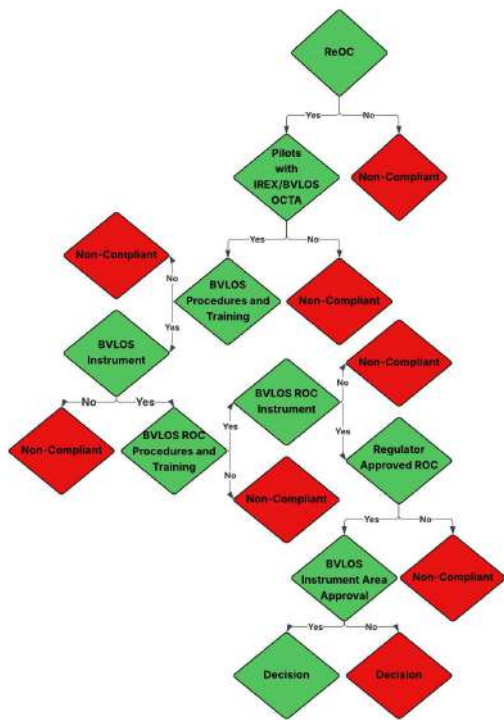


Figure20: BVLOS workflow

As DIAB operations push the boundaries of BVLOS capabilities, personnel licensing and training must

evolve accordingly. Organisations must not only meet CASA's regulatory baseline but also invest in continuous skill development to maintain safe and effective DIAB operations in increasingly complex airspace environments.

### 3.1.3 Operating Approval

#### BVLOS Area Approval

Utilising the JARUS SORA risk assessment method, obtaining BVLOS area approval requires a comprehensive evaluation of both ground and air risk for a defined area of operations, along with the implementation of risk mitigations, stakeholder engagement, and emergency response planning. Once approval is granted, additional site-specific considerations must be addressed. Individual site briefings must be conducted to familiarise pilots with the unique air and ground risks present at each location. Furthermore, both desktop simulations and real-world emergency response drills are essential to validate that contingency plans are effective under operational conditions.

With the introduction of drone-in-a-box (DIAB) systems, these approval processes became significantly more complex. Unlike conventional BVLOS operations, DIAB systems rely on automated deployment and remote oversight, necessitating additional risk controls for automatic decision-making, failsafe activation, and remote intervention. Site risk assessments must now account for factors such as unanticipated environmental changes affecting DIAB performance, cybersecurity vulnerabilities, and contingency planning for remote system failures.

#### Remote Operating Centre (ROC) Certification

For organisations operating DIAB systems, Remote Operating Centres (ROCs) play a critical role in overseeing automatic flight missions. ROC certification requires adherence to specific procedures, including a thorough Human-Machine Interface (HMI) assessment to ensure that the ROC is designed to support pilot situational awareness, effective

decision-making, and regulatory compliance. Additionally, redundant power, internet, and communication systems are fundamental requirements to maintain safe remote operations.

The complexity of ROC certification increases when integrating DIAB technology, as remote operators must be able to monitor and, when necessary, manually intervene in automated operations across multiple locations. This necessitates enhanced procedural safeguards, such as continuous system health monitoring, latency management strategies, and the ability to execute remote emergency overrides with minimal delay. Consideration needs to be given to the integration of third party localised ADSB monitoring into the broader dock eco-system. This has the ability to provide a greater appreciation of air risk without relying solely on software such as Flight Radar 24, especially when operating around aerodromes which are a common feature of most large remote mining operations.

#### **BVLOS Procedures**

Prior to launching any BVLOS operations, organisations must develop and obtain regulatory approval for detailed BVLOS procedures and then further procedures for remote operations. These procedures cover flight planning, risk mitigation, communication protocols, emergency response actions specific to operational environments and system monitoring.

DIAB-specific procedures must outline parameters for automated launch and recovery, remote system health monitoring, automated obstacle avoidance, and escalation protocols for unexpected system failures for example communication or internet failure.

Additionally, compliance frameworks must account for variable operational conditions, ensuring DIAB units function safely across a range of environmental and technical scenarios.

### **3.1.4 Further Considerations**

#### **Fatigue Management**

The shift to remote operations centers (ROCs) has enabled organizations to manage drone operations across multiple sites on a 24/7 basis, significantly enhancing operational efficiency. However, this continuous capability has introduced new and complex fatigue risks that were not previously encountered in traditional drone operations. To mitigate these risks, organizations have once again turned to crewed aviation fatigue management principles, implementing minimum flight duty limits, mandatory rest periods, and structured sleep opportunity requirements. These measures ensure that remote pilots maintain optimal cognitive function, decision-making ability, and situational awareness, reducing the likelihood of fatigue-related errors in remote automatic operations.

#### **In flight monitoring**

While automated flight has removed the need for direct manual control, the monitoring burden on remote pilots has significantly increased. Pilots must continuously track critical flight points, radio frequency broadcasts, sudden and extreme weather conditions, other air traffic, and ground risks, all while adhering to defined procedures for different flight stages. This heightened situational awareness is essential for safe and effective remote BVLOS operations, ensuring that pilots can rapidly respond to any anomalies or emergent threats. However, prolonged engagement in high-cognitive-load monitoring leads to mental fatigue, impacting decision-making and reaction times after several hours of continuous operation. Organizations must therefore consider structured duty cycles, cognitive workload management strategies, and automation-assisted monitoring tools to mitigate the effects of fatigue in long-duration remote flight operations.

#### **Situational Awareness**

Nothing replaces boots on the ground and firsthand local area knowledge. However, organizations oper-

ating remotely must actively enhance situational awareness to compensate for this absence. The integration of localized weather stations is essential, as nearby weather stations may not be relevant, providing real-time data on wind, temperature, and barometric pressure fluctuations, allowing pilots to anticipate weather changes without physically being on-site. Additionally, deploying CCTV cameras for ground monitoring and tracking incoming weather events can offer a crucial visual feed of the environment. To further bridge the awareness gap, intelligence-driven radio transcription monitoring can capture and process local air traffic communications, ensuring critical information is not missed. By leveraging these technologies, remote operators can build a comprehensive picture of the operational environment, mitigating the challenges posed by distance and delayed situational inputs.

### Emergency Response Planning and Testing

In emergency situations, pilots do not rise to the occasion—they fall to the level of their training. Operating remotely adds another layer of complexity and risk, making it essential to continuously train, replicate, and test emergency procedures. Effective training design ensures that an organization's emergency response plans are not just theoretical documents but practical, executable procedures that hold up under real-world conditions. Scenario-based training in safe-to-fail environments builds pilot confidence, ensuring that when they inevitably face an emergency, they have already experienced and managed similar situations in a controlled, near-real-world training environment.



Figure21: Dock 2 landing on-site

### 3.1.5 Cyber Security

#### Threats and Vulnerabilities

As drone operations become increasingly automated and reliant on remote communication, cybersecurity is becoming a major concern. Unauthorized remote access poses a significant risk to operational integrity, with potential threats including:

- **Command Hijacking** – Where external interference allows unauthorized individuals to take control of the drone.
- **Data Interception** – Exploitation of unsecured communication channels to access sensitive flight and operational data.
- **Weak Authentication Protocols** – Lacking proper access controls, making the system vulnerable to security breaches.

#### Mitigation Strategies

To protect against these vulnerabilities, robust security measures must be in place. This includes implementing end-to-end encryption to secure communication between the DJI Dock 2, the Remote Operating Centre (ROC), and pilots. Multi-factor authentication (MFA) ensures that only authorized personnel can access critical control systems, reducing the likelihood of breaches. Additionally, restricting remote access to verified users and conducting regular security audits allows for continuous assessment and improvement of cybersecurity measures.

#### Regulatory Engagement

It is essential to emphasize a collaborative and transparent approach with the regulating body (CASA, FAA etc) to facilitate the regulatory approval process. Unlike traditional regulatory engagement models, which can be rigid and adversarial, it is advantageous to share operational data and risk assessments early in the process. This proactive approach fosters trust, streamlines compliance, and

accelerates approvals for BVLOS operations in remote mining environments.

#### Airspace & Ground Stakeholder Management

Beyond regulatory compliance, stakeholder engagement extends to all affected parties, ensuring safe and coordinated operations. Key initiatives include:

- **Consultation with Airspace Users** – Engaging with local aviators and air traffic managers to mitigate the risk of airspace conflicts.
- **Community Engagement** – Addressing concerns related to drone privacy, noise pollution, and operational transparency.
- **Emergency Response Coordination** – Establishing direct communication with emergency services to integrate drone operations into existing response frameworks.

### 3.1.6 Safety Accreditations

#### BARS Accreditation and Compliance

Many Tier 1 mining organisations are BARS Member Organisations (BMO's) and, as such, demand a higher standard of safety and risk management from their aviation service providers. The Basic Aviation Risk Standard (BARS), developed by the Flight Safety Foundation, is an internationally recognised risk-based audit program tailored for the mining, resource, and other high-risk sectors. It provides a structured framework for assessing aviation operators, ensuring they meet rigorous operational, safety, and compliance standards.

BARS accreditation requires an operator to participate in an annual audit conducted by an independent accredited auditor. The audit focuses on key areas such as operational risk management, pilot training and competency, maintenance practices, emergency response planning, and regulatory compliance. The standard also emphasises continuous improvement, meaning operators must address

findings, implement corrective actions, and demonstrate ongoing adherence to best practices.

For mining organisations, engaging BARS-accredited operators ensures alignment with global aviation safety benchmarks, enhances risk mitigation, and provides a transparent, standardised approach to evaluating aviation safety performance. As a result, many Tier 1 mining companies mandate BARS accreditation as a prerequisite for aviation contractors operating within their projects.

### Approval Delays

BVLOS area approvals can take upwards of six months in Australia (closer to twelve-eighteen months), creating significant barriers to operational efficiency. As a result, industry stakeholders are advocating for the easing of regulations governing Class G airspace in remote environments in Australia. This push aims to reduce unnecessary bureaucratic delays while maintaining stringent safety standards.

### Operator-Led Approvals

The shift toward operator-led approvals represents a significant evolution in how BVLOS (Beyond Visual Line of Sight) operations are managed, particularly in remote and high-risk environments such as mining and energy. Rather than relying solely on case-by-case regulatory approvals, this model allows qualified and approved operators to take greater responsibility for conducting risk assessments and granting internal approvals, provided they can demonstrate the operations safely.

Operator-led approvals place accountability on the organisation to ensure its operational decisions are supported by robust governance, thorough risk management processes, and a proactive safety culture. This includes maintaining a comprehensive Safety Management System (SMS), ensuring regulatory compliance, and embedding continuous improvement across all levels of the operation.

Key elements of a successful operator-led approval framework include:

- **Mature Safety Management Systems:** With a focus on hazard identification, risk assessment, and continuous monitoring.
- **Strong internal independent oversight and assurance mechanisms:** To validate compliance with aviation regulations and internal standards.
- **Well-defined procedures and training programs:** Ensuring personnel are competent, current, and capable of making risk-informed decisions.
- **Use of advanced technologies:** Including detect-and-avoid systems, automated workflows, and real-time operational monitoring to support safe remote BVLOS operations.
- **Transparent engagement with regulators:** Sharing safety performance data, lessons learned, and evidence of internal oversight to build trust and maintain regulatory confidence.

This approach enables the efficient scaling of drone operations without compromising safety. It also fosters innovation by reducing administrative delays, encouraging operators to continuously improve their capabilities, and supporting the integration of new technologies and methodologies.

Ultimately, operator-led approvals represent a collaborative and forward-looking model that balances operational flexibility with rigorous safety and accountability standards.

### Future Trends

As BVLOS regulations continue to evolve, several key trends are shaping the future of drone operations. One major area of advancement is the integration of intelligence and automation, which is enhancing automatic navigation, real-time obstacle detection, and intelligent decision-making in dynamic environments. These technologies enable

drones to operate more safely and efficiently with reduced human intervention.


Another significant development is the expansion of airspace integration, aimed at improving coordination between crewed and uncrewed aircraft through unified traffic management systems, shared situational awareness, and digital flight planning. This is particularly crucial as drone operations become more frequent and complex.


Crucially, the emergence of one-to-many operations, where a single operator can oversee multiple drones simultaneously, is unlocking the true power of remote operations. This capability significantly increases operational scalability and cost-efficiency, especially in vast, low-risk environments such as

mining and infrastructure corridors. Combined with automated workflows and real-time data processing, one-to-many operations represent a foundational shift in how aerial data is collected and utilised.

Finally, regulatory bodies are beginning to adopt more flexible, risk-based approval frameworks, especially for remote and low-density airspace. These frameworks recognise the maturity of operator-led governance models and support innovation while maintaining appropriate safety margins. Together, these trends point toward a future where drone operations are more automatic, scalable, and seamlessly integrated into the broader airspace ecosystem.

### 3.1.7 Case Study: Regulatory example of ROC BVLOS Drone Operations in Mining

 **Client:** Norton Gold Fields (a subsidiary of Zijin Mining Group)

 **Location:** Approach Departure Path of Kalgoorlie-Boulder Airport

 **Project Focus:** Post-Blast Muckpile Analysis for Optimized Grade Control

 **Deployment Date:** 2025

#### Project Overview

Norton Gold Fields required aerial surveys of a pit area located within the approach and departure path of Kalgoorlie-Boulder Airport. The Kalgoorlie-Boulder aerodrome is one of the busiest regional airports in Australia, supporting significant fly-in fly-out (FIFO) operations servicing the Eastern Goldfields region, as well as a high volume of general aviation traffic. Operations in this area therefore require careful coordination to ensure aviation safety and regulatory compliance.

#### Implementation

An extensive stakeholder engagement process was undertaken as part of the SORA Safety Case presented to CASA. This process included close collaboration with the Kalgoorlie-Boulder Aerodrome operations team, as well as other airspace users who rely on the aerodrome to conduct their work and operate their businesses.

The objective was to enable the delivery of aerial survey services to Norton Gold Fields with zero impact on the normal operations of the airport.

A comprehensive airspace assessment was also conducted to understand local air traffic dynamics. This included analysis of traffic volume, peak periods, scheduled airline operations, runway usage, approach and departure paths, circuit patterns, and any aircraft behaviours unique to Kalgoorlie-Boulder Aerodrome. Special attention was given to the altitudes of aircraft transiting near the mine site to identify potential conflicts.

As part of the risk mitigations, a strict operational constraint was introduced requiring the RPA to be on the ground at least 20 minutes before any scheduled arrival or departure. To support this, we mapped out operational windows around the airport’s published schedule and incorporated a fail-safe buffer to ensure the RPA was safely returned to the dock well in advance of any crewed aircraft operations.

Outcomes

- **Zero Impact on Aerodrome Operations** - By developing a detailed understanding of aircraft movements and aerodrome dynamics, we were able to plan our operations precisely around scheduled arrivals and departures. This proactive planning ensured there was no disruption to airport activities, supporting safe and seamless integration with existing airspace users.
- **Improved Operational Efficiency** - The requirement to plan operations down to the minute introduced a higher level of precision and discipline. These improvements have translated into broader operational efficiencies, enhancing our planning, execution, and coordination processes across other projects.
- **Strengthened Stakeholder Relationships** - The collaborative engagement with the aerodrome operator and local airspace users built mutual trust and transparency. This strengthened relationships and established a positive precedent for future operations in controlled or complex airspace environments.

### Conclusion

These outcomes demonstrate that with thorough planning, stakeholder collaboration, and disciplined execution, complex RPA operations can be conducted safely and efficiently within high traffic airspace, without impacting existing aerodrome activities.

### 3.1.8 Dock Model Selection – M4D vs. M4TD

Selecting the Right Drone with Appropriate Sensors  
Choosing drones equipped with suitable sensors is paramount for specific mining applications. For instance, the DJI Matrice 4D series, compatible with the DJI Dock 3, offers versatility and reliability. Equipped with a range of high-resolution cameras and thermal imaging capabilities, these drones can effectively perform tasks such as equipment inspections and safety monitoring.



Figure22: DJI M4D & DJI M4TD sensors respectively

### Understanding Limitations

Deploying the DJI Dock in remote or complex environments requires careful planning to mitigate operational constraints. One of the most critical factors is site selection, which must account for signal range, terrain variations, and potential RF interference. A detailed Digital Terrain Model (DTM) can assist in identifying optimal placement locations by highlighting elevation changes that may impact connectivity. Uneven terrain, obstacles such as ridge-lines or vegetation, and nearby industrial equipment can all contribute to signal degradation, reducing the reliability of command and control links.

Additionally, battery management is a fundamental aspect of effective and efficient drone operations. The 54-minute max flight time, while impressive, is quickly reduced by operational realities. Maintaining a 30% battery reserve for safety, accounting for

high winds, and factoring in long transits to survey locations can significantly limit effective flight duration. Furthermore, in many mining environments, high ambient temperatures can prolong charge cycles and increase the risk of batteries overheating, impacting operational efficiency.

While none of these factors are outright prohibitive, they must be carefully considered when planning and deploying DJI Dock systems in challenging and complex environments. By proactively addressing these limitations through strategic site selection, terrain analysis, and effective battery management, organisations can maximise operational uptime and ensure consistent, reliable performance in the field.

## 3.2 INFRASTRUCTURE AND ENVIRONMENT



Figure23: DJI Dock 1 landing sequence view from drone

### 3.2.1 Site Location Assessment (SLA)

#### Line of Sight Signal Testing

Ensuring unobstructed communication between the DJI Dock and the drone is crucial for reliable operations, particularly in remote or rugged environments where terrain and infrastructure can impact connectivity. Working closely with site operators, conducting comprehensive risk assessments, and performing physical site visits are essential steps in

developing a clear understanding of potential connectivity obstructions.

▲ structured approach to line-of-sight signal testing includes:

**Situational Awareness Assessments:** Identifying potential obstacles such as terrain features, buildings, vegetation, or industrial equipment that may disrupt signals.

**Penetration Testing:** Conducting targeted tests to uncover weak spots and areas of low connectivity, validating assumptions made during planning.

**RF Interference Analysis:** Assessing the presence of competing signals from other equipment that could degrade communication reliability.

By systematically testing and mapping potential signal degradation points, operators can mitigate risks associated with signal loss and ensure the DJI Dock maintains consistent and secure connectivity with the drone throughout its entire operational area. Access to Power and Networking

As previously mentioned, battery and power management are critical for efficient drone operations. While some sites offer access to mains power and fiber-optic internet, the optimal location for the DJI Dock is often in remote areas where these utilities are unavailable. This presents challenges in ensuring a reliable and continuous power supply and stable network connectivity for remote operations.

Typical power requirements for the Dock at idle are approximately 3kW per day, with a maximum input power of 800W.

Power usage will change depending on the weather conditions and the timing, interval and frequency of flights. Before deciding on what power solution to use, it's important that a range of factors are considered.

While the DJI Dock's idle power consumption is a manageable 3 kW, the total power requirements, including the dock and associated infrastructure such as communications systems, internet connectivity, cooling, secondary weather stations, and CCTV, can reach approximately 6 to 8 kW per day when operating under typical mining-level workloads in harsh conditions .

Alternative power solutions such as solar, generators, or hybrid systems can provide viable options, but each comes with its own limitations—solar is dependent on weather conditions, generators require consistent fuel supply and maintenance, and hybrid systems add complexity and cost. Selecting the most appropriate power solution requires careful consideration of site conditions, operational uptime requirements, and logistical constraints.

On the networking side, reliable internet connectivity is fundamental for the DJI Dock's ability to transmit data, receive commands, and facilitate remote control functionalities. While fiber or fixed-line internet is ideal, remote sites frequently rely on satellite-based solutions like Starlink, which have become an industry standard. Idle, the Dock uses about 4KB/s, but in use, it requires up to 5MB/s. However, network latency, bandwidth limitations, and potential interference must still be accounted for when designing the operational setup.

Verifying the availability of stable power sources and internet connectivity is essential before deployment. Without these critical infrastructure components in place, the reliability and efficiency of DJI Dock operations may be significantly impacted, limiting its ability to perform automatic missions in remote environments.



Figure24: The DJI Power 1000 can power the DJI Dock for approximately 7 hours depending on usage

### Ongoing Maintenance Access

DJI specifies maintenance schedules for dock systems to ensure ongoing reliability and performance. While the maintenance requirements are not overly demanding, the core challenge of remote operations is the absence of on-site personnel. Therefore, ensuring the availability of trained maintenance staff, either through a dedicated team that can be deployed to site or by coordinating with the client to provide trained staff, is critical. This applies to both scheduled and unscheduled maintenance, as unforeseen issues may arise in the field.

By addressing these challenges with robust maintenance protocols and skilled staff availability, organizations can ensure that their remote operations remain reliable and efficient, even in the most demanding environments.

### Distance from Target Areas

Positioning the DJI Dock optimally within the operational area is essential to maximizing efficiency, coverage, and data capture quality. A well-planned location ensures that drones can reach and survey target sites with minimal transit time, reducing battery consumption and increasing operational effectiveness.

To achieve optimal placement, a comprehensive understanding of site requirements is necessary, including:

- **Frequency of Operations:** High-frequency deployments may benefit from centralized positioning to minimize travel distances.

- **Proactive vs. Reactive Operations:** Sites requiring rapid response (e.g., security or emergency monitoring) need strategic placement to enable quick deployment.

- **Areas of High Foot Traffic:** Avoiding congested areas reduces operational risks and potential conflicts with personnel or equipment.

- **Future Expansion Considerations:** Selecting a location that accommodates scalability ensures the dock remains viable as geographical coverage or operational demands grow.

By aligning dock positioning with operational needs, organizations can enhance efficiency, reduce operational risks, and maximize the value of drone-based data collection in both current and future applications.

### 3.2.2 On-Site Technical Requirements

#### Power Provision

Ensuring a reliable and continuous power supply is essential for the effective operation of the DJI Dock, particularly in remote mining environments where access to grid power may be limited. The power requirements for the DJI Dock, such as 110/240V or alternative off-grid solutions, must be carefully considered to ensure uninterrupted operations.

In areas without reliable access to mains electricity, off-grid power solutions are often the most viable alternative. These solutions must have sufficient capacity to support the dock's power needs while accounting for operational demands, including charging drones, temperature management and maintaining data transmission systems.

Backup power options like generators or solar power systems offer additional resilience, ensuring that the DJI Dock remains operational during power outages. Generators are effective in providing immediate power, though they require fuel supply and reg-

ular maintenance. Solar power systems, on the other hand, provide a sustainable energy source but depend on sunlight availability, making them ideal for sites with consistent sunlight exposure. Hybrid systems that combine solar power with battery storage or backup generators can enhance the reliability of power provision and minimize downtime in challenging environments.

Considering the site's specific needs, including climate conditions and operational scale, is key to selecting the most appropriate power solution. Implementing a combination of backup power systems ensures operational resilience, reduces the risk of downtime, and improves the overall efficiency of DJI Dock deployments in remote locations.

#### Redundant Communication and Power

Redundant communication and power systems are essential for maintaining effective airspace situational awareness and operational reliability. In remote and industrial environments, uninterrupted connectivity and power stability are critical to ensuring the DJI Dock can continue functioning during unexpected failures or outages.

Communication redundancy plays a crucial role in airspace awareness and operational safety. Integrating a Radio over Internet Protocol (ROIP) system enhances communication resilience by allowing operators to maintain reliable contact with airspace users, ground teams, and remote operations centers. Additionally, having multiple network pathways, such as a combination of fiber, cellular, and satellite connectivity, ensures continuous data transmission, even if the primary network experiences disruptions.

Power redundancy is equally important. Implementing Uninterruptible Power Supplies (UPS) and backup generators ensures that operations can continue seamlessly during power failures. Hybrid power solutions that combine solar, battery storage, and backup generators offer additional resilience,

mitigating risks associated with site-specific power limitations.

By incorporating redundant power and communication systems, operators can enhance the reliability of DJI Dock deployments in remote and complex environments, reducing downtime, improving safety, and ensuring continuous operational capability, even in emergency situations.



Figure 25: RocketDNA SolarSkid hybrid off-grid Dock solution

### 3.2.3 Remote Operating Centre

#### Staffing Requirements

In line with the licensing and regulatory considerations outlined in Section 3.1.1, the staffing of a Remote Operations Centre (ROC) requires careful planning to ensure that remote pilots are well-equipped to meet the demands of multiple clients and complex operational environments. The staffing structure must be designed to support the dy-

namic and often challenging nature of drone operations, particularly in remote locations and mining environments.

Key considerations include:

**1. Understanding Client Requirements:** Remote pilots must have a thorough understanding of the client's operational needs, including specific drone capabilities, flight durations, charge times, and the type of data required. This ensures that operations can be planned effectively, with the pilot's capacity to cover multiple sites and respond to client needs being optimized.

**2. Drone Capacity and Operational Demands:** Staffing plans must take into account the maximum flight times and charge times of drones, balancing these with the capacity of remote pilots to manage operations across different sites. Effective scheduling and coordination are required to ensure that pilots are available and that drone operations are not compromised by insufficient battery life or flight time. The ability to manage this resource constraint is crucial for ensuring efficient operations and avoiding delays.

**3. Unscheduled Work and Emergency Response:** One of the complexities of ROC staffing is the need to be flexible and responsive to unscheduled work or emergency situations. A pilot must be available to respond promptly to these needs, which may require on-demand deployment or rapid changes in flight plans. This necessitates careful coordination and potentially having reserve pilots or backup plans in place to handle urgent requirements without impacting ongoing scheduled work.

**4. Geospatial Data Training:** Beyond flight operations, remote pilots must also be equipped with geospatial data training. This allows them to effectively troubleshoot mission planning and make adjustments as needed. Understanding the client's data collection requirements, the specific terrain of mine sites, and how to incorporate that into the

mission planning process is crucial. Pilots must also be aware of the day-to-day processes on the mine site, as operational workflows may affect how drones are deployed and utilized.

#### **Implementation of Flight Control Software**

Utilising platforms like FlightHub 2 for mission planning and management is essential. FlightHub 2 offers comprehensive tools for scheduling missions, monitoring flight status, and managing data, thereby streamlining the integration of the DJI Dock into mining operations.

- **FlightHub 2 (FH2):** Integrated DJI software for mission planning and fleet management
- **RoIP (Radio over IP):** Secure communication channel for remote teams
- **Data Sources:** Integration with mapping platforms, GIS systems, and cloud storage for real-time data analysis

### 3.2.4 Ongoing Maintenance Requirements

#### **Fit for Purpose**

Ensuring that equipment is fit for purpose is essential for maintaining operational efficiency and safety, especially in the demanding environments where DJI Docks are deployed. The DJI Dock is designed to operate across a range of weather conditions. However, regular maintenance and inspections are necessary to ensure its optimal performance, particularly in the harsh environments of mining sites.

#### **Environmental Suitability**

Mining environments often present challenging conditions, including extreme temperatures, dust, moisture, and sometimes chemical exposure. While the DJI Dock and its associated drones are designed with specific Ingress Protection (IP) ratings, which offer some level of protection against dust and water ingress, it is essential to assess whether addi-

tional protective measures are necessary. For example, in environments with high dust levels or abrasive materials (like iron ore), implementing extra shielding, enhanced cleaning protocols, or dust-resistant seals could prevent sensor blockages, mechanical wear, and electronic malfunctions.

#### **Maintenance Schedules**

Establishing a routine maintenance schedule is key to ensuring the ongoing reliability and performance of the DJI Dock system. Regular inspections and scheduled servicing are necessary to identify potential issues before they impact operations. These maintenance activities should focus on:

- **Dock Inspections:** Checking for physical damages, ensuring that charging mechanisms are functioning correctly, and confirming that communication systems are operational.
  - **Drone Maintenance:** Inspecting propellers for wear and tear, cleaning sensors and cameras, and testing battery health to ensure that they continue to meet performance expectations.
  - **Software Updates:** Regularly updating both dock and drone firmware to ensure the systems are equipped with the latest features, optimizations, and security patches.
- #### **On-condition Vs Scheduled Maintenance**
- **On-Condition Maintenance:** This type of maintenance occurs when components or systems show signs of wear or malfunction, triggering immediate attention.
  - **Scheduled Maintenance:** This is performed at predefined intervals based on the manufacturer's recommendations or operational conditions, ensuring that the system operates at its full potential.

#### **Harsh Environmental Conditions**

Mining environments are some of the most challenging locations for deploying the DJI Dock, with extreme temperatures (often exceeding 50°C), high

winds, rain, and dust from minerals like iron ore. While the long-term durability of the DJI Dock under these conditions is still being understood, it is vital to plan for the regular maintenance of systems exposed to such environmental stress. Potential environmental impacts of mining dust include:

- **Short Circuits and Electrical Fires:** Iron ore dust can be conductive when it accumulates on electrical components, leading to short circuits. This can damage equipment and, in severe cases, trigger electrical fires due to overheating caused by accumulated dust.
- **Corrosion of Electrical Components:** The minerals in iron ore dust, particularly iron oxide, can accelerate the corrosion of metal parts in electrical systems. Over time, this can degrade the integrity of wires, connectors, and components, ultimately leading to system failures or shortened equipment lifespan.
- **Dust Buildup and Overheating:** Dust can accumulate on cooling fans, heat sinks, and other ventilation systems in electrical components, reducing airflow and contributing to overheating. This can severely affect the performance and longevity of sensitive components like control units and circuit boards.

- **Contact Degradation:** Fine dust particles can accumulate on connectors, switches, and electrical contacts, leading to poor electrical connections. This can result in voltage drops, signal degradation, or system malfunctions, particularly in critical systems.

### Training

To effectively manage these maintenance needs, it is essential to provide comprehensive maintenance training for personnel. Staff should be equipped to handle both routine inspections and emergency repairs. This training must be updated regularly to incorporate the latest best practices and technological advancements. Additionally, clear access routes and scheduled maintenance windows should be established to minimize downtime and ensure the timely resolution of any issues.

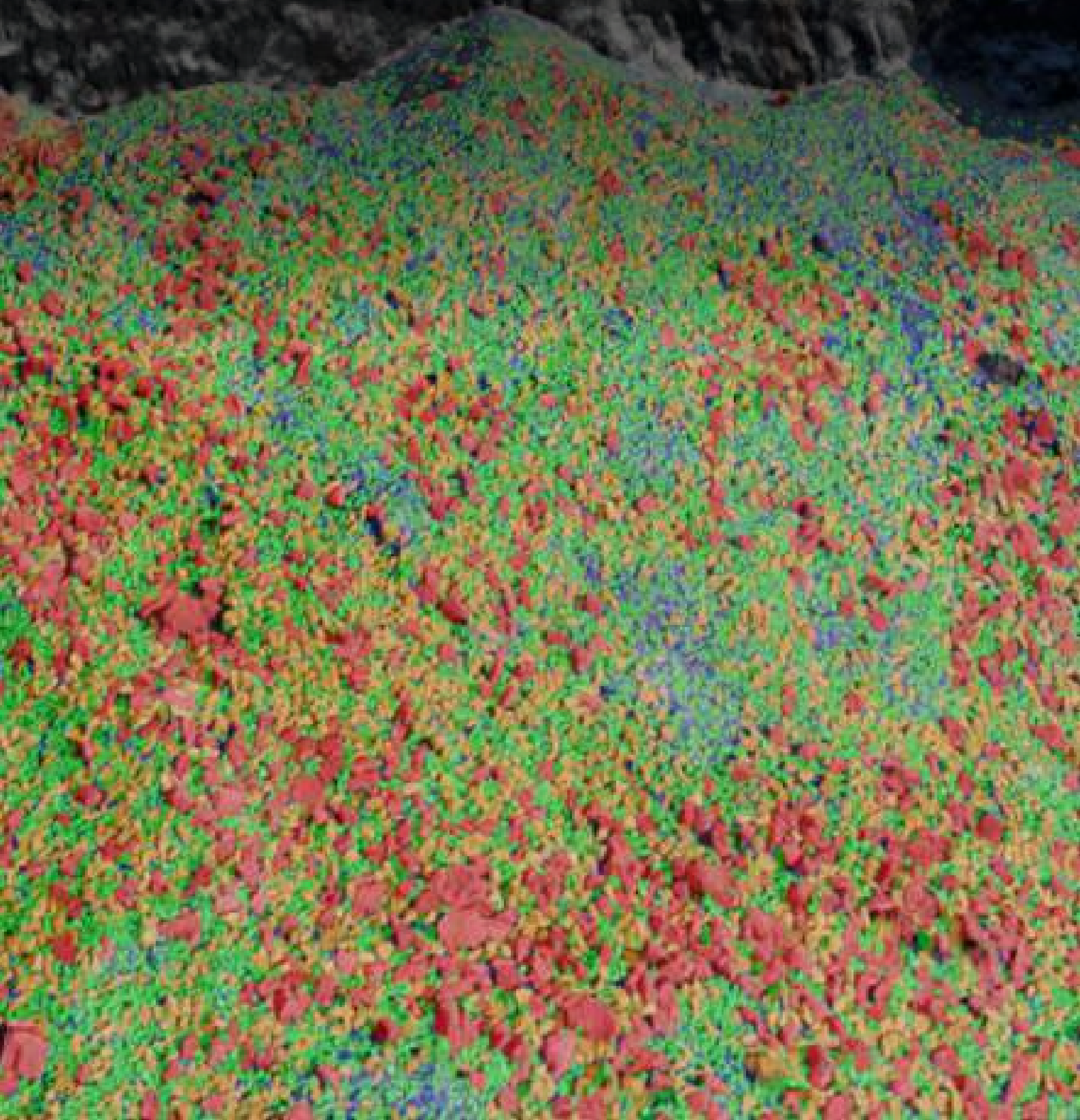
Having a structured plan for managing unscheduled repairs or emergency maintenance ensures that the DJI Dock remains operational and resilient even under extreme conditions.

By proactively addressing maintenance challenges, including the effects of mining dust and harsh environmental conditions, organizations can enhance the longevity, reliability, and safety of the DJI Dock, ultimately improving operational efficiency and reducing unexpected downtime.



Figure26: RocketDNA ROC setup

# 4.0 AUTOMATED SOFTWARE PROCESSING



## 4.1 WHY CHOOSE AUTOMATED PROCESSING?

The integration of the DJI Dock in combination with automated photogrammetry processing is a crucial step towards reaching fully automated data operations that ultimately reduces the workload on the operations teams.

### 4.1.1 Complete the workflow towards full automation

Data processing is an integral part of being able to derive meaningful and survey-grade results from aerial imagery, including volume calculations, survey reports, measurements and analysis.

Without the processing step being automated, a complete workflow cannot be accomplished.

Integration of data processing into the automated workflow allows for:

#### **On-demand results at the press of a button**

Data when needed, simply utilise the docked drone solution through Flighthub2 to fly the area needed, then wait as the data is uploaded, run through the integrated processing step, and results generated based on your requirements

#### **Scheduled data capture to generate a timeline history of the site. Ease of comparison**

With a docked solution, scheduling missions is easy. Schedule ahead of time for key events such as when the sun is at its zenith, or simply a certain time of the day. The drone will fly the mission in the sun and rain, and it will capture and process the data specified. Whether it be a 2D Orthomosaic, 3D results or even inspection photos of certain assets. These can then be viewed in 4D (XYZ, Time) to provide a more complete history of the site.

#### **Trigger-based capture for If This Than That (IFTTT) processing and reporting**

Processing and alerts may be triggered automatically based on certain events occurring on-site (with third-party integration)(possible in FH2 On-Prem with development). With custom integration of third-party processing software and accessories, the possibilities for event triggers and outputs are endless. Whether it be an inspection report when a bucket-wheel excavator shuts down, or a pre-blast site exclusion zone inspection to assist in ensuring no personnel remain in the danger zone, IFTTT integration can be endless.

#### **Rapidly produce data on your site datum, when needed.**

With the advancements in automatic GCP marking and machine-learning techniques, data can be rapidly processed on the site datum without the need for human intervention or aid.

With data being generated on datum, accurate comparisons can be made to compare and plot change across the lifetime of the project, or whenever needed with the dock solution.

### 4.1.2 Integrates automatic data capture and automated processing

With automated capture, the bulk amount of data can quickly bog down the processing team. Add to that the monotony of marking the same GCPs every day. Surely there is an easier way.

With the integration of automatic capture and automatic processing, the workflow from capture to result is streamlined to reduce working hours spent on the capture and processing stage.

Whilst the pilot no longer needs to be on-site to capture and download data, new advancements have also improved the automatic capabilities of processing software to include key features such as:

### Automatic GCP Marking

Automatic GCP marking can save as much as [94%](#) (Heliguy, 2023) of time in processing, potentially even more when implementing a fully [automatic solution](#).

Without this, human intervention and aid hours will grow linearly as more capture is required.

### Custom API integration

Custom API integration opens the door to endless possibilities and triggers in your workflow. Whether it be executing missions when a load cell is triggered, or opening the door to a variety of third-party processing packages to suit your needs, a custom solution can be tailored to suit your needs perfectly. With API access and integration for leading packages such as [Flighthub 2](#), [DJI Terra](#), [Dronedeploy](#), [Pix4D](#), [Agisoft Metashape](#), [Propeller Aero](#) and more, a custom solution can be created to suit almost any need and output.

## 4.2 EXAMPLE INTEGRATION WORKFLOWS

There are many ways to integrate capture, processing and output all into one workflow. To the right is an example of the savings in implementing an automated dock solution. The steps that no longer require human input are highlighted in green below, with semi-automatic tasks highlighted in yellow.

As shown, significant time-savings can be made when implementing a complete dock workflow, with some of the most time-consuming tasks can be automated.

With API integration and automated report generation, alerts can be set to analyse the quality of results and flag to the user whether errors may be present during the mission/processing steps. Depending on the package used, output reports can be generated based on user requirements. This allows for interactive [auto-generated reports](#), mak-

ing everything from stakeholder reporting to volume analysis much easier.

### 4.2.1 DJI Terra integration example

Figure 28 is an example of how to integrate DJI Terra with DJI Flighthub 2 and the Dock. Terra API can also be used for third-party software integration. Flighthub 2 has a feature that allows images to be uploaded after capture to third-party or local solutions as implemented by the user. This allows the user to process and analyse the captured data independent of Flighthub 2 should they decide to. This means that DJI Terra and Flighthub 2 On-Prem can be used locally should it need to, allowing for a more hands-on approach to processing in [user-friendly](#) software environment.

Alternatively, the media could also be imported directly into other automated processing software packages both locally and through the cloud in order to complete the automatic custom solution.

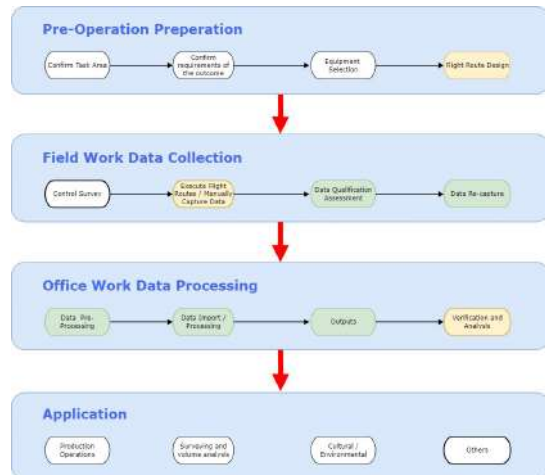


Figure27: Integration workflow example



Figure28: DJI Terra API Service

Source: DJI Terra API

## 4.3 PROCESSING SOFTWARE OPTIONS

There are many processing solutions available. With the implementation of a custom API, a wide range of software solutions can be utilised to generate the outcomes you desire.

From local solutions to cloud-based, there will be a solution that works for you.

### 4.3.1 Cloud-based processing

A cloud-based solution improves sharing functionality and processing speed, as well as ease of use and data storage.

#### **DJI Flighthub 2**

Flighthub 2 is used to control and plan dock missions already, but also has the functionality to process the data captured on the cloud, making it a complete package to suit most needs.

There are also different [security configurations](#), including the default setup for secure capture using US and EU-based AWS (Amazon Web Service) servers. There is the Flighthub Sync package, bypassing Flighthub 2 cloud storage and allowing the user to upload data directly to third-party storage solutions in the cloud. There is the On-Premises version, allowing for Flighthub 2 to be used solely through the local Intranet. Utilising Open API, which is an open platform based on RESTful specifications, developers can interact with third-party cloud platforms too.

Utilising the broad features of Flighthub 2 can greatly streamline the operation and fully utilise the latest features of the drone and dock. In particular, the Onboard Intelligence features of the DJI Dock 3.

#### **Pix4D Cloud**

Pix4D has long been a favourite of land surveyors, with custom API integration and simple incorporation with [Trimble Connect](#), it can connect and adapt

your old workflows to continue to generate the survey outputs required.

Pix4D Cloud Enterprise allows API Access, potentially allowing the user to link and upload data from Flighthub 2 and automatically mark GCPs and process the outputs required by the user.

[Timelines and automatic outputs](#) can be generated to maintain the automatic workflow benefits of the dock solution.

#### **Propeller Aero**

Propeller Aero is a leading UAV software company, based in Sydney, Australia. Having previously partnered with DJI to aid in providing [mining solutions](#), Propeller Aero is a well-trusted solution. By utilising [Aeropoints](#), GCPs can be rapidly deployed in new mission areas and marked with ease. Propeller also allows for external CAD data to be incorporated into cloud view (and mobile too), as well as the usual data-sharing solutions.

#### **Dronedeploy**

Dronedeploy provides an all-in-one cloud-based solution that can incorporate flight planning, data processing and automated reporting all in one package. By integrating planning, capture, upload, processing and analysis all in one solution, [Dronedeploy Dock Automation](#) provides a similar package solution to Flighthub 2, although without current support for the DJI Dock 3. With automatic GCP marking, Dronedeploy has the potential to allow a completely automated workflow.

Dronedeploy also has great support for project sharing, and even a phone app too.

#### **Other**

There are a variety of different software packages available, with more available every year. As drone uptake takes off, so too does the software world. The [DJI Ecosystem for the dock platform](#) maintains a list of officially supported solutions to integrate a Dock into your workflow.

### 4.3.2 Local-based processing

In some cases, a local-based processing and data storage solution may be the answer. This provides peace of mind and added customization to your workflow, and maintains full automation capabilities.

#### **DJI Flighthub 2**

Flighthub 2 On-Prem supports localized mapping, which utilizes the DJI Terra engine to process data locally, without utilizing the cloud.

Flighthub 2 also allows for automated media upload to third-party storage solutions, opening up the processing options to any local processing solution chosen by the user. The only limit is the automation capabilities of the software.

#### **DJI Terra**

Data can of course be imported into DJI Terra easily and effectively. Allowing outputs and familiarity with the package to be maintained.

With automatic GCP marking, there can be up to [94%](#) time-savings by the user during processing. The automatic ground classification and automated output features of Terra are also ideal for a simplified workflow.

#### **Pix4D API**

With Flighthub 2 API access and local storage options, a range of local processing options are available. By utilizing the Pix4D API and, the user can fully utilise the [Pix4dEngine](#) to be integrated seamlessly into the existing workflow. Allowing for an automated workflow, processed both locally and on the cloud.

#### **Agisoft Metashape**

Agisoft Metashape is one of the most popular and widely used photogrammetry processing software packages available. As such, it is very well-supported and familiar to many users. With both Java and Python programming features, Agisoft Metashape can be custom integrated into the workflow, to con-

tinue the automation to the local level. With automatic GCP marking and a range of existing [programming scripts](#) available, Metashape may be the solution that suits best.

## 4.4 COMPUTER VISION AND INTELLIGENCE FEATURES

With the release of the DJI Dock 3 and Matrice 4 series of drones, intelligence features have become commonplace, with simple integration into mission workflow as added to DJI Flighthub 2, as well as post-task detection and identification features.

Custom IFTTT commands can be utilised to allow for a more complete automation solution.

### 4.4.1 Object detection

Object detection is a key feature of the new DJI Dock 3. With built-in detection of Humans, Ground and Marine Vehicles, as well as the ability to upload and verify custom intelligence algorithms to detect a variety of [more specific objects](#).

With these built-in features, a dock solution can be better utilised and triggered based on certain events.

Below are some use-case examples

#### **Blast site security**

Utilising human and vehicle detection, the drone can be used to fly over the danger area of the blast site immediately prior to a blast. A custom notification can occur when a human and/or vehicle is detected and can either notify the pilot or trigger a certain action such as a pre-recorded message and flashing lights. With built-in intelligence identification features, automated monitoring and identification can be achieved with ease.

### Surveying and mapping

Safety and accuracy during flight missions can also be improved by utilising intelligence object detection features. By instructing the drone to stop mapping when humans or vehicles enter the view, the mapping mission can avoid mapping objects that aren't helpful/obstruct terrain

### 4.4.2 Change detection

As part of the DJI Flighthub 2 package, intelligence change detection is also included to automatically identify changes by comparing [repeated waypoint](#) mission capture, as well as [2D model](#) change detection. Enhancing manual analysis and reducing hours worked in manually marking change



Figure29: Image of a construction site

Image Source: EE Group

# 5.0 COMMERCIAL APPLICATIONS AND CUSTOMER CASE STUDIES



## 5.1 COMMERCIAL APPLICATIONS

Companies operating in mining, infrastructure, and large-scale industrial environments should strongly consider incorporating DJI Dock systems into their operations due to the significant productivity and cost-efficiency advantages they offer over traditional manual drone workflows. Unlike conventional drone methods that require an on-site pilot, equipment setup, and manual data handling, the DJI Dock enables fully automatic, scheduled, and on-demand flights with zero touch on-site and in office. This allows operations teams to drastically increase the frequency of data capture, enabling daily volumetric surveys, condition monitoring, and compliance checks without adding headcount or increasing site access risks. The reduction in labour, travel time, and equipment setup translates directly into operational savings and a faster return on investment.

Beyond efficiency, Dock-based operations ensure greater consistency, safety, and scalability. With automated flights executed under strict procedural controls and integrated directly into processing pipelines, the risk of human error is minimized and data quality becomes standardized across shifts and sites. Additionally, by removing the need for personnel to enter hazardous or remote areas, companies significantly reduce safety exposure while maintaining or improving visibility over critical infrastructure and production areas. The scalability of remote operations - where one pilot can manage multiple Docks from a single Remote Operating Centre (ROC) - further unlocks enterprise-wide value, supporting everything from real-time environmental compliance to emergency response with rapid drone deployment.

In Australia, RocketDNA has led the deployment of Dock technology within the Mining industry, demonstrating the transformative potential the technology has, across a variety of mining workflows. This section outlines key commercial applications, supported by case studies, to showcase how RocketDNA has utilised DJI's Dock platform to deliver value in the field.



Figure30: DJI Dock incorporated onto a read-to-deploy skid format, minimising installation time and construction setup required for risk-averse environments (Source: [RocketDNA](#))

## 5.2 TYPICAL WORKFLOW FOR AUTOMATED MINING APPLICATIONS

The end-to-end value of a DJI Dock programme is realised only when every phase, from mission design to data delivery, is orchestrated as a seamless, repeatable workflow. Below is a five-phase framework that RocketDNA uses to deploy and manage automated mining applications. Each phase is supported by commercial off-the-shelf (COTS) tools (e.g., DJI FlightHub 2, Cloud API) and proven operational practices that meet CASA BVLOS requirements.

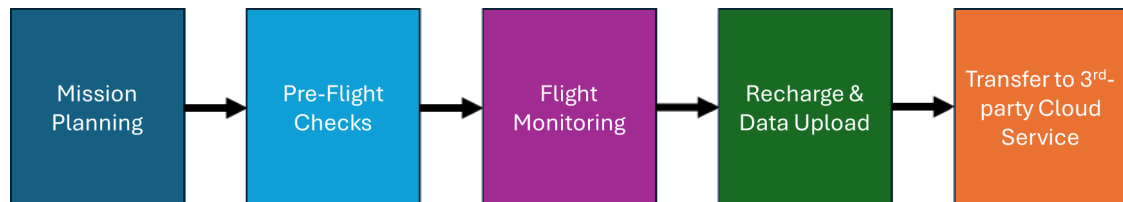


Figure31: Workflow for Automated Mining Applications

### Phase 1 – Mission Planning

Mission Planning is the foundation of every automatic programme: a well-designed route and risk assessment ensure the drone captures the right data while avoiding hazards and regulatory infringements. By locking repetitive survey paths and “no-fly” polygons into FlightHub 2 at the outset, sites minimise ad-hoc deviations, shorten approval cycles, and extend the life of both drone hardware and batteries. Careful planning also underpins sustainability—optimising flight distance and altitude reduces unnecessary energy draw and keeps the dock’s utilisation predictable for off-grid power systems.

- Consult ops & technical teams to define repetitive vs. ad-hoc missions (e.g., daily haul-road scans vs. on-demand post-blast flights).
- Conduct an on-site risk assessment to log obstacles such as pit ramps, communication towers and overhead HV lines.
- Create No-Fly Zones (NFZs) and altitude fences in FlightHub 2 so automatic flights cannot penetrate blast exclusion zones or plant areas.

### Phase 2 – Pre-Flight Checks

Even the most sophisticated automation still requires a formal go/no-go gate. Pre-Flight Checks validate that airspace is clear, stakeholders are briefed, and safety layers (Detect-and-Avoid, ADS-B, CCTV) are active. Completing this remote “sterile-cockpit” checklist ensures compliance with CASA BVLOS rules, while preventing last-minute scrubs that waste battery cycles or create data gaps. Robust pre-flight discipline is therefore critical to maintaining a high sortie success rate and building regulator trust in sustainable one-to-many operations.

- Verify regulatory approvals (ReOC, RePL-BVLOS, SORA/SAIL-2) and confirm risk controls.
- Engage local stakeholders (dispatch, blast crew, LV traffic) and issue site alerts.

- Activate layered Detect-and-Avoid sensors—surface radar, ADS-B receivers—to provide real-time airspace awareness to the Remote Operating Centre (ROC).
- Use VHF radio and CCTV feeds to verify flight path and clear ground personnel.

### **Phase 3 – Flight Monitoring**

Autonomy does not eliminate accountability: during every sortie an RPIC must supervise telemetry, air traffic calls, and ground conditions in real time. Continuous monitoring protects against dynamic risks—rogue helicopters, sudden weather shifts, or site vehicles straying into the mission area—and provides an immediate escalation path via Emergency Response Procedures. By combining live dashboards with rapid manual-over-ride capability, operators achieve the dual goal of hands-off efficiency and zero-compromise safety.

- RPIC monitors telemetry, ADS-B overlays and CTAF calls for de-confliction during each sortie.
- Follow Emergency Response Procedures (pause, manual control, RTH) if intrusions occur.
- ROC consoles display multi-sensor data (FlightHub 2 live map, radar, CCTV) so operators can act within seconds.

### **Phase 4 – Recharge and Data Upload**

The dock's recharge-and-upload cycle is where automation delivers its greatest sustainability dividend. Non-contact induction charging removes manual battery swaps, reducing e-waste and human exposure, while intelligent power management tops batteries only to optimal levels, extending their usable life. Simultaneous data off-load and health diagnostics close the loop—each landing generates a maintenance record and fresh dataset without touching the aircraft, enabling 24 × 7 readiness with minimal on-site labour.

- On touchdown, the DJI Dock 2 initiates sealed contact-pad charging; batteries reach 90 % in ~30 minutes.
- Media off-load begins automatically to on-prem or cloud storage.
- RPIC completes post-flight checks (battery health, mission log) before scheduling the next task.

### **Phase 5 – Transfer to 3rd-party Cloud Service**

Automated data capture has limited value if insights are trapped on an SD card. Seamless transfer to cloud photogrammetry or AI platforms turns raw pixels into georeferenced models, change-detection dashboards, and blast-movement predictions, often within minutes of landing. This final hand-off eliminates manual file handling, accelerates decision-making, and ensures that every gigabyte of imagery contributes to tangible ROI and ESG targets, such as reduced rework, lower fuel burn, and smarter reagent use at the mill.

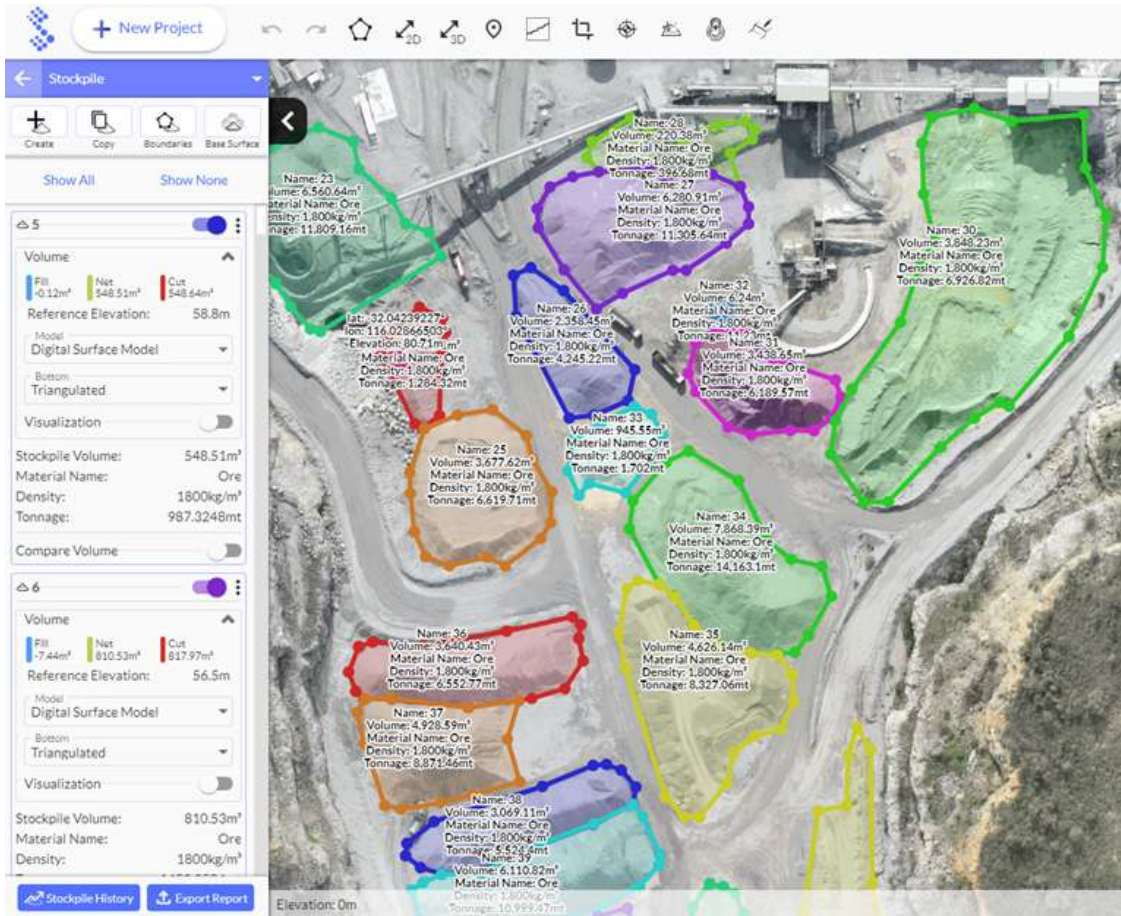


Figure32: Example of third-party software for automated reporting

### 5.3 CASE STUDY: ROCKETDNA DOCK DEPLOYMENT AT RIO TINTO'S GUDAI-DARRI MINE

**Client:** Rio Tinto

**Project Focus:** Autonomous Drone-in-a-Box (xBot®) Pilot Deployment

**Location:** Gudai-Darri Iron Ore Mine, Pilbara, Western Australia

**Deployment Date:** Mid-2024

#### Project Overview

Rio Tinto's Gudai-Darri mine, recognized as its most technologically advanced iron ore operation, sought to enhance its automation capabilities. In late 2024, RocketDNA introduced its xBot® drone-in-a-box solution to the site. This pilot aimed to evaluate the resilience and efficiency of drone docking systems within the challenging mining environment of the Pilbara region, characterized by extreme temperatures, magnetic red dust, and cyclone-prone conditions.

### Implementation

The xBot® system, specifically the SurveyBot variant, operates automatically, executing pre-programmed and ad-hoc missions. Each drone flight is remotely monitored by pilots based in Perth and Adelaide via Starlink connectivity. After completing its mission, the drone returns to its docking station for recharging, readying itself for subsequent tasks.

### Use Cases

At Gudai-Darri, the SurveyBot has been instrumental in:

- 3D survey mapping and updating pit models
- Capturing panoramic views of the pit and surrounding areas
- Conducting video inspections
- Post-blast data collection for drill and blast operations
- Inspecting berms and pit walls

These applications have streamlined daily aerial data capture for the site's Survey and Mining Technical teams.

### Outcomes

The integration of the xBot® system has yielded several benefits:

- **Enhanced Safety:** By automating aerial data collection, personnel exposure to hazardous pit environments has been reduced.
- **Operational Efficiency:** The automatic nature of the drones allows for consistent and frequent data collection without the need for on-site pilots.
- **Data-Driven Decision Making:** Timely and accurate data supports informed decisions, optimizing mining operations.

This deployment underscores the potential of automatic drone technology in modernizing mining operations, aligning with Rio Tinto's commitment to innovation and safety.

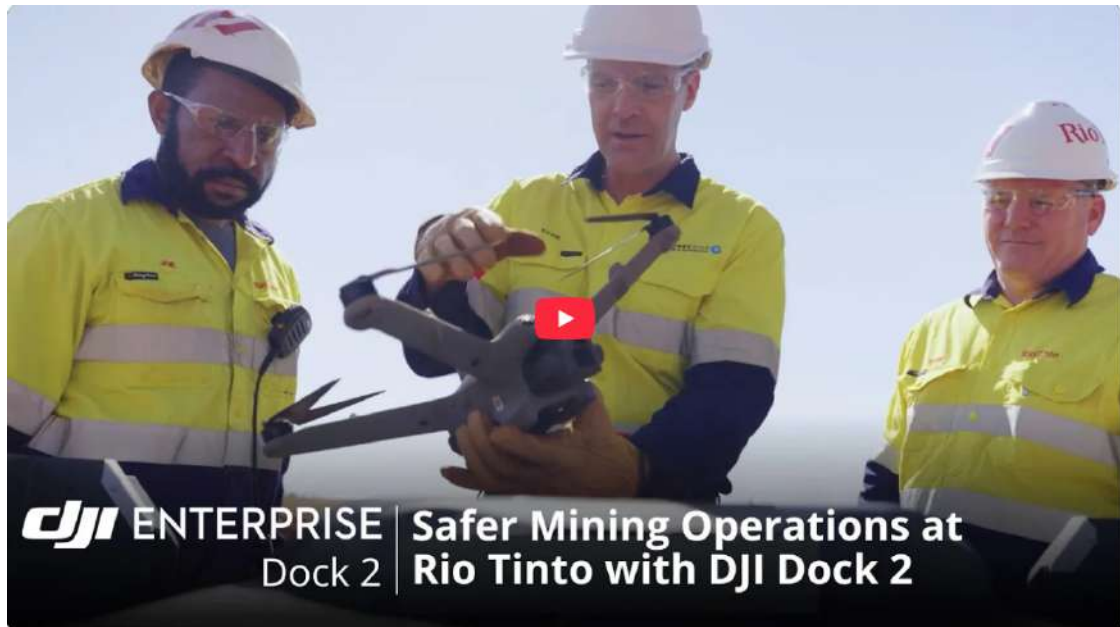


Figure33: Watch the DJI Dock in action on DJI's YouTube channel here.

## 5.4 CASE STUDY: ENHANCING ORE RECOVERY AT NORTON GOLD FIELDS WITH DOCK-BASED POST-BLAST ANALYSIS

 **Client:** Norton Gold Fields (a subsidiary of Zijin Mining Group)

 **Location:** Paddington Operations, Kalgoorlie, WA

 **Project Focus:** Post-Blast Muckpile Analysis for Optimized Grade Control

 **Deployment Date:** 2020s

### Project Overview

Norton Gold Fields aimed to improve ore recovery and reduce processing costs by integrating DJI's Dock technology with advanced blast movement modeling. The initiative focused on analyzing post-blast muckpiles to enhance grade control and minimize ore dilution.

### Implementation

After each blast event, the DJI Dock conducted high-resolution aerial surveys of the resulting muckpiles. The collected data was processed using photogrammetry to create detailed 3D models of the muckpile topography. These models were then imported into a 3rd-party intelligence-driven Muck Pile Modelling software, which utilizes sophisticated algorithms to simulate blast-induced rock movement and predict the post-blast location of ore and waste materials.

### Outcomes

- **Improved Grade Control:** By accurately modeling blast movement, Norton Gold Fields could delineate ore and waste boundaries more precisely, leading to better-informed digging strategies.
- **Reduced Ore Dilution:** The enhanced accuracy in identifying ore zones within the muckpile minimized the inclusion of waste material during excavation, thereby reducing ore dilution.
- **Lower Processing Costs:** With a higher concentration of ore being sent to the processing plant, the company experienced decreased consumption of chemicals and energy, leading to cost savings.

### Conclusion

The integration of drone-based surveys with muckpile modeling at Norton Gold Fields' Paddington Operations has proven to be a successful strategy for optimizing ore recovery and reducing operational costs. This approach exemplifies the benefits of combining Dock-based drone technology with 3rd-party tools to help speed up the decision making process and increase overall productivity.



Figure34: Ore Spotting using real-time intelligent analysis (Image Source: RocketDNA)

## 6. ACKNOWLEDGEMENTS

DJI would like to thank the teams at both EE Group Australia, and RocketDNA Ltd, for their contributions to this report.

## 7. DEFINITIONS

- AI: Artificial Intelligence
- ADS-B: Automatic Dependent Surveillance-Broadcast
- API: Application Programming Interface
- AWS: Amazon Web Services
- BARS: Basic Aviation Risk Standard
- BMO: BARS Member Organisations
- BVLOS: Beyond Visual Line-of-Sight
- CAD: Computer Aided Design
- CASA: Civil Aviation Safety Authority (Australia)
- CCTV: Closed Circuit Television
- COTS: Commercial off-the-shelf
- CRM: Crew Resource Management
- CTAF: Common Traffic Advisory Frequency
- DIAB: Drone-in-a-box
- DJI: Da-Jiang Innovations
- DSM: Digital Surface Model
- DTM: Digital Terrain Model
- ESG: Environmental, Social and Governance
- FAA: Federal Aviation Administration (United States of America)
- FH2: DJI Flighthub 2
- FIFO: Fly-in Flyout
- GCP: Ground Control Point
- HF: Human Factors
- HMI: Human-Machine Interface
- ICAO: International Civil Aviation Organization
- IFR: Instrument Flight Rules
- IFTT: If This Than That
- IP: Ingress Protection
- IREX: Instrument Rating Examination
- JARUS: Joint Authorities for Rulemaking on Uncrewed Systems
- LV: Light Vehicle
- M3E: DJI Mavic 3 Enterprise
- M3T: DJI Mavic 3 Thermal
- M4D: DJI Matrice 4 Dock
- M4E: DJI Matrice 4 Enterprise
- M4T: DJI Matrice 4 Thermal
- M4TD: DJI Matrice 4 Thermal Dock
- MFA: Multi Factor Authentication
- NFZ: No-Fly Zones
- OCTA: Outside Controlled Airspace
- ROC: Remote Operations Centre
- ROI: Return on Investment
- ROIP: Radio over INternet Protocol
- RPIC: Remote Pilot in Command
- SAIL: Specific Assurance and Integrity Level
- SLA: Site Location Assessment
- SMS: Safety Management System
- SORA: Specific Operation Risk Assessment
- TSF: Tailings Storage Facility
- UAS: Uncrewed Aircraft System
- UAV: Uncrewed Aerial Vehicle
- UPS: Uninterruptible Power Supply
- VHF: Very High Frequency
- VLOS: Visual Line-of-Sight

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