Remote charging unit Phase II

PROGRAMME	Longevity of Current Mining (LoCM)
MILESTONE	LoCM22WP2-6 Close-out report

UNDERGROUND TESTING DOCUMENTATION GUIDELINE – TR6

PROGRAMME MANAGER	Martin Pretorius	**DATE**	25/07/2023
RESEARCH AGENCY	University of Pretoria		
PROJECT LEAD	Wolter de Graaf	**PROJECT TEAM**	Ruan Els
			Thomas Oates
			Glenn Guthrie
			Wietsche Penny

REF NO:	LoCM22WP2-6GLv4

INDEX OF CONTRACTOR DOCUMENTS

REF NO:	MSV-RCU-INDEX	INCEPTION DATE:	2023
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ROYAL BAFOKENG PLATINUM
MORE THAN MINING

FILE INDEX

	DESCRIPTION	RESPONSIBLE PERSON SIGN ON COMPLETION	STATUS
	INITIATOR TO ENSURE THAT THE FOLLOWING PRE-REQUISITES ARE MET:		
1	INDEX OF CONTRACTOR DOCUMENTS		
2	MEDICAL CERTIFICATES		
3	SCOPE OF WORK AND RISK AREAS DEFINED		
4	RBPLat HEALTH AND SAFETY POLICY		
5	ISSUE-BASED RISK ASSESSMENT APPROVED BY RBPLAT RISK MANAGER Mandela-Test-UG-0001 - Remote Charging Unit	Jacques Markram	Signed
6	LIST OF PEOPLE THAT WILL BE ON SITE		
7	COMPETENCY CERTIFICATES/DECLARATION OF COMPETENCE (SPECIFIC TASK) SIGNED BY CONTACTOR REPRESENTATIVE		
8	SAFETY TRAINING RECORDS – SUPERVISORS, LEGAL LIABILITY ETC		
9	YOUR OPERATING PROCEDURES (SWP OR SOP)		
10	RBPLATS REPORTING AND INVESTIGATION OF ACCIDENTS POLICY PROVIDED		
11	RELEVANT CODE OF PRACTICES		
12	PROOF OF TRAINING / COMPETENCIES CHECKED		
13	DRIVER/OPERATOR LICENSING, AUTHORISATION AND PROOF OF COMPETENCY COMPLETE (SIGNED BY RBPLAT ENGINEER)		
14	TOOLS AND EQUIPMENT REGISTER		
15	SUITABLE PERSONAL PROTECTIVE EQUIPMENT ISSUED – LIST OF PPE		
16	FIRST AID EQUIPMENT IF REQUIRED		

REF NO:	**MSV-RCU-INDEX**	**INCEPTION DATE:**	**2023**
VERSION NO:	**1.0**	**LAST REVISION/REVISED DATE:**	**2023**

17	FIRE EXTINGUISHERS IF REQUIRED SPECIFIC TYPE		
18	PRE-WORK COMMENCEMENT MEETING AND DOCUMENTATION		
19	SITE INSPECTION DOCUMENTATION Mandela RCU Infrastructure Checklist V1		
20	HAZARDOUS SUBSTANCES - MSDS		
21	LEGAL APPOINTMENT BY THE RBPLAT 3.1a AND 4.1		
22	INDUCTION TRAINING		

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1 Scope

The details and documents contained within this safety file detail the information specific to the short term testing of a prototype remote charging unit at Maseve North Shaft. The prototype unit was developed under the SAMERDI research centre at the University of Pretoria under the Mandela Mining Precinct. The remote charging unit is a proof-of-concept prototype in the journey to developing a remotely operable explosives charging unit for underground mining in South Africa.

The prototype remote charging (**Figure 1**) unit to be tested at Maseve North Mine is the second iteration design of the remote charging unit and in its current configuration will not be charging holes with explosives. The objective of the development and testing of the remote charging unit is to prove it is feasible to use a remotely operated, battery powered, device to insert a mock charging lance into drilled holes underground.

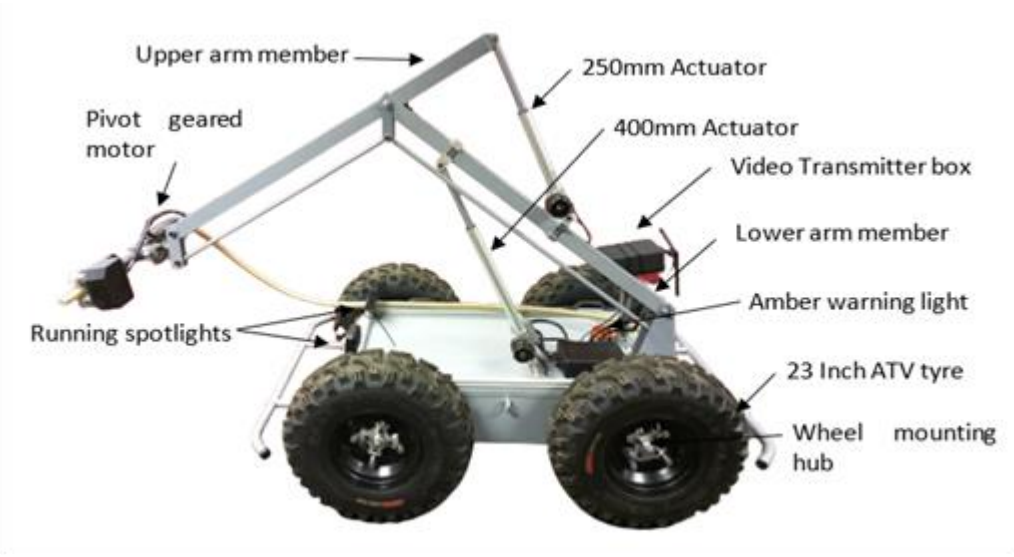

Figure 1: Schematic of the Remote Charging Unit

2 Risk Areas

A workplace risk assessment and control analysis was done and approved by RBPlats (Mandela-Test-UG-0001). The risk areas defined were based on the process map of activities involved in the testing of the remote charging unit. Based on this the risk areas involved are:

- Area where the remote charging unit is loaded/offloaded onto/from a mine utility vehicle on surface.
- Area where the remote charging unit is loaded/offloaded onto/from the mine utility vehicle underground.
- Test area underground where the remote charging unit will be filmed and tested.

ROYAL BAFOKENG PLATINUM
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Safety, Health & Environmental Management at Styldrift and Maseve Mine

OUR VISION

At Styldrift and Maseve Mine our vision is to seek and deliver the "good from mining". To do that we will exhibit sustainable financial returns to our shareholders, through operational excellence. We will pursue carefully considered PGM growth opportunities, while fulfilling our responsibility to care for our employees as well as the communities and environment in which we carry out our business.

OUR MISSION - SAFETY, HEALTH AND ENVIRONMENT (SHE)

Our SHE mission is to achieve a resilience state of mind where we will adapt to changing conditions, respond to emergencies rapidly and recover from disruptions quickly. Styldrift and Maseve Mine subscribes to the principle of Zero Harm and agrees that every mineworker must go home unharmed every day.

SAFETY	HEALTH	ENVIRONMENT
All injuries are preventable.	All occupational illnesses are preventable.	All environmental incidents are preventable.
We will learn from unwanted events and put systems in place to prevent recurrence. Note: In terms of the MHSA contractors are employees.	Our health monitoring program will allow for early discovery of potential occupational illness situations. We will address it by a holistic process of continuous sustainable health improvement interventions focusing on promotive, preventive, curative and rehabilitative practices.	All the necessary steps will be taken to design for minimum environmental impact. If environmental impacts or incidents do occur, we will put systems in place to prevent recurrence. Styldrift and Maseve Mine will do ongoing monitoring , evaluation and independent audits to guide our future plans.
Our safety standards and procedures are non-negotiable and must be implemented as required by all employees of Styldrift and Maseve Mine.	At Styldrift and Maseve Mine we will consider all related legislation and some best practice rules as the minimum requirements when developing health standards. All approved health standards must be consistently applied at all times.	Approved Environmental Management Performance standards and procedures shall be applied throughout Styldrift and Maseve Mine as a minimum requirement. This will be non-negotiable to achieve continuous improvement.

OUR SHE POLICY

This SHE Policy must be read together with the HIV/Aids Policy, TB Policy and Sustainable Development Policy.
We understand that our operations have the potential to negatively affect the Health and Safety of people and can cause damage to the Environment.
As an underground mining operation with an onsite concentrators at BRPM and Maseve, our focus is on, but not limited to the following significant SHE risks:

SAFETY	HEALTH	ENVIRONMENTAL	CLIMATE CHANGE
Fall of Ground Management	HIV/AIDS	Water Pollution	Greenhouse gas emission management and adaptation
Trackless operations	Hearing Impairment	Waste Handling	Responsible management of natural resources (air, water & land)
Lifting and Rigging	TB	Disturbing Natural Resources	Energy management and savings
Slip & fall and cage related activities	Non-Communicable Diseases	Biodiversity Management	
Equipment / Material handling	Substance Abuse	Dust	
	COVID-19		

In order to manage these risks, we are committed to apply our SHE model for assessing new onsite initiatives and activities as well as assessing failure to the alignment with our SHE Strategy:
Our SHE Management comprised of the following elements:

1. Styldrift Mine and Maseve Mine have drafted this SHE Policy in line with the Mine Health and Safety Act requirements and has implemented ISO 45001 and ISO 14001 standards as the SHE management systems at all operational sites.
2. **Leadership and employee's participation:**
   - Styldrift and Maseve Management is committed to proactive leadership in relation to SHE management systems .
   - Management will continually improve the SHE Management System and maintain ISO 45001 and ISO 14001 certification at all operational sites.
   - In our rules we will ensure that accountability for SHE is placed on the senior management level.
   - At Styldrift and Maseve compliance to SHE standards and procedures takes priority over other business imperatives.
   - We will protect employees from reprisals or victimization when they have reported incidents , hazards, risks and opportunities for improvements.
3. **Roles , Responsibilities and Authority :**
   - Top management shall demonstrate its commitment to ensure effective consultation and participation of employees at all levels and functions in the organization.
   - Top Management will define roles, allocate responsibilities and hold people accountable for the effective implementation of the SHE management system.
   - Management shall ensure consultation and participation with employees or employee representatives at all applicable levels and functions for the development ,planning , implementation ,performance evaluations and actions required to fully implement the SHE management system.
4. **Consultation and participation of employees:**
   - Styldrift and Maseve mine has established and implemented process to ensure effective consultation and participation of employees at all levels and functions in the organization.
   - The different roles ,responsibilities , accountabilities and authorities of all roles players shall be documented and communicated on time.
5. **Planning: Hazard identification, Risk assessment and determining controls:**
   - We will identify the safety and health hazards at Styldrift and Maseve mine, assess the associated risks, prioritize the significant risks and then effectively manage these Safety and Health risks.
   - For the Environment we will identify the significant environmental aspects, both periodically and over the mine's life cycle, assess the associated impacts, prioritize the impacts and effectively manage it
   - We will further assess our vulnerability to climate change risks on an ongoing basis through appropriate specialist methodologies and put plans in place to minimize the effect.
   - We will make use of opportunities to enhance our SHE standards as required by the relevant laws, other legal requirements and best practices. All applicable legal , regulatory and other SHE requirements will be identified , documented and maintained in a database that is accessible to all relevant employees.
   - We determine and take into account how these legal and other requirements apply to the organization when established , implementing ,maintaining and continually improving our SHE management systems.
   - Styldrift and Maseve mine has established , implemented and shall maintain the process to determine and have access to update legal and other requirements that are applicable to its SHE hazards and risks including environmental aspects and impacts.
   - We will develop and apply our SHE standards as required by the relevant laws, other legal requirements and best practices. All applicable legal, regulatory and other SHE requirements will be identified , documented and maintained in a database that is accessible to all relevant employees.
   - We will determine and take into account how these legal and other requirements apply to the organization when established , implemented, maintaining and continually improving our SHE management systems.
   - We will keep on improving our emergency response plans and integrate it with other business process.
   - We will evaluate the effectiveness of these plans regularly.
   - The hierarchy of control will be applied in the SHE management system, where ALARP will be the final outcome in all risk decisions.
6. **Objectives and programme(s):**
   - We will set appropriate and measurable SHE targets, objectives and goals with performance indicators that we can measure our performance against regularly.
   - The SHE objectives and targets forms an integrated part of our overall business planning process. It is applied throughout our operation to ensure continuous improvement.
7. **Competence :**
   - We will ensure that all employees are trained and assessed for competence before they are instructed to perform their tasks in line with their job function.
   - Nobody will do a job that s/he is not trained to do. Management will develop dynamic training material that is improved and updated regularly to ensure continuous enhancement of the competence of all employees.
8. **Awareness :**
   - We will promote and create awareness of the significant Safety and Health hazards and risks that the employees can be exposed to and also what the community can expect as Environmental impacts of our activities.
9. **Communication:**
   - RBPlat has established and maintained process that are needed for internal and external communications of the relevant SHE management system issues. These include interested parties.
   - The proactive involvement, communication and consultation with all appropriate employees and stakeholders in matters of SHE management system is imperative and is actively promoted.
   - We will take into account the diversity aspects (e.g. gender , language , culture , literacy and disability when considering communication needs).
   - We will report our SHE performance annually to stakeholders through our Integrated Annual Report. Regular communication is maintained through other channels of communication with the relevant stakeholders, including communication with local communities and persons that can be affected by our activities. The organization shall maintain and retain the relevant documented information of the SHE communication and engage with local communities and persons that can be affected by our activities.
10. **Documentation:**
    - All the relevant SHE information documentation will have reference numbers that can be easily identified and traced when access to information is required.
    - An electronic database will be maintained where documents shall be controlled with all the relevant, SHE information.
    - The system will be readily available when access is required.
    - Documented information of external origin necessary for planning and operation of the RBPlat SHE management systems shall be identified . where appropriate it will be loaded in the data base.
11. **Operational control:**
    - No entry is allowed into an unsafe working place. Employees are to withdraw when a working place become unsafe.
    - No unsafe act will be allowed.
    - We will implement effective control measures to manage the identified hazards and associated risks to safety and health that can result from our activities or work done by contractor working for or on behalf of Styldrift and Maseve Mine.
    - Any change on operations, processes, personnel or activities will be identified and managed to actively address it on time to minimize the risk / impact it can have.
    - The prevention of unplanned environmental damage and pollution arising from our operations and activities will be through the implementation of effective control measures to manage environmental aspects.
    - Procument of products or services rendered within our operations by contractors will be controlled by our SHE processes.
12. **Emergency preparedness and response:**
    - Effective and efficient SHE emergency preparedness systems will be in place to respond to any emergency with the correct assistance on time.
    - We will ensure that we have obtained commitments from outside parties to respond appropriately and on time in the case of a major emergency or crisis situation.
13. **Performance evaluation:**
    - All employees, contractors and business partners will go through a strict evaluation process where they must comply with our requirements and commit to undertake their activities in accordance with our standards, legal, regulatory and other SHE specifications as prescribed by Styldrift and Maseve Mine in our contractor management policy.
14. **Internal Audit :**
    - Our SHE performance, system effectiveness and equipment applicability will be monitored and audited regularly to identify trends for review and make revisions where required.
15. **Management review:**
    - Progress and compliance on SHE system will be measured and assessed regularly. It will be independently assured at least annually to determine our compliance to the SHE requirements and achievement of targets.
    - We will establish the ongoing applicability of the SHE requirements and relevance of our SHE system, to suit our overall targets against the business sustainability strategy.
16. **Improvements:**
    - Reporting and recording of all SHE incidents/nonconformance and accidents, including near hits is compulsory for all employees including contractors through our electronic SHE data base system(Silo).
    - All reported events will be investigated and analyzed to determine the root causes so that the corrective action and preventative measures can be taken.
    - Corrective and preventive actions will be developed and implemented to closed out the unwanted events identified.
    - The learning points will be shared to prevent a repeat.
17. **Continual Improvements:**
    - We shall continually improve the suitability , adequacy and effectiveness of the SHE management system

This policy will be reviewed at appropriate intervals and revised where necessary to keep it current. This policy shall be available to the public and all interested parties upon request.

Grant Magano (Mine Manager) (Chairman H&S Committee) Representative: Organized Labour

Revision No: 15.0
Dated: 14 March 2023

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ROYAL BAFOKENG PLATINUM
MORE THAN MINING

Name & Surname	ID No	Contact details	Occupation & Company	Signature

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

REMOTE CHARGING UNIT – LOCM22WP2

Competency Declaration Letter

University of Pretoria

ENTERPRISES
University of Pretoria

MANDELA MINING PRECINCT
MINDS FOR MINES

Tuesday, 09 May 2023

To whom it may concern

This letter serves to certify the following individuals as competent in operating the Remote Charging Unit (RCU) based on previous operating experience:

1. **Alan Glenn Guthrie** (8905185250083) – Mechanical Engineer: **+/- 20 hours** RCU operating experience
2. **Wietsche Clement William Penny** (9008035531085) – Mechanical Engineer: **+/- 20 hours** RCU operating experience
3. **Ruan Pieter Els** (9510075013085) – Mining Engineer: **+/- 4 hours** RCU operating experience
4. **Thomas Edward Oates** (9509055070081) – Mining Engineer: **+/- 4 hours** RCU operating experience

Role	Name	Signature	Date
1) Project Lead	Wolter de Graaf		5 May 2023
2) Programme Manager	Martin Pretorius		5 May 2023
3) Head of Department or Business Unit	Ronny Webber-Youngman		5 May 2023

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REMOTE CHARGING UNIT – LOCM22WP2

Technical Readiness Level and Training

University of Pretoria

ENTERPRISES
University of Pretoria

MANDELA MINING PRECINCT
MINDS FOR MINES

Tuesday, 09 May 2023

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION AND PROJECT BACKGROUND

This report aims to discuss the Technical Readiness Level (TRL) of the prototype Remote Charging Unit (RCU) to be tested in the underground environment and the operator training relating to this unit. This is to supplement the documentation and requirements set out in the RB Plat Maseve Testing of new equipment Procedure document (**Reference no: MSV-ALL-MNG-PRO-M 1094, ver 1.0**)

As part of the Longevity of Current Mines (LoCM) programme, this project is seeking the opportunity to improve the safety of personnel being exposed in the high-risk areas. The project will demonstrate the capabilities of the remote charging system in the underground mining environment which will remove the explosives loading personnel from the high-risk area. This study will demonstrate the remote charging capability by conducting underground trials of the rugged RCU. The trials are aimed to demonstrate the capability of the unit to mock load blast holes to simulate explosive charging. The lance will be inserted into a pre-drilled hole and pushed to the toe of the hole and then retracted. After simulating charging, the operator will move the unit to the next hole to be "charged." The operator will be located at a safe distance under well supported hanging wall and will be able to see the position of the blast hole on a small monitor.

Figure 1 depicts a descriptive image of the assembled RCU. The descriptions indicate the specifications of the components that form part of the actuation system of the RCU. A list of all the electronic components used is shown in **Table 3** (see **APPENDIX**).

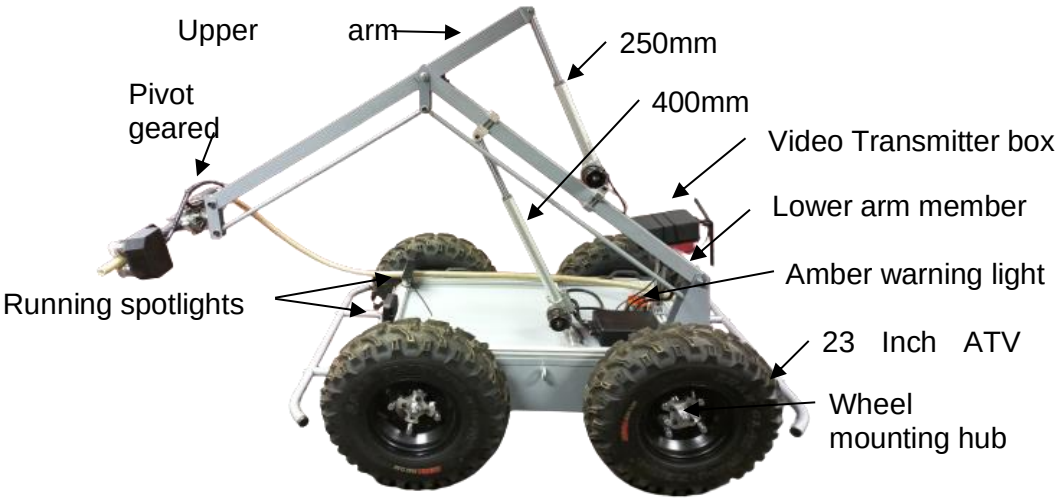

Figure 1. Schematic of the RCU prototype 2 (Guthrie, et al., 2023)

The remote-control system (**Figure 2**) consists of a commercial 2.4GHz radio control transmitter (FrSky Taranis x9D Plus 2019) and a receiver (FrSky X8R). The system utilizes frequency hopping to avoid interference from other 2.4GHz sources like Wi-Fi. The system can communicate over a distance exceeding 100m with line of sight. The transmitter is powered by a lithium-ion battery, and the receiver is powered by the 5V supply from the main control board (Guthrie, et al., 2023).

All radio frequency (RF) components used are off-the-shelf products and are approved by the Independent Communications Authority of South Africa (ICASA) requirements for RF equipment.

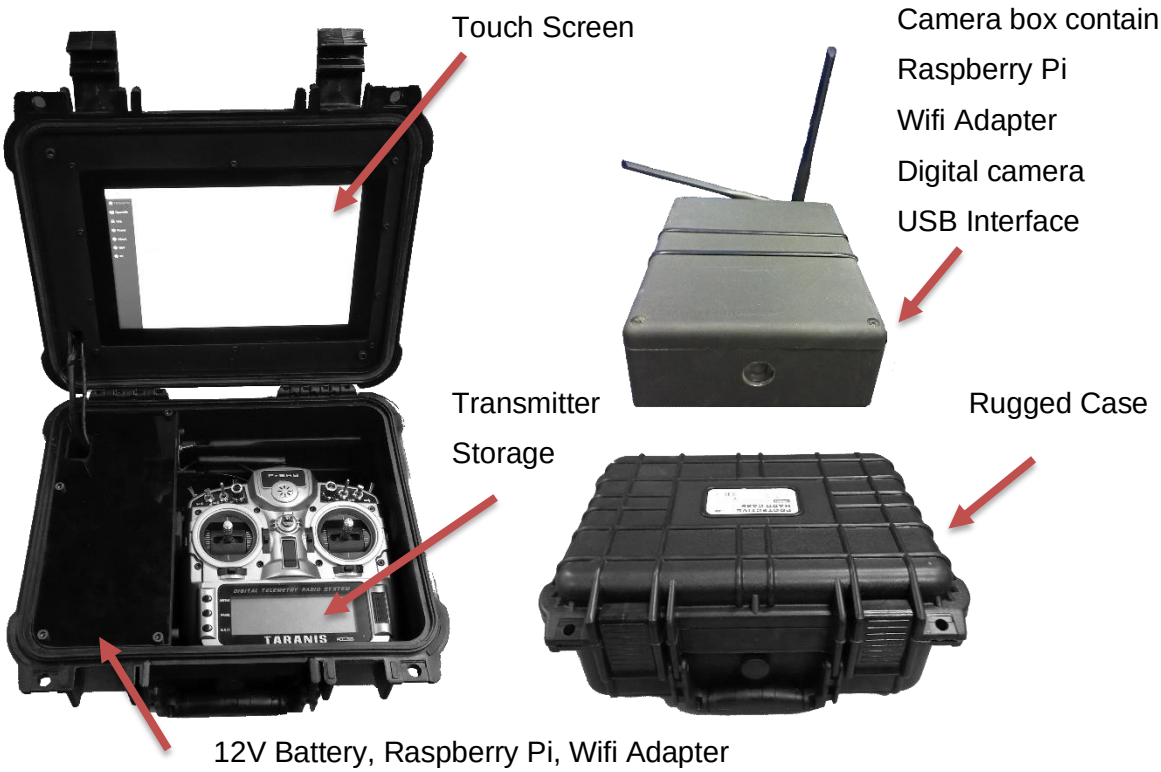

Figure 2. RCU remote control system components (Guthrie, et al., 2023)

The mobile unit is mounted with a box that contains a Raspberry Pi, a Wi-Fi adapter, and a digital camera. The camera is used to provide the operator with a view ahead while manoeuvring the mobile unit. The computer also has a secondary USB camera that captures the view from the charging mechanism. The video is streamed from this computer to a second Raspberry Pi computer using a 5.8GHz communication link (Guthrie, et al., 2023).

2. RCU SAFETY CONSIDERATIONS

The various hazards associated to the RCU were identified and evaluated in the RBPlat approved Risk Assessment (**Approval Number - Mandela-Test-UG-0001 - Remote Charging Unit**). The RCU is fitted with two emergency cut-off switches, located in the front and back of the RCU as indicated in the figures below. These switches cut power the motors and completely shuts down the unit. This is to be used in the event of the unit malfunctioning or other relevant emergencies.

Figure 3. Emergency cut-off switch (Back of RCU) (Els, et al., 2023)

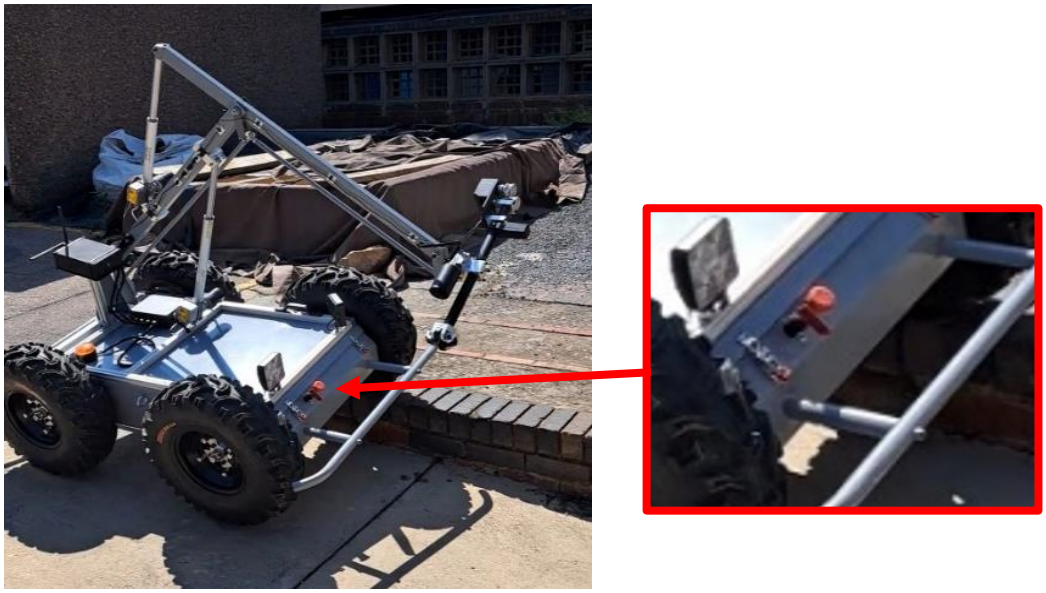

Figure 4. Emergency cut-off switch (Front of RCU) (Els, et al., 2023)

A 10 m track was marked between orange cones as indicated in the images below (**Figure 5**). This was done to calculate the speed of the unit and to evaluate the braking capability of the unit. **Figure 6** depicts the various stages of the speed and brake test conducted. From the last photo it is evident that the unit came to a standstill immediately. The average speed of the unit was calculated at 5 km/h. The speed of the unit is limited through the software and not the motor capacity. The manageable speed and instant braking capability is a good indicator for safety, especially for collision avoidance. Braking is achieved when the operator releases the accelerator control on the remote. The unit does not have brakes on its wheels and therefore does not stop like conventional vehicles. The unit is programmed to automatically lower the power to the motors as the acceleration button on the remote is disengaged, effectively bringing the wheels to a stop. This is why the unit comes to an immediate stand still. There is therefore no risk of the unit running away due to a braking system failure. The motors have a very stiff gearing system, therefore in the event of a motor failing the unit will still not run away (Els, et al., 2023).

Figure 5. Set-up of a 10 m track to test speed and braking of the (Els, et al., 2023)

Figure 6. Speed and brake test (Els, et al., 2023)

Another safety consideration for underground is the light and visibility of the unit underground. According to the Mine Health and Safety Act (Act 29 of 1996), the lighting requirement for self-propelled mobile machines are no less than 10 lux at a distance of 20m in the direction of travel (Mine Health and Safety Council, 1996). The unit is fitted with two 15W LED Spotlights (9-32VDC, IP67, ACDC) which are 1350 Lumen per light at a beam angle of 30°, providing 31.5 lux at 20m in the direction of travel and therefore within the lighting requirements for the underground environment. Images of the low light testing is shown in **Figure 7**. The unit is also fitted with a pulsing strobe light (**Figure 8**) to assist in indicating unit location and proximity for safety purposes.

Figure 7. Low light testing of RCU (Left: RCU, right: Operator video feedback) (Els, et al., 2023)

Figure 8. Image of pulsing strobe light on RCU (Els, et al., 2023)

3. REMOTE CHARGING UNIT TECHNICAL READINESS LEVEL

The TRLs were conceived by NASA and their nine-level scale is now widely accepted for technology development projects. TRLs are used to classify technology maturity moving up a scale from TRL1 (initiation of research) to TRL9 (commercialisation) with increasing technology maturity (Univetsity of Cape Town, 2023).

Research Contracts and Innovation (RC&I) of the University of Cape Town (UCT) has developed a table (**Figure 9**) providing the definitions of technology maturity at each TRL. This table will be used to define the TRL of the RCU.

<table>
<tr><th>Level</th><th>TRL 1</th><th>TRL 2</th><th>TRL 3</th><th>TRL 4</th><th>TRL 5</th><th>TRL 6</th><th>TRL 7</th><th>TRL 8</th><th>TRL 9</th></tr>
<tr><td rowspan="3">Science & Engineering</td><td rowspan="3">Basic Idea</td><td rowspan="3">Concept Developed</td><td rowspan="3">Experimental Proof of Concept</td><td rowspan="2">Lab Demonstration</td><td rowspan="2">Lab scale validation (early prototype)</td><td rowspan="2">Prototype demonstration</td><td>Capability validated on economic runs</td><td>Capability validated over range of parts</td><td>Capability validated on full range of parts over long periods</td></tr>
<tr><td>Pilot system demonstrated</td><td>System incorporated in commercial design</td><td>Proven system ready for full deployment</td></tr>
<tr><td>Component and/or system validation in laboratory environment</td><td>Laboratory scale, similar system validation in relevant environment</td><td>Engineering/pilot-scale, similar (prototypical) system validation in relevant environment</td><td>Full-scale, similar (prototypical) system demonstrated in relevant environment</td><td>Actual system completed and qualified through test and demonstration</td><td>Actual system operated over the full range of expected mission conditions</td></tr>
<tr><td>Software</td><td>Software to test and evaluate basic concepts on simple model problems representative of final need.</td><td>Escalate model to more realistic representation of industrial system. Confirm basic formulation.</td><td>Model contains all major elements of need. Solve industrial strength problems by code developers OR achieve functionality by expert users. Document performance. GUI.</td><td>No specialist intervention required from programmers/developers. This includes basic GUI interface. If required, programming to be according to ISO standards.</td><td>Install, run and evaluate software in actual goal environment (e.g. prospective client's computers). Demonstrate use by clients</td><td>Evaluation done by target representative clients on representative hardware platforms. Complete GUIs, users manuals, training, software support etc. Typical user driven "bug hunting"</td><td>Product proven ready through successful operations in operating environment.</td></tr>
<tr><td>Medical Science</td><td colspan="2">Basic Research</td><td colspan="2">Preclinical Research</td><td>Late Preclinical Research</td><td>Phase I Trials</td><td>Phase II Trials</td><td>Phase III Trials</td><td>Phase IV Trials</td></tr>
<tr><td>Phase</td><td colspan="3">Research</td><td colspan="3">Translation/Development</td><td colspan="3">Commercialisation</td></tr>
</table>

Figure 9. Technical Readiness Levels (Univetsity of Cape Town, 2023)

Based on this table and the feedback from the mechanical team from the University of Pretoria (UP), the RCU to be tested in the underground environment is currently at TRL5, aiming to achieve TRL6 after the underground tests are completed. This suggests that although the laboratory testing phases have been completed, the unit will need to be tested in a relevant environment. The unit, in its current state and TRL, is still a prototype and therefore used as a proof-of-concept. The unit has been tested in simulated conditions on surface, with representative underground tests to be concluded as part of the proof-of-concept testing to achieve TRL6.

4. OPERATOR TRAINING (SURFACE TESTING)

Due to the current TRL of the RCU (TRL5) the unit is still in proof-of-concept testing phase and does not have official training and certification at this point in time. However, the mechanical engineers (Alan Glenn Guthrie and Wietsche Clement William Penny) who designed and constructed the unit as well as the research team comprising of mining engineers (Ruan Pieter Els and Thomas Oates) who assisted in conducting surface testing, gained experience operating the unit. The mechanical engineers have more operating hours experience (+/-20 hours) due to in-between testing during the assembly phase of the unit, whereas the mining engineers were limited to the time spent during surface testing (+/- 4 hours).

Table 1 indicates the types of testing, the schedule followed, and comments on the methodology used during the surface testing of the RCU.

Table 1. Surface Testing Schedule (Els, et al., 2023)

Item tested	Date	Time	Location used for testing	Comments
Weighing of the RCU (fully assembled)	Friday 24 Feb	9:30-9:45	VDG Labs	Using load cells, the unit weight was recorded at 220 kg.
General manoeuvrability (Driving, turning, moving of arm and some obstacle testing)	Friday 24 Feb	9:45-10:00	UP Campus (Behind the VDG Labs)	The unit was driven around, tuned left and right and was driven on tar, cement, sand and aggregate surfaces. The unit was also driven over a curb as well as at an angle with two wheels on the curb and the other on the ground to test general object climbing/handling.
Remote arm and charging lance testing	Friday 24 Feb	10:00-10:15	UP Campus (Behind the VDG Labs)	The movement of the control arm, up and down, was tested as well as the rotation of the charging lance mechanism. The minimum height and maximum height of possible charging was also measured.
Hole identification and charging Set-up	Friday 24 Feb	10:15-10:30	UP Campus (Behind the VDG Labs)	Blue crates with square holes were used to set up an artificial face with artificial holes. The holes mere measured and outlined with masking tape to visualise a “drilled hole” on a face. The hole locations varied from 150mm to 1500mm high and had different spacings to simulate typical U/G burdens.

Hole identification and charging (Test)	Friday 24 Feb	10:30-11:15	UP Campus (Behind the VDG Labs)	The RCU was operated to simulate aligning the unit with the face, identifying a hole, then charging a sequence of 4 holes in a square pattern with 500mm burden (height and width). Hole identification and charging ability was first tested with the following runs done to conduct time studies for average cycle times. The next testing was moving the unit to simulate charging holes at different heights and attempting to charge holes whilst the unit had to drive over obstacles.
Speed and brake testing	Friday 24 Feb	11:15-11:30	UP Campus (Behind the VDG Labs)	A 10m length was measured and marked with orange cones. The unit was run at full speed between the cones and then decelerated to indicate stopping time and distance after the cones. The speed was calculated to be on average 5 km/h with the stopping time and distance being instant.
Slope negotiability	Friday 24 Feb	11:30-11:45	UP Campus (Behind the VDG Labs)	The slope negotiability of the unit was tested with the first attempt requiring the unit to drive up two wooden planks at 23 degrees. This was done with ease and a next step was introduced with the wooden planks replaced by steel ramps (similar set-up to the two wooden planks). The steel ramps were smoother (less surface friction) but despite this, the unit was still able to drive on the ramps without slipping. For the next step, the steel ramps were elevated using a forklift to measure the maximum inclination the unit could navigate (32 degrees).
Discussions on second phase of testing	Friday 24 Feb	11:45-12:00	UP Campus (Behind the VDG Labs)	Discussions on testing grounds for phase two of testing as well as the travelling arrangements.
Lunch break	Friday 24 Feb	12:00-13:30	UP Campus	
Low light testing	Friday 24 Feb	13:30-13:45	VDG lab or with the lights switched off	Images were taken when the lights were on and then when the lights were off to observe the

				efficiency of the lighting on the unit.
Travelling to the TUKS Baja grounds and set-up for rough terrain and obstacle testing	Friday 24 Feb	13:45-14:50	UP Campus to TUKS Baja Grounds	The RCU was strapped onto a trailer and taken to the TUKS Baja grounds. At the grounds large angular rocks were placed to simulate underground obstacles. A short road was also constructed from various rock sizes to simulate the rough terrain.
Obstacle testing	Friday 24 Feb	14:50-15:00	TUKS Baja Grounds	The unit was driven over a pile of angular rocks to test obstacle navigation in both forward and reverse.
Rough terrain testing	Friday 24 Feb	15:00-15:15	TUKS Baja Grounds	The unit was driven over the rough, rocky road constructed to evaluate rough terrain navigation and the effectiveness of the tyres on angled/sharp rocks.
Distance communication test	Friday 24 Feb	15:15-15:20	TUKS Baja Grounds	The unit was driven as far as possible in line of sight to test communication capability of the remote with the unit. The maximum distance was approximately 100m. This was not limited due to the communication system but to the limited operator visibility of the unit beyond 100m.
Operator video feedback testing	Friday 24 Feb	15:20-15:30	TUKS Baja Grounds	The unit was once again driven as far as possible in line of sight to test communication capability of the operator video feedback. The maximum effective distance before video disturbance was approximately 90m. When the unit and operator was not within line of sight, the video feedback system could only function effectively up to approximately 40m.
Cleaning the testing area, loading the unit and travelling back to UP Main Campus	Friday 24 Feb	15:30-16:00	TUKS Baja Grounds to UP Campus	After testing the rocks were cleared and the unit once again secured onto the trailer whereafter the team proceeded to travel back to the UP Campus.

Below is an example of one of the various tests conducted, namely the hole identification and charging simulation test. Plastic pallets with a grid of holes were used to construct an artificial stope face. Openings were highlighted using masking tape with the hole number and height from the ground to the centre of the hole, written on the tape of each hole (**Figure 10**).

Figure 10. Set-up of artificial stope panel with artificial drilled holes (Els, et al., 2023)

Figure 11 indicates the operator video feedback where the operator identifies the hole to be charged, aligns the unit to the face and the lance to the hole. **Figure 12** indicates that the hole was identified and aligned successfully as the charging lance moves into the hole.

Figure 11. Hole identification and charging on simulated stope face (Els, et al., 2023)

Figure 12. Inserting the charging lance into the identified hole to simulate charging (Els, et al., 2023)

Figure 13 indicates the range of charging of holes of the RCU at the bottom hole (150mm from the ground) and the top hole (1500mm from the ground). Additional images (**Figure 14**, **Figure 15** , **Figure 16** and **Figure 17**) of some of the surface testing can be seen in the appendix of this report.

Figure 13. Bottom hole charging (left) and top-hole charging (right) (Els, et al., 2023)

Table 2 indicates the performance comparison between the first and second prototype and is a good indication of the improvements made for the ruggedised RCU.

Table 2. Performance comparison of RCU iterations (Els, et al., 2023)

Item of measure	Prototype 1	Prototype 2
Weight of the assembled unit	105 kg	220 kg
Size of the unit (without charging arm)	1000mm x 1200mm x 500mm	1050mm x 1650 mm x 600mm
General manoeuvrability	Good manoeuvrability of the unit and charging lance	Excellent manoeuvrability of the unit and charging lance
Charging lance angle	Body of unit articulated (-18° to 18°)	Charging lance mechanism rotated (no restriction) There are cables on the mechanism so the lance should be rotated around its axis (more than 180 degrees in either direction)
Speed and braking	Approximately 3.6 km/h (braking not tested)	Approximately 5 km/h (braking distance instantaneous)
Strength and stability (Robustness)	Very lean design, not very robust	Strong, heavy design. Low centre of gravity and very robust
Turning radius and agility	Very small turning radius (not measured). Not very agile and may tip over easily	0m (turns on its vertical axes), very agile and low centre of gravity
Max inclination negotiable	9°	32°
Obstacle negotiation	Can overcome small obstacles but has the risk of getting stuck or falling over	Can overcome (reasonable) obstacles with ease without the risk of falling over. The potential of getting suck is significantly lower but not zero.
Variable terrain negotiation	The unit is limited to effective negotiation of smooth surfaces	The unit can negotiate various surfaces from smooth to very rough terrain
Hole identification and alignment	Using line of sight and a laser pointer	Using camera feedback system on the lance
Operator feedback	No feedback, just line of sight	Line of sight as well as video feedback from two angles (Charging lance and the direction of the unit)
Charging identified holes	Lance is accurately aligned and can go in and out of the hole	Lance is accurately aligned and can go in and out of the hole
Min and max charging heights	150-1500mm	150-1500mm
Lighting capability	Strobe light only	Strobe light and two front facing lights (Front of the unit)
Battery capacity	2.4 kWh Lead-acid battery (Battery life sufficient for the purpose of proof of concept)	3.5 kWh Lithium battery (The battery capacity proved more than sufficient during testing of the unit on surface)

5. CONCLUSION

Based on the current TRL of the RCU (TRL5) the unit is classified as a prototype and is still in proof-of-concept phase. Although thorough surface testing was conducted in simulated conditions, underground testing is to be done to verify the surface results for more representative results. Due to the unit's TLR, there is no official training or certification, however the mechanical engineers (Alan Glenn Guthrie and Wietsche Clement William Penny) and mining engineers (Ruan Pieter Els and Thomas Oates) who took part in the construction and testing of the RCU to date has the most operating hours and experience and will therefore be the most "qualified" to operate the unit.

6. SIGNATURES

Role	Name	Signature	Date
1) Project Lead	Wolter de Graaf		26 April 2023
2) Programme Manager	Martin Pretorius		26 April 2023
3) Head of Department or Business Unit	Ronny Webber-Youngman		26 April 2023

REFERENCES

Els, R., Oates, T., de Graaf, W. & Guthrie, A., 2023. *LoCM21WP3-5,* s.l.: Mandela Mining Precinct (Unpublished).

Guthrie, A., Els, R., Oates, T. & W.W., d. G., 2023. *LoCM21WP3-4,* s.l.: Mandela Mining Precinct (Unpublished).

Mine Health and Safety Council, 1996. *Mine Health and Safety Act, Act 29 of 1996.* s.l.:Mine Health and Safety Council.

Univetsity of Cape Town, 2023. *Innovation Support/technology-readiness-levels.* [Online] Available at: http://www.rci.uct.ac.za/technology-readiness-levels [Accessed 25 April 2023].

APPENDIX

Table 3. List of components used for RCU electronics system

Qty	Description
1	48V 3.5KWH LiFePo4 Battery US3000C
1	Mean Well DC-DC Converter, 24V dc/ 8.4A Output, 36 → 72 V dc Input, 200W
1	Main power lockout switch
1	Esp32 Microcontroller development Board
2	Odrive Brushless DC Motor Controller
3	Brushed DC motor speed controller, DC12/48RT50BL-XW, Keya
1	Stepper motor driver HY-DIV268-5a
1	Amber Flashing Beacon Light, 18-30 V, Xenon Bulb, IP67, Moflash X80 Series
2	15W LED Spot, 9-32VDC, IP67, ACDC

Figure 14. General manoeuvrability testing on different surfaces (aggregates, tar, cement and sand) (Els, et al., 2023)

Figure 15. Rough terrain test (driving over a constructed rough, rocky road) (Els, et al., 2023)

Figure 16. Obstacle and tilt test (driving at an angle with two wheels on an elevated surface and the other two wheels on the ground) (Els, et al., 2023)

Figure 17. Slope test (drive on steel ramps until maximum inclination is determined) (Els, et al., 2023)

REF NO:	MSV-RCU	INCEPTION DATE:	2023-04-29
VERSION NO:	1.0	LAST REVISION/REVISED DATE:	2023-04-29

MASEVE TEST MINE

STANDARD OPERATING PROCEDURE

TESTING OF THE REMOTE CHARGING UNIT AT MASEVE NORTH SHAFT

"INDUSTRY TEST MINE"

VERSION: 1.0

INCEPTION DATE: 2023-04-29

LAST REVISION DATE: 2023-04-29

APPROVAL DATE:_____IMPLEMENTATION DATE:_____

REFERENCE NUMBER:_____

OLD REFERENCE NUMBER:

Table of Contents

1 Aim

To establish a standard operating procedure for testing the prototype remote charging unit as required by procedure MSV-ALL-MNG-PRO-M 1094.

2 Scope

Introduction

1.1. Royal Bafokeng Platinum (RBPLat) is the owner of the Maseve North Shaft. It is a modern mine with decline access to a trackless mining layout underground. The Maseve mine was initially established to access and mine the Merensky and UG2 Reefs in terms of the Mining Right under Section 23 of the Mineral and Petroleum Resources Development Act, 2002 ("MPRDA").

1.2. The Maseve North Shaft is currently on care and maintenance. During an evaluation study, it was found to be the most suitable mine to operate as an Industry Test Mine facility. Following the assessment outcome and negotiations that followed, a Memorandum of Understanding was drafted and agreed to between RBPlat, the Minerals Council and the Council for Science and Industrial Research (CSIR), allowing this mine to be used as the Industry Test Mine.

1.3. The Minerals Council and the CSIR are the responsible legal hosting entities of the Mandela Mining Precinct. The Mandela Mining Precinct facilitates various research and innovation projects as part of the following (SAMERDI) programs:

- Mechanized Mining Systems
- Longevity of Current Mines
- Advanced Orebody Knowledge
- Real-time Information Management Systems
- Successful Application of Technologies Cantered Around People.

1.4. Portions of the Maseve surface and underground mining areas were made available to the Mandela Mining Precinct as the coordinator to facilitate test work and to launch or demonstrate the operability of the systems, tools and equipment required to implement the SAMERDI programs. RBPlat supports the Minerals Council and the CSIR initiatives to revitalise mining research, development, and innovation in South Africa to ensure the sustainability of the South African mining industry.

1.5. As a part of LOCM22-WP2 Remote Charging Unit, a SAMERDI project, a prototype remote charging unit was developed. The aim of this unit is to remove people from the working face during the loading of explosives in underground stopes by using a remotely operated unit. The unit is not equipped with explosives, nor will any explosives be loaded by the unit as a proof-of-concept prototype.

1.6. A requirement of LOCM22-WP2 is the underground testing of the prototype unit to determine whether the concept prototype has met criteria defined in the LOCM22-WP2 reports. These criteria include:

1.6.1. The remote charging unit is capable of handling underground terrain.

1.6.2. The remote charging unit can maneuver a mock charging lance into drilled holes.

1.6.3. The remote charging unit is capable of inserting and extracting a mock charging lance into a drilled panel to simulate charging a face.

1.7. The remote charging unit in its current second design iteration will not:

1.7.1. Carry explosives.

1.7.2. Charge shot holes with explosives.

1.7.3. Operate beyond the test area designated by the management of Maseve Mine

3 Definitions

Test Mine	Maseve North shaft
Risk assessment	An assessment in line with section 11 of the Mine Health and Safety act
Testing OEM	Company/person or entity that intends to make use of the test mine facilities
Mock Charging Lance	A hose attached to the loading boom of the remote charging unit
Remote Charging Unit	A proof-of-concept prototype unit to remotely insert a mock charging lance into a panel of drilled holes
Underground testing section	The predetermined area of the mine that has been prepared for equipment testing.

4 Abbreviations

Abbreviation	Explanation
CSIR	Council for Science and Industrial Research
SAMERDI	South African Mining Extraction Research, Development, and Innovation

5 General

5.1 Updates

This Procedure will be reviewed after 48 months and updated if required.

After every serious injury, the relevant Risk Assessment will be reviewed and revised if required, following that the content of this Procedure will be evaluated and updated if found to be inadequate.

5.2 Contraventions

Any breach of this Procedure shall be regarded as Refusal/Failure to carry out a lawful instruction and will be dealt with as per the RBPlat behavioral procedure.

5.3 Scanned copy of original signed Team Member list

Name	Designation	Affiliation	Years Experience	Signature

6 General

6.1 The remote charging unit description

The remote charging unit (**Figure 1**) is the second design iteration of a prototype remote charging unit. The remote charging unit is a remotely operated, battery powered, device designed to insert a mock charging lance into drilled holes. This is achieved by manoeuvre an actuated boom on a mobile platform. The unit is remotely operated using a controller module (**Figure 2**). There are two cameras mounted on the remote charging unit which are used to position the remote charging unit and the mock charging lance to drilled holes.

The remote charging unit can be disassembled into two parts. The upper assemblage can be removed from the chassis to enable easier handling and reduce the total mass of the remote charging unit.

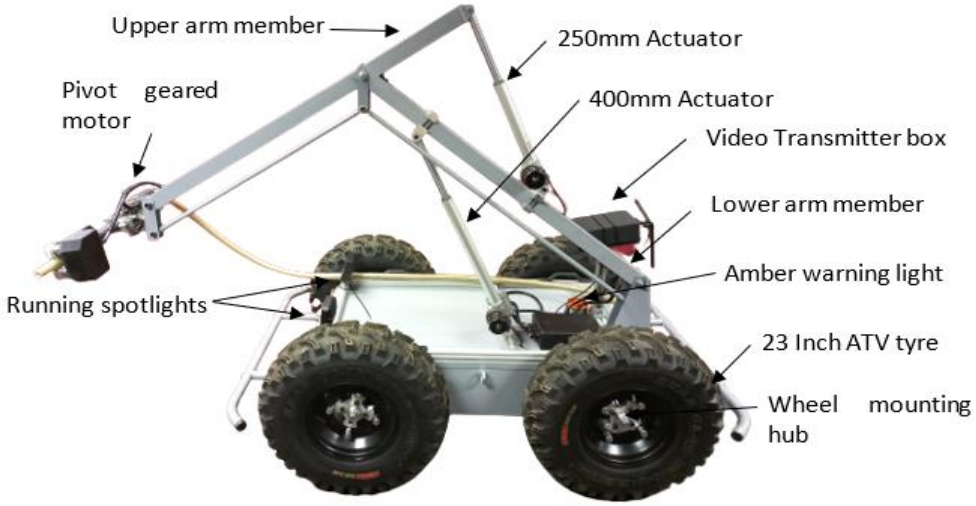

Figure 1: Schematic of the remote charging unit

Figure 2: Schematic of remote charging unit controller

6.2 Testing Procedure

During the compilating of the associated Workplace Risk Assessment and Control (WRAC) analysis a process map (**Figure 3**) of the activities associated with the testing of the remote charging unit was drafted. These activities will form the basis of the operating procedure.

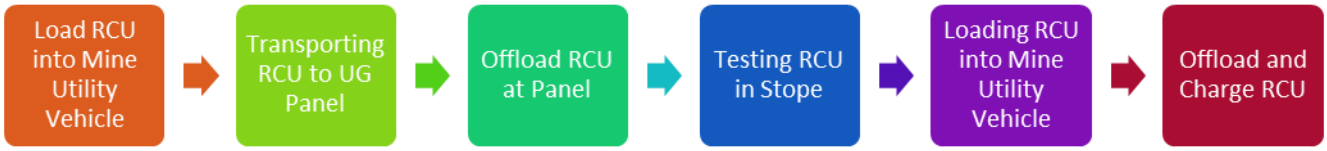

Figure 3: Process map for Remote Charging Unit (RCU) testing

6.3 Loading remote charging unit into mine utility vehicle.

The remote charging unit will be disassembled into smaller components next to the mine utility vehicle on which it will be transported underground. The unit will be disassembled to ensure the mass off the assemblies to be loaded is manageable within the ergonomic limits of the persons loading it.

Each component will be securely fastened to the mine utility vehicle. The operator of the mine utility vehicle and the research team will ensure the unit is sufficiently fastened. Before the unit is transported the mine utility vehicle operator and research team will verbally confirm the unit is adequately fastened.

The research team and the operator of the mine utility vehicle will ensure the secured actuating boom does not exceed the underground roof clearance.

6.4 Transporting the remote charging unit to the underground panel.

The unit will then be transported to the testing section underground, the operator of the mining utility vehicle will as reasonably practical, travel in a manner that least disturbs the remote charging unit.

The research team and operator will ensure the secured actuating boom does not exceed the underground roof clearance.

6.5 Offload the remote charging unit at the underground panel.

Once the mine utility vehicle has arrived at the underground panel, the operator will wait for the research team before starting to unfasten the remote charging unit. The assemblies of the remote charging unit will be untied and offloaded by the research team. Persons offloading the assemblies will ensure the components lifted are within the ergonomic lifting capacity of group.

6.6 Testing remote charging unit in stope

Before entering the test area, the miner will ensure the area is made safe. Any drilled holes in the test area will be cleared of explosives and checked prior to any testing is done. The area must be ventilated according to the mine standard.

The research team will ensure that the remote charging unit is not operated in areas with a stoping hight smaller than 1.5 m to ensure the unit does not become stuck.

The following equipment will be available nearby the testing area:

- CO_2 Fire Extinguisher
- First Aid Kit
- Ropes to recover the remote charging unit.
- Means of communication with the mine control room

Only members of the research team are to operate the remote charging unit. The remote charging unit shall not be operated outside the confines of the designated test area. The remote charging unit has a maximum speed of 6 Kmph, at this speed the unit does not pose a significant risk in the event of a collision with a pedestrian. However, the research team and mine personal shall, as reasonably practicable, maintain a distance of no less than 10 m between the remote charging unit and persons during testing. Whilst operating, no persons shall be downdip of the remote charging unit.

Research team members will ensure all videographic equipment taken is approved by the mine. The research team members shall as reasonably practicable, maintain a safe distance from the remote operating unit whilst filming and documenting experiments. Research team members shall ensure they are do not enter an area not deemed safe by the mine.

In the event of an emergency during testing, the research team shall notify the mine personal and control room. Beyond first response measures the research team shall not act to recover or control unwanted events that have occurred beyond their training and competence. This includes the recovery of the remote charging unit in the unlikely event of a fall of ground.

6.6 Loading remote charging unit in stope.

Once testing is complete the remote charging unit shall be inspected by the research team to ensure there are deformations to the remote charging unit that may pose a risk to the persons handling the assemblies. Once the remote charging unit is deemed safe to handle, the remote charging unit shall be disassembled and secured to a mine utility vehicle following the same procedure mentioned in **Section 6.3** and transported to surface following the same procedure mentioned in **Section 6.4**.

6.7 Offload and Charge the RCU

The remote charging unit is to be offloaded on surface following the same procedure listed in **Section 6.5**. The unit will then be reassembled and manually driven to the research team transportation.

REF NO:	MSV-RCU Operator License	INCEPTION DATE:	2023-05-05
VERSION NO:	1.0	LAST REVISION/REVISED DATE:	2023-05-05

MASEVE TEST MINE

PROCEDURE: Operator licensing, authorization and proof of competency

TESTING OF NEW EQUIPMENT AT MASEVE NORTH SHAFT

"INDUSTRY TEST MINE"

VERSION : 1.0

INCEPTION DATE: 2023-05-05

LAST REVISION DATE: 2023-05-25

APPROVAL DATE:_____IMPLEMENTATION DATE:_____

REFERENCE NUMBER:_____

OLD REFERENCE NUMBER:

REF NO:	MSV-RCU Operator License	INCEPTION DATE:	2023-05-05
VERSION NO:	1.0	LAST REVISION/REVISED DATE:	2023-05-05

Table of Contents

REF NO:	MSV-RCU Operator License	INCEPTION DATE:	2023-05-05
VERSION NO:	1.0	LAST REVISION/REVISED DATE:	2023-05-05

1 Aim

To issue an operating license to the various operators of the Remote Charging Unit (RCU) based on the sign-off on proof of competency from RB Plat Engineer.

2 Scope

Introduction

1.1. Royal Bafokeng Platinum (RBPLat) is the owner of the Maseve North Shaft. It is a modern mine with decline access to a trackless mining layout underground. The Maseve mine was initially established to access and mine the Merensky and UG2 Reefs in terms of the Mining Right under Section 23 of the Mineral and Petroleum Resources Development Act, 2002 ("MPRDA").

1.2. The Maseve North Shaft is currently on care and maintenance. During an evaluation study, it was found to be the most suitable mine to operate as an Industry Test Mine facility. Following the assessment outcome and negotiations that followed, a Memorandum of Understanding was drafted and agreed to between RBPlat, the Minerals Council and the Council for Science and Industrial Research (CSIR), allowing this mine to be used as the Industry Test Mine.

1.3. The Minerals Council and the CSIR are the responsible legal hosting entities of the Mandela Mining Precinct. The Mandela Mining Precinct facilitates various research and innovation projects as part of the following (SAMERDI) programs:

- Mechanized Mining Systems
- Longevity of Current Mines
- Advanced Orebody Knowledge
- Real-time Information Management Systems
- Successful Application of Technologies Cantered Around People.

1.4. The Minerals Council, through its members and the CSIR on behalf of the Department of Science and Innovation ("DSI"), obtained approval to establish the Industry Test Mine. The Industry Test Mine is set to test the systems, technology and infrastructure required to implement the programs mentioned in clause 1.3 above. The Industry Test Mine will be used as a Test Mine facility to evaluate the readiness, operability, and capability of test systems, tools and equipment in an integrated manner.

1.5. Portions of the Maseve surface and underground mining areas were made available to the Mandela Mining Precinct as the coordinator to facilitate test work and to launch or demonstrate the operability of the systems, tools and equipment required to implement the SAMERDI programs. RBPlat supports the Minerals Council and the CSIR initiatives to revitalise mining research, development and innovation in South Africa to ensure the sustainability of the South African mining industry.

3 Definitions

Test Mine	Maseve North shaft
Risk assessment	An assessment in line with section 11 of the Mine Health and Safety act
Testing OEM	Company/person or entity that intends to make use of the test mine facilities

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5 General

5.1 Updates

This Procedure will be reviewed after 48 months and updated if required.

After every serious injury, the relevant Risk Assessment will be reviewed and revised if required, following that the content of this Procedure will be evaluated and updated if found to be inadequate.

5.2 Contraventions

Any breach of this Procedure shall be regarded as Refusal/Failure to carry out a lawful instruction and will be dealt with as per the RBPlat behavioural procedure.

6 Confirmation of Competency Check Completion

The following individuals have been checked for competency:

Name and Surname	ID no	Proof of competency provided (Yes/No)	Competency checked (Yes/No)
Alan Glenn Guthrie	8905185250083		
Wietsche Clement William Penny	9008035531085		
Ruan Pieter Els	9510075013085		
Thomas Edward Oates	9509055070081		

REF NO:	MSV-RCU Operator License	INCEPTION DATE:	2023-05-05
VERSION NO:	1.0	LAST REVISION/REVISED DATE:	2023-05-05

This is to confirm that the individuals above (Alan Glenn Guthrie, Wietsche Clement William Penny, Ruan Pieter Els and Thomas Edward Oates) have been certified, checked and authorized to receive an operating license to operate the RCU at Maseve Mine.

RB Plat Engineer **Date**

RB Plat Manager **Date**

REF NO:	MSV-RCU-TER	INCEPTION DATE:	2023
VERSION NO:	1.0	LAST REVISION/REVISED DATE:	2023

ROYAL BAFOKENG PLATINUM
MORE THAN MINING

Equipment type	Serial No (If applicable)	Date and Duration	Description/Comments

REF NO:	MSV-RCU-TER	INCEPTION DATE:	2023
VERSION NO:	1.0	LAST REVISION/REVISED DATE:	2023

Signature of Mine Representative (s)

Name	Designation	Employee ID	Date	Signature

- **mpretorius@mandelaminingprecinct.org.za** Thu, 9 Mar, 08:30

to Jacob J. Ngakane, Jurgens Visser, Philip Coetzer

- You are viewing an attached message.

University of Pretoria Mail can't verify the authenticity of attached messages.

Dear Jacob

I trust you are well. Thank you for the arrangements for the visit to Maseve on Tuesday. The team was taken underground to block 11, and found the area perfect for testing the remote charging unit.

After working through all of the requests and information provided in various communications, please see below the updated schedule, site requirements and approvals required.

Arrangements already approved:

- The equipment for transporting the unit from surface to the 11 block is sorted, which Maseve Engineer will assist.
- Lighting of the block 11 area will also be arranged by the Engineer.
- The drilled holes have emulsion still in the holes, which Sipho suggested he can wash out the holes and make the area safe to enable testing.

Unit specifications:

Item	Description	Measure
De-assembled unit	Weight Dimensions	**Top robotic arm assembly:** Approximately 25 kg Approximately 200 mm x 700 mm x 2000 mm (Can be adjusted) **Bottom unit assembly:** Approximately 195 kg 1050 mm x 1650 mm x 600 mm
Lights	Lux / illumination	(2X) 15W LED Spot, 9-32VDC, IP67, ACDC (1350 Lumen per light)
Assembled unit	Weight Dimensions	220 kg 1050 mm x 1650 mm x 1300 mm

Equipment specifications:

- CO2 fire extinguishers
- A chain, block n tackle and straps to secure the unit on the TMM
- The unit requires a 3-point plug and 220V to charge the battery
- Someone with 1st aid training and a 1st aid kit
- Means of communication with the team to surface (if an RBPlat employee will not always present with the team)
- Transport for the personnel underground and back to the surface

A time schedule is being structured for 3 days at Maseve: It would be greatly appreciated if the test work could commence on **Monday, 13 Mar 2023 to Wednesday, 15 Mar 2023**.

Day	Item / Activity	Time	Comment	Responsibility
1	Medical / Induction	08:00 to 09:30	Ruan Els, ID 9510075013085 Thomas Oates, ID 9509055070081 Glenn Guthrie, (Details TBC) Additional Mechanical Engineering Assistant (Details TBC) MMP Staff (Details TBC)	Maseve
	Off-load unit	09:30 to 10:30	Off-load unit from vehicle Engineer to check unit	UP Maseve
	Loading unit	10:30 to 11:00	Loading unit on transport unit and secure	Maseve
	Transport unit	11:00 to 12:30	Transport unit from surface to block 11	Maseve
	Off-load unit	12:30 to 13:00	Off-loading unit Remotely drive the unit to the assembly point in block 11	Maseve UP
	Assemble unit	13:00 to 14:00	Assemble the unit and prepare for test work	UP
2	Underground testing	08:00 to 14:00	Transport at least 4 people to block 11 (Nr of people TBC) Conduct testing Transport at least 4 people to surface from block 11 (Nr of people TBC)	Maseve UP Maseve
3	Underground testing	08:00 to 12:00	Transport 4 people to block 11 Conduct testing De-assemble unit Remotely drive unit to loading area	Maseve UP UP UP
	Loading unit	12:00 to 12:30	Loading unit on transport unit and secure	Maseve
	Transport unit	12:30 to 13:30	Transport unit and 4 people from block 11 to surface	Maseve
	Off-load unit	13:30 to 14:00	Off-loading unit	Maseve

REF NO:	**MSV-RCU-PWCMD**	**INCEPTION DATE:**	**2023**
VERSION NO:	**1.0**	**LAST REVISION/REVISED DATE:**	**2023**

All activities mentioned are already addressed in the approved risk assessment (Approval Number - Mandela-Test-UG-0001 - Remote Charging Unit)

Request for authorisation

- Approve test work process
- Approve unit to be tested underground by Engineer
- Cameras to be taken to Block 11 to take photos and videos. This is to capture video footage of the unit in action. (which type?)
- Permission to take a toolbox and a laptop underground should there be any mechanical or electronic challenges
- The unit requires a 3-point plug and 220V underground, to charge the battery

We trust you find this in order.

Kind regards

ROYAL BAFOKENG PLATINUM
MORE THAN MINING

1 Remote charging unit test site infrastructure requirements checklist

Site Details	Agreement
Reconnaissance trip	7 March 2023
Duration	1 Day
Identify Area	Block 11 has been identified. Drilled holes have emulsion been charged, needs to be washed out. Lighting requirements was discussed with Engineer, who stated that lighting can be provided as well as serviced. Off-loading of RCU unit in close proximity of Block 11
Transportation - RCU	A low-bed unit has been identified as the potential transport unit to transport the RCU from surface to block 11 underground and also return the unit from block 11 to surface. Engineer will assist in the loading, transporting and off-loading of the RCU.
Transportation - people	Transport vehicle is available to transport max 4 persons per trip.
Medical Certificates	RB Plats medical centre to be utilized to conduct medical fitness test. The request is that this will cover the three days at Maseve
Drift Location(s)	Ideally conditions like those in a narrow reef stope.
Power / Energy Requirements	The prototype has its own battery lithium-ion battery, battery life is sufficient to test for 8 hours without charging.
Ventilation Requirements	Mine Standard – To simulate normal operating conditions
Special Lighting Requirements	Mine Standard – Unit has own illumination
Underground Dimension Requirements	Unit has a maximum reach of 1.5m. Ideally a narrow reef stope. If not a panel with drilled holes, approximately 0.5 - 1m above the footwall.
Number of People On-site / Underground	***University of Pretoria***: Wolter de Graaf, Glenn Guthrie, Ruan Els, Thomas Oates **Mandela Mining Precinct**: Martin Pretorius, Themba Mabunda, Lwando Bhethshu (optional)
EMC / Wireless / Technology Requirements	Mine Standard – Valuable to see if normal mining equipment interferes with the 2.4 and 5 GHz signals used for unit.
Communication Requirements	None
Water Requirements	Hosepipe to spray down would be valuable to test waterproofing
Air / Compressor Requirements	None Required

REF NO:	**MSV-RCU-SID**	**INCEPTION DATE:**	**2023**
VERSION NO:	**1.0**	**LAST REVISION/REVISED DATE:**	**2023**

Site Details	Agreement
Equipment / Vehicle Requirements	Transportation for unit to test site (The unit is designed to fit on a bakkie)
Temperature Requirements	Mine Standard – To simulate normal operating conditions
Inspection of Equipment / Materials and Services (All products, tools, and services brought onto RBPlat property must be approved by the RBPlat MHSA Section 3.1 (a) Manager in conjunction with the Regulation Section 2.13.1 appointee.	Engineer to check Remote Control Unit when unit is brought on site
Hazardous Materials Usage / Regulatory Compliance	No Hazardous materials used. MSDS for Lithium Ion Battery Attached
Special Insurance Requirements	None
Offices	One office for the overnight charging of the RCU battery. Ideally near a place, which is secure, where the battery (40 kg) can be offloaded. (Optional)
External Parking Requirements	2 to 3 Vehicles
Training Requirements	Induction

Description of Work	Testing the capabilities of a prototype Remote Charging Unit (RCU).
	Verification of the RCU's ability to:
	• Handle rough terrain underground
	• Insert charging lance into a sequence of drill holes
	Conducting Time study of:
	• RCU's Terrain handling
	  ○ RCU to be capable of handling in stope footwall conditions
	• RCU Charging Sequence
	  ○ Hole alignment
	  ○ Lance insertion
	  ○ Lance extraction
	• RCU multiple hole sequence
	  ○ Time taken to charge a sequence of holes

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Site Details	Agreement
	▪ As many as possible to simulate a stope Video analysis of: • RCU maneuverability • Hole Alignment and lance operation • Sequence of hole charging
Videographer, Photographer Requirements	Research team to bring cameras to capture footage of RCU
Site Visit Completed Date	