



MANDELA MINING PRECINCT
MINDS FOR MINES

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AUGMENTED REALITY SOLUTION FOR ROCK DRILL OPERATORS AND MINERS

Close-Out Summary Report



CLSOE –OUT SUMMARY- AUGMENTED REALITY SOLUTION FOR ROCK DRILL OPERATORS AND MINERS				
PROGRAMME	SATCAP		WORK PACKAGE	4
FINAL REPORT- MILESTONES 3 & 4 CONSOLIDATED				
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PROJECT SUMMARY

Project overview

The study has been commissioned by the Mandela Mining Precinct, through the Successful Application of Technologies Centred Around People (SATCAP) Programme to the Council for Scientific and Industrial Research (CSIR). SATCAP focusses on the effects, impacts and challenges on mining modernisation on people in the mining sector. For 2021, SATCAP projects considered skills development to support a modern workforce for modern mining.

The aim of this Work Package (WP) was to demonstrate the “**art of possibility**” through developing a simulated solution to support upskilling of rock drill operators (RDOs) and miners in mining operations for gold (Au) and platinum group metals (PGM). This aim was materialised through the design and development of a simulated solution which was verified through piloting and exhibiting thereof with the industry.

The intent of developing the augmented reality (AR) experience was to support RDOs and miners in training, to support modern training for a workforce, as well as reflect on value that may emerge for industry. The simulated AR solution developed validated the concept that was proposed initially, including: AR technology; underground communication technology as adopted from the military; the concept of a connected miner using tablets; just-in-time (JIT) blended learning training material; and has integrated with peer South African Mining, Extraction, Research, Development and Innovation (SAMERDI) research work.

As the scope of the SATCAP project considers skills development of RDOs and Miners, this study has focussed on the AR training, the production and feasibility aspects of the AR solution, and the application thereof within mine.

The project outputs include:

- An exemplar training module
- A training slide deck
- A training video
- Final (scientific) report

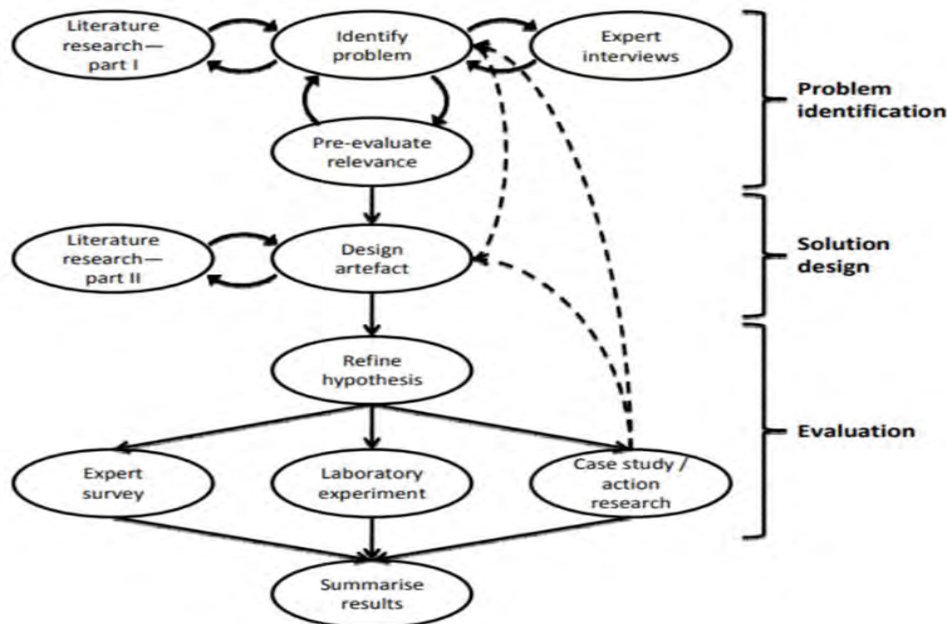
Should mines opt to use AR training for RDOs and Miners, then the outputs are accessible for mining companies’ use through the Mandela Mining Precinct. The training outputs are generic to allow for all Au/PGMs mines’ potential use.

Context and methodology

Due to the modernisation of mines, to support health and safety the role of traditional training needs to be re-assessed in relation to modernised training approaches. Reskilling, upskilling and cross skilling of workers through modern training approaches may be considered through the introduction of AR technology, and the appropriate application thereof. This was considered, through this study, by the development of an AR technology to support drilling mark-off (drill hole markings) associated with underground conventional mining of tunnels, stopes or gulleys, for potential use for RDO and miner

training. This development was preceded by workshops and interviews to solicit inputs from stakeholders in order to evaluate the appropriateness of the suggested solution.

The study has used a Design Science Research approach.



In addition, desk-top literature review was conducted by the historically disadvantaged South African (HDSA) student involved in the project. Inputs from suppliers informed the data gathering process towards solution design and development. A classroom based pilot study was conducted at a multi-commodity mine to review the solution, and a demonstration and exhibit sessions were held with stakeholders, for validation.

Project partners

The Mandela Mining Precinct commissioned WP 4 under the auspices of the SATCAP programme. The CSIR was contracted to act as the lead to provide an AR solution that could be used for RDOs' upskilling/training, in Au and PGM modernising mines. The project was conducted in collaboration with WinWin International (WWI) and Enterprises University of Pretoria (EUP). Service providers/suppliers have been sub-contracted by the collaboration partners to contribute expertise and development to the project outputs. An HDSA student supported the desk-top literature review.

Ethics clearance

The CSIR research ethics committee (REC) review meeting was on 23 September 2021 and feedback has been received. The ethics application required modifications, following which clearance was received on 11 October 2021. (Ref. 376/2021). During the pilot study on 19 November 2021 adherence to the ethical clearance protocols were followed and records of the pilot study participants' consent were obtained.

Limitations

Contracting delays were evident. The multi-contracting, sub-contracting and sub-sub-contracting levels applicable caused a sequential dependency of payments that caused challenges. As a result,

development delay risks were ensued by service providers. Work among sub-contract service providers commenced based on good faith and trust relations.

Due to the current global crisis relating to the coronavirus (COVID-19) pandemic, restrictions were imposed on physical meetings and liaisons. As mitigation, this project has predominantly relied on virtual communication and electronic data transfers to share information and engagements. COVID-19 had impacted the project data gathering and demonstration approach. Virtual sessions restricted the option of reviewing the solution at actual mining operations, to be able to ascertain the actual training impact. The pilot study was undertaken in classroom venues with members consisting of various mining roles and levels. The exhibition was prepared at the University of Johannesburg (UJ) mine simulator mine for a near 'real feel' and experience, but was exhibited virtually in the form of videos and presentations.

Summary of key findings

It is evident from the study that when it comes to digital training, a 'one size fits all' approach cannot be adopted. Mines are at varying degrees in terms of modernization. Some findings are that:

- Mines are using AR training methods to some extent;
- Mines cannot take a 'one-size fits all' approach regarding digital training, as their contexts differ, and a blended approach to training is preferred by mines;
- Classroom learning, on-job and on-shaft learning remains important;
- Digital learning may be used meaningfully for refresher training when returning back from leave, or for remote and self-learning more readily;
- Factors like literacy levels, ageing or a younger workforce, pitch and level of training needs consideration in terms of the approach around digital training;
- Mines have infrastructure differences, and so Wi-Fi and other infrastructure needs for digital training will need the specific mine's consideration;
- Financial obligations for digital training needs consideration by mines. Licensing costs etc. will have an impact;
- The study focus is on RDO and miner training and not with the production and feasibility aspects of the AR solution and application within mine;
- Digital training may not allow for physical factors to be taken into account always. So digital training should be complemented with other training methods; and
- The pilots conducted suggested that mines cannot be expected to 'switch or plug-into' digital training. Their needs, specific contexts, modernisation strategy, and stakeholder inclusion, will inform the transition to modern training methods.

Summary of recommendations

The following were recommendations based on experiences observed during data gathering, student reports, piloting and exhibition of the AR solution:

- Training recommendations included the consideration of blended learning - classroom training and on-the-job training is still needed;
- A blended learning approach can support animated learning, and immersions vs static learning;
- Digital learning may allow for navigation between languages of choice;
- Digital learning may allow for training availability digitally;

- Digital literacy skills are needed to use digital solutions;
- AR application will need to consider mines' contexts, infrastructure needs, financial inputs, and workforce readiness;
- Aside from training, AR use in other functional domains may be used should mines be ready for such transition;
- Device recommendations considered tablets usage, but training of RDOs is essential;
- The pitch and level of the AR training needs consideration as RDOs may lack the needed literacy levels and digital acumen;
- Training methods may be modernised through inclusion of AR training methods. A one size fits all approach is not recommended, so mines need to consider their specific needs in consideration for implementation of AR training;
- The suggested solution requires that miners and RDOs be upskilled to use digital devices. Digital literacy is needed as well as training on usages of the AR devices themselves;
- AR used for mark off suggests that the solution is suitable for a miner instead of a RDO and Mining Health and Safety Council (MHSC) and Mine Qualification Authority (MQA) considerations are required around role diversification; and
- Operational testing and readiness levels of the AR technical solution may be considered for future utilisation in mines and may elicit further study in the technical, technology centred SAMERDI programmes.

Transfer to industry

Transfer to industry will allow for the following:

Training module

Training modules exist in various forms:

- Standard Operating Procedure (SOP).
The standard operating module includes descriptions of the process overview; equipment guidance, marking process and troubleshooting. This is free to use or amend by industry.

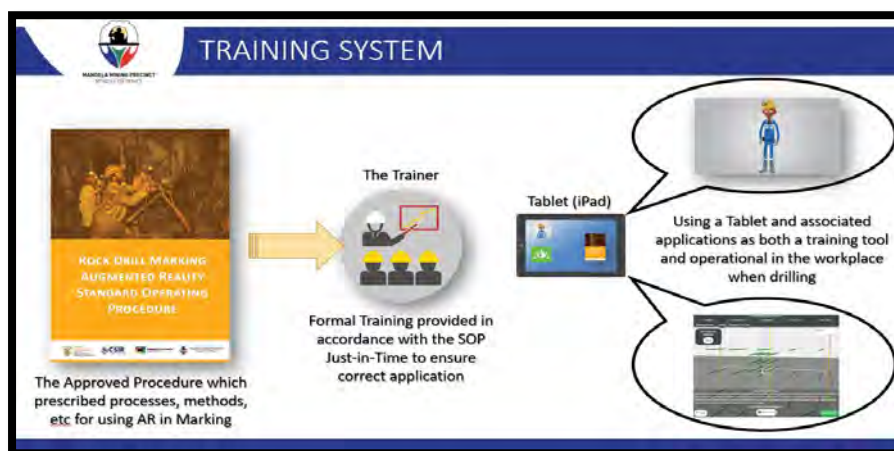
In addition to the SOP module, the following training material has been provided:

- Publication Development Specification (PDS):
This specification provides guidance on the structure and format of the training material, according to which the training material has been developed. This is transferable to the industry to adapt, change or expand to suit mining needs.
- Facilitator guide:
A facilitator guide has been compiled that relates to the SOP to guide and support a training facilitator in conducting the learning module of the SOP, defines the learning unit for an AR process, and provides module answers for questions in the delegate guide. This is free to use or amend by industry.
- Delegate guide:
A delegate guide has been compiled that provides a guide to assessment and defines the learning unit of an AR process, and poses questions for the learner to answer. This is free to use or amend by industry.



Training slides

A set of training slides that relates to the SOP has been made available to the industry. This is free to use or amend to adapt, change or expand to suit mining needs.

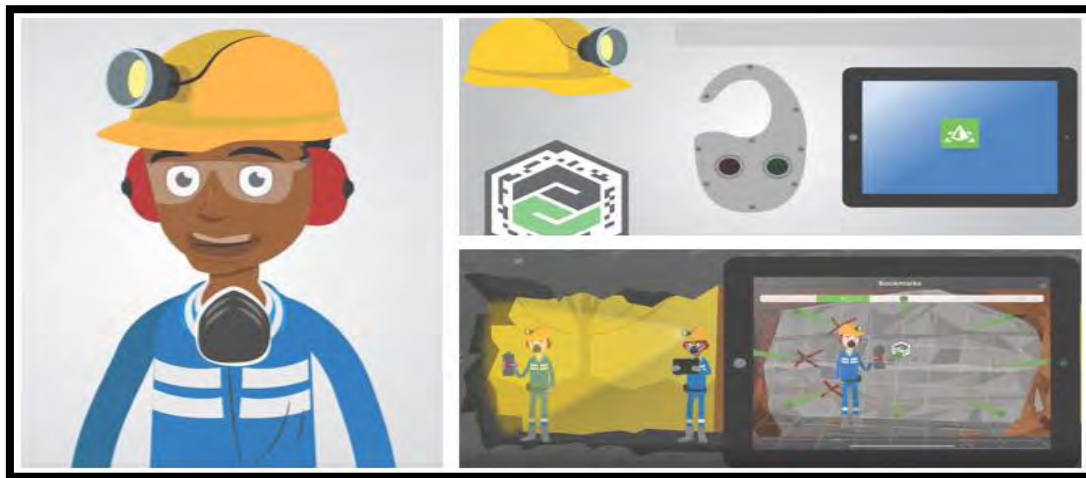


Training video and animations

Various training support materials have been provided:

- Animation clip:
An animation clip set has been developed for separate languages being English and Zulu. The purpose of the animation was to demonstrate the AR solution process, introducing the equipment, and demonstrating how the equipment is used to conduct drill hole markings at the stope face. The animation clips are developed in a movie format, and assistance from the supplier that developed it is required if changes are required.
- Training video:
A training video has been developed to demonstrate the facilitation and content of the training to assist trainers.

- AR experience:
A video has been developed that demonstrates and explains the working of the AR experience.



Animated training material

IP and licensing considerations

The solution has been developed by the supplier so intellectual property in terms of design and development of the solution resides with the supplier. The supplier has been acknowledged through the study for such contribution. Mines may have access to the simulated solution via University of Johannesburg mining faculty, and licensing has been secured for a limited period, to allow for mines and mining students' access. Should mines wish to further test, enhance and implement the solution, as per their specific needs, then the solutions supplier may be contacted.

Links

Accessible to industry are as per the links below:

- [Training modules](#)
- [Training slides](#)
- [Training Video](#)

Project outputs and relevant information for WP4 is accessible via the MMP website and RTIMS Portal.

Conclusions

The study has considered modern training methods to support a modern workforce for modern mining. A modern workforce may require new training methods. Reskilling, upskilling and cross-skilling the workforce may call for enhancing the way we do training. AR training may provide mines with the option to enhance their training to support a modern workforce for modern mining. To note, the suggested solution requires that RDOs be upskilled to use digital devices. Digital literacy is needed as well as training on usage of the AR devices themselves.

While taking into account the recommendations, it is to be noted that the solution suggested fits into the space of the Fourth Industrial Revolution (4IR) and thus has included the development of an AR solution integrated with the Underground Stope Communication System (UGSCS) - a research

technology found in the Real Time Information Management System (RTIMS) programme. It utilises 4IR devices such as high performance tablets comprised with functions that are inherently provided by such devices, such as photo and video capturing, internet connectivity, hosting application and containing sufficient digital storage space. This study has not considered nor tested the communications aspect, as the communications system development and testing is a RTIMS mandate.

In addition, the simulated AR solution has not been tested underground in relation to supporting of production, as optimising of production is a technical focus and resides within the other SAMERDI technical programmes, for example Mechanised Mining Systems (MMS).

However to note that an AR technology solution will need training thereof for effective operation. To this end, the training material arsenal developed during the project has included a Publication Development Specification (PDS) that defines a standard to which training material is developed. The training module is developed accordingly consisting of a Standard Operating Procedure (SOP) that introduces aspects of the AR solution, supplemented by animation clips in various languages to show how the solution works. In addition, a facilitator's guide, a delegate's guide, training presentation, and a training video are also provided. All of the above are deemed transferable to industry with the notion that the industry may adapt it to their needs and contexts.

The solution development has set the foundation platform to extend it to other applications of AR and has opened the possibility to conduct it at the mining stope where such capabilities are not yet available, giving a good stepping stone for further AR or other considerations. To note, AR applications that can be extended beyond just the marking of drill holes and the training thereof. The AR training experience may consider training for: hazardous situations, operations and maintenance due to the possibility that underground stope communication may be integrated with the AR training experience, using devices that can also extend usability ranges.

To note, compliance aspects, from MHSC, MQA, DMRE and all regulatory bodies still remain relevant for mines in application of the training (or integrated) solution.