 *Anglo American Platinum*

PEOPLE-CENTRED MODERNISATION IN MINING

Position paper



MINERALS COUNCIL
SOUTH AFRICA

TABLE OF CONTENTS

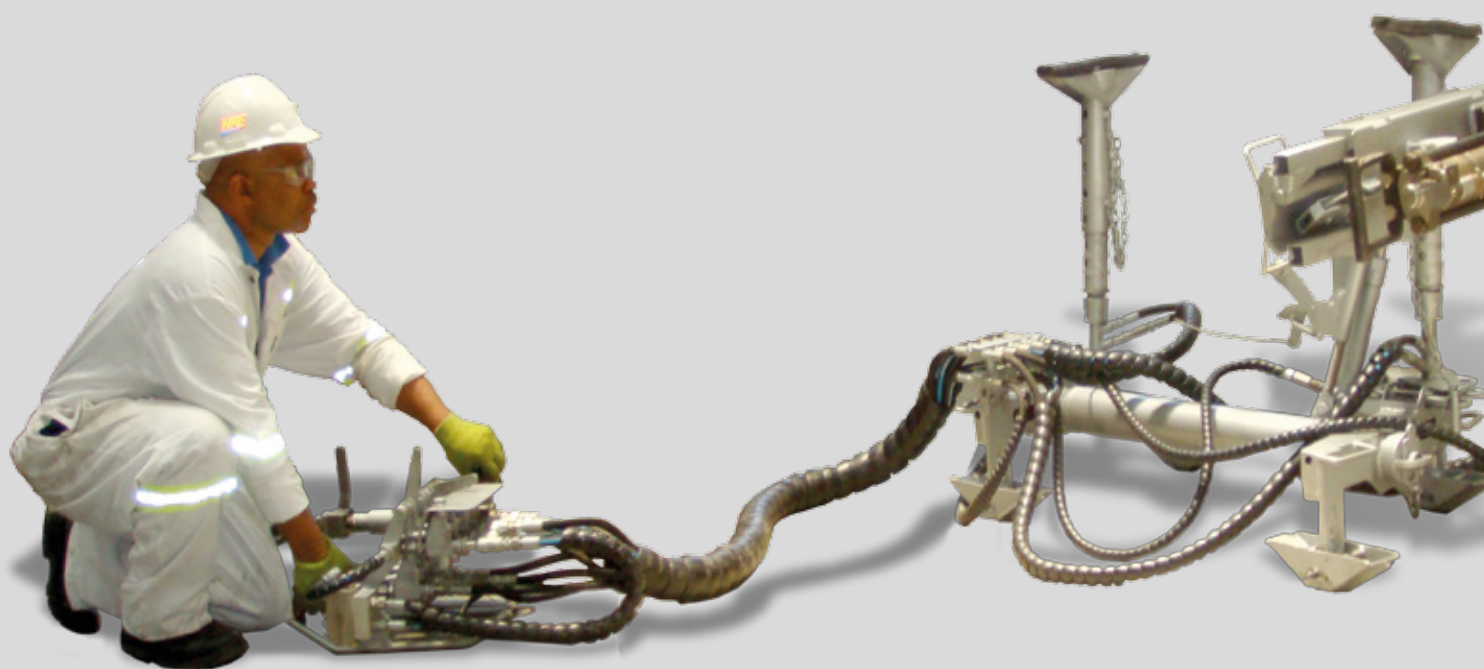
Introduction	1
The mining industry and the South African economy	1
Why modernise?	2
The Minerals Council South Africa's position	4
The Mining Phakisa	6
Recent developments	8
The Mandela Mining Precinct	9
The way forward	12
Conclusion	IBC



It is estimated that the mining industry is responsible for approximately

1.4 million jobs

 *Stope walker with operator / Credit: Hydro Power Equipment (Pty) Ltd*



INTRODUCTION

In a country in which 15 million people are unemployed (amounting to more than 25% of the total population), mining's contribution to employment is critical, and all efforts need to be made to ensure that these positions are protected and expanded.

#MakingMiningMatter

South Africa has many cutting-edge mines and is a global leader in deep-level mining. However, the methods the South African mining industry has used to extract gold and platinum group metals (PGMs) from the earth have remained largely unchanged since the early 1900s. For the most part, stoping – drilling, blasting and cleaning – is still the order of the day.

As the industry seeks to access the remaining reserves and resources that lie at increasing depth, these methods are shown to be unsustainable. They pose health and safety challenges, do not promote productivity and production, and come at significant cost. In many instances, they are not feasible at all.

To address these issues – to ensure the health and safety of miners, to retain and create jobs, to prevent the premature closure of mines, and to provide these essential commodities to the world in a way that is economically viable – the industry together with other stakeholders is making a collective move towards modernisation. This move is fundamentally people-centred and has employment and economic development at its core.

THE MINING INDUSTRY AND THE SOUTH AFRICAN ECONOMY

In 2018, the mining industry:



	contributed R351 billion to GDP
	contributed R91 billion to fixed investment
	paid R22 billion in taxes and R7.6 billion in royalties
	employed 453,543 employees who supported 4.5 million dependents
	paid employees R131 billion
	created 1.4 million indirect jobs

INTRODUCTION CONTINUED

WHY MODERNISE?

Operating environments, especially in gold and PGM mining, have historically been, and continue to be, labour- and time-intensive. As mines deepen and economically viable ore bodies extend further and further from shafts, miners are required to travel great distances before they can begin their work, which decreases drill time.

They also have to negotiate ever-narrower reefs and steeper gradients, and put their work on pause when blasting takes place. Safety and health, productivity and production, and costs are all negatively impacted as a result.

Within the next decade, as conventional methods fall short of accessing the rich reserves and resources available at depth, mines will be forced to close, leaving their employees and their employees' dependents without an income. Research suggests that, without modernisation, 200,000 jobs will be lost in the next 10 years. Taking into account the estimate that every miner supports 10 family members, this could impact some two million people in South and southern Africa.

By contrast, incorporating modernised methods has the potential to keep these people employed by extending the lives of South Africa's gold and PGM operations. A low-grade mine with a current conventionally mined life expectancy of four years, could extend operations to 15 years using mechanised drill and blast methods and, with full mechanisation and 24/7 operations, to as much as 25 years. Rolled out across the industry, modernisation could unlock the potential of an equivalent 11 large gold mines and eight platinum mines. In this way, modernisation not only preserves existing jobs, but also creates new jobs, so contributing safely and profitably to the economic development of the communities surrounding mining operations and society at large.

Critically, the envisaged modernisation process involves retraining people currently at the rock face performing arduous, repetitive and potentially risky tasks to operate low-profile, multi-functional machinery remotely or from a safe and healthy distance. In time, the industry will be in a position to train an entirely new generation of mineworkers to perform these tasks, including more and more women. In this way, modernisation efforts are as much about developing people and enhancing transformation as they are about implementing technological innovations and improving processes.

On the Witwatersrand Basin, host to the world's largest gold resource, the virgin rock temperature at depths of 2km can reach 40°C. On the Bushveld Complex, where 80% of the world's platinum is found, these temperatures can hit 70°C. Finding solutions to extract metals under these conditions is therefore not an economic convenience, it is a practical imperative.

And that is just the start. Extracting gold and PGMs from low-grade ore also requires new approaches and interventions, and dealing with hard, high-stress rock environments without the use of explosives demands advanced research. The eventual objective is a system that combines all elements to deliver, wherever possible, 24/7 mechanised operations that keep skilled personnel out of harm's way and produce higher margins.

In order for modernisation to be possible, a concerted and collaborative effort by all parties, both public and private, has to be ensured. The Minerals Council South Africa (Minerals Council) is supportive of all modernisation initiatives and, wherever it can, is facilitating and co-ordinating these within the industry and between the industry and its stakeholders.

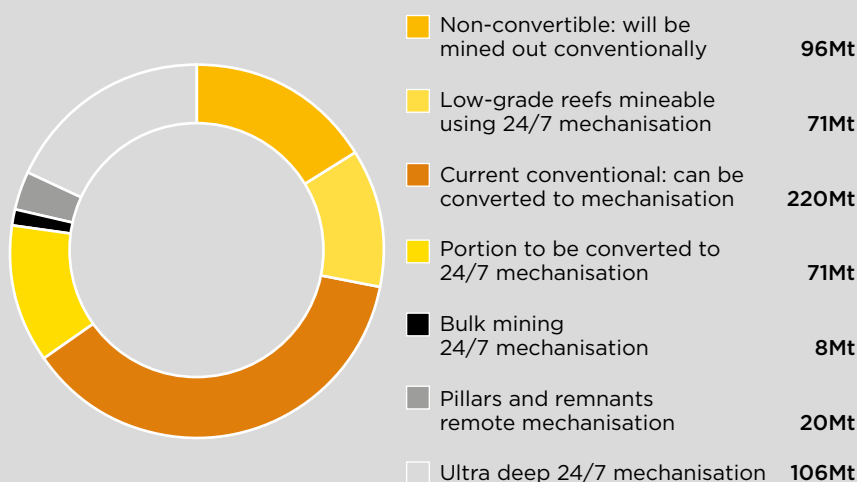


A low-grade mine with a current conventionally mined life expectancy of four years, could extend operations to

15 years

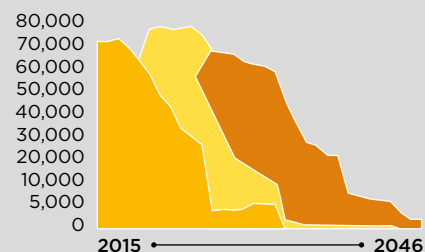
using mechanised drill and blast methods

Gold



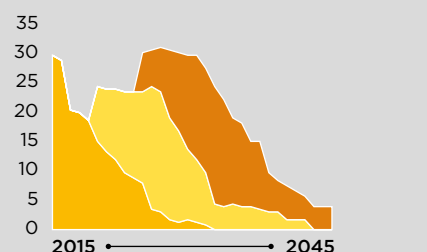
Total resources: 592Mt-496Mt can be mined using mechanisation. This is equivalent to 11 large gold mines, which would otherwise be sterilised.

Gold mines TEC



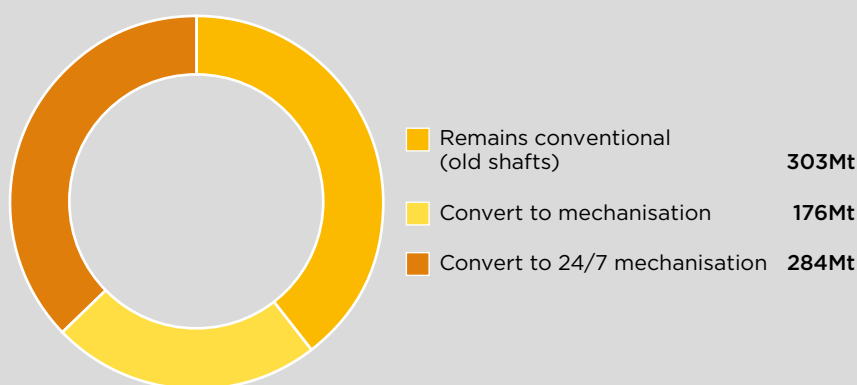
Conventional Mechanised
24/7 mechanised

Gold mines tonnes per year



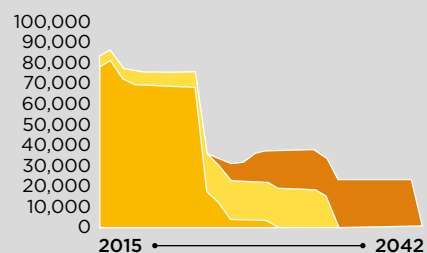
Conventional Mechanised
24/7 mechanised

PGMs



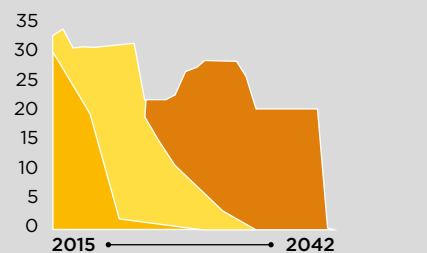
Mechanisation can preserve 360Mt of production – without mechanisation, these resources are not economical. This is the equivalent to eight large mines.

PGM mines TEC



Conventional Mechanised
24/7 mechanised

PGM mines tonnes per year



Conventional Mechanised
24/7 mechanised

Footnote: The graphs included here are based on estimates of South Africa's three principle gold companies. Similar considerations apply to South Africa's platinum mines although their resources are nowhere near as exhausted as those of the gold mines.

MINERALS COUNCIL SOUTH AFRICA'S POSITION

Modernisation is a key strategic priority for the Minerals Council and it aims to create an enabling environment for industry-wide change.



■ Universal drill rig / Credit: Hydro Power Equipment (Pty) Ltd

The Minerals Council views modernisation as an opportunity to address some of South Africa's most concerning educational and employment problems. The country's education system, which is inadequate for many people, often leaves its learners without the knowledge and skills necessary to compete in the global economy.

The Minerals Council has, as its focus, the preservation of existing jobs and the creation of new, skilled positions in an increasingly modernised industry. Modernisation is not the replacement of people with machines and it is not a euphemism for job losses. It is a process of transition and transformation that focuses on:



recognising that people are at the heart of the industry with a focus on improving employees' skills, safety, health, quality of life and professional fulfilment



turning to account South Africa's mineral resources in the safest, healthiest, most efficient, cost-effective and sustainable manner possible



conserving natural resources, and preserving and restoring the environment



contributing to the development of local and labour-sending communities



recognising that metals and minerals are valuable, useful and necessary



treating transformation and growth as key imperatives of the mining industry and nation



Health and safety – Definition

The industry's health and safety focus areas include rock falls, transportation, emissions and noise. Between 1993 and 2016, in a drive towards zero harm, mining fatalities have reduced by 88%.

Even those who are sufficiently educated struggle to find work amid the ongoing employment crisis. The mining industry, with modernisation in its immediate future, is in a position to train, develop and employ this important and disadvantaged demographic, so creating the next generation of skilled South African miners.

To meet these objectives, the Minerals Council is promoting new ways of doing things. The current approaches to people, technology and processes need to be examined, re-imagined and reconfigured to secure the future of South Africa's mining industry.

MINERALS COUNCIL SOUTH AFRICA'S POSITION CONTINUED



CASE STUDY:

Minerals Council South Africa platinum fuel cell

In 2015, Africa's first 100 kilowatt (kW) fuel cell that runs on platinum and natural gas was installed at the Minerals Council South Africa in Johannesburg, providing baseload power to the entire building. This new, modernised approach demonstrated the fuel cell industry's potential to revolutionise the way power is delivered – from cars to mobile phones and computers, as well as homes and workplaces. Minister of Trade and Industry Rob Davies said this feat would see South Africa gain entry into the manufacturing and distribution of fuel cell components, which would significantly increase platinum demand.

THE MINING PHAKISA

In 2015, a multi-stakeholder engagement forum, the Mining Phakisa, was held. Its aims were to foster growth, transformation, investment and employment preservation and creation in the mining industry, together with all relevant parties and sectors. These included industry, equipment manufacturers, universities, research institutions, and government departments such as the Department of Science and Technology (DST), the Department of Trade and Industry (DTI) and the Department of Mineral Resources (DMR).

The Phakisa spanned five weeks of intensive work and debate and came to the conclusion that an ad hoc approach could no longer be contemplated. Its aims could only be achieved through the development of innovative research and development (R&D) initiatives that combined the knowledge, skills and expertise of everyone involved.

To achieve this, the Phakisa adopted the South African Mining Extraction Research, Development and Innovation (SAMERDI) strategy, which outlines the need:

“to maximise the returns of South Africa's mineral wealth through collaborative, sustainable research, development, innovation and implementation of mining technologies in a socially, environmentally and financially responsible manner that is rooted in the well-being of local communities and the national economy.”

Practical steps were put in place following this agreement:

- The DST made the Carlow Road facility (now known as the Mandela Mining Precinct) available for the co-ordination and facilitation of mining R&D, for manufacturing and for sustainable development initiatives.
- The DST granted, through National Treasury, funding of R210 million over a four-year period, which may be increased and continued.
- The DTI granted R8 million for the establishment of the Mining Equipment Manufacturers of South Africa (MEMSA) as a development cluster to increase the capacity and capability of local mining equipment manufacturing, both for the local and export markets. MEMSA is hosted within the Mandela Mining Precinct.
- The Minerals Council South Africa, in addition to seed funding of R10 million in 2016, has pledged about R35 million for 2018.
- Commitments have also been made by the mining universities and the Council for Scientific and Industrial Research (CSIR) to participate in these programmes in a fully collaborative manner.

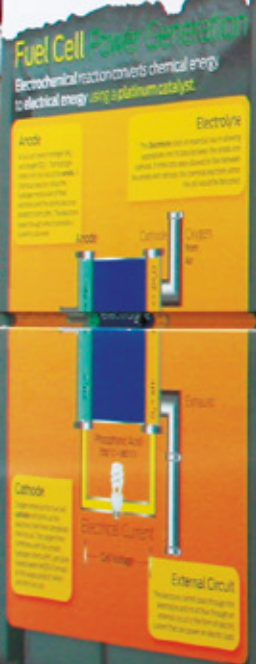
As a result of these developments, mining R&D has accelerated and the industry and its relevant stakeholders have experienced renewed energy in accessing the many and varied benefits of modernisation. Recent months have seen concerted and tangible progress in this regard.

The South African Mining Extraction Research, Development and Innovation (SAMERDI) strategy outlines the need: “to maximise the returns of South Africa's mineral wealth through collaborative, sustainable research, development, innovation and implementation of mining technologies in a socially, environmentally and financially responsible manner that is rooted in the well-being of local communities and the national economy.”



PLATINUM POWER
FUEL CELL

PLATINUM POWER
FUEL CELL



environmental
responsibility

CO₂



In 2015, Africa's first 100kW fuel cell that runs on platinum and natural gas was installed at the Minerals Council South Africa

Minerals Council South Africa 100kw commercial building baseload fuel cell

heating
the
building

reducing CO₂
emissions




RECENT DEVELOPMENTS



in sponsorship received from Gold Fields,
New Concept Mining and Sibanye-Stillwater
for the Wits Digital Mining Laboratory



 The Digital Mining Laboratory (DigiMine) / Credit: University of the Witwatersrand, Wits Mining Institute (WMI)

Since the Phakisa, several interventions have taken place to further drive the industry towards modernisation, the most significant of which are the developments at Carlow Road. The Mandela Mining Precinct that now operates there is actively working to modernise the industry, and has been guided in its endeavours by many researchers and innovators from a range of industries.

THE MANDELA MINING PRECINCT

In 2016, the old Minerals Council South Africa Research Organisation campus in Auckland Park, Johannesburg, was redesignated the Mandela Mining Precinct, the industry's new innovation, manufacturing and sustainable development centre. It is here that the collaboration between private and public stakeholders and their commitment to modernisation will be borne out and given the space and resources to be put into practice.

To cover its costs in the short term, the precinct has received confirmation of funding from both government and the Minerals Council, as outlined above. These funds leverage and augment the estimated R500 million to R1 billion already invested by mining companies in their own initiatives, as well as further investment by mining equipment manufacturers in individual product development. Additional partners involved in the precinct include MEMSA, the Mine Ventilation Society, the Geological Society, the CSIR, the Mine Health and Safety Council, Coaltech, and research institutions at the Universities of the Witwatersrand, Pretoria, Johannesburg and South Africa.



CASE STUDY:

The Wits Digital Mining Laboratory

The first phase of this project saw the Wits Mining Institute build a mock underground tunnel to simulate an underground mining environment for teaching, learning and research purposes. The 70m tunnel features a stairwell equipped with a mock vertical shaft, a stope, a lamp room and a control room. "The institute's mission is to make mining safer and more sustainable by harnessing fast-developing technologies and practices from different sectors, which are sadly not always incorporated into mining applications quickly enough to address the industry's many challenges," says Professor Fred Cawood, the institute's head. The project, which cost R15 million, received sponsorship from Gold Fields, New Concept Mining and Sibanye-Stillwater.



RECENT DEVELOPMENTS CONTINUED



CASE STUDY: The University of Pretoria virtual reality centre

In a first for Africa, the University of Pretoria’s mining engineering department, together with Kumba Iron Ore, has created a world-class Virtual Reality Centre. The centre enhances education, training and research in operational risk across industries by providing a unique, full-service, integrated virtual reality resource. It incorporates physical infrastructure as well as expert consulting and technical support services, and includes an all-in-one 3D stereoscopic, immersive visualisation platform comprising a lecture hall, 3D stereoscopic theatre and 3D 360-degree cylinder. In addition, it grants access to virtual reality simulation products and modules representing a wide range of existing environments and practical scenarios.



The precinct's research programme has six work streams, each of which operates under expert leadership.

1



Developing the longevity of current mining operations:

This work stream is focused on developing the longevity of current mining operations by improving health and safety, increasing the efficiency of extraction and reducing costs. This work stream seeks to build on the strength of South African mining equipment manufacturers' capabilities and offerings, and on the collective knowledge and ingenuity of the industry's members

2



Mechanised drill and blasting:

This aims to develop fully mechanised mining systems that allow for remote drilling and blasting of narrow, hard rock orebodies, such as those found in gold and platinum mines.

3



24/7 non-explosive rock breaking:

Developing systems for continuous mining means allowing for ore extraction to be performed completely without the use of explosives. For this to be possible, the entire mining system must change, but the benefits include massive improvements to health and safety, an increase in the life of mines and a reduction of waste.

4



Advanced orebody knowledge:

Since mechanisation and modernisation require better knowledge of the orebody ahead of the mining face, this involves developing and using accurate 3D real-time models to see through the rock and so assist with safety, health and planning.

5



Real-time information management systems:

The ability to use real-time information for monitoring and control purposes would allow for pro-active interventions that can correct deviations and unsafe and unhealthy conditions as they arise. It would revolutionise safety, health and production in the industry. Using the Internet of Things* underground thus becomes an imperative for the future.

6



Successful applications of technology (map):

The modernisation of mining will have to be people-centred and positively impact skills levels. Change management will need to be a key component of this shift as employees at every position come to understand the associated upstream and downstream processes.



***The internet of things – definition**

The Internet of Things (IoT) is about connecting electronics and objects to the internet. It is the use of different data sources from these connected sensors to gain insights on and interact with the objects. It is comprised of four levels: the objects and electronics concerned (the so-called “things”), communicators (ethernets and satellites), IoT processors and human interfaces.

RECENT DEVELOPMENTS CONTINUED

Separate to the work being undertaken at the precinct, but with a view to inform these efforts, the Minerals Council is also gathering expert opinion on what trends could and should influence the industry's modernisation strategy to 2030. Part of this process has involved the expertise of innovation consultancy the Research Institute for Innovation and Sustainability (RIIS), which has been tasked with analysing the mining industry ecosystem and developing a people-centred road map to guide how to take modernisation forward.



CASE STUDY:

CMTI disruptive innovation through stope mechanisation

Sibanye-Stillwater's Burnstone mine is currently testing a remotely operated drilling machine developed by mechanical engineering consultants CMTI. The machine will be operated from a remote distance or central point, improving operator productivity and enabling the machine to access dangerous and previously inaccessible areas to unlock reserves. The machine can mine at lower operating heights, so increasing yield and reducing costs. The Mining Precinct's technology assessment and readiness database has been established to assist mines in identifying technologies such as that of CMTI, and in monitoring and evaluating their performances.



CASE STUDY:

DOK-ING MVD-XLPD

DOK-ING, one of Anglo American's innovation partners, has developed an MVD extra-low profile dozer (XLPD) that is remotely controlled and can be used for underground mining and construction purposes. The dozer is diesel-powered, and can work well beyond miners' capabilities in difficult and harsh environments, including gradients of 30° and heights of 1.2m to 1.6m. It can handle 50 to 120 tonnes of ore per hour and needs minimal maintenance. The MVD-XLPD's remote control is also so easy to use that operators can be trained in a matter of days.



THE WAY FORWARD

During the course of 2017, RIIS conducted several events to improve the state of innovation in mining and to explore and find solutions for some of the issues faced by modernisation. These events sparked dialogue about social innovation, provided a platform to imagine an ideal mining future, brainstormed ideas to problems found throughout the mining cycle, and developed conceptual innovations to health and safety challenges in the industry.

Concerted, sincere collaboration and an increased focus on people, RIIS's research demonstrated, are central in taking mining innovation forward. These efforts must involve an increased focus on relationship-building between industry players, as well as between industry and employees, community members and civil society. Doing so will clarify the roles of different stakeholders and will serve to address the current trust deficit.

The influence of the mining industry, RIIS suggests, can also be used to leverage opportunities in other industries. "To facilitate mining innovation, the industry should decide to become an enabler of green and manufacturing technologies, instead of depending on them to pave the technology frontier. This means investing in secondary industries. It also means finding ways of catalysing job creation in other industries," says RIIS's report.

Imagining an ideal mining future and finding solutions to the mining cycle brought forth ideas about health, safety and regulation; productivity, efficiency and competency; technology and automation; and socio-economic factors. The vision is to create and sustain an industry where people and the environment are cared for; where user-friendly robotics and high-level artificial intelligence*, together with augmented and virtual reality**, drive efficiencies; where employee skillsets meet the needs of an advanced industry; and where social issues are

THE WAY FORWARD CONTINUED

addressed and a productive, positive culture is nurtured.

These ideas represent the collective voices of the industry's members and stakeholders. They supplement the conclusions already drawn by the Mining Phakisa and put into action by the Mandela Mining Precinct, and will continue to orientate and guide modernisation efforts as they progress.



CASE STUDY: Anglo American

Anglo American Platinum is testing equipment for hard rock, mechanised mines to operate with extra-low and ultra-low profile mining technology. In its 2016 integrated report, the company says, "Our aim is for 80% mechanised production from the repositioned portfolio. The move to mechanisation will ensure these alternative mining methods will be safer and more productive, therefore more cost-effective for the business."



*Robotics and artificial intelligence - definition

Robotics development and application in South Africa's deep-level, hard rock gold mines is about having affordable, small, robust, trackless and remotely operated machines perform tasks traditionally undertaken by people. The intention is to remove miners from risky environments and to retrain them as machine operators instead. Using artificial intelligence, or programmed information that enables a machine to perceive its environment and take appropriate actions, these machines can work in narrow, confining workspaces, improving accuracy and productivity.



■ **Robotics and Artificial Intelligence**
Credit: Anglo American Platinum



**Augmented and virtual reality - definition

Immersive technologies, such as augmented and virtual reality (AR and VR), allow information to be delivered and processed in new and compelling ways. While AR overlays interactive digital information on top of the physical world, VR replaces the real world with a simulated one. Their systems are made of hardware, software and reality tracking subsystems.



■ **University of Pretoria Virtual Reality Centre**



■ **CMTI Mining and Manufacturing MT100-Sweeper** Credit: Sibanye-Stillwater

CONCLUSION

Today, in a way never seen before, there is a well-resourced, multi-stakeholder and collaborative initiative under way to modernise the South African mining industry. The approach is people-centred and technologically innovative; it has been carefully considered and is in the process of being strategically implemented.

As R&D progresses, possible solutions will need to be thoroughly tested and, when proven, gradually implemented. The move to modernisation will need to be iterative but unrelenting. Staying with conventional mining is no longer an option.

Given time, the result will be a mining industry that is safe, healthy, profitable and sustainable. It will be globally relevant, having developed South African solutions to international mining problems, and it will contribute positively to the people it employs, to the communities it affects and to society at large. It will also be increasingly agile and adaptable to changing circumstances, forever developing and using the latest innovation to the advantage of its production targets and balance sheet. The result will be to make mining matter more for longer.



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