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SUSTAINING ZERO HARM IN A MODERNISED MINING ENVIRONMENT

AFRICAN MINING NETWORK

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HEAD OF INNOVATION: NOSA
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JOHANNESBURG

OBJECTIVE OF THE PRESENTATION

EXECUTIVE SUMMARY

- Substantial improvements have been made in terms of the strive towards zero harm in the mining industry;
- However, the impact of mine modernisation on the industry (including health and safety) remains largely uncertain;
- A literature review (1997-2016) indicated that approximately twenty leading practices (versus best practices) exist which should guide mine modernisation;
- Several of these practices eludes to the fact that indicate that the modernisation of mines will have an profound impact on the safety of individuals as well as the social dimensions of mining communities;

EXECUTIVE SUMMARY

- Mine modernisation will alter the role of individuals responsible for health and safety and; individuals exposed to the effect of a modernised work environment (man-machine interaction);
- The effect of mine modernisation is far more encompassing than merely the physical safety and will also impact on both the psychosocial wellness and interpersonal competencies of individuals;
- Several South African and international stakeholders are recognising the importance of the health of the "whole being" of individuals;
- Recommendations on the manner in which the industry should react to mine modernisation need to be considered for implementation.

SIGNIFICANT PROGRESS

- The Department of Mineral Resources stated: “in terms of mine health standards, the local mining sector had improved over the years, but not as much as the DMR would have liked.

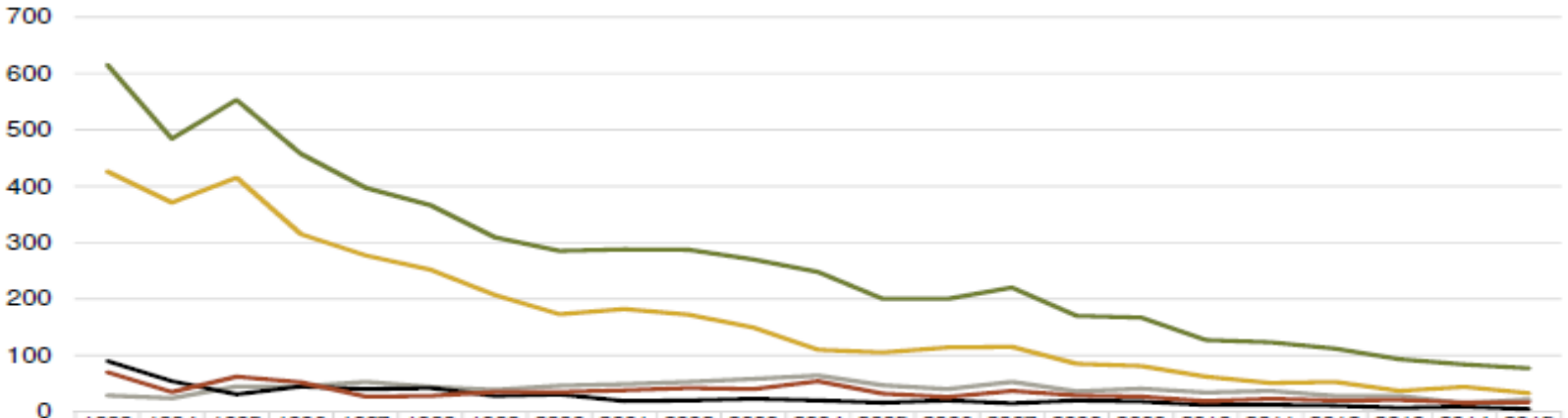
- The Mineral Resources Minister stated: “while the mining industry has not yet been able to achieve its goal of zero harm, it has made significant progress towards doing so.”

- The Chamber of Mines stated: “It’s a lot of these ‘first ever’s (in terms of lowering fatalities and incident rates) together that are giving us the trend we are seeing and giving people hope that we can say it is possible to have fatality-free operations.“

Number of fatalities by commodity

CHAMBER OF MINES of South Africa

- The mining industry has made significant progress over the past two decades to improve safety and occupational health in the mining sector, with an 87% reduction in the number of fatalities between 1993 and 2015
- Industry reduced fatalities for eight (8) consecutive years since 2007



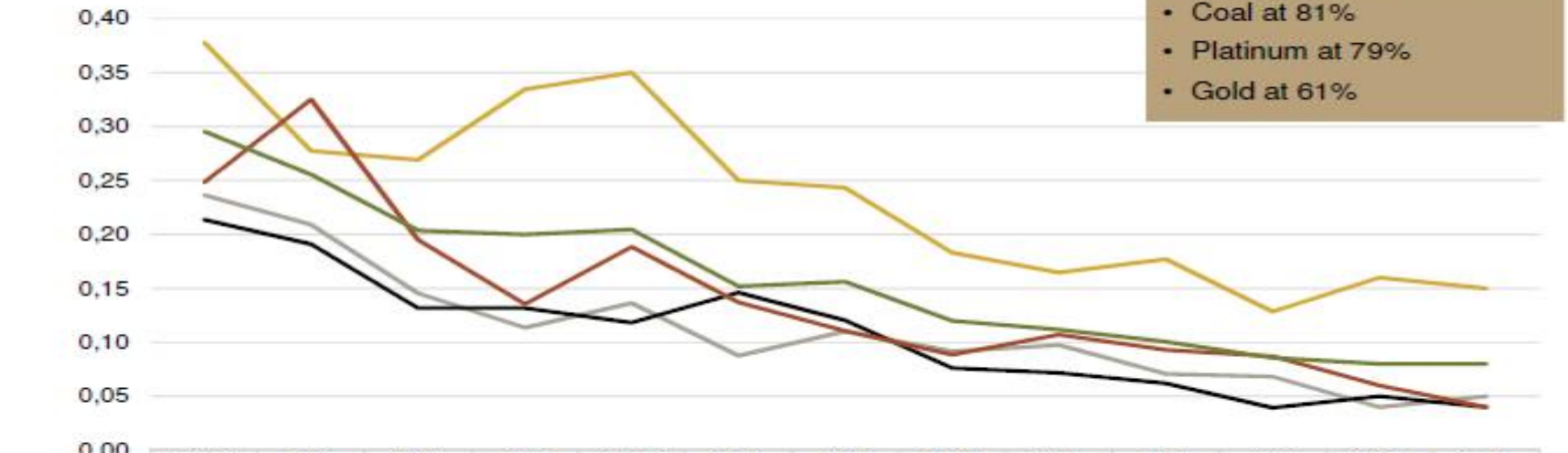
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Gold	426	371	415	315	277	252	207	173	182	172	149	110	105	114	115	85	81	62	51	53	37	44	33
Platinum	29	24	45	45	53	44	39	46	49	53	58	64	47	40	53	36	41	34	37	28	28	15	22
Coal	90	54	31	45	40	42	28	31	19	20	23	20	16	20	15	20	18	12	12	11	7	9	5
Other	70	35	62	52	27	28	35	35	38	42	40	54	32	26	37	29	27	19	23	20	21	16	17
All	615	484	553	457	397	366	309	285	288	287	270	248	200	200	220	170	167	127	123	112	93	84	77

Fatality rates by commodity (per million hours)

CHAMBER OF MINES of South Africa

Improvements

- Other commodities at 84%
- Coal at 81%
- Platinum at 79%
- Gold at 61%



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Gold	0,38	0,28	0,27	0,33	0,35	0,25	0,24	0,18	0,16	0,18	0,13	0,16	0,15
Platinum	0,24	0,21	0,15	0,11	0,14	0,09	0,11	0,09	0,10	0,07	0,07	0,04	0,05
Coal	0,21	0,19	0,13	0,13	0,12	0,15	0,12	0,08	0,07	0,06	0,04	0,05	0,04
Other	0,25	0,32	0,19	0,14	0,19	0,14	0,11	0,09	0,11	0,09	0,09	0,06	0,04
All	0,30	0,26	0,20	0,20	0,20	0,15	0,16	0,12	0,11	0,10	0,09	0,08	0,08

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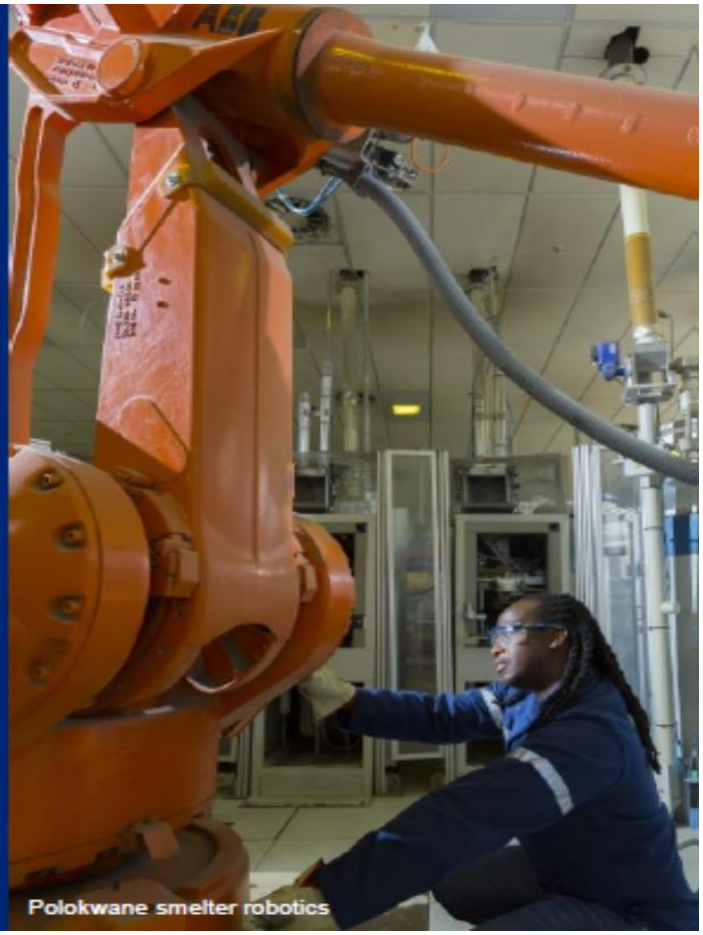
2016 Industry Safety Performance Update
(year-to-date)

CHAMBER OF MINES of South Africa

	Fatalities			Injuries		
	Actual			Actual		
	01/01/2015 – 03/10/2015	01/01/2016 – 03/10/2016	% change	01/01/2015 – 03/10/2015	01/01/2016 – 03/10/2016	% change
Total	**59**	**67 (72 10/11)**	**-14**	**2361**	**1958**	**17**
Gold	29	29	0	927	827	11
Coal	5	4	20	165	142	14
Platinum	15	23	-53	982	763	22
Other	10	11	-10	287	226	21

WHAT DOES THE FUTURE LOOK LIKE

Redefining Mining

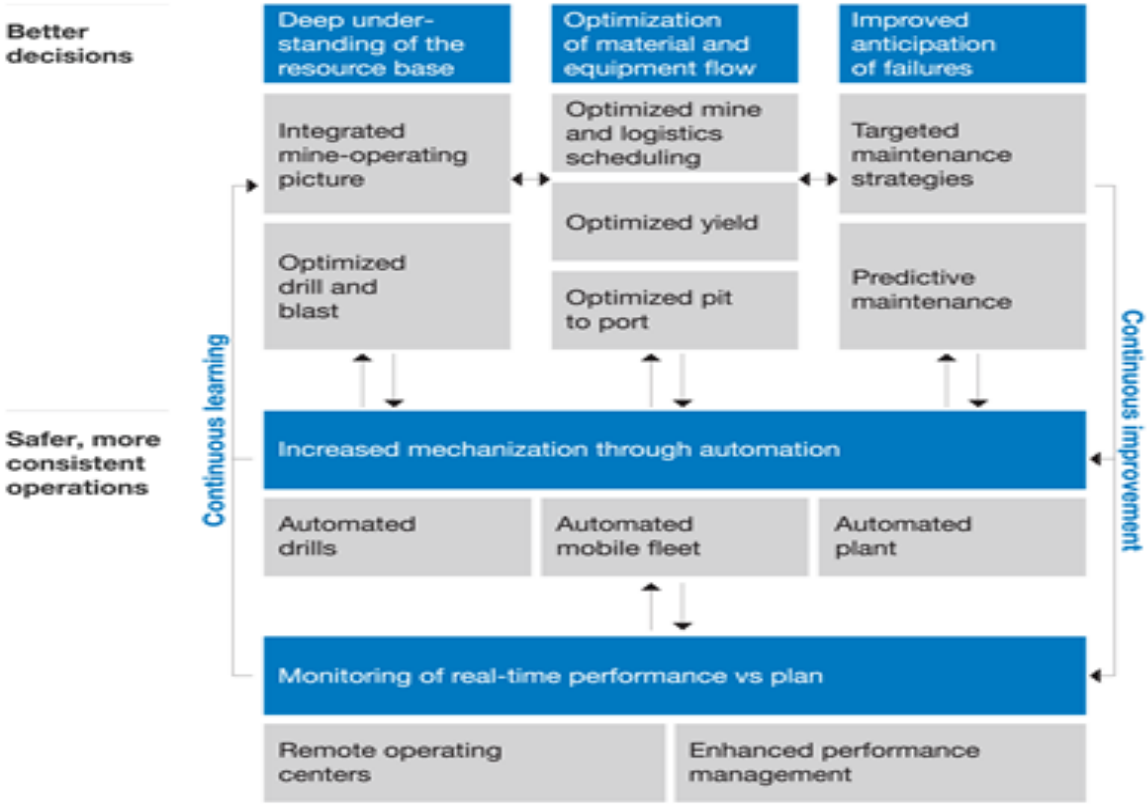

Polokwane smelter robotics

ROADMAP TO MODERNISATION

Mining Operations Transition from Conventional to Autonomous						
LEVEL	**0**	**1**	**2**	**3**	**4**	**5**
	CONVENTIONAL	**MECHANISED**	**REMOTE**	**SEMI-AUTOMATED**	**AUTOMATED**	**AUTONOMOUS**
SURFACE AND UNDERGROUND	**Conventional**, labour intensive mining methods utilising hand-held machinery.	**Mechanised** labour intensive and/or dangerous tasks. Operator rides on board the machinery.	**Line-of-sight remote operation**. Operator needs to be in close proximity to the machine.	**Tele-remote operation** of machinery from a central control room. Automation of certain functions to improve productivity.	**Total machine functionality automated.** Machinery monitored from control room, human remote intervention only when necessary.	**Artificial intelligence.** Machinery able to plan and execute its own mining plan based on mine model. Requires no interaction or human intervention.
EXAMPLES	Hand-held drills Scraper winches Shovels	Underground coal mining Open pit mining Massive underground mining	Underground drill rigs Continuous miners Roof bolters	Tele-remote LHD's Underground drill rigs Haul trucks Undersea mining	Underground drill rigs Open pit autonomous haulage systems Underground autonomous halage systems	DARPA grand challenge
DRIVING FACTORS		Safety Health Productivity	Safety Health	Productivity Quality Utilisation "Quality jobs"	Productivity Quality Labour Hazardous environment	Productivity Quality Utilisation Efficiency

The steps through which mining operations will progress whilst transitioning from conventional mining (manual labour) to autonomous mining (unmanned, self-regulating equipment) i.e. to become modernised.

Five areas of digitization exist for significant value creation.



McKinsey&Company

MODERNISATION OF MINES

- ❑ Improving operational efficiency and productivity
- ❑ Lowering the cost of labour
- ❑ Ensuring uninterrupted operational processes
- ❑ Ensuring a stable and secure working environment
- ❑ Improving safety and strive towards zero harm
- ❑ Maintenance of equipment

Mining companies no longer talk about the unreliability of the technologies associated with automation, mines will come to depend upon automation in profound and unspoken ways, and they can because automation works reliably, is flexible, safe and can be maintained." (Dudley, McAree & Lever, 2010).

MODERNISATION OF MINES

"Innovation has also led to massive increases in output and productivity, shifting the sector from being heavily labour-intensive to being increasingly mechanised and automated at a scale that would have been unimaginable in the past. For example, long wall coal mining, developed through a series of innovations in the 20th century, improved recovery rates and labour productivity by around 20% while also dramatically improving worker safety." (Deverall, 2016)

So we understand the motivation behind mine modernisation but do we have a clear understanding of the impact thereof on health and safety and related factors?

GLOBAL INDUSTRY PRACTICES

Twenty global leading practices have been identified that portray the manner in which mine modernisation will impact the mining industry in terms of:

- ❑ Health and Safety
- ❑ (Psycho) social wellbeing
- ❑ Human factors
- ❑ Social dimensions of communities
- ❑ Employment demographics
- ❑ Skills requirements
- ❑ Interaction between man and machine

(McNab et al. (2013) Exploring the social dimensions of autonomous and remote operation mining)

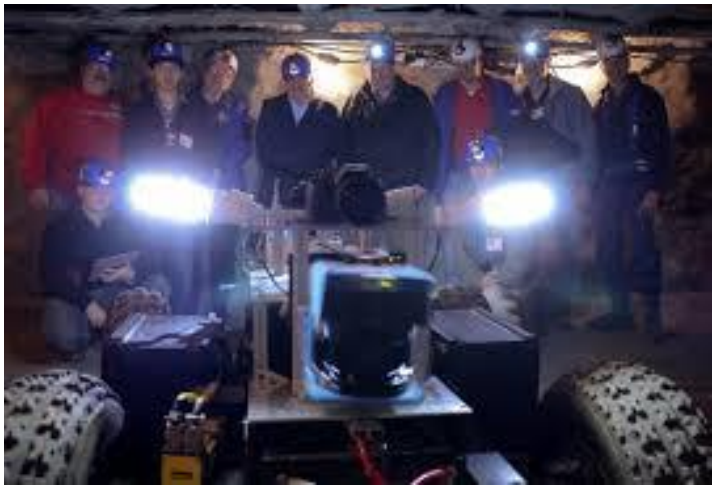
GLOBAL INDUSTRY PRACTICES…CONTINUED

- Health and Safety (including psycho-social wellbeing, human factors; interpersonal competencies)
  - Reduced on-site risk
  - New risks – working with automated vehicles
  - New risks – working in ROC

- Social dimensions of communities
  - Change in social services
  - Change in focus of mining company social investment and community relations

GLOBAL INDUSTRY PRACTICES…CONTINUED

- Skills requirements
  - Change in skills base of workforce and service providers
  - Change in education and training needs
- Employment demographics
  - Change in size of workforce
  - Change in culture and workplace relations
  - Change in workforce participation levels
  - Change in employment opportunities
- Interaction between man and machine



GLOBAL INDUSTRY PRACTICES…CONTINUED

Changes in employment demographics:

- ❑ Fewer workers at the mine site
- ❑ Changed roles – troubleshooting, oversight & maintenance
- ❑ Shift of employees to ROC
- ❑ Higher degree of technical skills required

GLOBAL INDUSTRY PRACTICES

Bristow (2014) states: “In theory, if you become more mechanised some operations roles, such as driving trucks and manually operating drilling rigs and underground equipment, are likely to disappear over the longer term. In an open pit mine, in-pit roles could be reduced by about half. New roles in equipment maintenance, data processing and process analysis, operational control and mine planning are likely to emerge. These new roles require different competencies, such as knowledge and skills in mathematics and science, and an aptitude for using information technology.”

GLOBAL INDUSTRY PRACTICES…CONTINUED

Although the number of incidents decreased, injuries associated with mechanised mining tended to be more severe, mainly due to the magnitude of the energies released in pedestrian/machine interactions.

Some of the identified causes of reported incidents include:

- Interactions between equipment and equipment and equipment and people
- Non-adherence to operating procedures
- Unplanned/inadvertent movements of equipment
- Operator error due to fatigue or substance abuse
- Poor visibility, noise and other adverse work environment conditions

GLOBAL INDUSTRY TRENDS...CONTINUED

Botha (2016) summarises the H&S and related factors/aspects that need to be considered when health and safety management systems are introduced in a mechanised mining environment in the following way:

- ❑ Psychological
- ❑ Physiological
- ❑ Sustainability related (i.e. community health)
- ❑ Technical (i.e. equipment reliability)
- ❑ Risk management and critical controls

MODERNISATION OF MINES…CONTINUED

The successful implementation of machinery with novel technology may be influenced by numerous factors of which the key ones remain to be identified and measured. Lynas and Horberry (2011) state: When a system fails it is often for more than one reason or factor:

- ❑ Purely technical failures
- ❑ Human-machine interface design failures
- ❑ People operating the system
- ❑ Amount of training operators received
- ❑ Physically and mental aptitude of operators
- ❑ Resistance to change
- ❑ System failure due to operating procedures or the environment

MINE MODERNISATION AND HUMAN FACTORS

…"there is now more of a focus on interface design, acceptance of new technologies, and the changing skill requirements for those who operate and maintain the new equipment. **They argue there is the potential for automated systems to overload, confuse and distract, rather than support, or assist the operator, and highlight approaches like standardization, appropriate training and risk assessments, alarm integration, operator and manager consultation and feedback, as vital components of system success.** (Lynas & Horberry, 2011)

SUGGESTIONS AND RECOMMENDATIONS

Dr Kieren Moffat (Resources in Society Group Leader, CSIRO Mineral Resources Flagship in Australia) states during a personal interview in February 2015.

- ***Conduct a technology "audit" or assessment of current and future levels of modernisation on mines – that is, what is happening where in terms of modernisation and the impact thereof***

- Use the results of the abovementioned audit to develop various combinations of options to address the health and social /employment in addition, we need to ascertain how many individuals will be affected (Horberry and Lynas, 2012)

- Consider various "options" for job creation (for example, infrastructure/agriculture) – focus on creating **meaningful and sustainable jobs** (consider the long-term effect of meaningful versus meaningless work)

Thank you

This presentation is dedicated to:

Yvonne Mnisi, Solomon Nyerende and Pretty Nkambule

(Lily Mine Disaster February 2016)

The Most Important Thing To Come Out of A Mine Is The Miner