UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

Systems approach to improve utilisation of autonomous drilling at an open pit mine in South Africa.

Tabotabo Talane

(Student number: 883062)

School of Mechanical, Industrial and

Aero University of the

Witwatersrand Johannesburg, South

Africa.

Supervisors: Dr Andries Botha

A Research report submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, in fulfilment of the requirements for the degree of Masters in Engineering.

Date: 19/12/2024

PLAGIARISM DECLARATION FOR HIGHER DEGREE STUDENTS

I, Tabotabo Talane (Student number: 883062)
am a student registered for the degree of MSc in Systems Engineering (ECA07), in the year 2023.
I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that ALL the work submitted for assessment for the above course is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.

Signature: _____ Date: 19 Dec 2024

EXECUTIVE SUMMARY.

Mining companies have opportunities to feed the continuously growing global economy. However, these opportunities come with challenges. Technologies like drilling automation can help combat these challenges while improving operational efficiency. Although the importance of investing in technology is well appreciated, mining houses still struggle with the sustainable and effective use of introduced technologies.

This study looks at the challenges faced by one of the open pit mines in South Africa. The case study mine has introduced ADS (autonomous drilling system) to aid in improving both health and safety, and operational efficiency, but utilisation of the system remains low. The aim of this study is to investigate potential causes of the problem and to come up with an actionable solution to tackle the challenges faced and improve the use of ADS.

Six semi-structured interviews were conducted where experts in the field of autonomous drilling shared their insights into factors affecting the adoption of ADS. The interview data were recorded, transcribed and analysed using thematic content analysis. The analysis of the interview data yields seven themes: stakeholder engagement and buy-in; management support and trust; process management and KPIs (key performance indicators); ownership, accountability and influence; site capability; culture and attitude shift; and implementation approach.

Using the systems approach and soft systems methodologies (SSM), the study found that effective stakeholder engagement and communication with workers early in the project can lead to a positive attitude towards the introduced system, improving its adoption. Further, management support becomes vital to build trust and team resilience, especially during challenging times. Additionally, the way of managing processes must evolve and adapt to accommodate the technology system introduced, and this requires a mindset shift from a leadership perspective. Operating standards and procedures of the entire drilling process, from planning to execution, also need to evolve with the introduction of technology to ensure that upstream processes become enablers of the effective use of the technology. Like standards and procedures, key performance indicators are those metrics that managers track, and they also need to be updated to allow accountability and ownership around the use of technologies like ADS. With commitment and drive from operational leaders, technology implementation can succeed. The correct implementation approach will increase the chances of success. The approach must be guided by an effective stakeholder engagement and requirements analysis. A proper approach in tandem with both management support and team commitment can result in the sustainable adoption of new technologies, including ADS.

Table of Contents

1. RESEARCH BACKGROUND/CONTEXT

The global economy has seen significant growth in the last few decades, with increased demand for natural resources (Sun & Anwar, 2015). The increased demand for natural resources presents an opportunity for mining industries. However, mining companies face their own challenges: increased complexity of ore bodies and more stringent environmental and social regulations. The sustainable development drive presents a unique challenge for mining producers. On one side, mining can be viewed as substantial in fuelling economic growth at both national (particularly for developing countries) and global levels. On the other side, mining can be viewed as having negative impacts towards the surrounding environment and communities (Shen, et al., 2015).

There has been an increase in public awareness of the negative environmental and social effects of mining, leading to more stringent regulations on mining activities (Soderholm, et al., 2015). More and more countries introduce requirements for social development plans, where mining companies are required to uplift the socio-economic state of communities surrounding their respective operational areas (Al Rawashdeh, et al., 2016). More stringent regulations encourage mining houses to operate responsibly and safely. Other challenges include the continuous depletion of natural resources, leading to the mining of inferior grades of ore and more challenging extraction environments (Soderholm, et al., 2015). Richer and shallower mineral deposits are depleting, leaving more costly and more difficult-to-access deposits (Ediriweera & Wiewiora, 2021).

Mining companies have embraced the importance of environmental and social responsibilities for long-term profitability, forming partnerships with communities and regulatory bodies for a sustainable future (Shen, et al., 2015). Mining companies are introducing innovative technologies directed at improving productivity and aiming to become greener to lessen negative environmental impacts (Ediriweera & Wiewiora, 2021). The challenges faced direct mining companies towards looking for opportunities to improve their core extraction processes, where they can leverage technology to reduce their negative environmental and social impacts while creating safer workplaces. In addition, technologies that can improve productivity and cost efficiency become vital for mining companies to broaden their margins. Autonomous drilling system is one of few technologies directed at improving mining core processes.

In mining, in-situ rock containing minerals of value is broken, enabling the liberation of desired minerals from the host rock (Ben-Awuah, et al., 2016). The most common method of rock breakage in mining is drilling and blasting. Drilling and blasting at each mine are the first processes in the mining production cycle responsible for the first stage of rock breakage, allowing for efficient digging and extraction of the mineral-bearing rock out of the earth's crust. The method entails drilling holes at predetermined positions and to required depths. The drilled holes are loaded with explosives in controlled amounts. When blasted (detonated), the explosives contained in the holes release energy sufficient to break the surrounding rock mass into planned fragment sizes (Jimeno, et al., 2017). This integrates drilling and blasting, rendering the method self-explanatory.

Drilling and blasting are crucial operations in open pit mining as they directly influence downstream processes (Abbaspour, et al., 2018). The explosive energy needs to be effectively utilised to break the host rock into fragments that can be safely and efficiently dug, loaded onto trucks and transported to desired destinations (waste rock to dumps and mineral-bearing rocks (ore) to the processing plant) (Temen & Afum, 2015). At the processing plant, the mineral-bearing rock is further broken by crushers, and in some cases, the mineral of value is extracted from the broken host rock and shipped to relevant markets (Gupta & Yan, 2016).

As the degree of fragmentation from the drill and blast process influences the efficiency of digging, transportation and ore processing, one can begin to appreciate the importance of drilling in the mining cycle. Downstream activities have their efficiency and productivity leaning on overall drilling quality and productivity (Jimeno, et al., 2017).

Innovation efforts are continually expended on improving drilling practices (Isheyskiy & Sanchidrian, 2020). One aspect of innovation introduced to surface mining is autonomous drilling, which aims to create safer conditions and improve drilling efficiency and quality. The operator is situated remote from the drill machine in a control room, with minimal intervention on the drilling process (RioTinto, 2023). Introduction of autonomous drilling is also one of the strategies to make operations safer as it eliminates the physical human-machine interface, thus reducing operators' exposure to hazards. Safety is one, but not the only benefit offered by autonomous drilling. Operational efficiency is part of the gains mining organisations operating autonomous machines report (Noone, 2020).

Noone (2020) argues that operations become more predictable and stable as autonomous machines follow a predetermined procedure. These are some of the benefits the case study mine is trying to unlock with ADS.

The case study mine is one of the only two mining operations in South Africa owned and operated by Company x. This mine is an iron ore producer based in the Northern Cape Province of South Africa. The mine produces 13.6 Mt of iron ore annually through the collaboration of all departments at the case study mine, from exploration to delivering the product to relevant markets. The case study mine is an open pit operation with three active mining pits.

Iron ore is used to make various alloys, and its most important use is steelmaking (Ghosh and Chatterjee, 2008). Steel's importance in the global development posits the case study mine as crucial contributor to the modern society.

2. PROBLEM STATEMENT/MOTIVATION

Mining is one industry that has been perceived as a laggard in adaptation to the modern world and this is in part owing to the slow rates of technology adoption in its core processes (Ali and Rehman, 2020). The struggles of technology adoption in mining can be attributed to more challenging working environments (Ranjith, et al., 2017). The core processes include drilling, in which holes are drilled to targeted depths to be loaded with explosives for blasting (detonation), giving rise to the 'drill and blast' rock breakage method. Autonomous drilling is one operational technology introduced to surface mining operations. The aim is to remove operators from the drill machines and limit their intervention, looking to improve both safety and operational efficiency (RioTinto, 2023).

Rio Tinto (2023), as an organisation that is at the forefront of automation, arguing that autonomous drilling can bring benefits. The mining producer reported safety and health as the chief benefits as operators are no longer exposed to operational hazards. Traditionally, the operator is physically situated in the drill machine during operation, exposed to hazards.

Matetic (2005) posits that noise-induced hearing loss (NIHL) is one of the most prevalent health risks in mining. Operators are exposed to noise when in the drill machine, with increased risk with each day at work.

Noone (2020) bolsters Rio Tinto (2023) argument by reporting that mining firms look to technology and automation to boost health and safety performance. Poor health and safety performance can lead to loss of lives, which can result in an undesirable reputation for mining companies. A tarnished reputation leads to the loss of social license to operate.

Contraction of silicosis is another risk in mining. In South Africa, there is a trust fund valued at R5 billion that mining houses contributed to, which is directed at compensation towards mineworkers who contracted silicosis at work (Davis, 2018). Inhalation of silica dust generated from drilling activities can lead to contraction of silicosis (Davis, 2018). Increased compensations lead to a reduction in cost efficiency, which is vital for profitability. With autonomation lies a potential for mining houses to remove mineworkers from harm's way while increasing productivity and profitability.

Both Rio Tinto (2023) and Noone (2020) argue that safety is not the only benefit offered by autonomous drilling and that improvement in Operational efficiency also follows. Rio Tinto (2023) operates 26 autonomous drills and boast improvement in drilling accuracy and efficiency, owing mainly to reduced human error and continuous operation compared to delays such as shift change and meal break lost time. Noone (2020) supports this statement by reporting that firms boast a 30% increase in operational efficiency owing to automation. Making mining more profitable and reputable through innovative, responsible and safe operations can help clarify its role towards sustainable development.

Even with the easily recognised benefits of autonomous drilling, Rogers et al. (2019) warn mining houses that introduction of technology alone cannot provide a competitive advantage. There needs to be a proper technology implementation strategy, with logistics put in place for the intended mode of operation. The introduction of new technologies in mining can be influenced by various factors, which must be understood and leveraged for successful adoption. Mining companies struggle the most with the implementation approach of new systems as they overlook the 'soft' factors and continuous improvement (Shen, et al., 2015).

The case study mine introduced the Autonomous Drilling System (ADS) Technology. Since the system was introduced, its utilisation has been very low, with operational teams resorting to and preferring traditional manual operation. The system was introduced to improve safety and operational efficiency by removing personnel from directly operating the drill machines.

The slow adoption rate is against the organisation's intentions as huge investments were injected into the autonomous drilling project. With the introduction of the system, new work and labour patterns were established to suit the intended way of operation; as such, the quality and productivity of drilling declines when the operational team resort to traditional operation. Downstream processes are affected and often require rework, a form of waste. Specialists were brought to site to assist, but the improvement in utilisation is yet to be realised. The challenge prompts holistic intervention to improve the adoption of the ADS system, looking into significant barriers to successful operation.

3. RESEARCH QUESTIONS

How can the adoption of the introduced autonomous drilling system be improved?

4. RESEARCH OBJECTIVES

The chief objective of this research is to improve adoption of the autonomous drilling system. The sub-objectives are to:

a. Identify possible factors inhibiting the adoption of the new technologies and investigate their influence on ADS adoption at the case study mine.
b. Benchmark current practices at the case study mine with other mines where technologies are best implemented and adopted.
c. Develop an implementation framework to improve the adoption the ADS by filling the gap between the case study environment and best practices from research findings.

5. LITERATURE REVIEW

The literature review focuses on theories and models around technology implementation, and the nature of socio-technical factors affecting the adoption of new technologies. The discussion also looks at socio-technical and systems theory as potential solutions to dealing with most of the discussed barriers. Due to limited research on autonomous drilling, the literature review will look at the introduction of similar technologies in mining.

5.1. Technology implementation: Frameworks and theories.

Technological innovations present an opportunity for organisations to keep up with evolving challenges. Most organisations have embraced the need to innovate and set themselves apart from competitors. Although a decision to innovate is a step in the right direction, organisations still struggle to fully absorb technological innovations, missing most of the intended benefits (Wilkins, et al., 2007). There has been research aimed at understanding the gap between a decision to innovate and successful adoption, leading to development of frameworks such as Diffusion of Innovation (DoI), Technology Organisation Environment (TOE) framework; and Technology Acceptance Model (TAM) (Ediriweera & Wiewiora, 2021) (Wilkins, et al., 2007).

Diffusion of Innovation (DoI) mainly focuses on the spread and gradual adoption of innovation within an organisation and states that diffusion rates depend on both the technology and the social system surrounding its intended use (Gruenhagen & Parker, 2020). According to the DoI framework, for innovation to be absorbed, there must be an organisation-wide awareness on its relative advantage. Further, the innovation benefits must be observable, highlighting the importance of the features of both the technology and its promoters (Ediriweera & Wiewiora, 2021). Evolutionary Diffusion Theory (EDT) serves as an extension of the DoI framework. The addition that EDT provides is that innovation adoption is a gradual process that occurs in stages from initial introduction to full absorption; it is not instantaneous (Wilkins, et al., 2007). This highlights a requirement for continuous nurturing of the implementation efforts.

Technology Acceptance Model (TAM) aims to predict individuals' predisposed behaviour towards new technologies (Wilkins, et al., 2007). According to TAM, the introduced technology's perceived usefulness and ease of use drive intention to use, which leads to its effective use. According to Wilkins, et al (2007), TAM is a suitable for the implementation stage, after the decision to introduce a technology has been made.
Wilkins, et al (2007) combined aspects of DoI and TAM to introduce the Technology Implementation Model (TIM).

Technology Implementation Model (TIM) adds gradualism and iteration from EDT to TAM. Figure 1 show the resultant TIM schema. Unlike TAM, the TIM framework recognises that the actual use of the new technology can alter the perceived usefulness and ease of use, which drive attitude and intention to use. If the technology proves to be useful and easy to use, the intention to use is reinforced, and the technology is used more, creating a reinforcing loop. The inverse also applies: if the technology fails to deliver, perceived usefulness dampens, leading to a negative attitude towards its use. The result being reduced intention to use. This gives rise to the importance of the technical aspect of the innovation adoption process. Even with initial positive attitude towards the technology, its failure to deliver on the technical front can dissuade users.

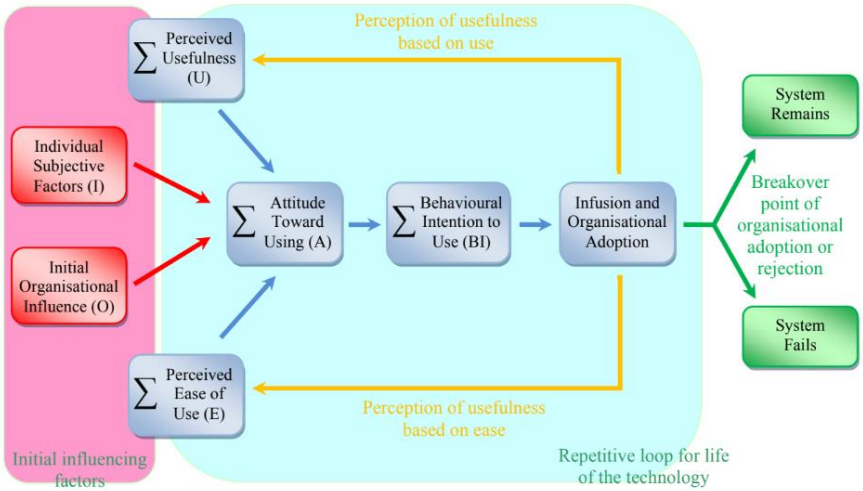

Figure 1:Technology Implementation Model. From Wilkins, et al (2007)

Jahanmir and Cavadas (2018) suggest that increasing user positive attitude towards technology can be more effective, and further argues that lead users' opinions can help subsequent users warm up to new technologies. Organisations need to assess their teams and select those with a positive attitude towards technology to be involved in the trialling/initial stages, and their positive review can be influential to the rest of the team. Taherdoost (2018) adds that end users' acceptance is pivotal to the success of introducing new systems. End users must be seen as crucial stakeholders and encouraged to participate in the development of new technologies.

The TOE framework recognises that during technology introduction, the technical, organisational and environmental aspects must all be considered and jointly managed (Ediriweera & Wiewiora, 2021). According to Nilsen (2015), these individual aspects can interact and influence each other in an unpredictable way.

The technology aspect posits that during actual use, the technology must present relative advantage when compared with the legacy system of working.

All soft factors such as leadership support, effective communication and awareness cannot sustain a technology that is not delivering (Wilkins, et al., 2007). This notion is reflected in the TIM framework by Wilkins, et al (2007) discussed above, which showed that perceived usefulness and intention to use are part of a feedback loop connected to the actual use of the technology. The organisational aspect considers organisational factors such as working and communication structures, employee involvement, performance and reward systems, organisational culture and risk tolerance (Ediriweera & Wiewiora, 2021). The environment aspect of the TOE framework focuses on the context in which the technology will be used as this can also influence adoption. In open systems, context is active and dynamic, continuously influencing technology implementation processes (Nilsen, 2015). The TOE framework prompts analysis of socio-technical theory, delving into the importance of jointly managing social and technical issues during technology implementation.

5.2. Socio-technical factors in technology implementation

Factors impacting technology adoption are multi-faceted and interact with each other in a way that is difficult to predict (Nilsen, 2015). Implementation of new technologies will necessitate changes in organisational structures. This change might pose a threat to some stakeholders, giving rise to social issues (Haber & Carmeli, 2023). If ignored, social issues can derail and debilitate technology implementation processes. According to Bednar and Welch (2019), technologies must be viewed as tools to be used by people, stating the importance of human-centred implementation processes.

Classical engineering approaches are centred around the technology independently, requiring the workforce to adapt to it. According to Bauer and Herder (2009), this approach seldom works when introducing technologies to organisations. The introduction of technologies requires socio-technical approach, where the interdependence between the introduced technology and its surrounding social setting is considered (Bauer & Herder, 2009). Socio-technical theory advocates for considering people as assets that need to be developed and seeing that the output of organisational systems is affected by the interaction between the social and technical aspects. Further, suitability between the social and technical aspects must be achieved. Dual shaping of both the technical and social aspects must be prioritised, requiring a shift in paradigm, from a technological imperative to a joint optimisation (Abbas & Michael, 2023). Organisations must carefully manage the co-evolution of both technical and social aspects of technology implementation process (Bednar & Welch, 2019).

Flemish, et al. (2012) states that the only time innovation will work is when mining organisations design the human-technology interaction properly. Human factors are even more important for the South African mining industry owing to its labour intensity (Smit and Mji, 2008).
The high levels of labour can debilitate adoption of new technologies if social factors are ignored. Bednar and Welch (2019) argue that the human-technology engagement can be a barrier towards change in organisations. Mining companies' top weakness in bringing changes and introducing new systems and technologies is their inability to extensively consider 'soft' factors, the ones that influence human behaviour (Shen, et al., 2015).

The theories and frameworks underpinning the introduction of technology in organisations reveals factors that must be considered to close the gap between the decision to innovate and successful adoption of innovations. The TOE framework is better suited for discussing socio-technical drivers and barriers to innovation adoption in mining as it is multi-faceted and comprehensive (Ediriweera & Wiewiora, 2021). Some factors can be both drivers and barriers, depending on their presence or absence (Bednar and Welch, 2019).

Understanding drivers and barriers to the adoption of new technologies is essential (Ediriweera & Wiewiora, 2021). This understanding can aid in steering implementation efforts in the right direction. The major factors will be discussed using the TOE framework (technological, organisational and environmental factors).

5.2.1. Technological factors

Technological factors become important during actual use of introduced technologies. Firstly, the new technology needs to present a clear relative advantage (Ediriweera & Wiewiora, 2021). Initially, perceived usefulness of the technology can be boosted by social influence and awareness of its intended benefits, sparking intention to use. With time, if the technology does not deliver on its intended benefits, perceived usefulness will plummet. This can debilitate the adoption process (Wilkins, et al., 2007). In addition to perceived uselessness, Ediriweera and Wiewiora (2021) argues that the introduced technology needs to be compatible with existing systems.

Each organisation has existing systems that must be considered when introducing new technologies. Martin (2004) suggests consideration of all existing systems that will interact with the introduced technology. This will enable interoperability of the introduced technologies with existing systems. Interoperability is an important technological factor that must be considered during technology adoption process (Ediriweera & Wiewiora, 2021).

Many mining sites suffer from poor relationship between technologies, where introduced technologies are usually not interoperable with existing technological systems (Job and McAree, 2017). Effective integration of the introduced technology into the existing technological system and processes can minimise unintended consequences and increase intention to use.

Loow (2022) argues that it can be difficult to conclude on the benefits of new technologies as they can bring both positive and negative effects. Martin (2004) also acknowledges the possibility of new technologies bringing negative effects, highlighting the importance of consideration of the global system and its existing subsystems when introducing the system of interest.

Job and McAree (2017) argue that a consistent methodology of effecting change must be developed. This will guide the approach. Before introducing new technologies, gap analysis must be performed extensively as the implementation approach will depend on this (Shen, et al., 2015). Implementing new technologies must focus on predetermined points of intervention (Abson, et al., 2017). Understanding points of intervention is better achieved by the requirements analysis process, which is important in any system development project (Buede & Miller, 2016). This will aid in introducing a technology that is required and fit for purpose. In addition to introducing fit-for-purpose technologies, organisational readiness must also be ensured.

5.2.2. Organisational factors

The overall set-up and culture of an organisation generally influence its way of operation. Employee attitude, risk tolerance, organisational readiness, and knowledge levels are organisational factors mostly affecting adoption of new technologies in mining (Ediriweera & Wiewiora, 2021). Taherdoost (2018) states that end-user acceptance and confidence are crucial for the development and introduction of new technologies. Buede and Miller (2016) further acknowledge the importance of stakeholder inclusion early in the project. Poor communication with internal and external stakeholders can undermine new technology implementation efforts (Ediriweera & Wiewiora, 2021). End users need to understand the motivation behind the introduction of new technologies. The perceived usefulness of the introduced technology is one of the factors having direct effect on its adoption and sustainable operation (Taherdoost, 2018). The relative advantage of the new technology, in relation to the current way of operation, must be clearly communicated and understood across the organisation. According to Ediriweera and Wiewiora (2021), understanding relative advantage can reduce perceived risk of adopting the new technology.

It can be perceived as risky for employees to adopt new technologies as these will disrupt operations and possibly result in reduced performance. The risk of sacrificing short-term and volumetric targets, which are cultural to mining, can lead to employee hesitation as these targets are linked to the profitability of mining companies, which in turn has a direct impact on job security (Ediriweera & Wiewiora, 2021). The fear of unemployment is one the primary reasons autonomous mining technologies are not favoured, especially in developing countries (Ali and Rehman, 2020). Barham, et al. (2014) bring a concept of risk and ambiguity and point out the importance of appreciating the difference between the two. Risk is something known and measurable, while ambiguity is unknown (Barham, et al, 2014). The differentiation of risk and ambiguity is crucial as the two are often confused. Where there is a risk surrounding the introduction of new technologies, it must be clearly communicated, eliminating ambiguity. Barham, et al. (2014) assert that ambiguity is the main culprit and end-user awareness must be prioritized. This builds trust, which is essential during innovation processes in labour-intensive sectors such as mining.

Trust is a critical organisational factor that determines the innovation-absorptive capacity of organisations. Trust must be established between employees and top management (Ediriweera & Wiewiora, 2021). Employees understand the negative impacts of disturbed production performance, which can be reduced margins. A decline in profitability is closely linked to retrenchments, which have been evident in mining. Employees resort to doing what they know works to ensure stable production, thus protecting their jobs (Ediriweera & Wiewiora, 2021). Haber and Carmeli (2023) state that technophobia exists in organisations, where employees (especially veteran employees) have fears towards new technologies, desiring to revert to legacy way of working. With new technologies, there is generally fear of criticism, leading to reluctance towards learning to operate new technologies (Haber and Carmeli, 2023). The willingness to learn new technologies can be boosted by top management support.

Top managers' attitude plays a significant role in the adoption of new technologies (Damanpour and Schneider, 2006). The voice and attitude of top managers play a vital role in any organisation. Any change initiative that lacks commitment and active support from top managers is prone to fail at any stage (Shen, et al., 2015). Damanpour and Schneider (2009) state that the characteristics of top managers play a vital role towards technology acceptance/adoption and its efficacy. Top management support must be consistent and remain present throughout the implementation process, fostering continuous improvement.

In addition to support, top managers need to set and communicate clear goals for the technology introduction process. This will also require integration of the new technology into the measures of performance and reward systems.

Performance can be reduced during the transition to new technologies. If there are rewards linked to performance, employees can view new technologies as barriers to their earning potential. Short-term gains and volumetric targets are cultural to mining, with bonuses linked to these. This nature of mining can make it difficult for employees to favour innovation because it can disturb performance in the initial stages (Ediriweera and Wiewiora, 2021). As performance can be disturbed, if an organisation is not prepared to support workers during this period, dissuasion can emerge, slowing the creation of the new norm. Changes in the ways of work need to be in tandem with changes in incentives, at least during the transition period (Atkin et al., 2017).

5.2.3. Environmental factors

Kumar, et al. (2018) state that the nature of the industry and economy can also play a role in new technology adoption. The discussions above mentioned that the mining industry is infamous for its slow technology adoption. Kumar, et al. (2018) statement is valid because the slow uptake of new technologies is not isolated to one or a few organisations; adoption of new technologies in the mining sector is generally considered to be slow. Factors causing slow technology adoption in mining are ubiquitous and real (Job and McArie, 2017).

The remoteness of mining operations also makes it more challenging to engage with external stakeholders like technology suppliers and research institutions (Ediriweera & Wiewiora, 2021). The reduced engagements with specialists hinder knowledge transfer and isolate mining sites from accessing firsthand information from suppliers. The challenge is more relevant to workers as their knowledge and awareness levels affect their impetus to accept new technologies (Jahanmir & Cavadas, 2018). The remoteness of mining sites also isolates them from shared critical infrastructure (Ediriweera and Wiewiora, 2021).

Job and McAree (2017) found that one significant barrier to autonomous drilling is that mining organisations do not set up site systems adequately for implementation.

The discussed factors encompass both technical and social factors influencing technology introduction in organisations. The socio-technical approach's roots can be traced back to systems theory (Haber and Carmeli, 2023).

5.3. Systems theory.

Systems theory is a conceptual framework that aims to stress the interrelatedness and interdependency of system components (Marciniak, 2024). Systems theory has multi-disciplinary origins, rendering it applicable to variety of disciplines, especially in complex settings, where classic cause-effect models fail (Lai and Lin, 2017). Practitioners of systems theory are said to have cultivated systems thinking, which Peter Senge lists as one of the key competencies required for provision of sustainable solutions (Hieronymi, 2013). Systems theory advocates for analysis of relationships between elements of the system, and relationships between the system and its environment (Adcock, et al, 2024). The perspective of systems theory is that a system is more than the aggregate of its elements/components, and that it must be studied as an entity. The system as an entity has properties that cannot be exhibited by any of its components (Hieronymi, 2013). The system is said to have an 'emergent' behaviour and the interrelatedness of its components rendered complex (Nilsen, 2015)

Complexity exists when a system is open in nature (exchanges with its environment) and its elements are self-regulated (components have their own will and intended purposes) (Lai and Lin, 2017). Complex systems are those that exude self-organisation, adaptation and innovation (Hieronymi, 2013). Systems theory and approach aim to aid systems to survive in different circumstances and to deal with complexity as it arises. Like nature, real life problems are highly interlinked and complex (Hieronymi, 2013). Organisations can be viewed as complex systems due to the presence of diverse actors and processes with different priorities (Bai, et al, 2016).

A complex system's elements interact in a way that cannot be predicted, and to understand the system better, it must be viewed as an integrated whole (Nilsen, 2015). This necessitates sustainable and flexible solutions that can continuously deal with ongoing challenges and opportunities (Bai, et al, 2016). Because systems theory recognises primacy of relationships between elements, its appreciation and application limits unintended consequences (Adcock, et al, 2024). According to Sony and Naik (2020), organisations must be seen as complex systems and studied in totality as wholes.

Organisations are made up of interdependent components that create performance from complex relationships (Sony& Naik, 2020). Systemic methods are suitable for situations with various stakeholders bound by complex relationships (Hieronymi, 2013). Organisations qualify as such situations.

Calvo-Amodio (2019) suggests that conventional engineering management methods continue to fail in complex engineering situations due to the rigidity in the approach. Conventional engineering management methods involve very little social and organisational factors in their approach and mostly fail in human activity systems (HAS) (Calvo-Amodio, 2019). Introducing new technologies, especially in operational settings, requires a multidisciplinary approach due to the diversity of variables and perspectives (Ediriweera and Wiewiora, 2021). Nguyen and Bosch (2012) argue that systems thinking approach is the most suitable for tackling problems when there are differing perspectives. Iheukwumere, et al. (2021) found that the systems approach is the best for dealing with complexity.

5.4. Systems approach

Systems approach encompasses methods that apply systems theory and systems thinking. Numerous attempts have been made to define systems thinking, but there is still no straight definition of the term. The correct definition can shine light on its proper and relevant application (Arnold & Wade, 2015). Arnold and Wade (2015) argue that definition of systems thinking needs to be related to its purpose.

According to Iheukwumere, et al. (2021), systems thinking approach yields results, especially when problems result from diverse factors, with no direct cause-effect relationships. Arnold and Wade (2015) argue that these factors do not only coexist, but also have relationships that create emergence. The factors do not act in isolation, and it would be ineffective to try and solve problems of this nature in silos (Arnold and Wade, 2015).

Iheukwumere, et al. (2021) highlights management autonomy as being important in multi-factor causation problems and this is consistent with Damanpour and Schneider (2006), who posit that management's attitude plays a vital role in organisations' ability to tackle complex problems. Arnold and Wade (2015) further insists that it is becoming more vital for people in leadership roles to embrace, learn and attain systems thinking skills.

The presence of human factors in the introduction of new technologies in the mining setting introduces complexity (Calvo-Amodio, 2019). The systems approach, as stated by Iheukwumere, et al. (2021), can aid in understanding challenges associated with adoption of new technologies in people driven industries such as mining.

Leveson (2012) outlines that traditional models of causality are becoming inadequate with the continued introduction of new technological systems at a rapid rate. From systems thinking perspective, the introduction of multiple systems brings about interconnectedness. Iheukwumere, et al. (2021) lament that systems thinking knowledge can aid in steering the emergence of these relationships into a desired direction while minimising unintended consequences. Understanding systems dynamics becomes crucial for using the inevitable interconnectedness to generate desired results.

Abson, et al. (2017) highlight another term in systems theory: leverage points. According to Abson, et al. (2017), leverage points are parts of the system that must be considered for effective results as they lead to 'interventions that matter'. In complex systems, the meaningful points of intervention are often not obvious. Abson, et al. (2017) argue that firstly, one needs to be able to understand complex systems and be able to simulate their behaviour. After the understanding of complex relationships between parts of any system, it becomes relatively easy to find points of meaningful intervention.

Nyemba et al (2019) also reports on the usefulness of systems approach in capacity building efforts and that for the sustainability of formation of new systems, each stakeholder needs to be seen as a cog of a wheel such that the model still works with the absence of other stakeholders.

According to Arnold and Wade (2015), systems thinking is required when there are these factors: purpose, elements and interconnectedness. Autonomous drilling system seek to achieve a certain purpose as discussed above. Further, the system's operation towards this purpose will be achieved by different parts (elements) acting together (interconnectedness). This confirms ADS as a system, and its reliance on human factors makes it even more complex. Applying the systems approach becomes vital when dealing with multi-factor causation problems (Iheukwumere, 2021). One approach that has been considered as suitable for dealing with complexity and HAS is soft systems methodologies (SSM).

5.5. Soft Systems Methodologies

Soft Systems Methodologies (SSM) was developed in the 1970s by Peter Checkland (Augastsson et al., 2019). The development of SSM was prompted by a need to address complex problems that are difficult to define. These are the problems that are prevalent in the real-world situations.

Traditional, stepwise approaches were found to be ineffective when dealing with most real-world situations due to increased interconnectedness and interdependencies between multiple factors (Augastsson et al., 2020). Traditional engineering analysis tend to be reductionist in approach, underestimating the importance of relationships between the parts of a system. This 'hard' engineering approach can only be effective where there are low levels of interconnectedness and interdependencies (James Cook University, 2022).

From its introduction, soft systems gained popularity due to its success in addressing ill- structured problems, promoting a learning effort towards problem-solving (Jackson, 2003). Checkland and Poulter (2016) argue that soft systems approach is mostly about learning about the situation and taking informed effort to improve it. The learning culture and embracing of different worldviews before defining the problem situation puts SSM ahead of hard systems when dealing with complex situations. Soft systems thinking becomes essential when dealing with situations that involve human factors, (Jackson, 2003).

According to Checkland and Poulter (2020), the system with significant interdependencies parts will have emergent properties that cannot be exhibited by any part of that system. Some of the emergent behaviours can be unanticipated. Soft systems methodologies approach become essential due to its promotion of a learning culture towards problem-solving (Checkland & Poulter, 2016). The learning approach avoids prematurely defining the problem while it promotes thorough understanding of the problematical situation.

The first step of SSM entails understanding the problem situation, also called problematique (Sriram, 2016). Using SSM, the assumption that all stakeholders understand the problem is avoided. Problems in the real-world situation can be difficult to define. Stakeholders also hold different opinions about the problem and intervention options (Augastsson et al., 2020). According to Conte and Davidson (2020), SSM is suitable for exploring complex problems where stakeholders hold divergent views and have differing goals and agendas.

Augastsson et al., (2019) argue that systems must be viewed as human activity systems (HAS) mainly to navigate social and political issues, which are both usually ignored in engineering. Checkland and Poulter (2020) state that SSM is about learning your way from problem to solution, attempting to factor as many aspects of the problem situation as possible.

Figure 2 shows the SSM stages. The first stage is attributed to understanding the problem situation in detail, without thinking about solutions. According to Barbrook-Johnson and Penn (2022), many projects have failed due to disagreements about problem definitions. At this stage, divergent views about the problem are addressed and all stakeholders understand that the problem is multifaceted and requires a continued and collaborative approach. The tool used commonly in SSM to facilitate collaborative exploration of the problem situation is drawing of rich pictures. According to Barbrook-Johnson and Penn (2022), rich pictures are a great way of exploring complex situations and systems. Conte and Davidson (2020) add by stating that rich pictures foster common understanding of complexity, where stakeholders hold different views. In summary, SSM promotes learning about the problem situation instead of attempting to solve a pre-defined problem.

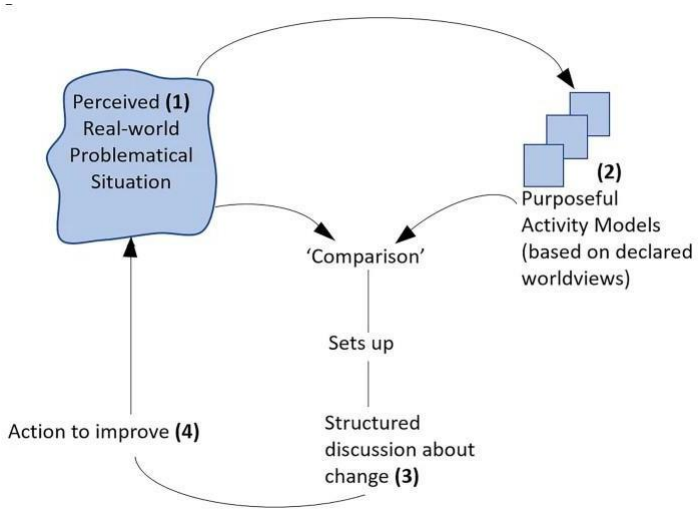

Figure 2:SSM process summary (adopted from Augastsson et al., (2019))

When the problem is thoroughly understood and all stakeholders hold a common view about the problem situation, the intervention team can model the system situation. The SSM now moves from the 'real world' to the conceptual models, where stakeholders debate their view of the perfect model.

The conceptual modelling usually begins with root definitions, using CATWOE mnemonic (Augastsson et al., 2019):

- Customers: Group of beneficiaries affected by the system.
- Actors: Actors responsible for carrying out activities of the system

- Transformation: The change that happens, the purpose of the system
- Weltanschauung: Underlying views about the system and its transformation.
- Owners: owners of the system
- Environment: Environmental constraints and enablers

Root definitions define different system elements, packaging the insights and differing perspectives within the problem system (Kalonji, 2020). According to Siriram (2017), root definitions can assist in capturing the reality of the situation, revealing relevant problems to tackle using the gap between the 'As-Is' and 'To-Be' models. Root definitions facilitate drawing of concept models that represent separate worldviews of the problem situations. Concept models are not perfect representations of the problem situation, but they form solid basis for discussions (Augastsson et al., 2019). After drawing the conceptual models, the intervention team can compare these models with the real-world situation, laying foundation for improvement efforts.

In the final stages, the team explore and debates suitable intervention options. According to Checkland and Poulter (2020), the suitable intervention must be both desirable and culturally feasible. This ensures the solution is most relevant for each problem situation and considers as many facets as possible, including both social and political aspects. Augastsson et al., (2020) adds that the problem context and environment are vital as the introduced solution will influence the overall system. Likewise, the overall system (context) will influence the intervention (solution). To avoid unintended consequences, interventions must be suited for the context in which they will exist (Martin, 2004). Augastsson et al., (2020) adds that in SSM and complex systems, there is no such thing as the final solution. This posits SSM interventions as continuous improvement and learning efforts better suited to deal with real world dynamism.

5.6. Summary

According to literature, autonomous drilling comes with improvement to safety and health of drilling operational teams, coupled with operational efficiency. The case presented can be valid as introducing autonomous drilling removes operators from hazardous environments, with minimal and remote involvement. In mining, operations lose operating times owing to shift change and meal breaks, including travelling time from mine entrance to the machine on the field. Autonomous drilling can remain operational during these times, increasing production time.

Although benefits of autonomous drilling are apparent, existing research raises the importance of setting up each operation to receive such a technology. The factors that can inhibit successful implementation and operation of autonomous drilling become crucial towards understanding the problem faced by the case study mine. According to the reviewed literature, important factors such as infrastructure, leadership attitude, organisational culture, and incentives can make or break adoption of new operational technologies like ADS. In addition to organisational factors, the technologies must be designed with the intended operational setting/environment in mind. This involves ensuring interoperability between the introduced technology and existing technologies.

Existing research also states that problems associated with introduction of new operational technologies in people-centred industries like mining can be very complex. The human factors make the problems of this nature unstructured, and the multidisciplinary effort required increases the complexity. According to literature, systems thinking is required when there are these factors: Purpose, elements and interconnectedness. Autonomous drilling system seek to achieve a certain purpose as discussed above. Further, the system's operation towards this purpose will be achieved by different parts (elements) acting together (interconnectedness). This confirms ADS as a system, and its reliance on human factors make it more complex owing to multiple perspectives. According to literature soft systems methodologies approach is very effective in addressing multiple perspectives.

There are multiple departments involved in the realisation of autonomous drilling at the case study mine, making this a multidisciplinary effort. The multidisciplinary nature creates a possibility of diverse factors causing the current problem. The reviewed literature suggests that the application of the systems approach becomes vital when dealing with multifactorial causation.
Systems approach offers to shine light on problems like this, where there are no direct cause-effect relationships.

It was further noted that conventional engineering fails to address complex problems with social factors, suggesting that soft systems approach becomes indispensable in these settings.

6. RESEARCH METHODS

The research takes the form of a qualitative study. There are no clear dependent and independent variables, and it is challenging to draw a hypothesis. Qualitative methods are suitable for case-based research where the researcher wants to know more about a particular situation, like a detective investigating a crime (Gerring, 2017). According to Hammarberg et al. (2016), qualitative methods are more suited for eliciting the experience, meaning and perspective of those involved in the process being investigated. Using more profound qualitative methods leads to rich information based on firsthand experience, which can also elicit insightful knowledge from experts in the chosen field of study.

The qualitative study follows the phenomenological method because it seeks to understand the process through the experience of those involved in the problem setting. This method was chosen because it relies on the experiences of those who experienced the introduction of ADS. As Wilson (2015) puts it, "the objective of phenomenology is to understand human experience." This further tries to factor in the human elements into the study.

A systems approach is followed, with more focus on soft systems thinking. The soft systems methodologies (SSM) approach was chosen because the problem is unclear and involves human factors. The soft systems approach allows one to look at the problem from multiple 'worldviews', broadening the analysis of the problem situation (Jackson, 2003). Jackson (2003) argues that the SSM approach is more suitable for complex problems involving human factors. Further, Iheukwumere et al. (2021) report that the systems approach yielded more results than other methods when dealing with multi-factor problem situations. Checkland and Poulter (2016) also argue that the SSM approach is very effective in dealing with capacity-building efforts as it promotes an inclusive and collective learning culture, capable of effecting collaboration between system designers and operational teams. Nyemba et al. (2019) posit that in capacity-building efforts, like the introduction of new systems, the systems approach can derive the concept of a system of systems where subsystems can work effectively in the absence of their counterparts. The system of systems introduces sustainability, ensuring the successful operation of a system even in the absence of other subsystems. System designers, termed 'the designing system' by Martin (2004), are primarily absent during the day-to-day operation of the ADS technology, and the system’s operation must remain undisturbed by this.

6.1. Research Design

Figure 3 shows the overview of the study, outlining the steps and methods used. From section 6.2 through section 6.6, more details of each step and related chosen methods are discussed. The research will closely follow SSM steps shown in figure 2: finding out about the problem situation, formulating purposeful activity models, debating the situation, and taking an action to improve.

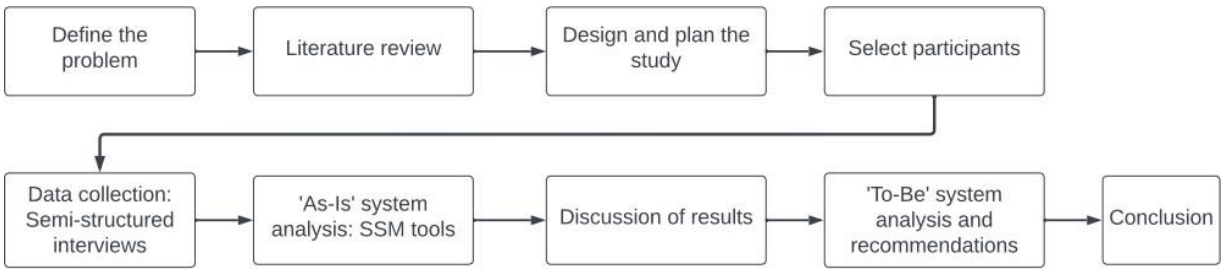

Figure 3: Research flow diagram (Author's own work)

6.1.1. Define the problem situation.

The definition of the problem situation includes looking at case study mine processes and drawing a rich picture to ensure that the problem statement encompasses real issues. Rich pictures effectively explore complex issues with conflicting understandings by fostering holistic and purposeful thinking (Bell & Morse, 2013). Rich pictures are essential in complex problems due to their ability to creatively and holistically analyse the problem situation with minimal preconception, allowing for more understanding of the real-world situation. Effectively defining a problem puts one at a better chance of including all driving factors in the initial stages of systems projects (Walker, et al., 2014). Problem statement and motivation for the study are discussed at this stage. Understanding the problem leads to critical research questions and objectives, guiding the literature review.

6.1.2. Literature review

The investigation starts with a literature review. The literature study aids the researcher in understanding the existing concepts and theories around the chosen topic. The aim is to understand the perspective and findings of other researchers who probed the desired study field. The literature review explores ways to improve adoption of autonomous drilling system by looking at possible factors that inhibit the adoption of new technologies. A literature review is about finding what is already known about the chosen topic and finding suitable research methods (Ashley, 2012).

6.1.3. Selection of participants and data collection.

Data collection follows literature review and planning, and it only began after the ethics clearance was approved. The clearance reference for this study is MIAEC 107/23W. The study collects data through six semi-structured expert interviews conducted on Microsoft Teams with all the ethics considered. The main aim of the interviews was to further investigate factors affecting the adoption of new technologies and how these factors can influence the adoption of ADS. The data gathered is rich qualitative information from experts who introduced ADS at other mines.
The interviews are recorded and transcribed on Microsoft Teams with the consent of each interviewee.

6.1.4. Data analysis and 'As-Is' problem situation

Findings will start with revisiting the problem statement, drawing system hierarchy and rich pictures as the first level of findings. Drawing of the system hierarchy and rich picture fall under the 'finding out about the problem situation' step of the SSM process. The collected data is analysed to turn it into useful information from which conclusions can be drawn. The analysis is performed after all interviews are undertaken. The analysis includes validating the data to ensure its usefulness to the study. Validation is performed with the critical research question in mind. The 'As-Is' systems analysis using SSM tools (PQR-formula and CAPETOWN model) is performed to understand the problem situation further and draw concept models to lay the foundation for improvement efforts. Thematic content analysis is used to aid in categorising prevalent concepts from the interview data. This stage falls under the 'formulate purposeful activity models' step of the SSM process.

6.1.5. Discussion of results

The discussion of results aims to create meaningful relationships between responses and to elicit meaningful information from extracted themes. The results of the interview data analysis are contrasted with findings from the literature review. The discussion of results also relates the findings to the problem situation at the case study mine. The 'what' affinity diagram and the interrelationship diagraph are used to further discuss the potential barriers and their interactions. This attempts to find root causes, using the grouped possible factors. This stage in line with the 'debate about the situation' step of the SSM approach.

6.1.6. 'To-Be' model and recommendations.

The 'To-Be' models and recommendations stage look at translating the study findings into an actionable framework to aid in introducing ADS. The systems approach is used to analyse the current processes and give recommendations. After the root causes have been identified, the 'To-Be' root definitions are drawn using the PQR-formula and CAPETOWN model and compared with the 'As-Is' model, showing areas of intervention. Improvements are categorised using a 'how' affinity diagram. The possible solutions and recommendations are packaged using a tree diagram.

6.2. Instrumentation

The primary data sources are semi-structured interviews with experts introducing ADS at mines, particularly mines where the system performs optimally. The interviews give in-depth information from both firsthand and expert-level experience. Microsoft Teams is used to conduct the interviews because the researcher and the proposed interviewees are in different locations, and some interviewees travel extensively. The interview script is compiled with questions closely related to the research question and attempts to elicit information that can aid the researcher in achieving the research objectives.

6.3. Sampling

A purposeful snowball sampling method is used, as autonomous drilling is a niche area of study with a close-knit community. The snowball sampling method is proper when finding the right participants is difficult, as other participants can be used to find others with similar experience and expertise (Naderifah et al., 2017). The population under consideration for this study is experts in introducing ADS at mines. Selection criteria: at least five years of mining experience, particularly in introducing new operational technologies to mines.

Elements for selection: access to a computer (Microsoft Teams), English speaking (interviews will be conducted in English), a minimum of 5 years of mining production drilling experience (understanding drilling dynamics), and a minimum university degree or more than ten years of experience in the said field.

6.4. Data Collection

Data is collected using semi-structured interviews as an in-depth understanding of the problem situation is required. Interviews provide depth and detail to situations (Edwards & Holland, 2013). The researcher can better understand the problem situation with interviews as they mainly involve open-ended questions, leading to participants expanding on their responses (Jones, 2020). Selected participants received a research information sheet and consent forms to sign and return to the researcher via email. Only participants who signed and returned the consent form were interviewed. Interviews occurred from November of 2023 and spanned to January of 2024.

6.5. Data Analysis (findings)

Thematic content analysis is used as a method of data analysis. Thematic content analysis allows the extraction of rich information from interview data and can reveal the experiences and beliefs of the participants as it focuses more on the meanings of responses (Crowe et al., 2015). Thematic content analysis is used primarily in qualitative research to extract patterns of meanings in collected data (Morgan, 2022). The analysis started by coding of data following stages shown in figure 4. The inductive coding method was used. Inductive in the way that the researcher followed the flow of the data, noting emerging codes relevant to the study. The coding began with broad codes during initial stages and progressed to handwriting of the data and more detailed codes. The author noted down list of emerging codes for each interview and used common codes to create themes using an affinity diagram. The codes recorded were then aggregated and categorised into emerging themes using an affinity diagram. The chosen themes were linked to concept of systems thinking and soft systems methodologies. The final affinity diagram of the themes is included in the results section, and the discussion of results followed these themes.

The analysis includes using SSM tools to explore the problem situation further. The 'what' affinity diagram groups possible causes into themes/categories. The interrelationship diagraph finds root causes from the possible causes grouped. After identifying the root causes, the 'how' affinity diagram groups possible solutions into categories.

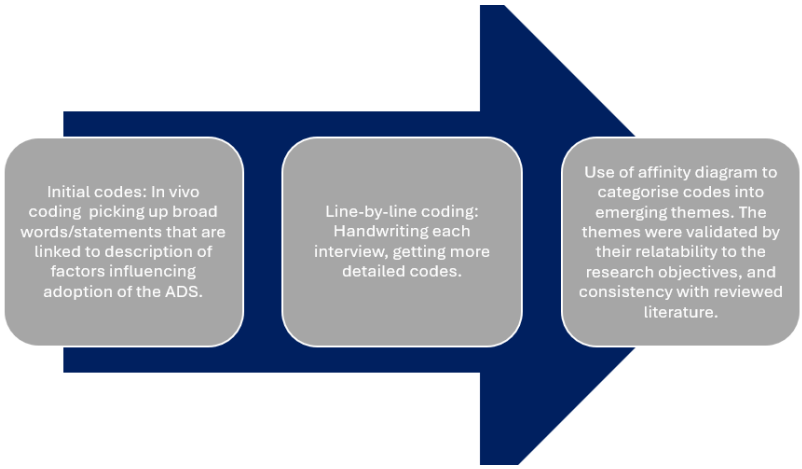

Figure 4: Data analysing steps.

6.6. Validity and Reliability/Validation and Verification

The results from the interviews are triangulated with previous research. Further, affinity diagrams assist in grouping patterns in ideas and experiences from different interviewees, converging commonalities. Convergence of information from different sources effectively validates qualitative data (Carter, et al., 2014). Data source triangulation is also performed. According to Carter et al. (2017), data source triangulation involves collecting qualitative data from different types of people or groups. The interviews collect data from operational experts working for mines and experts from system suppliers (two distinct groups of participants).

Microsoft Teams recording, and transcription functions are used to ensure the reliability of the interviews. This ensured the acquisition of verbatim data, which is always desirable for the analysis of interviews. Recording and transcription are the most reliable data-capturing methods (Poduthase, 2015). The findings from interviews are iteratively checked against literature. Validity searches whether the study examines issues intended to be probed (Coleman, 2022). The relationship between interview questions and the critical research question is continuously evaluated for validity. The Interview responses are related to answering the research questions and fulfilling the study's objectives.

7. ETHICAL ISSUES/CLEARANCE

Ethics compliance is ensured in this study, which includes consent from participants. Complete confidentiality and anonymity of the participants are also ensured. The real names of each participant are not revealed in this report. Participants are referred to as 'Participant 1', 'Participant 2', etc. Interviews only commence after ethics clearance has been granted.

The ethics clearance was granted through the school ethics committee.

The ethics clearance number for this study is MIAEC 107/23W.

8. FURTHER EXPRESSION OF THE PROBLEM SITUATION.

Before discussing results, a systems approach is used to understand the problem situation better. A thorough understanding of the problem situation will enhance improvement efforts directed at sustainable adoption of the ADS technology. The analysis compares current practices at the case study mine against literature. Some gaps were found between current practices and best practices as suggested by literature. Situation expression serves as an extension of the problem definition discussed above. System hierarchy and a rich picture will be used to express the problematical situation. These were drawn using author's overall experience of the problem situation. A system hierarchy is required to show the system's boundaries. Each system's boundary assists with delineating areas of control but needs to be porous to allow the system to communicate with and adapt to its environment (Augastsson et al., 2020). Figure 5 shows the ADS system hierarchy with the system's boundary depicted by the red ring, with the owner of the system being the Head of automation, and the actual drill automation technology being the lowest in the hierarchy. The overall system under inquiry is the 'soft' system, consisting of all actors, tools and techniques, that enables autonomous drilling. Support teams encompass training department, maintenance engineering and OEM consultants.

Figure 5: System hierarchy (Author's own work)

Problem situation is expressed through rich picture to depict the overall context. Rich pictures are a great way of exploring complex situations as they foster a shared understanding of complexity, where stakeholders hold different views (Conte and Davidson, 2020) (Barbrook-Johnson and Penn, 2022).

Figure 6 depicts a rich picture of the ADS problem situation. Important aspects shown in the rich picture: Stakeholders lack continuous engagement, with roles and responsibilities not clearly defined. Measures of effectiveness and KPIs are not aligned across the board, each stakeholder group have their own separate KPIs, which are in conflict at times. There is also inadequate fit-for-purpose equipment and supporting infrastructure. Moreover, the existing operating standards and procedures are not aligned with the introduced technology. This is an overview of the issues from the author's experience and engagements with the operational teams.

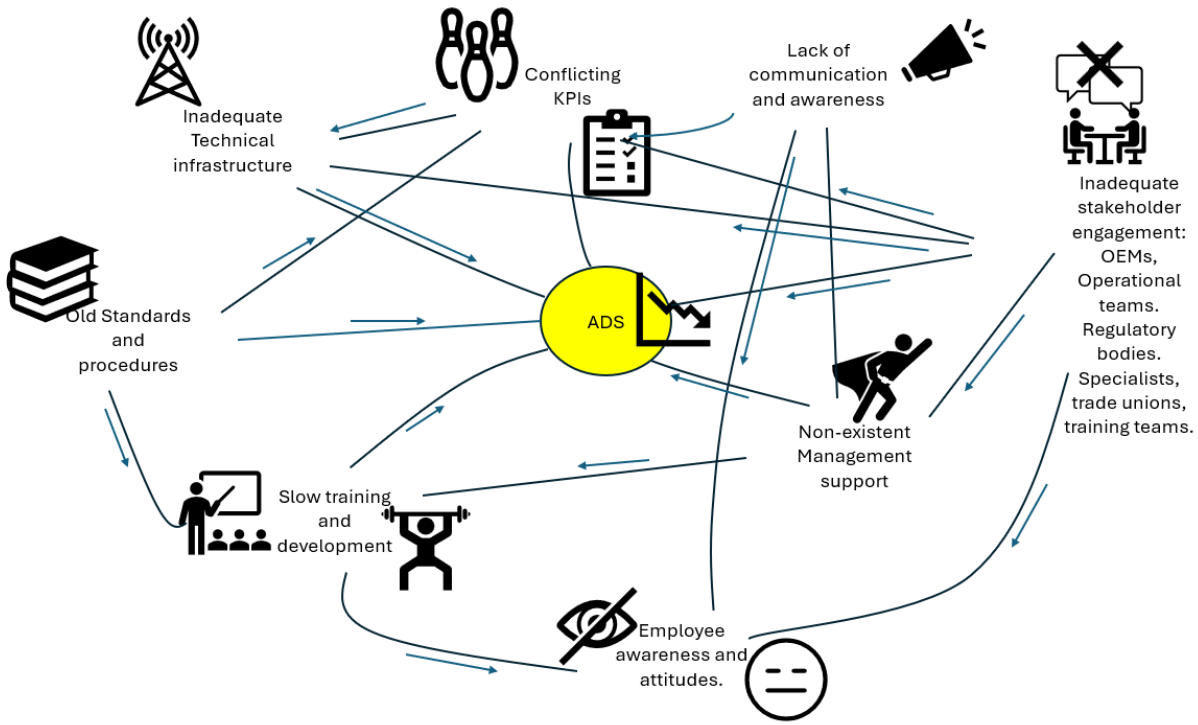

Figure 6: ADS rich picture. (Author's own work)

9. FINDINGS

The study is performed to improve the adoption of autonomous drilling technology at one of the open pit mines in South Africa. Six expert interviews are conducted to get more information about the topic. The experts' experience ranged from 6 to 25 years in mining. All experts are currently involved in introducing ADS at other mine sites, both from technology providers' and mining specialists' perspectives. Three interviewees were project specialists from two leading providers of ADS technology and the remaining three were automation mining engineers working for leading global mining houses. In this way, the interview included both system providers and their mining clients. It is important to note that most of the participants did work as frontline drilling supervisors. The interviews aided in understanding factors to focus on and how these factors can be geared towards desired results. The study results are categorised into themes that represent prevalent factors discussed by the participants during the interviews. This followed coding of the data and using thematic analysis. Table 1 shows the themes that grouped the data. Each theme is reported in detail below.

Table 1: Themes and codes

Stakeholder buy-in and collaboration	Management support and trust	Process management and KPIs
• Project fails without involvement of main stakeholders • No inter-departmental communication • Turning into a blame game • Buy in from people essential • Involving even the detractors • Strategy for negative people • Communication approach important • Continuous dialogue helpful • Explain benefits to all • Buy-in from operational management • Stakeholders not engaged from the beginning • Operating in silos	• Operational management not supporting the technology. • No authority to enforce compliance • People do not trust technology. • Continuous support from top management • Allow people to learn • Buy-in from management • Not drive from management. • Managers not briefing crews. • Fear of job cuts. • Build trust and acceptance	• Existing processes and procedures. • Rhythm and flows. • Operational KPIs not aligned to the technology. • No criteria to be met by operators. • Drawing of policies and procedures. • Process tracking. • Change how mines are managed. • Goals must be clear. • Road map must be drawn.

Ownership, accountability and influence	Site capability	Culture and attitudes
• Levels of work to be respected • Influential people to take ownership • Operational managers understanding what needs to be done • People making operational decisions must be accountable. • Accountable people at right levels. • Operational leaders enforcing discipline • Frontline leaders' role • Specialists have little influence on discipline • It is all about ownership • Everyone to understand their role	• Gaps in IT capability • Infrastructure • Not adequate resources and people in training department • Operational team capability before full implementation • Operational readiness to be all inclusive. • No adequate supporting equipment • Technical requirements • Supply chain process	• Blame game when things go wrong • Functional teams pulling apart • Culture and approach • Anticipate people negative towards technology • Change in how mines are managed • Change mindset of people • It takes a lot of discipline • Change in management routines

Approach
• Understanding where you are operating • No one-size-fits-all • Remember the environment the technology must operate in • Working in silos • Consider socioeconomic climate of the region

9.1. Stakeholders buy-in and collaboration.

Stakeholder engagement is one of the most important processes during project lifecycle, and it can make or break a project. Ensuring all stakeholders are included can assist in attaining buy-in from all parties involved. When everyone understands the objectives and is clued up on the current and future processes of the project, they tend to be open and amenable to the project's goals. Attaining stakeholder buy-in can be crucial in minimising rejection of new technologies. At an advanced level, buy-in can also mean stakeholders contribute positively and share ideas to advance the project, fostering collaboration.

The participants believed that the introduction of new technologies like ADS can be stalled without buy-in from the main stakeholders at mine sites. All participants emphasise this importance and believe that transparency and effective communication play an integral role in mustering and rallying all stakeholders towards the desired direction to improve technology adoption. Some participants believe that mines fall short of effectively engaging all stakeholders.

"...I think the most important thing by far is having people's buy into the concept of what you're trying to achieve..." [Participant 2-Line 320]

According to the participants, buy-in from operational management is also necessary. Managers enforce compliance and make operational decisions. Participants believe that if operational managers do not believe in the technology; people will not be held accountable. Managers are also required to engage with trade unions. According to some participants, engagement of the trade unions is also not done effectively.

"...first of all, you have to have the buy-in of your management and that of your production team. You have to sit down with them and explain the benefits of autonomous (drilling) because if you don't have the buy-in and they don't believe in it, trust me it is not going to be a success... And that's where most of the clients made the mistake. Now they want to get the union on board, it almost too late" [Participant 3-Line 820]

"After executives buy-in, you need to identify who are the people who will make the operational readiness plan work, and work with those people...." [Participant 4-line 1010]

Collaboration and team spirit also came up as part of the elements that make technology projects work. From the interview data, participants stressed that each team member must be invested in the project and understand their roles clearly.

"It was not a one-man job, it was the buy in from the GM (General Manager) right down to the operators, everybody was involved and everybody wanted to make success of it and improve it..." [Participant 3-Line 725, 730]

"So, you try to come with a common ground because for technology to be successful, you need the other person to see why it's important…" [Participant 5-Line 1385, 1390]

9.2. Management support and trust

Top management support becomes crucial when organizations navigate change. With the support of top management, trust is built with operational teams. Trust becomes essential during organizational changes, especially when introducing technologies like automation, where one person can operate multiple equipment at a push of a button, threatening job security.

Participants explained the dynamics of management support during times of change, relating it to employee trust. With management support, operational teams' buy-in is believed to be more present. All participants believe operational leaders are vital in allowing mining sites to adopt autonomous drilling. Management support at the case study mine needed to be improved.

"The drive was not there from the management side" [participant 3-Line 575]

"So, if you make sure you have people at the right level, people who make operational decisions and have influence, take charge of these people and you have won the battle. They will also enforce discipline, bring trust and acceptance to that technology" [Participant 4- Line 1020]

"There needs to be, you know, continuous support from a management perspective. You know, even when things go wrong, there needs to be that sense of encouragement and sense of drive. It's very soft things…But I think what's really the core is giving people the breathing space and the focus to actually allow the project in an operational environment to grow and develop." [Participant 2-Line 350]

All participants appreciated employees' lack of trust in the introduction of automation technologies, which is believed to stem from their fear of job losses. Managers can, therefore, support and encourage employees during this period to lessen the fear and create an environment conducive to growth.

"People are often intimidated and don't trust technology, so like I said it is about taking people along with you and creating an environment where detractors become enablers". [Participant 2-Line 325, 330]

"The unions were under the wrong impression thinking of job cuts. They weren't properly engaged from the beginning of the process." [Participant 3-Line 815, 820]

"The perception that technology is going to take our jobs is real, it is very, very real…but to people like that, how do you now sell it differently" [Participant 5-Line 1415, 1420]

"If we are going forward with automation and we're saying that we're going to have, for instance, two people or a person operating at some stage, three machines, which is our goal, what's going to happen with the other two. The issue of fear of job loss comes to mind" [Participant 6-Line 1780]

One participant pointed out the importance of communication and transparency at the initial stages of the technology introduction. They believed trust could be built with transparency, clear communication, and environmental sensitivity. Most mines are believed to be doing the opposite —not communicating clearly and not showing people what the future looks like.

"So, we need to be sensitive and communicate a clear message and in detail what is going to be the new labour structure, what is going to be additional requirements."

"That is our main challenge within South African operations, we are not clear about the impacts, we just hear we are not going to cut jobs. What assurances are there?" [Participant 4-Line 930]

"…but we sell to top management and top management down clearly (brief) people down below to say, this is what's going to happen because most of the people when they hear autonomous, they think of job cuts and autonomous is not there for job cuts. We (are) uplifting the skill of that operator." [Participant 3-Line 640]

9.3. Process management and KPIs.

One must think of existing processes before discussing the introduction of technology. Existing processes and how they are managed drive both key performance indicators (KPIs) and organisational culture. From the planning stage and setting of objectives and goals, to execution, process management influences the degree to which organisations realise their objectives—these range from standard procedures and policies to performance tracking and reporting.

Most participants highlighted the importance of having rigorous standards and policies in place for the organisation and the project of interest. Additionally, participants believe setting clear objectives and goals become essential in managing technology implementation projects.

"So, the sites where it's easiest to integrate, if the site already has established processes, very well documented procedures, rhythms and flows of the site…it seems a lot of sites have a lot of processes that developed rapidly but were never standardised." [Participant 1-Line 95,100]

"From governance perspective, as a mine site, you need very sound governance in terms of existing processes, right from planning to execution…you also need governance on how you change your processes." [Participant 2- Line 305, 310]

"We now will enforce that we get standards right (so) that we can successfully implement and go forward with this". [Participant 3-Line 585]

"if you don't enforce the discipline there, that is when you start deviating from the standard. And that's when you started picking up problems. And then unfortunately you can't drill autonomous. You have to go back to manual" [Participant 3-Line 615].

The common belief in process management is that the way mines are managed needs to change. A mine with advanced technology cannot be managed like a mine deploying conventional methods. Leaders need to change their mindset. Refocusing and establishing modified KPIs to accommodate the technology is also believed to be important.

"If the section manager does not have their KPIs linked to the project, it comes as additional work for them."

"…effectively drawing of policy and procedures that support your technology implementation, interdepartmental KPIs and data analytics, what data are you looking for and making the data available to managers and frontline leaders." [Participant 1-Line 215].

"What is absolutely critical for site management to realize and accept is that you are essentially trying to run a project in an operational environment. Okay, so you have people who have daily jobs, responsibilities, tasks, who are now expected to add more work onto their plates and give it all the effort that's required to make it work, right? I think that, in my view, and I haven't seen this done before, there needs to be a change in the way sites are managed to allow the technology to grow and foster." [Participant 2- Line 345]

"So, I think in that space, in the operational readiness space, there's a change management aspect of it. There's an SIB (stay in business) aspect of it. There is a construction management aspect of it. And then there's value chain integration aspect of it. And that requires you to be able to establish new management routines or modify existing management routines to centralize the technology." [Participant 4-Line 955]

9.4. Ownership, accountability and influence.

There need to be roles and responsibilities in every purposeful organisational effort. Clear roles and responsibilities assist in ensuring accountability and creating an environment where each contributor in the team assumes ownership of their duties. Clear roles and responsibilities capacitate organisations to realise their goals and continuously live up to their mandates.

Although the importance of ownership and accountability is understood, the participants had a common belief that accountability is mainly misplaced. The people with real influence and who make operational decisions, such as the operational managers, are not adequately included in the accountability structure of the technology implementation efforts. The accountability is left to someone external to the operational structure, such as a consultant. That is also reflected in the belief that operational managers do not have their KPIs linked to technology as they are technically not required to enforce its adoption.

"Overall, it is challenging, you have a project manager who is contracted to the mine, they are not really integrated into the mine and not into the accountability structure of the mine. (The project) is not driven by a project owner from the mine site, at a manager level, someone who has influence. People with influence rarely have time to discuss autonomous (ADS) issues, they are invested in their KPIs." [Participant 1-Line 70]

"And what I've seen also, if you don't have good leadership buy-in like, for example, like given example of X. It's not on his KPI. It's not part of his mandate. It's not part of his job. There's no way in his contract that says, right, I want meters, but I want quality meters. No, we just want meters. And that's what he's going to deliver, right? I mean, it's human. Why bother yourself for something that nobody asked you for...?" [Participant 5-Line 1545]

Participants further believe that the main problem is taking ownership and being invested in the project's success. Accountability is required from the operational leaders' side, people who have influence and can build trust and enforce discipline. Participants believe that operational leaders at the case study mine need to see making the technology work as their responsibility.

"If I could sum it up however in one word, it would be ownership. I see clients and customers (mines) who are successful at this stage are those who take ownership of the project (and) take ownership of the process. So, in other words, instead of us pushing success on to customers, customers are pulling knowledge from us so that they can be successful. I don't know if that makes sense."

"I'm aware of the struggle at (case study mine) and I'm not going to say that the systems that have been deployed there don't work. But I think that from what I've seen, you know, the challenges that I've spoken about, the sense of ownership, operational (team) involvement, I get the sense that those are some of the larger challenges on site there than anything else." [Participant 2-Line 420].

"The main reason for failure for autonomous (drilling) on the mines is that there is not enough focus on that topic (from operational management) …everyone must know what to do…there is no drive from management…the pressure (to adopt the technology) must come from management" [Participant 3-Line 600]

No, the thing is, as a specialist…you're a consultant and you must remember that you have to be a consultant. Yeah, you don't have influence. You don't have influence, and I think that's where most of these projects fail because…People who actually have money (and influence) are the people on site and those are the people who you need to ensure they take ownership." [Participant 4-Line 1055, 1060]

9.5. Site capability

The capability of an operation or organisation to adopt technology depends on its overall set-up, from people and culture to resources and infrastructure. Each operational site must be prepared to receive the technology it intends to introduce. People need to be capable, and the equipment and overall infrastructure need to be fit for purpose. The existing processes must be able to absorb that new element and run with it until it becomes the new normal.

It was evident from the interview data that participants rate operational readiness among the top factors when it comes to introduction of technologies. Additionally, the participants believed that it is only few operations that get this initial process right.

"So, definitely operational readiness on it and a lot more testing of the sites infrastructures and criteria before you implement the project. So, within any technology space, you have to go and do a whole operational readiness assessment of your site. Obviously reaching out to the OEMs (original equipment manufacturers) for their requirements for the technology, making sure that your site can handle the technology. I know from one site, operational readiness wise, from an IT (Information Technology) point of view, we were very far behind and once the project came in, we actually realized, this is how far we are behind. And we played catch up for a good eight (8) months before we got to a space in the IT space, where we could say, hey, we can now run this sustainably and in a healthy way" [Participant 1-Line 145-155].

Site capability from the perspective of people and processes is also believed to fall short at most mines. Participants say it becomes essential to ensure that training material is suited to the technology's objectives and that people can be trained to run the technology sustainably on a daily basis. Sites struggling to run the technology sustainably are believed to have failed to develop adequate training requirements.

"*They had not even implemented what training material needed to be in place for autonomous (drilling). They had not even got criteria for autonomous operators in place. So HRD (Human Resource Development) didn't even have people and resources available to start using the technology once it was in place."* [Participant 1-Line 170]

"I think this thing boils back down to operational readiness, having it very clear and well-equipped operational readiness team that is going to handover to operations…and ensure that once the project team detaches from the work, the team that is actually left on site can continue the work." [Participant 4-Line 950]

"*But from a governance perspective, you need, if you're a mining company that wants to implement autonomous drilling, you need very sound governance in terms of existing processes in terms of how drilling is executed."* [Participant 2-Line 305,310]

Apart from people and processes, participants also stress the importance of getting the technical requirements right and sourcing the right equipment at the right time. They believe that even when people are open to technology, if the technical infrastructure is not set up appropriately, the continuous operation will be a challenge, and this will frustrate people. Participants believe one cannot afford to lack in that space.

"From a technical perspective, we need to make sure that the infrastructure and the equipment that we have is completely supportive of that, because you also can't slack from a technical perspective." [Participant 5-Line 1495]

"You look at your network setup, because you need it strong…you need to look at what is it going to cost you to upgrade your network." [Participant 3-Line 690]

"*So, technical requirements, quite obvious, you know, you need to have sufficient network infrastructure on site, you need to have an effective GPS setup."* [Participant 2-Line 305]

One participant recounted that one of the main reasons they struggled with implementation was that they did not meet the support equipment requirements.

"We did not account for the fact that there needs to be a match between network trailers to the number of drills we have" [Participant 4-Line 985]

Proper supply chain management meets technical requirements. Getting the right tools at the right time can capacitate sites to absorb intended technologies. One participant suggests that if supply chain processes are not aligned to the project objectives, the project will be stalled, causing delays and downtimes.

"So, supply chain, my supply chain aspect of things needs to be on top of, needs to be on top." [Participant 4-Line 1210]

9.6. Culture and attitudes shift.

The common understanding is that culture plays a vital role in an organisation's success in navigating change. Introducing new ways of working will require an analysis of existing culture and attitudes. Culture refers to commonly held beliefs, written or unwritten, in each organisation. It mainly manifests itself in easily perceivable behaviours but can also be latent.

The interview data prevalently showed that existing culture, in relation to technology, needs to be understood before implementing technology. Culture is believed to influence how people work and how managers lead. Most participants' perception of culture comes when they explain how mine sites deal with setbacks during the project. Moreover, a common belief among the participants is that shifting attitudes and behaviours towards the desired direction is possible.

"And then it sounds like it always turns into a blame game." [Participant 1-Line 155]

"Having sound stable processes is one thing, but you need to have a culture and an approach that allows for processes to be changed in such a way that people actually use and adopt the changed processes."

"*So, in any project of that scale, you're going to have people that have a negative frame of mind. And you have to accept that, but you also have to have a strategy of how you're going to change that."* [Participant 2-Line 325]

"You have to change the mindset of the people, their personal behaviours, as (managers) we have to change it and say, "hey guys let's sit down..." [Participant 3-Line 5575]

"At one site, operators pushed back but when we got to day 4 of theoretical training, these people's minds changed completely, they saw the bigger picture… Once they see the bigger picture, they all buy in, they get excited about autonomous drilling." [Participant 3-Line 635]

When I started my mining career, I was against this. I did not believe in autonomous drilling…my then manager said to me "look at the big picture" …and I fully believe in auto (drilling system) now" [Participant 3-Line 760, 765]

9.7. Implementation Approach

Approach is about how an organization goes about implementing new technologies. The kind of approach invariably affects acceptance and the ease at which a new normal can be created. The approach discussed here is relational to the people side of things, the 'soft' part.

One participant stressed that an implementation approach will differ from one organization to another and that when it comes to people, the way of communication becomes an integral part of that approach. One participant stressed that an implementation approach will differ from one organisation to another, and that communication becomes an integral part of that approach when it comes to people. At a larger scale, the participant also brings differences in regions beyond organisations. Some countries are more amenable to automation technologies than others. A wrong approach can result in people rejecting the technology.

"I think at the end of the day, I think it goes back to you understanding where you're operating. So, if you are talking about implementation of this in Australia, I can say, Australia or South American operation compared to an African operation, the challenges we have are not the same… So, if I'm to bring it to a South African context or a Southern African setting, African context, we are a labour-intensive…in South Africa, we have issues in terms of economic instability and unemployment rates and such things. So, we need to be very sensitive on how we actually picture it." [Participant 4-Line 905]

10. SSM MODELS OF THE SITUATION.

The modelling of the problem situation begins with the root definition of the ADS implementation process, using two methods: The PQR-formula and CAPETOWN model. Root definitions bridge the 'real world' and conceptual situations. According to Siriram (2017), root definition can assist in capturing the reality of the situation, revealing relevant problems to tackle, using the 'As-Is' and 'To-Be' models.

The PQR-formula is useful and effective for root definitions. In its application it answers three questions: what is to be done (P), how this must be done (Q) and why must it be done (R) (Augustsson, et al., 2020). The PQR-formula for the as-is situation is shown in Table 2. The CAPETOWN mnemonic is for Customers, Actors, Performance, Environment, Transformation, Owners, Weltanschauung, and Nature. The CAPETOWN model will show the 'As-Is' situation, depicting the current processes. Table 3 shows the 'As-Is' CAPETOWN model.

Table 2:PQR-formula (Author's own work)

P	Enable introduction of autonomous drilling technology
Q	By informing operational managers of the requirement to introduce the new technology and presenting them with documents and videos showing the motivation and benefits of the new technology
R	This is to ensure that the technology is rolled out on time and well within budget.

Table 3: As-Is CAPETOWN model (Author's own work)

Customers	Operational managers
Actors	Drill automation specialists, OEM consultants, Maintenance engineering team, drilling standards and procedures, Training department, Mine site projects team.
Performance	Compliance to project schedule and cost.
Environment	South African Mining industry, production (operational) setting, remote, mine site, brownfield.
Transformation	Source and introduce drilling automation technology, complying to schedule and cost
Owner	Head of Automation
Weltanschauung	Selling the technology to operational managers will ensure quick absorption as they are the ones controlling the operational teams. Compliance to schedule shows the success of the implementation process. All stakeholders understand the benefits of the technology.
Nature	Purposeful, Manmade and open system.

11. DISCUSSION OF RESULTS: DEBATING THE SITUATION

The interview results in general are consistent with literature. There was a strong consistency in how both social and technical factors impacted the introduction of autonomous technologies in mining. Although the literature focused on the general introduction of technologies in mining, the interview results echoed similar factors. However, discussing all findings and relating them to their significance to the research objectives is essential. Systems thinking methods (affinity diagram and interrelationship diagraph) are also used to discuss the factors holistically.

11.1. Inclusive stakeholder engagement and awareness.

The participants explain that there needs to be buy-in from all stakeholders at each mine. This brings forth the need for an all-inclusive stakeholder engagement from the initial stages of the project. Further participants argued that a well-conducted stakeholder engagement can cause team members to contribute positively to the project, fostering the spirit of collaboration. The data from the interview regarding to stakeholder buy-in is consistent with literature. The existing literature explained the importance of end-user acceptance and confidence when introducing new technologies. When all stakeholders feel included and are clued up about the technology to be introduced, they get invested in making it successful. This was not the case with the case study mine. Stakeholder engagement process only targeted operational managers, with no effective engagement with frontline workers.

The interview data also suggested the need for transparency and clear communication about the technology and how it will affect the way of work. Furthermore, most of the participants believe that most mines need to include and effectively engage all stakeholders in the initial stages of technology introduction efforts. The lack of clear communication and engagement with key stakeholders can stall the implementation of new technologies.

Communicating and discussing the benefits of the new technology in detail also has a positive impact on people accepting the technology. The fundings suggest that people respond positively when technology is perceived as useful. People need to see and understand how the technology will improve both themselves, their way of work and their remuneration. It is an important task to increase people's positive attitude towards the technology as this will lead to sustainable adoption. An organisation's choice of incentives can deter innovation/change adoption because they drive performance. Participant 5 and Participant 6 addressed the issue of remuneration benefits and added that how automation will influence this must be discussed.

Monetary incentives have been cultural to mining and other extractive industries, and their influence on performance, including the adoption of technologies, must not be overlooked. Incentives and the overall reward system at the case study mine remained the same. The teams still chased volumetric targets to increase their earning potential, reverting to old ways of working whenever they felt the technology was slowing them.

The common belief amongst the participants is that it is the top management's role to ensure that people see the technology through a positive lens. The interview data suggests that trust needs to be built within the organisation for acceptance and buy-in. Further, participants stressed the importance of top management support in establishing this trust. People need to feel that top management has their best interest at heart in addition to the organisation's objectives. All participants stressed the prevalent fear of job losses when people hear about automation technologies. One participant argued that the high unemployment rate and job scarcity in South Africa exacerbate the fear of job losses, and that technology implementation efforts must be made sensitive to this. The existing literature also reported that employees can perceive adopting new technologies as risky, and the reason is two-fold. First, they fear being replaced by the technology. Secondly, productivity can slump during the initial stages, or the technology can fail altogether, impacting mines' profitability. With reduced profitability, mines can cut jobs. So, people would rather stick to what they know works in efforts to maintain job security. With non-existent management support towards the automation drilling system at the case study mine, this lack of trust is compounded.

11.2. Management support and trust

Top management's voice and attitude play a crucial role in influencing people, and any intervention that lacks management commitment is prone to fail. Management's commitment becomes vital because people need guidance and support during uncertain times, such as navigating change. The attitude of top managers the case study mine is one of the chief influencers of the technology's acceptance/adoption because this dictate how people perceive the technology and its usefulness. Additionally, the same applies to the relationship between site operational management and top executives. Operational managers need to trust the objectives laid out by top executives, who need to enforce compliance by restructuring KPIs and reward systems. According to the participants who were involved in the ADS technology implementation at the case study mine, there is misalignment in objectives between executives and operational managers.

Operational managers stick to delivering their KPIs, which do not include the technology adoption objectives. The mine has been running with drill automation technology utilisation well below target, without the intervention of operational managers.

The interview data also suggests that when seeking buy-in, organisations tend to focus more on operational managers than frontline supervisors and operators. Implementation teams often assume that managers will always be committed to the organisation's objectives and transfer the commitment down to frontline workers. One participant added that operational managers are crucial to the success of technology implementation efforts and that their commitment is necessary. In addition to their commitment, operational managers need a clear mandate and objectives, requiring their KPIs to include technology adoption and utilisation. Operational managers must be seen as permanent agents of change and their role in technology adoption must be clearly defined and standardised. To foster trust and transparency, organisations must deliberate about modifying processes and governance to accommodate new technologies.

11.3. Process management and KPIs

Participants agree that the way operations are managed needs to change. Site standards and procedures need to be redrawn to enable the absorption of new technologies. Furthermore, participants found that from their experience, it is easier to introduce autonomous drilling on mine sites with stable and standardised processes. It is essential to have a technology implementation road map that must be standardised. The interview data further suggests that management routines need to change. It was a common belief amongst the participants that at most mines, key performance indicators (KPIs) are not realigned to allow for accountability around technology utilisation. Technologies keep being introduced, but KPIs stay the same, only tracking volumes. This applies to the case study mine, resulting in lack of accountability around technology implementation.

Incentives are closely aligned with KPIs. Together with KPIs, choice of incentives also drives performance. Participants argue that when technology falls short of expectations, operators quickly abandon it and return to old ways of working. This discredits the technology and results in a negative attitude towards it. Participants suggested that the way of management needs to change to allow people a breathing space to learn. Participant 5 went further to state that a learning culture must be created where people grow with the technology. However, this cannot happen when KPIs are not realigned to accommodate the use of the technology.

People will commit to doing what managers track and what they are paid for. Participant 6 added that some mines have monetary allowances for people working in high-risk zones. One of the objectives of automation is to remove people from high-risk zones, and it is unclear how this will affect those monetary benefits. Change management processes need to be clear and transparent such that these uncertainties are eliminated.

The interview data also revealed that most mines need to be clearer about the impacts of switching to new technologies. Redrawing site standards and procedures, and realigning KPIs and incentives to accommodate new technologies will foster accountability and ownership around the implementation process. Requirements will be clear, and people will understand their roles in making the technology a success.

11.4. Ownership, accountability and influence.

The participants' responses focused on the challenges of accountability and ownership. Additionally, participants believed that accountability was misplaced, with people making operational decisions not being held accountable for technology utilisation. Accountability for improving technology adoption lies with the consultant contracted to the mine, without much influence on daily operations. At the case study mine, accountability lies with a specialist who sits at head office, remote from the mine site. This makes it difficult to have a lasting impact on operational teams.

The participants also believed that operational managers perceive technology management as additional work. Operational managers make daily operational decisions and significantly influence end-users (workers). Without managers' encouragement and motivation, everything will slow down on the technology front. The operational chain of command needs to be respected as one must get to the teams by holding their managers accountable. This is why the operational managers' buy-in is critical; it will be challenging to improve the adoption of new technologies without their total commitment and support. Participant 5 argued that when introducing technologies, project managers need to be sensitive to the responsibilities and KPIs of functional (operational) managers and find a way to integrate the project's objectives into these. The consensus is that any change that lacks commitment and active management support will not be sustainable, which is truer for operational managers like section managers in the mining context. Roles and responsibilities must be clear, and accountability must be consistent with given authorities. Operational managers have full authority on daily operations but are not held accountable for slow technology uptake.

This is a common flaw in mining when introducing new technologies, with the case study mine included.

All participants suggested that section managers and other frontline leaders must be a gateway to the crews, enforcing technology utilisation and supporting crews when necessary. Operational management need to be trained, with their mandates on technology adoption clear; this will foster ownership and accountability. Operational managers need to have a desire for the technology to work effectively. According to the interview responses, there is no outside party that can enforce compliance like operational managers because that is the working and proven chain of command.

Fosberg et al. (2005) argue that top executives must balance responsibilities and authority between functional departments and the project team. When there is commitment and sense of responsibility from management and leadership perspective, they will ensure that the mine site is set up and capable of receiving the new technology, from both social and technical perspectives.

11.5. Site capability

Site capability in terms of governance and technical requirements also plays a role in adoption of new technologies by mine sites, as reported by the participants. The interview data showed that most mine sites are not ready for autonomous drilling. Infrastructure falls short of technical requirements. From a governance perspective, it is easier to introduce new technologies in stable and standardised processes. Some participants believe that sites do not adequately train people to operate these technologies sustainably. Training and human resources (HR) departments need to be considered critical and essential at the case study mine. This is to ensure that the people factors are considered effectively.

The interview data also suggests that organisations must be willing to spend the capital required to acquire equipment and infrastructure required to keep the autonomous technology running. Operational readiness is a prevalent term within the interview responses. Organisations need to think holistically to ensure all supporting processes are running satisfactorily. One must consider existing processes before introducing new technologies. Site capability in terms of people, processes and infrastructure becomes essential and requires holistic thinking. The interaction between the new technology and existing operational setting (people included) must be designed holistically. The implementation of the autonomous drilling technology must not be seen as a once-off process. The process needs to be continuous, with the technology developing and improving with the people. Some participants (mainly the technology suppliers) echoed that the technology works, and that the problem is the operational teams.

This is not a prudent view; the technology also needs to be unrigid and develop with the people. Technology suppliers need to be open to alter their technology to suit each mine site conditions and avoid one-size-fits-all approach. Participants argue that organisations cannot afford to fall behind regarding technical requirements such as support processes, equipment and infrastructure because this can lead to unnecessary delays. People get frustrated when unnecessary delays occur, causing negative attitude towards the technology. Although the social factors are critical, A comprehensive operational readiness needs to be considered so that technical requirements are met. Buede & Miller (2016) stress the importance of performing requirements analysis during the initial stages to ensure all gaps are covered before they become problems. This also means considering barriers related to culture and attitudes and finding ways to circumvent them.

11.6. Organisational culture shift.

Participants argued that there needs to be a culture shift, that people's attitudes about technology need to be changed. Many sites underestimate the possible negative attitudes towards automation technologies and their overall effect on technology adoption. This is the reason behind the case study mine initially focusing on operational managers, neglecting all other stakeholders. The assumption was that the operational managers will make it work. Participant 2 argued that an all-inclusive organisational commitment must be made to embrace technology and cultivate innovation culture. There must be preparation to bring people along from the negative to the positive side, and it must be appreciated that this cannot be done overnight. Participants argue that once people understand the bigger picture, the pushback ceases and people become eager to make the technology work. When the culture is not rebuilt towards embracing innovation, people get frustrated when experiencing challenges with technology and resort to blaming each other. Participant 5 pointed out that introducing technologies needs a learning culture where people face challenges and still want to make the technology work. Likewise, the technology suppliers need to be open to modify the technology to increase usefulness and ease of use in each situation. People need to start understanding that they need to grow with the technology, and the only way to do that is by approaching challenges positively. Understanding the culture and employees' attitudes aid in understanding the environment in which the technology is required to operate, and this in turn helps with tailoring the approach suitable for the environment.

Some participants acknowledged that the approach is not one-size-fits-all. One must understand each context and consider this when selecting an appropriate approach. The interview data suggests that the participants favour an all-inclusive approach that avoids working in silos. In addition, participants point out that effective communication is the most essential part of an approach.

Different environments require different communication styles. As Participant 5 puts it, one must understand their audience. Social factors are always present in mining organisations, where cross-departmental collaboration is essential. Some of the participants reported that they have experienced clashes between departments at some mines and that there can be cultural differences within the same organisation.

11.7. Interaction between factors.

In most cases, the expert interviews are consistent with findings from literature. The researcher found the intersection points between literature and expert interviews. The analysis continues with a 'what' affinity diagram. The categories focus on grouping the main challenges that are applicable to the case study mine. The interrelationship diagraph is then used to reveal potential root causes, exposing intervention areas.

Potential factors causing the problem from literature and interview data are grouped and categorised using an affinity diagram. Affinity diagrams are used to organise large qualitative data and unlike grouping data into predefined categories, they are built from the bottom up (Lucero, 2015). The bottom-up labelling becomes essential to avoid bias and tunnel vision. The grouping is closely guided by the themes that were extracted from the interview data, and they also aligned closely with the themes from literature research. Five main groupings are drawn: People, processes, culture and attitude, infrastructure and equipment, and implementation approach. Table 4 shows issues in each category.

Factors prevalent in the problem situation are often interconnected, with root causes not very clear. Interrelationship diagraph can assist with shining light on potential root causes. Interrelationship diagraph shows cause-effect relationships, aiding in revealing key driving factors (Alexander, 2018). According to Sriram (2016), root causes must be separated from symptoms. Interrelationship diagraph for factors discussed in this study is shown in Figure 7.

Table 4: 'what' affinity diagram

People	Processes	Culture	Infrastructure and equipment	Approach
-Involving stakeholders late -Inadequate awareness and training -Lack of collaboration between departments -Inadequate leadership commitment -limited communication leading to lack of trust.	-Management routines not aligned with the use of technology -Technology utilisation not part of operational managers' KPIs -No holistic procedures from planning to execution of autonomous drilling (Some processes become bottlenecks e.g. block preparation)	-Working in silos -Blame culture -Technology slows work down -Easily going back to old ways when facing challenges with technology -Frustrated by technology challenges	-Lacking critical parts -Support equipment inadequacy -Challenges with network connectivity	-One-size-fits-all -Implement and tag stakeholders along the way -See gaps as we go -Evolutionary approach

With the root causes exposed, the points of intervention in the system become clear, laying a foundation for effective improvement efforts. In this case, the root cause is shown to be the approach, which was one-size-fit-all (box with the most outgoing arrows in figure 5). This is consistent with both literature and interview data. The implementation approach directs all other factors because with the right approach, most problems can be solved. The problem with a one-size-fit-all approach is that it undermines the stakeholder engagement process and requirements analysis, which are supposed to assist in tackling situation-specific barriers. The other potential root cause is minimal leadership commitment, which addresses operational managers not assuming accountability and ownership to make the technology work (the box with the second-most outgoing arrows in figure 5). Without operational leaders' voice and commitment, any new technology adoption will stall. These root causes are consistent with literature, without a fit-for-purpose approach and management support, technology implementation efforts are likely to fail.

The symptoms of failure manifest as negative attitude towards technology (the box with the most inward arrows in figure 5). Negative attitude is then an issue that can be addressed by taking people along and changing their mindset through continuous engagement and management support. With teams full of drive, continued management support and fit for purpose approach, ADS can begin to thrive. A 'To-Be' CAPETOWN root definition shows the desired situation, leading to a 'how' affinity diagram which is used to depict potential improvements.

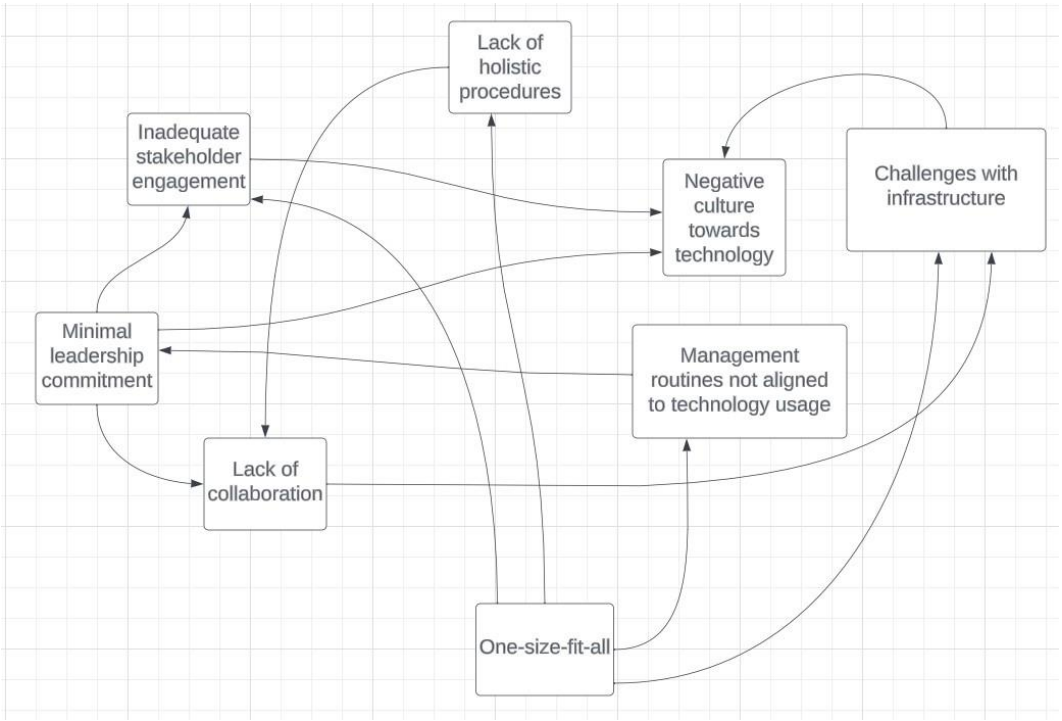

Figure 7: Interrelationship diagraph (Author's own work)

12. TO-BE MODEL

The To-Be situation is modelled using both PQR-formula and CAPETOWN model. These captures and defines the drilling process at the case study mine that is both feasible and culturally desirable. The 'To-Be' models are drawn using applicable findings from both literature and interview data, prompting a shift in focus towards both social and technical factors. The modified root definitions are shown in tables 5 and 6. Changes occurred on 'Performance' to include holistic measures of effectiveness that are process-based and include people aspects. Changes to 'Transformation' include improving holistic process efficiency and fostering collaboration. Change to 'Weltanschauung' create impression that makes the team more open to collective learning and management that support the crews and show unwavering commitment to ADS adoption and innovation. And the nature of the system must be open and flexible to self-adjust as required to tackle situational hindrances, improving resilience.

Table 5:To-Be PQR-formula (Author's own work)

P	Increase absorptive capacity at the mine site and ensure organisational readiness
Q	By deploying a staged and targeted approach to inform and train operational teams (from managers down to drill operators), and clearly setting objectives and expectations.
R	This is to ensure that the organisation is ready from both social and technical perspective, drastically increasing chances of successful and sustainable adoption.

Table 6:To-Be CAPETOWN Model (Author's own work)

Customers	Drilling teams: managers, supervisors and drill operators.
Actors	Drill automation specialists, OEM consultants, Maintenance engineering team, drilling standards and procedures, Training department, Mine site projects team, HR team, trade unions
Performance	Percentage trained supervisors and operators, Process effectiveness (meeting of social and technical requirements), compliance to schedule and budget.
Environment	South African Mining industry, production (operational) setting, remote, mine site, brownfield.
Transformation	Consideration of social and technical aspects to increase absorptive capacity towards drilling automation technology, complying to requirements, schedule and budget.
Owner	Head of Automation, Mine Manager
Weltanschauung	To successfully introduce the technology, overall positive attitude from operational teams, from managers to drill operators, is required. The social and technical aspects need to be considered in tandem, to increase absorptive capacity and ensure organisational readiness. People are assets and need development.
Nature	Purposeful, Manmade and open system.

13. RECOMMENDATIONS: ACTION TO IMPROVE.

The root causes were found to be the approach and leadership elements. The ideas to combat these were drawn from the interview data and literature. The result must be a fit-for-purpose approach that is situational and, central to that approach, there must be continuous operational management drive and support. Table 7 shows the 'how' affinity diagram including ways to improve ADS adoption. From the people perspective, stakeholder engagement can assist in creating a fitting situational approach. Part of taking people along and making them part of the journey is through awareness and training. Ensuring accountability of operational management will assist them to drive ADS adoption and take ownership.

The 'how' affinity diagram is drawn to categorise potential improvements. The improvements are recommendations from both literature and expert interviews, with careful consideration to their applicability to ADS process at the case study mine. Finally, a tree diagram packages the recommended framework for improvement of ADS adoption.

Requirements category is connected to people through stakeholder engagement and involvement. Performing a requirement analysis allows the approach to be effective and tackle real challenges. Process integration ensures that the introduced technology gets assimilated into the value chain, and this will require change management to be performed effectively. Mapping the drilling process from planning to execution will assist in ensuring that upstream processes become enablers and not bottlenecks. Conversely, looking at downstream process to ensure that the introduced technology does not become a bottleneck.

The overall improvement recommendation is packaged in Figure 8. The improvement is centred around change management process. Ensuring proper and effective change management can put in effect all other improvement efforts. Planning and establishing stakeholder engagement; and setting up gap analysis can be aspects of the change management process. Integrating the autonomous drilling process into the existing mining cycle is a task that can also be performed during the change management process. The output of the change management process should be mapped stakeholders and plan for engagement, documented socio-technical requirements, the autonomous drilling standard and procedure with clear roles and responsibilities, and measures of effectiveness for the implementation process.

Table 7: 'How' affinity diagram (Author's own work)

People	Requirements	Process integration
-Seek multiple perspectives through stakeholder engagement -Awareness and training -Ensure accountability of operational leadership	-Perform requirements analysis -Verification and validation after each stage of the project -Perform gap analysis	-Ensure change management -Map the drilling process from planning to execution -Foster interdepartmental collaboration

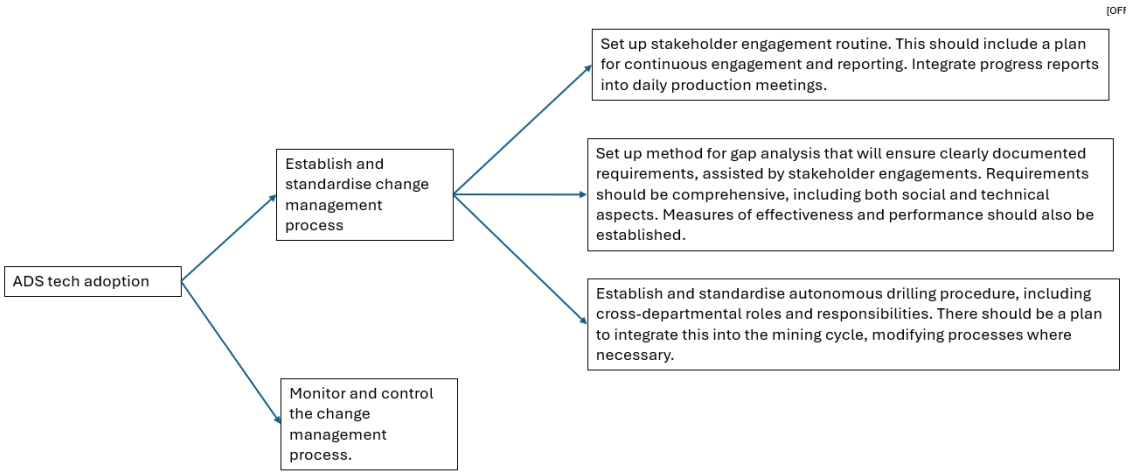

Figure 8: Proposed improvements (Author's own work)

14. SUMMARY: DISCUSSION OF FINDINGS.

The major factors that debilitate implementation and adoption of new technologies in mining lean more towards organisational issues. The use of SSM tools becomes very useful in matters of this nature, as discussed in the preceding sections. The steps of the systems analysis included: defining system boundaries; drawing of rich pictures to understand the problem situation; root definitions to establish stage for conceptual models; drawing of affinity diagrams to provide categories for main themes of discussion; using interrelationship diagraph to uncover potential root causes that enable effective intervention efforts; and finally using tree diagrams to package possible interventions. The major factors when incorporating both the system analysis and interview results included:

- Stakeholder engagement is essential at the initial stages of introducing new technologies. The stakeholder groups for this research were found to be frontline workers; frontline leaders/managers and training providers. Frontline workers need to understand the benefits of ADS towards their work and most importantly, their remuneration. Managers also need to be capacitated to motivate and support frontline workers, which mainly relies on company executives providing necessary support and trust. Organisations need to capacitate their training departments as they aid in ensuring technical competence of frontline workers and shifting mental models through theoretical awareness campaigns.
- Stakeholder engagement and gap analysis can aid in selecting a fit-for-purpose approach when introducing new technologies. Both these are encapsulated by the requirement analysis process, where each step in the technology implementation is validated by its necessity towards meeting situational objectives.
- Process integration is essential when introducing new technologies. Newly established processes must be assimilated effectively with the existing processes to avoid suboptimization and unlock overall value chain gains. An effective process integration can be accomplished by effective change management approach, ensuring that both upstream and downstream processes are aware of how the new technology affects their way of work and in turn, how their way of work can influence the effective adoption of the newly introduced element.

- The implementation approach impacts how the technology is received. Through effective stakeholder engagement and gap analysis, proper implementation approaches and change management methods can be selected, drastically improving the chances of success.
- Management support becomes essential when organisations navigate change. An organisation's executives must support site management teams, who must continuously support frontline workers. Organisational commitment is vital when implementing changes, and the demeanour of top management towards that change must reflect this commitment.
- SSM tools have proven to assist in uncovering major factors driving organisational changes as the issues uncovered are significant and relevant to the research question and objectives.

15. CONCLUSION

The study investigates the possible causes that inhibited autonomous drilling system adoption at the case study mine. Furthermore, plausible solutions are investigated for improvement of ADS adoption. The aims of the study are achieved through semi-structured expert interviews in conjunction with literature review. The analysis of the interview results yielded seven themes: stakeholder engagement and buy-in; management support and trust; process management and KPIs; ownership, accountability and influence; site capability; culture and attitude shift; and implementation approach. Soft systems methodologies (SSM) tools revealed two root causes: Inadequate approach and minimal leadership commitment. The study found that the approach lacked stakeholder engagement and effective communication with workers, leading to negative attitude towards the introduced technology. The lack of management support exacerbated the situation as this increased the negativity, especially during challenging times. Processes were also found to be managed in the traditional fashion as site standard and procedures were not updated to accommodate the technology. There is standard for autonomous drilling but its integration with existing standards and procedures is non-existent. Without effective integration, upstream processes become bottlenecks to the use of the introduced technology. Key performance indicators are those metrics that managers track, and they were not updated to enable operational leaders to track the effective use of the introduced technology.

With the autonomous drilling not included in operational managers' KPIs, there is no accountability and ownership towards using the system, leading to blame culture and lack of collaboration. On most sites the implementation approach was found to be one of the causes of the problem. The approach comes as one-size-fit-all, leading to neglection of stakeholder engagement and requirements analysis. This led to delays and reworks, frustrating the operational teams. Without the learning culture established, team resilience is minimal, and frustration leads to operational teams resorting to traditional way of working. It was found that to create a new normal, learning culture need to be established to allow the teams to grow with the technology.

Collaboration and team resilience is necessary when creating the new normal. Stakeholder engagement and awareness become cornerstone towards securing stakeholder buy-in, fostering collaboration, and increasing team morale and sense of ownership towards adopting the new technology. To minimise challenges, the implementation approach must be situational with an effective requirements analysis process in the initial stages.

With an effective requirements analysis and change management processes, the introduced system stands a better chance at being integrated into existing processes and meeting the validated needs of the entire value chain. The right approach in tandem with management support and team commitment can result in sustainable adoption of new technologies, including ADS.

16. FUTURE RESEARCH

This research uncovers factors influencing adoption of new technologies and its extent was limited to experts in ADS technology. The research uncovered the need for stakeholder engagement and central to this were frontline workers. Further research uncovering the beliefs and views of frontline workers is encouraged. Moreover, another essential stakeholder group are mine professionals (mining engineers and maintenance engineers), who also need to be heard as they are in the setting of mining operations, exposed to day-to-day activities of the mine at tactical planning level. The views of mining professionals need to be intersected with their educational and training background, exposing how institutions of higher learning prepare mine professionals to support mines with adoption of mining technologies and drive innovations. The overall solution will require tripartite collaboration between mining houses, higher education institutions and relevant legislative bodies.

17. REFERENCES

Abbas, R. & Michael, K., 2023. *Theory Hub.* [Online]
Available at: https://open.ncl.ac.uk/theories/9/socio-technical-theory/
[Accessed 11 November 2024].

Abbaspour, H., Drebenstedt, C., Badroddin, M. & Maghaminik, A., 2018. Optimized design of drilling and blasting operations in open pit mines under technical and economic uncertainties by system dynamic modelling. *International Journal of Mining Science and Technology*, 28(6), pp. 839-848.

Abson, D.J., Fischer, J.,Leventon, J., Newig, J., Schomerus, T., Vilsmaier, U., von Wehrden, H., Abernethy, P., Ives, C.D., Jager, N.W., Lang, D.J., 2017. Leverage points for sustainability transformation. *Ambio*, Volume 46, pp. 30-39.

Adcock, R., Singer, J., Hybertson, D., Sillitto, H., Lawson, B., Wells, B., Martin, J., 2024. *Overview of the Systems Approach.* [Online]
Available at: https://sebokwiki.org/wiki/Overview_of_the_Systems_Approach
[Accessed 12 November 2024].

Al Rawashdeh, R., Campbell, G. & Titi, A., 2016. The socio-economic impacts of mining on local communities: The case of Jordan. *The Extractive Industries and Society*, 3(2), pp. 494-507

Alexander, M., 2018. The Interrelationship Digraph Using R. *Software Quality Professional*, *20*(3), pp.49-54.

Ali, D. and Rehman, A.U., 2020. Adoption of autonomous mining system in Pakistan–Policy, skillset, awareness and preparedness of stakeholders. *Resources Policy*, *68*, p.101796.

Arnold, R. D. & Wade, J. P., 2015. *A definition of Systems Thinking: A Systems Approach.* Hoboken, Elsevier.

Ashley, L. D., 2012. Planning your research. In: *Research methods and methodologies in education.* s.l.:SAGE, pp. 31-40.

Atkin, D., Chaudhry, A., Chaudry, S., Khandelwal, A.K., Verhoogen, E., 2017. Organisational Barriers to Technology Adoption: Evidence from Soccer-Ball Producers in Pakistan. *The Quarterly Journal of Economics*, 132(3), pp. 1101-1164.

Augustsson, H., Churruca, K. and Braithwaite, J., 2019. Re-energising the way we manage change in healthcare: the case for soft systems methodology and its application to evidence-based practice. *BMC health services research*, *19*(1), pp.1-11.

Augustsson, H., Churruca, K. and Braithwaite, J., 2020. Change and improvement 50 years in the making: a scoping review of the use of soft systems methodology in healthcare. *BMC health services research*, *20*, pp.1-13.

Bai, X., Surveyer, A., Elmqvist, T. & Gatzweiler, F., Guneralp, B., Parnell, S., Prieur-Richard, A., Shrivastava, P., Siri, J., Stafforsd-Smith, M., Toussaint, J., Webb, R., 2016. Defining and advancing a systems approach for sustainable cities. *Current Opinion in Environmental Sustainability*, Volume 23, pp. 69-78.

Barbrook-Johnson, P. and Penn, A.S., 2022. Rich Pictures. In *Systems Mapping: How to build and use causal models of systems* (pp. 21-32). Cham: Springer International Publishing.

Barham, B.L., Chavas, J., Fitz, D., Salas, V.R.,; Schechter, L., 2014. The roles of risk and ambiguity in technology adoption. *Journal of Economic Behaviour & Organisation,* Volume 97, pp. 204-218.

Bauer, J. M. & Herder, P. M., 2009. Designing Socio-Technical Systems. In: *Handbook of the Philosophy of Science.* North-Holland: ScienceDirect, pp. 601-630.

Bednar, P. M. & Welch, C., 2019. Socio-Technical Perspectives on Smart Working: Creating Meaningful and Sustainable Systems. *Information Systems Fronteirs,* Volume 22, pp. 281-298.

Bell, S. & Morse, S., 2013. How people use rich pictures to help them think and act. *Systemic practice and Action Research,* Volume 26, pp. 331-348.

Ben-Awuah, E., Richter, O., Elkington, T. & Pourrahimian, Y., 2016. Strategic mining options optimization: Open pit mining, underground mining or both. *International Journal of Mining Science and Technology,* 26(6), pp. 1065-1071.

Buede, D. N. & Miller, W. D., 2016. *Engineering Design of Systems: Models and Methods.* 3rd ed. s.l.:Wiley.

Calvo-Amodio, J., 2019. Using activities as human drivers in human activity systems. *systems research and behavioural science,* 36(5), pp. 678-686.

Carter, N., Bryant-Lukosius, D., DiCenso, A., Blythe, J., Neville, A.J., 2014. The Use of Triangulation in Qualitative Research. *Methods & Meanings,* 41(5), pp. 545-547.

Checkland, P. and Poulter, J., 2020. Soft systems methodology. *Systems approaches to making change: A practical guide*, pp.201-253.

Coleman, Phil (2022). Validity and Reliability within Qualitative Research for the Caring Sciences. International Journal of Caring Sciences, 14(3) pp. 2041–2045.

Conte, K.P. and Davidson, S., 2020. Using a 'rich picture'to facilitate systems thinking in research coproduction. *Health Research Policy and Systems*, *18*(1), pp.1-14.

Crowe, M., Inder, M. & Porter, R., 2015. Conducting qualitative research in mental health: Thematic and content analyses. *Australian and New Zealand Journal of Psychiatry,* 49(7), pp. 616-623.

Damanpour, F. & Schneider, M., 2006. Phases of the adoption of innovation in organisations: effects of environment, organisation and top managers. *British Journal of Management ,* Volume 17, pp. 215-236.

Damanpour, F. & Schneider, M., 2009. Characteristics of Innovation and Innovation Adoption in Public Organisations: Assessing the Role of Managers. *Journal of public administration research and theory* , 19(3), pp. 495-522.

Davis, R., 2018. *Does the class action silicosis go far enough?.* [Online]
Available at: https://www.dailymaverick.co.za/article/2018-05-04-analysis-does-the-class-action-silicosis-settlement-go-far-enough/
[Accessed 09 January 2023].

Ediriweera, A. & Wiewiora, A., 2021. Barriers and enablers of technology adoption in the mining industry. *Resources Policy,* Volume 73, pp. 102-188.

Flemish, F., Heesen, M., Hesse, T., Kelsch, J., Schieben, A., Beller, J., 2012. Towards a dynamic balance between humans and automation: authority, ability, responsibility and control in shared and cooperative control situations. *Cognition, Technology&Work,* Volume 4, pp. 3-18.

Forsberg, K., Mooz, H. & Cotterman, H., 2005. *Visualising project management.* 3rd ed. Hoboken: John WIley & Sons, Inc.

Gerring, J., 2017. Qualitative methods. *Annual Review of Political Sciences* , Volume 20, pp. 15-36.

Ghosh, A., Chartterjee, A. Ironmanking and steelmaking theory and practice. New Dehli, PHI Learning Private Limited.

Gruenhagen, J. H. & Parker, R., 2020. Factors driving or impeding the diffusion and adoption of innovation in mining: A systematic review of the literature. *Resources Policy,* 65(101540).

Gupta, A. & Yan, D., 2016. *Mineral Processing Desing and Operations: An introduction.* 2 ed. Amsterdam: Elsevier.

Haber, L. & Carmeli, A., 2023. Leading the challenges of implementing new technologies in organizations. *Technology in Society,* 74(102300).

Hammarberg, K., Kirkman, M. & de Lacey, S., 2016. Qualitative research methods: when to use them and how to judge them. *Human reproduction,* 31(3), pp. 498-501.

Harrington, J., 2016. Affinity diagrams. In: J. Harrington & F. Voehl, eds. *The innovation tools handbook.* Boca Raton: CRC press.

Hieronymi, A., 2013. Understanding Systems Science: A Visual and Integrative Approach. *Systems Research and Behavioral Science,* 30(5), pp. 580-595.

Iheukwumere, O., Moore, D. & Omotayo, T., 2021. Analysis of multi-factors affecting the performance of Nigeria's refineries: a systems thinking approach. *International journal of productivity and performance management.*

Isheyskiy, V. & Sanchidrian, . J. A., 2020. Prospects of Applying MWD Technology for Quality Management of Drilling and Blasting Operations at Mining Enterprises. *Minerals,* 10(10), p. 925.

Jackson, M. C., 2003. *Systems Thinking: Creative Holism for Managers.* Hull: John Wiley & sons.
Jahanmir, S. & Cavadas, J., 2018. Factors affecting late adoption of digital innovations. *Journal of businnes research,* Volume 88, pp. 337-343.

Jimeno, C. L., Jimeno, E. L. & Carcedo, F. J., 2017. *Drilling and blasting of rocks.* s.l.:Routledge.

Kalonji, R., 2020. CAPETOWN model and SEMP approaches for COSATU and Ellies renewable energy. 10.13140/RG.2.2.28176.35842

Kumar, G., Engle, C. & Tucker, C., 2018. Factors Driving Aquaculture Technology Adoption. *Journal of the World Aquaculture Society ,* 49(3), pp. 447-476.
technologies in organizations. *Technology in Society,* 74(102300).

Lai, C.-H. & Lin, S., 2017. *Systems Theory.* [Online]
Available at: https://www.researchgate.net/publication/316283969_Systems_theory
[Accessed 04 11 2024].

Leveson, N. G., 2012. *Engineering a Safer World: Systems Thinking Applied to Safety.* Cambridge: The MIT Press.

Loow, J., 2022. Understanding technology in mining and its effect on work environment. *Mineral Economics,* Volume 35, pp. 143-154.

Lucero, A., 2015. Using affinity diagrams to evaluate interactive prototypes. In *Human-Computer Interaction–INTERACT 2015: 15th IFIP TC 13 International Conference, Bamberg, Germany, September 14-18, 2015, Proceedings, Part II 15* (pp. 231-248). Springer International Publishing.

Marciniak, A., 2024. Global Theories of Archaeology. *Encyclopedia of Archaeology (Second Edition),* Volume 1, pp. 10-19.

Martin, J. N., 2004. *The Seven Samurai of Systems Engineering: Dealing with the Complexity of 7 Interrelated Systems.* Chantilly, INCOSE.

Matetic, R., 2005. *Mining Publication: Hearing Loss in the Mining Industry: Overview of the NIOSH Hearing Loss Prevention Program at the Pittsburgh Research Laboratory.* [Online]
Available at: https://www.cdc.gov/niosh/mining/works/coversheet1377.html
[Accessed 09 January 2023].

Morgan, H., 2022. Understanding Thematic Analysis and the Debates Involving Its olving Its use. *The qualitative report,* 27(10), pp. 2079-2091.

Naderifah, M., Goli, H. & Ghaljaie, F., 2017. Snowball Sampling: A Purposeful Method of Sampling in Qualitative Research. *Strides in Development of Medical Education,* 20(1).

Nathan, S., Newman, C. & Lancaster, K., 2019. Qualitative Interviewing. In: W. S. U. P. N. A. School of Science and Health, ed. *Handbook of Research Methods in Health Social Sciences.* Singapore: Springer, pp. 391-410.

Nguyen, N. C. & Bosch, O. J., 2012. A Systems Thinking Approach to identify Leverage Points

for Sustainability: A Case Study in the Cat Ba Biosphere Reserve, Vietnam. *systems research and behavioural science*, 30(2), pp. 104-115.

Nilsen, P., 2015. Making sense of implementation theories, models and frameworks. *Implementation Science,* 10(53).

Noone, G., 2020. *What does the future hold for automation in the mining industry?.* [Online] Available at: https://www.nsenergybusiness.com/features/automation-mining-industry-future/ [Accessed 4 May 2023].

Nyemba, W. R., Carter, K. F., Mbohwa, C. & Chinguwa, S., 2019. A systems thinking approach to collaborations for capacity building and sustainability in engineering education. *Procedia Manufacturing,* Volume 33, pp. 732-739.

Poduthase, H., 2015. Rigor in Qualitative research: Promoting quality in Social Science Research. *Research Journal of Recent Sciences,* Volume 4, pp. 25-28.

Ranjith, P.G., Zhao, J., Ju, Minghe., De Silva, R.V.S., Rathnaweera, T.D., Bandara, A.K.M.S., 2017. Opportunities and Challenges in Deep Mining: A Brief Review. *Engineering,* 3(4), pp. 546-551.

RioTinto, 2023. *Pioneering Automation and Robotics in Mining.* [Online] Available at: https://www.riotinto.com/about/innovation/automation [Accessed 12 February 2023].

Rogers, W. P., Kahraman, M.M., Drews, F.A., Powell, P., Haight, J.M., Wang, Y., Baxla, K.; Sobalkar, M., 2019. Automation in the mining industry: Review of Technology, Systems, Human Factors, and Political Risk. *Mining. Metallurgy & Exploration,* Volume 36, pp. 607-631.

Shen, L., Muduli, K. & Barve, A., 2015. Developing a sustainable development framework in the context of mining industries: AHP approach. *Resource Policy,* 46(1), pp. 15-26.

Siriram, R., 2017. A Hybrid (Soft and Hard) Systems Approach to Project Management. *SSRG International Journal of Industrial Engineering (SSRG-IJIE),* 4(3), pp. 1-16.

Smit, A. C., Mji, A., 2012. Assessment of Numeracy Levels of Mine Workers in South African Chrome Mines. Numeracy, 5 (3) article 4

Soderholm, K. et al., 2015. Environmental regulation and competitiveness in the mining industry: Permitting processes with special focus on Finland, Sweden and Russia. *Resource Policy,* Volume 43, pp. 130-142.

Sony, M. & Naik, S., 2020. socio-technical systems theory: A systematic review and proposed theoretical model. *Technology in Society,* Volume 61.

Sun, S. & Anwar, S., 2015. R&D status and the performance of domestic firms in China's coal mining industry. *Energy Policy,* Volume 79, pp. 99-103

Taherdoost, H., 2018. A review of technology acceptance and adoption models. *Procedia Manufacturing,* Volume 22, pp. 960-967.

Temen, V. A. & Afum, B. O., 2015. Reducing Drill and Blast Cost through Blast Optimisation – A Case Study. *Ghana Mining Journal,* 15(2), pp. 50-57.

Walker, D., Steinfort, P. & Maqsood, T., 2014. Stakeholder voices through rich pictures. *International Journal of Managing Projects,* 7(3), pp. 342-361.
Wilson, A., 2015. A guide to phenomenological research.. *Nursing standard (2014+),* 29(34), p. 38.

Wilkins, L., Holt, D. & Swatman, P., 2007. *'Through A Glass Darkly': Can Theoretical Models for Technology Adoption Add Value to Enterprise Wide System Implementations?* Melbourne, ResearchGate.

18. APPENDIX A: ETHICS CLEARANCE

Bruno Emwanu <Bruno.Emwanu@wits.ac.za>
to me

Tue, 3 Oct 2023, 04:54

Dear Tabotabo,

I am pleased to inform you that the School Ethics Committee completed assessing your ethics application for your MSc (50/50) research project titled: "Systems approach towards improving adoption of autonomous drilling at an open pit mine in South Africa.". The ethics number you have been given is MIAEC 107/23W.

Please use your ethics number as a reference for all future correspondence on this matter.

Regards,
Dr. Emwanu

19. APPENDIX B: PARTICIPANT INFORMATION SHEET

18/08/2023

Dear Sir/Mam,

Re: Participation in Research on systems approach towards improving adoption of autonomous drilling at one of the open pit mines in South Africa

I am a part-time MSc student in the School of Mechanical, Industrial and Aeronautical Engineering at the University of the Witwatersrand, under the supervision of Dr Andries Botha. My MSc title is: Systems approach towards improving automous drilling system adoption.

Adoption of autonomous drilling at one of the open pit mines in South Africa has been progressing slower than planned. The operational teams resort to manual operation of the drills even after the introduction of the autonomous drilling system. This study aims to unpack the causality systems of the slow uptake in the introduced system, and learn from introduction of technologies at other mines as it is my belief that this not the issue only isolated to the mine of interest.

I would like to formally invite you to participate in this study. As an expert who is continously involved in introduction of new operational technologies to mines, your knowledge and experience would contribute significantly.

The study will be conducted between September and December 2023. Involvement in the study would entail a Microsoft Teams interviews with you, as an expert in this field, at your convenience. During these interviews I would like to understand the processes involved in introducing new technologies and how mining houses can set up their operational teams to sustainably adopt introduced technologies, and understand more about the issues faced during interaction with the mine operational teams and how you would tackle these issues for sustainable operation of the introduced technologies. The interviews would be conducted on Microsoft Teams at your convenience and will be about 30 minutes.

Participation in the study is voluntary, and you may withdraw at any time. Anonymity (regarding company name and any owner/manager/employee names) and confidentiality of information provided will be assured and respected. I would like to record and transcribe the interviews for future analysis. Your consent at the time of the interview will be requested. If you do not wish the interviews to be recorded, this will be respected.

The results of the study will form part of my MSc dissertation report, and may also be reported in academic papers and at conferences. A summary of the results of the research will be made available to you on request.

Please contact me if you have any questions regarding the research and participation in the study.

I look forward to hearing from you.

Yours faithfully
Tabotabo Temosho Talane

Tel: +61 498 678 708

Supervisor: Andries Botha

20. APPENDIX C: CONSENT FORM

Dear Participant,

Thank you for accepting to participate in this study. Please complete this consent form as you see appropriate. By signing this consent form, you are indicating that you have read and understood the description of this study and that you agree to the terms as described below:

	Mark with X	
	YES	NO
I confirm that I have read and understood the information about this study as provided in the participant's information sheet.		
I understand that my participation is voluntary and that I am free to withdraw at any time without any penalties or negative consequences against me.		
I grant permission for the interview to be audio recorded.		
I agree that the information I provide may be treated as strictly confidential and anonymous and only the research team will have access to the interview data.		
I understand that the information acquired from the interview will not be recorded in excess of what is required for this study.		
I agree that the results of this study may be recorded in academic journals and at conferences.		
I have had the opportunity to ask any questions related to this study and I have had all my questions answered to my satisfaction.		
I may request a report summary, which will come as a result of this study.		

With full knowledge of all above-mentioned terms, I agree to participate in this study.

Participant		Consent taken by (Researcher)	
Name		Name	
Signature		Signature	
Date		Date	

21. APPENDIX D: INTERVIEW QUESTIONS

Interview script

Greetings	
Introductory statement.	Mine X had autonomous drilling introduced 8 years ago. The overall utilisation of the system is very low in comparison to the intended use, with operational teams resorting to manual operation of the drill fleet. The problem with struggling to adopt new technologies is not isolated to Mine x. This study aims to unpack the causality of mines struggling in adopting similar operational technologies and, to consequently find plausible ways to aid Mine x in improving the utilisation and efficacy of the system successfully.
Ethics.	I aim to record this interview for further analysis later in the study and I would like to inform you that this is a confidential conversation, and your identity will be kept anonymous. Please confirm that you consent to having this interview for the purpose discussed and that it can be recorded for later analysis.

	Interview questions
1.	Please state your highest level of education and your field.
2.	May you please state your current role?
3.	How many years of experience do you have in mining?
4.	How many sites have you help introduce new operational mining technologies. a. Less than two? b. Two or more?
5.	What would you say are reasons for introducing new operational technologies in mining?
6.	Can you discuss your overall experience on introduction of new operational technologies in mining?
7.	What is your take on the relationship between overall setup of mines and their abilities to sustainably adopt new operational technologies?
8.	Can you describe differences between mines that were successful in adopting new operational technologies to mines who struggle to do so?
9.	Can you discuss considerations to take before introducing new technologies to mines?
10.	Please describe the most challenging times with regards to introducing new systems.
11.	Can you describe a situation where you felt positive and highly motivated to work with mining operational teams in introducing new technologies?
13.	What would your measures of effectiveness be in processes such as introducing new operational technologies.
14.	Please discuss your overall learning from the process of introducing new technologies in operational mining.

22. APPENDIX E: INTERVIEWS TRANSCRIPTS.

Masters interview 1

Interviewer

So, the first question is just going to be really the qualification questions. Just the first background, so it's just education and sort of experience. Yeah, just so this is just to say because for my criteria, I've looked at people that have at least five years' experience in mining that have been dealing with this. So yeah, so it's just that to confirm that like we meet that criteria and then if we don't meet it then we see how to analyze the data. So just a brief background of your education and your experience.

Participant 1

Okay, no problem. So, I'm a qualified fitter and mechanic by trade. I've been working in the drilling industry since 2013. I've done various roles in drilling, basically from hands - on technical to site supervisors to site managers. In automation, I was working as an automation specialist from 2018 involved with the Mogalakwena automation project.

Basically, the start of that project from Greenfield till when we got it to a fully tele-remote setup and then the contract was awarded to a competitor. From there I got involved with Sishen and basically, we've ramped up Sishen from where it was a year ago to where we're at the moment. So overall qualifications wise, I have a trade. Drilling experience, 10 years, automation experience since 2018.

So that's five years of learning automation experience now.

Interviewer

Oh, that's cool. You have answered everything in a nutshell. So more or less how many If that is an answerable question, how many sites have you worked with?

Participant 1

I've worked with Grootegeluk. I've also worked with Kumani Bruce and Kumani King, as well as Sishen and Mogalakwena in the autonomous space. In the drilling space, I've worked with the Glencos, Exarros, BHP, the list...

Interviewer

Yeah, yeah, I understand your list will go on and on. So it's cool, I think, yeah, I've got that.

So, I wasn't aware that Mine z is also in this space. Are they also trying to automate the drill?

Participant 1
Correct, they currently have four autonomous 270s.

Interviewer
That's good. So, from your perspective, maybe like, I know we have this buzz about introducing this auto drilling and other technologies and mining. So just like focusing on auto drilling, because like we obviously pumping a lot of money as organizations into it. So, any potential benefits, why would we, in your opinion, why would we want to do this?
Why would sites want to introduce this?

Participant 1
Absolutely, there's a benefit to it. So, remember, in any process, your objective is to eliminate variability. So, if you have an auto drilling product, it's going to perform consistently over a large space of time. And as soon as you have consistency, you have predictability. So, you have an estimate ground hardness on a pattern. You've got a pretty good penetration rate that's at an average and you can give good numbers to say, I can finish that pattern in two days.
And there's a pretty good chance you're going to finish that pattern in two days. And at the same time, you're removing operator variability. I mean, each operator is at a different level of training, a different level of life.
Each day, an operator is in a different mood. You know, there's never that consistency. So, you're removing that factor. Once you've eliminated the inconsistencies, obviously the lifespan on your GETs and all your tooling is going to increase substantially. And also, what we're finding on a lot of sites, the equipment is actually lasting longer. So, your maintenance on your equipment and your lifespan of your machines can be pushed out. underground We've done some studies.
We've done some feasibility studies up to 25% that we've increased the equipment life just by going autonomous.

Interviewer
Thank you. So, like this one is going to be as broad as I can be. It's just going to be with the sites that you work with in introducing new technologies, like maybe you've been involved in other technologies, including auto drilling. It's also a technology that can be considered here. So, what would you say your overall experience is dealing with the mining operational teams?

Participant 1

So, overall, we've had a lot of challenges dealing with it and integrated it into the mining operation. And I think a lot of the time the biggest reason for that is we normally get stuck with a project manager who's either contracted to the mines, so they're not really integrated into the mines way of doing things or integrated into the accountability structure on the mine. It's not always being driven by a project owner on the mine. So as in from mine manager level owning the project, being able to filter the technology down into all the teams that it needs to, especially in the drilling section, because we touch on so many different departments from mining technical to actual drill and blast so just it really starts to roll out quickly. And you need somebody that's in charge or at least has influence in all those departments. And we very often find it's a challenge getting that person identified because you'll only get a few minutes of their time a week.

And they're not really, it's not their key KPIs, it's not their focus area. So, it has been a challenge getting technologies rolled out on sites.

Interviewer

Yeah. Yeah. So, I think the next question is going to be a follow up to the one that you what you're discussing.

So, like, what is your overall take on the relationship between the setup of mines, like the way the mine is set up? Obviously, the org culture and stuff like that, and their abilities to sustainably adopt new technologies, like, what are those variables that enable mines make or break that process of introducing new technologies?

Like that relationship of the setup of a mine and his ability to adopt? What are those key factors that aside or all come as I have to sort of discuss not only the circumstances, we can also look on the other side to say, what are the barriers that we've seen your experience with the side where you've tried cold and the federal where you found it easy, what are the main differences in those sort of sites?

Participant 1

Okay, that's quite a lot to unpack in one question. Yeah, okay. I understand that. Okay, let me start at the beginning. So, the sites where it's easiest to integrate, if the site already has established processes, very well documented procedures, rhythms and flows of the site, if that's very well established, it's a lot easier to start looking at that documentation and saying, okay, where can we adapt their current procedures to meet the needs of the new technology or the new demands?

And then it's again easier to get that re -communicated.

But we find a lot of sites on to that level of operational maturity where the documentation is in place properly already for the current process that they have, because it tends to seem like a lot of customers, they've built so many processes and developed quite rapidly but never standardized.

Yeah. And then we're trying to take auto drilling and automation as a whole, and it's very all - encompassing. So, we've got to now go and shake up all those processes, upstream processes from the planning to the survey and integrate into all of that. And we're finding these gaps in the standard process that they do. never mind just optimizing for automation. So definitely customers with more well - established process and procedures, much easier to integrate. Also, some customers, we've had challenges with communication where there's no communication interdepartmentally.

So, you have a lot of barriers in that the maintenance team is pulling one way, the mining team is pulling one way, and the BI and finance is pulling in a completely different direction.

So, where you've got mine sites with all the departments aligned and have the same KPI for the project, much easier.

Interviewer

Yeah, that makes sense. So just reading up, obviously there's a lot about this before I could set up this interview. So, what's your take on maybe culture and leadership role? What do you think about the influences there? I'm just saying the way that the leaders, we have seen both lines that catch you guys on site to introduce the technology, the role of the site leaders, like site managers, of the customers, what's the role in showing that adoption of these whatever systems that they're trying to introduce that is successful. Like leadership, what's the role of leadership in showing that this becomes a success?

Participant 1

So, it's absolutely critical. If your key stakeholder from site is not actively involved, your project is going to grind to a halt. And the reason for that again, it comes to driving that interdepartmental communication because from a project team or a project perspective, you're not empowered to give anybody instructions. You can make requests all you want, but if the person or the section manager above you or the section manager of the section that you need help from doesn't see the value or doesn't have any KPI that's linked to your project, it's just additional work for them. So, if you don't have someone in a very senior capacity now saying, hey, you actually need to do that, this is my KPI, you need to pull your weight. We don't get any traction, and we see it time and time again. We stall in certain departments because the person that we need assistance from is either too busy or doesn't give it the time of day and there's no authority to force compliance.

Interviewer

Well, yeah, that makes sense.

So, the other one, I think we touched on this, like when we discussed this in the previous question, you just mentioned the processes, the procedures and processes must be in place. That's critical, but can you just think of other considerations that before you actually look for a supplier to introduce this new technology, before you do that, what is it that as a site you need to establish, consideration that you need to establish before you can even think of starting this project?

Participant 1

So definitely operational readiness. So, within any technology space, you have to go and do a whole operational readiness assessment of your site. Obviously reaching out to the OEMs for their requirements for the technology, making sure that your site can handle the technology.

I know from an Anglo perspective, operational readiness wise, from an IT point of view, we were very far behind and once the project came in, we actually realized, oh shit, this is how far we are behind. And we played catch up for a good eight months before we got to a space in the IT, OT space sector, where we could say, hey, we can now run this sustainably and in a healthy way. And it caused a lot of friction within the project because now the project is not performing how it should be because there's another site and then it sounds like it always turns into a blame game. But it's actually just the operational readiness wasn't done properly. And you put the cart before you put the cart before the horse, so to say.

Yep. So definitely operational readiness on it and a lot more testing of the sites infrastructures and criteria before you implement the project.

Interviewer

Yep, yep. That makes sense. So this is going to be based on your experience.

So, one question a just described a site where in your experience was the most challenging just describe. The experience that you had the site that was the most you can call the most challenging. you don't need to name the site. You say you experienced describing your experience like how was it like?

Participant 1

Okay, so I'm just going to mention it's the largest platinum mine in Southern Africa. Okay. But it was definitely extremely challenging.

From each department had their own roadblocks stopping the project from the HRD and training side. They had not even implemented what training material needed to be in place for autonomous. They had not even got criteria for autonomous operators in place.

So HRD didn't even have people and resources available to start using the technology once it was in place. So HRD was from the start to huge roadblock. The second one came in from the drilling and blasting team. They didn't even have criteria that needed to be met for operator, what do you call it? Basically, fitness to work where you do your Vienna testing and dover testing and things like that. They didn't even have criteria for operators. So, there were certain operators that don't meet those standards. There was just so many challenges within each department that trying to integrate the project was absolute nightmare. And then at the same time the KPI was never assigned to the mine manager. It was assigned to a consultancy company. So, the consultancy company had no direct effect on the site. So, it became very challenging to run and integrate the project.

Interviewer

Yeah, I know. I think that makes sense.

I think even when the... Just from my experience, even when the... That was just what you... speaking about the KPIs, even when the incentives were not aligned to, I think the most challenges were that the incentives were not aligned to what they were trying to achieve.

So, we're still chasing meters, but we want to also put auto. So, and then obviously the operators, they're looking at meters, just their bonus, whatever that seems to describe, distracted, they're not going to very much accept it. So yeah, definitely, yeah, I think about the KPIs, it makes sense in that way. So yeah, Thank you. So, like if you are sort of looking at the process like this, like during the process of introducing the, the project of auto and stuff like that.

What would your measures of effectiveness be? Like, obviously you do not want to just start the project and then leave it and say, like you just said, when we started this, things are going well at decision. Like, what are those measures of effectiveness for you to try to get the manager to say, things are going well, things are not going well?

Okay, well, definitely for the autonomous project, we're looking at utilization of the fully autonomous functionalities.

Participant 1

So, we have the utilization of the technology as a KPI. Then at the same time, obviously for auto drilling, one of the KPIs is to improve whole quality. So, if we can reduce redrills, so we will look at percentages of redrills, if we're bringing that down, we know the project is becoming a success. Then we also start to look at things like time to completion of the block. When we started drilling to completing the block, where are we in relation to our schedule compliance? Yep. And if we can come in on schedule or before schedule, we're doing well.

Interviewer

Yep. It makes sense. So obviously you've had this experience, like you've had this rich experience in this field. So, your learnings from it all did say, just your key learnings, most important learnings from introducing this.

Like for you, if now you're to start your own mind fight, and then you want to like go to a supplier maybe to come in, then introduce auto at your site, what would the learnings be for you going forward with the knowledge that you've got?

quiet so far?

Participant 1

Sure. That question requires some thought. There's so many. But I definitely think when it comes to learning, effectively drawing up policies and procedures that support your technology implementation, definitely a key learning.

From the drilling side, there's interdepartmental relations that you have to touch on and understand their KPIs to be able to start to drive your KPIs forward. You need a holistic understanding of the mining and drilling environment.

Data analytics. Understanding the data that you're looking for and understanding the data that's available. and seeing how you can take what's available and display it in a format that you need and require, and also making that data available to the frontline managers in a format that's easy for them to basically, let me give an example, the foreman in the morning walks in and he can see, okay, last night we utilized the technology by this much, we did this many meters, da, da, da, da. So he's got a easy to read, easy to understand report in his hand, and he can then say, okay, operators, you did very well this morning, or you didn't perform as expected, or hey guys, this department dropped us, we need to focus there. But everything summarized nicely in the report, good data, and it can support the frontline guy, and that frontline guy then translates it into performance.

Interviewer

Oh, okay, cool. Yeah, make sense, the three is three forward.

So, yep, I think we covered most of the things that I wanted us to discuss, all of them actually. So yeah, I think I'm timing this very well. So yep, I'll see you in the next two minutes, and then just gonna thank you, I think you answered all questions that I had. Just gonna thank you for the time that you took out of your busy schedule, obviously you're busy. So, you have a sit down and talk with me, I really appreciate this. So, thank you very much.

Participant 1

Yep. No problem, no problem, only a pleasure to help.

There are quite a few students at the moment doing masters in automation, well with an automation angle, even internally within our own company. So, it's interesting and I'm very curious to see the results coming forward.

Interviewer

Yeah. I'll probably share the final report with you. I'll probably do that. So, did you just do some... I'll probably do that, share the report with you, just some sanity check with them, my final result, and then just done picking. Now you can, yeah, can have a way in from your side.

Participant 1

Perfect. I always want to give an extra set of eyes and see if it makes some sense. Yep, yep, I'll do that. But cool, if there's any other questions or anything that you need, feel free, drop me an email anytime. Might be a slight delay in reply with our time difference. Reach out anytime.

Interviewer

Okay, thank you very much.

Masters interview 2

Interviewer

Although your identity is going to be sort of hidden, but the results of this are going to be used in the final report of my masters. Yeah, just so that you know that. The technical masters. So, it's a master’s in systems engineering. So yeah. That's that. Cool. Yeah. Okay. So, my next question would be just sort of like this is about autonomous drilling and stuff. So just before we delve into anything, just I'm just trying to qualify whatever that is that I'm working on. So in that, in qualifying that is just to sort of get people like you as experts to just sort of just explain what would you say the motivation is, why should we even talk about introducing autonomy in like drilling like the guys that as I said, probably for them is always easier to just like go back to their old ways and then to sort of operate the drill manually. So, what is it that like would qualify and motivate the guys to sort of say, this is the reason why we are trying to transition mode of operation. So why are we introducing autonomous drilling?

Participant 2

So, so the common answer is basically three words, safety, productivity, efficiency. But I in my

experience, I think it extends beyond that, right? If you want, if you want to implement automation. In my view, your operations have to reach a certain maturity. So, in other words, there is a process that needs to be followed from a manual drilling process. And you need to reach a kind of threshold where you cannot achieve more from the equipment without automation. And automation is a very broad term. Automation can mean onboard one touch or single function automation, or it can go up to what they say is full autonomous drilling. So, in my view, automation is definitely an enabler for safety, removing operators from the hazardous areas, but also an opportunity to limit the amount of people working on a drilling pattern. So, there's the safety part of it. I think that's quite obvious and that goes without saying. But from a productivity and efficiency perspective, it really is about taking your operations to the next level. So once you reach a point where you cannot extract higher levels of productivity from your operation without technology, that's when you look at automation. And once again, broad spectrum in terms of what type of automation can be used. Automation without reaching that point for me is dangerous. It's risky in the sense that you're not, you're spending a lot of money, but you're not going to necessarily get your return on investment. Because you're not at that operational maturity level. So essentially, it's about trying to extract as much out of the drilling equipment as practically possible. So, more time, more use of the machines and more effective use of the machines.

Interviewer

I think that just lead on to the next question. It's just closely related to that. I think you touched on it a bit. And that just speaks to what you said, like the relationship between the setup of an operation and its readiness to sort of say, they want to implement something like autonomous drilling. I think you've worked with technology a lot before. So, in a broader space, like before you can say you're introducing some of the things that you're doing. something new, like you've spoken about the readiness of your operation and then also the value that whatever that you're trying to bring in compared to what you're doing now. So, narrowing it down to autonomous drilling, like just more details
about what do you think about the setup of mines and their readiness, their relationship with their readiness to adopting autonomous drilling. Like what must be set up before you can say you want something like autonomous, let's say you need it, but like the setup of your mine.

Participant 2

Yep. Yeah. So, there's governance requirements and technical requirements. So technical requirements, quite obvious, you know, you need to have sufficient network infrastructure on site, you need to have an effective GPS setup. You ideally want your bench to be set up in such a way that you can have bench cameras, you can have access control, all of the typical technical stuff that goes with it.

But from a governance perspective, you need if you're a mining company that wants to implement autonomous drilling, you need very sound governance in terms of existing processes in terms of how drilling is executed. From planning a block to creating drill plans, to creating geofences, to execution, bench preparation, that governance has to be in place. It's not necessarily a prerequisite. You can lead up to that stage, but you also need very strong governance around how you change your processes. Having sound stable processes is one thing, but you need to have a culture and an approach that allows for processes to be changed in such a way that people actually use and adopt the changed processes. Because you can't approach autonomous drilling in the way that you would manual drilling. In other words, your entire drilling process will change. It's very easy to put that change on a piece of paper, but implementing that change becomes quite a challenge for most. In my experience, it's not one of those things where you need to go from, today you're running this process, tomorrow you're running the updates and autonomous process. But it's about having a roadmap that allows people to have the breathing space, the time, the support to actually go from existing process to future automated process. So, I spoke about the governance side of things and the technical side of things, but I think the most important thing by far is having people's buy into the concept of what you're trying to achieve. And you will have people that are keen and eager to adopt technology. You have people that are not keen, the detractors. But it's about taking everybody along with you. So, in any project of that scale, you're going to have people that have a negative frame of mind. And you have to accept that, but you also have to have a strategy of how you're going to change that.

You can't go to Paul, who's an operator, who's been operating for many years on the machine, who doesn't want to move to a control room because he doesn't trust the technology, and tell him, listen, this is the greatest thing since sliced bread, and he's going to believe you. People are often intimidated and have difficulty trusting technology. So, it's about being able to, like I said, take people along with you and creating an environment where detractors become enablers. And that doesn't happen overnight.

Interviewer

Yep. Thank you very much for that. You spoke about governance with that. What you think is the role of the site management? I'm just guessing the role you've spoken about, getting the buy -in. Because here we're talking about maybe probably the front -line supervisors and operators. But the role of the buy -in from the site management, and then their role in supporting those below them in getting the buy -in.

Participant 2

Got you. So, there's two ways that automation, regardless of whether it's on drills or trucks or whatever, is implemented.

So, it's either bottom up, so you have people on the ground that have realized that this sort of technology can help or you get top down where you have highly reliable technology and management, CEOs, chief technical officers, chief operating officers that come to the realization that some form of automation is needed. In both scenarios, whether it's top down or bottom up, what is absolutely critical for site management to realize and accept is that you are essentially trying to run a project in an operational environment. Okay, so you have people who have daily jobs, responsibilities, tasks who are now expected to add more work onto their plates and give it all the effort that's required to make it work. I think that, in my view, and I haven't seen this done before, there needs to be a change of, the way sites are managed to allow the technology to grow and foster. So, you know, reducing the amount of operational responsibilities to allow a project to actually take place, shifting the focus away from, you know, traditional KPIs to KPIs that are linked to the actual project. There needs to be, you know, continuous support from a management perspective. You know, even when things go wrong, there needs to be that sense of encouragement and sense of drive. It's very soft things, and I think it varies very much from company to company, because every single company has a different culture and every single department, you'll find within mining companies in my experience I've found has a different culture. But I think what's really the core is giving people the breathing space and the focus to actually allow the project in an operational environment to grow and develop.

Interviewer

Okay, cool. You've answered that. So, so, like, I think we discussed most of the things I wanted to discuss. I just like to get insights from your experience, like, can you just describe your overall experience with sites? Obviously, you're working with multiple sites with sites. Just in general, where you've introduced technologies and then you felt like it was getting traction and just describe that sort of a setup where it gained traction, and it was a positive feedback from the site.

Participant 2

So, yeah, I mean, I'm not going to name the specific site and projects of the customers we work with. But one of the things that we within our company put a lot of time and effort into, and this is regardless of the level of technology or where the project or what equipment, or what technology we put on the ground. The approach we take is that we are not selling a product. We are selling a solution. So, it's not though we put the product We've got projects where the first piece of equipment was probably put on the ground three years ago, four years ago, we'll actively engage with those customers to provide the guidance and the support that's necessary to ensure that any obstacle that prevents the system from performing is dealt with in the correct way. We are the subject matter experts. We need to transfer that knowledge and skills.

And that also doesn't happen overnight. That happens through continuous dialogue, continuous support. And I think that's been a key recipe for our success. For projects where we haven't been as successful as we've liked, you know, some of the things I've observed in Southern Africa is that typically, you know, your engineering departments buy into the concept and want to support the initiatives. And regardless of the technology, but we find typically that there's either kickback or lack of drive from the operational team. And the operational team is probably the most important team because that's essentially the group of individuals that need to make the system or the technology work. And once again, not specifically talking from an autonomous drilling perspective. It's regardless of the type of technology. The other thing that we found that has been quite useful is that once again, regardless of the type of technology we deploy, we have a specific framework, a project execution framework that we use. We call it the automation blueprint. It's called the automation blueprint, but we've used it for digitalization projects as well. So having that structure, having a clear idea of what needs to be achieved by when, who's responsible, and having that, continuous engagement with customers we found has worked quite well. We're not always successful 100%. We're not always successful. We can't force customers or companies to go with what we advise. Ultimately it's them at the end of the day they've invested in the in the in the technology and it's up to them to make it work but you know what I've described definitely increases the likelihood of success and what we what we deem by success is not automated drilling for one day or use of situational awareness software for one day we want to see the technology use successfully on a sustainable basis on a day -to -day basis and that's what we define as success and that's why we continuously try and be involved in projects wherever we can.

Interviewer

That is great. I think speaking on sustainability and on operation of the autonomous drills just leads to just another question that I have. So, if you've been working this project, so in the process of the project, what are the indicators to you that this process is going to like not the final I think it's a journey, not a destination like you said. Like you said, sustainable sort of operation every day is not like something that you're going to say that we're done. So, one of your measures of effectiveness be when you sort of gauge with the teamwork that you've done with the site, what will be your measures of effectiveness to indicate if the things are really working or things are not working?

Participant 2

So, there's the tangible stuff. So, if you create a plan, compliance to plan is obviously and indicates a success. If I could sum it up however in one word, it would be ownership. I see clients and customers who are successful at this stage are those who take ownership of the project take ownership of the process.

So, in other words, instead of us pushing success on to customers, customers are pulling knowledge from us so that they can be successful. I don't know if that makes sense.

Interviewer

It makes complete sense. I think it's just linked to what we discussed earlier, the role of the operations team in ensuring that the projects are safe. I think we cannot overlook the importance. Yeah, that's why I sort of asked earlier about the role of site management in pushing for this.

Participant 2

So yeah. We know for a fact that from its technical point of view, the technology works. I mean, the sites, you might know where they're getting 85% upwards usage of autonomous drilling, as an example. We have sites in South America, in Peru, that are
achieving 85% plus autonomous drilling. So, the technology is capable of working. It's really up to the site to take ownership and make it work. And look, I mean, I'm aware of the struggles at some mines and I'm not going to say that the systems that have been deployed there doesn't work. But I think that from what I've seen, you know, the challenges that I've spoken about, the sense of ownership, operational involvement, I get the sense that those are some of the larger challenges on site there than anything else.

Interviewer

Okay, I'll get that. Okay, I think looking at the list of questions that I had, I think we covered everything here. So yeah, we're right on time, 30 minutes. So yeah, okay, cool. Thank you very much, for taking time out of your busy schedule.

Participant 2

Absolutely. Absolutely. Absolutely pleasure. Drop me a mail if you need any more information. And good luck with the rest of your masters.

Masters Interview 3

Interviewer

I know how but like yeah, but it's fine. It's not a problem. It's not an issue Yeah, yeah, I think it's it's just great out in looking but it's fine. I can't record it my phone while we talk sort of problem uh Yup, so Oh good Oom Peet.

So just to give you a bit of a background on beer Yeah, like I said, this is just for my master's work so choose to just study autonomous drilling and then really just about how I Some minds struggle to adopt it and some mind successful in adopting it so Just want to really understand the factors at play.
So, it's not really that much technical. It's just more about people and adopting Autonomous drilling so Yep, so I'm just gonna start with a more Next question and just to speak about you and your experience and your current role if you don't mind on beer Just to give you a background about your experience in mining.

Participant 3
So, I started my mining career 1996 When I joined the BS, I was in a scheduled apartment day for 10 years. Mm -hmm. And then I at the BS the BS it's a open cast and underground mine in the northern country. Okay. So, I was security officer there and I had to do a lot with the boys working in the plant and that tickled my interest on the mining process itself. Then I obviously resigned from the beers. I joined a contractor. I started off as a risk manager by then. They were doing support underground and everything and ventilation and two-meter water tunnels and roadways, bags, plants, all that.
So, I worked for that company basically four years. I was busy in Africa, in Mali on a project. And another mine called and then they offered me a foreman position learning all.
And when I was at learning all, I was performing quite well there, about three years, three and a half years. Unfortunately, we had a fatality at our learning section at that mine. And then I was schooled at night to ask, I must take over the duties to stand in as mine I was here, drilling, autonomous drilling, and block prep, and I will clean up.
I took up the challenge, and that's the first time that I experienced autonomous drilling. By that time, the drills were just finished up, commissioned by the engineering department, and we basically put them into production, I think it was six months to a year, when the fatality occurred, and like I said, didn't approach me. And that's when my autonomous drilling started, then I was the one I was here for autonomous drilling, and I had to go with HR, five of those people. We visited different mines, where they had autonomous loop truck, just to understand what this autonomous drilling is about, and the grading of the operators and everything, and push back from the unions, what did they experience, so that we don't run into the same problems. And we basically started up autonomous drilling from scratch, we retried all our operations on one touch, when we were done with that, we moved to fully autonomous drilling training day, and yeah, and then I basically run that section for six to seven years, the autonomous drilling, the normal drilling, the block prep and the contracted drilling that I was here and unfortunately my journey came to an end at x and I was on my way to Zimbabwe where I was offered my ownership position and the informers approached me and informers is currently the, if I can put it like that, the leading are we in

on autonomous, our system is adjustable to any drill, any drill as we are most of the current companies that's in autonomous work, their system is just applicable to their product. If you can't say, if I say OEM A, their system can't be put on OEM B drill or OEM C or OEM B drill. but our flow on the system is compatible to any OEM system. It doesn't matter if it's A, B, C, D, or E. Unfortunately, I can't mention the name is taboo but you know what I'm talking about. No, I have to. So, our system is compatible with all of them. Naturally, I moved to flow on us and I started off as site manager for him in Northern Cape. So, I started off with him in Northern Cape. I was basically a year in the Northern Cape. My site manager got sick and eventually passed away. So, I had to fulfil his duties. And then the challenge become bigger at Mohawkuna. We were expanding one of our client lines in Limpopo, more pressure and then it was raised to the company, approached me and asked, but don't I want to put in a hand in a system just to get things under control and make it a smooth transition, which I accepted the challenge and I became the area manager of South Africa, the design manager of South Africa for travelling. And recently we saw a contract with the truck, the rapid mine. And we are basically building the first row here and within the next two weeks, we're going to put it into production for your customers.

We are already like six weeks, especially on the project. And that has also now become part of me. So, I'm doing South Africa, Guatemala, Malabar, Mohawkuna, and then included Botswana also. At half journey, I must visit all four of these sites once a month, but yeah, my role at this stage is when the customers are unhappy about something, and my site manager can also get it. problem in all the other sites and then also the amount of management and the discussion see what plans we can implement to get us back on track and it's just about keeping the customer happy and delivering on our promises. So that's basically the background with me. Okay, well thank you very much. That was informative, that was informative. Also, I didn't know your manager passed away. So, yep, sorry for that OVN. No problem, he had cancer. It was the first pass passing from the call. She passed away, and I think I actually knew him, gave me all the constants. The guy used to jam in anything, and he just got diagnosed with cancer and was basically eight months' time from diagnosed or passed away. It was very hard on all of us. I mean, except for his passing, we lost also a great deal of knowledge. I mean, he's been running Guatemala from day one. He's been in charge, and we didn't have any issues on that side, and that's due to the end that he had on that side.

Interviewer

Oh, no, I see. I'll see. I'm here to understand about condolences. And then this room. Okay, we're going to move to the next question. So, the next question is just for general reasons to start autonomous drilling. So you've been exposed to many sides. You've been exposed to South Africa in Botswana. So, when you think about it, why do people want to move towards autonomous drilling when you think?

Participant 3

Okay, so your most important reason, number one problem, is you're taking the operator away from that immediate asset. And when I'm saying you're taking the operator, you're taking the operator out of the cab, you're putting in a safe environment that's in the control room, or in the command center at the block. And you don't have that exposure of your operator with exposure to the noise, exposure to the dust, exposure to the vibration of the drill. And then also exposure to if there is cracks or form of ground, anything on that crease. You don't have that operator inside the cab. That's number one. Number two, efficiencies. You get much longer production hours out of this drill by basically by self - changing. where you don't need to take people into the pet and out of the pet, they change on surface level, they anti with each other, they draw, continue drilling, you continue drilling through costing times, if your block is outside the blast diameter, depending on client wise, where there's 300 meters or 500 meters for your equipment, you just move through your field operator, that role will stay in production, you draw through at normal weather, if you've got lightning stones and everything, that role can continue drilling, you just remove your personnel from the field centre, and then also you have better ROP rate of penetration, so you'll get more meters, if you calculate the hole, we did a study, and in the year times it also added up to over 1000 hours of drilling that you're gaining. if you just take into consideration blasting times and self - change lines so there's a lot of gain and then the second thing is after third thing is that drill we set it up within the OEM specs so the OEM will say for us listen this is a maximum pull down this is a maximum torque this is a maximum rotation what this drill is designed for and then we design that parameters and we lock it down you've got to play in between that parameters when I'm saying you've got to play if we say maximum rotation is 65 you can adjust it to 55 or 58 or 50 whatever your ground conditions is like but you will not be able to take it over the limit yes I go to 70 you understand so we control it but we do give the operator a bit of yeah to say you can play with it inside the design parameters doing that you know you're not forcing this piece of equipment to run max the whole time if I can make an example if you've got a mysterious bins and you drive it the maximum kilometres per hour is 240 and you drive it every time 240 kilometres per hour that message is only going to last so long yeah then you're going to reach the end of life and that is what our system is doing then also our system is looking at the OEM signals and their inputs their IOM modules and everything and when we encounter we pick up a program then we give a alarm and a fault and the operator has to acknowledge it to say okay this fault came up or this alarm came up some of our alarms in the phone only acknowledge you only acknowledge them but if it keeps on happening then it will then the machine will go into a trap status then it will trap that part no it will not trap the whole function okay and then we get to some serious alarms if that occurs it will trap the door completely bring it to shut down and say listen something needs to happen here some serious alarms and false that came up now are we in and funders need to investigate see what's the problem fix it and

then you carry on if I can take an example of that yeah like your all -stop communication in the command centre your network needs to be very strong so if your network is weak you will get all stop comes loss all stop comes loss and that's meaning The command centre and the PLC on the drone is not talking to each other, so the information is not getting through, then the drone will shut down, all that is fixed, because that's a major problem.

But on the case, like I said, and I'm going to repeat, you get the operator out of the environment, that there is water in them, you've got your rate of penetration that's increasing, you've got your efficiency that's increasing, you've got a diesel's efficiency saving of up to 30%, that you use these diesel, because that drone is designed to drill within that parameter set. So, you've taken the human factor out of it, because we as humans, we like to think, force the speed of rotation, more pull down, IRAs, we're going to get better meters, that's not the case, that's not the case, trust me, we are just damaging that equipment, because sometimes you need to lessen the pull down, sometimes you have to give a bit more pressure, sometimes you have to give a little bit less rotation, depending on the type of material that you're drilling in, and we set up the exact conditions, so you've got a diesel size also of around about plus minus 50% on your diesel usage, and that's the main factors. Yeah, thank you very much, that's informative. All good? Thank you for answering your question. Yeah, the resins are very clear. The biggest game, the biggest game to do is, if I can ask you like that, how much will you say is your life worth? We can put that in numbers, yet we can put it in, in his sort of money. You can't put the price tag on that. Yeah, you can't. So just from removing the operator from that hazardous environment, it's already a mess of saving. It's already a mess of messes, because you can't put the price tag on anybody's life. Yes, but only it is, it is, I fully agree with you, it is, yeah, it is. So now you, I think, I'm sure you've worked with sites that in your overall experience you've worked with sites that successfully adopted the autonomous drilling and then I'm sure you've worked with others that are struggling to. fully implemented so in your experience will be the major differences between these two sides the side that can adopt and run with it and the sides that keep triggering that keep going back to old ways and then they auto -use its very low what would the differences be between these two sides in your experience okay so first of all you have to have the buy -in of your management and your production team you have to sit down and explain to them the benefits of economists and if you don't have the buy -in and they don't believe in it yeah trust me talk double it's not going to be a success and it's you have to change the mindset of the people their personal behaviour you we as farmers we have to change it to say hi guys come on let's sit down let's talk this is what needs to happen so if you've taken a certain client of us we were the best in the world everybody came and look at how autonomous was done yeah and we lost a few key positions we had something experienced people filling their positions okay but the drive the drive wasn't there from management side okay so guys this need to be implemented it needs to be a success it was a success why can't we still get there um that is

what I picked up why those sides are struggling number one there's no commitment from if i can say from the client itself to say listen let's get the block standards up to standard let's get the equipment up to standard and let's buy the necessary because a lot of the clients is looking on money that they have to spend and In return on in this man. Yep, immediately you only gonna see it after a few months and if you've got all your tracking stuff in place in all your books then you will see okay. Yeah, my return of investment starts to come in now but like I said, that's a buy -in from management. And once the point is approved Then the pressure needs to come from management. They need to step down and say No matter what We bought this product It was proven that it's work. We now Will enforce that we get the standards right that you can Successfully implement and go forward with this.

Yeah, I've got other times and normally When there's an issue, then we'll arrange that and say, but can't we do this and this and this? We are open for discussion. Then we note it down. I put my system engineers and everybody, I just collected them and our product specialist team, and our both team specialists, and our software developer engineers. I basically raise a ticket to them and say, this is a request from the client, have a look at that, and then ASAP, we might work on it and say, okay, it is doable or now it's not doable, or give us another two months to explore and see what we can come off with. So, we just don't shoot any suggestion down. Any suggestions come to the table. We escalate it to our necessary team members, and say, I'm going to get it to us and give us feedback and tell you if it's doable or not. The members are all changing environments. The wholetime it's changing, and Autonomous is the way that it's going. No matter what, we've got a lot of clients that's approaching us now, possible clients in the Northern Cape area especially, on the smaller roads to say, what can you put in place for us? In my test roads, Autonomous, because we as a company, we are falling behind on the technology, and we move the gap, and we need to catch up. But the main reason for failure of Autonomous on our minds, is that there's not enough focus put on that topic, and everybody thinks, okay, once a block is there, you can start up Autonomous. It's not like that. We have to look at the over and the under due motions, the infills. I mean, some of the instances of some of our clients, we have about two to two and a half, meters back full of material on the blocks. I mean, if you take basic training principles, and if you fill in too much, that drill must go through that loose material, meaning it's going to struggle to colour everything, whether it's manual, whether it's one touch, whether it's free or not. You don't want to drill through two meters and two and a half meters of that full material because once you reach in the hole and you retract, that loose material is just going to fall back into your hole. It's going to cause either blockage is down that drill hole, or it's going to fall out from the bottom. Just saying when drilling blocks come in measure and say, okay, but listen, the holes are to show we need to re -drill, then it's costing you a lot of money. So basic principle, get your blocks to standard, get them on elevation, give drilling a proper block, then drilling can give a proper block.

For blasting to charge and blasting will do a proper blast for load and all. So, it's just got a circle effect the whole time. If you've got good drilling, you will have a good blast. You will have good load and long techniques. And when they're done loading up the elevation and flows, coming back again you will have a good roadblock. So that cycle is just continuing the whole time.

And sorry to say but if you don't enforce the discipline there, that is when you start deviating from the standard. And that's when you started picking up problems. And then unfortunately you can't drill autonomous. You have to go back to manual. And then you're bringing back the risk of operated drilling manual. You know that over drill or they drill short, and they just move to the next also. You don't have that GPS system that's telling you, okay you have to go exactly to elevation. And our system measures it and it goes back, re -measure again once it's got the same measurement within the tolerance of 300 about or 300 millimetre under elevation. Yep. We will not re -drill the system as all is fine and we will repack. But then like I said, then you have a perfect block. But if you're starting with 1 .5 to 2 .5 meters of loose material that you have to drill through, I mean you can't expect a decent drill. All that must be charged. I'm good. Now I understand. So, you spoke about training. So, they say that when they lose people when they get new ones, they don't train people for auto. Like you mentioned that. So, when you were talking, you mentioned that they are, if losing people on site, like sometimes you're training these people and then you lose them. So when we replace people, we not get the buy -in from the new ones and train them, or cause that they would have come from mines that are operating manual, if you are recruiting new people, you still need to also sort of get their buy -in and then so that they can continue is, once you think of that, does that happen? Yes, I'm going to be now open and honest with you, Tabu, I'm not going to mention names. We recently did the training of a lot of our sites in South Africa and outside and one specific client when we did the training. The operators push back and say no, but this and when we were a day full of the training and I'm talking about the theoretical planning, these people's mindset completely changed, and they saw the bigger picture and say, but hang on, we didn't know this is what autonomous is involved. Oh, I see. I almost benefit from this. So, I think it's the way that you sell the product, but we sell to top management and top management down clearly, people down below to say, this is what's going to happen because most of the people when they hear autonomous, they think of job cuts and autonomous is not there for job cuts. We are uplifting the skill of that operator, remember, we're taking that operator out of the cab. He doesn't know that feeling of how this drill is responding. He doesn't hear that drill drilling, okay, this is going high or there's a mess or whatever. He's only having to rely now on the knowledge that he had on drilling and then also he have to rely now on the visuals of the cameras displayed in the control room. He must now think how that drill is reacting through what he's seeing on the cameras and what he's seeing on the HMI screen and the screens installed in the control room and based on the information that he's seeing; he must come to a conclusion how that drill is performing.

So, we definitely upskilling that skill and I mean, that's uplifting in the skill and that's also a benefit for the operators. Once they see the bigger picture, then they go through to say, but hang on, number one, my life is not at risk.

I'm sitting in a very safe environment, kilometres away from there. grow. Why do I want to expose myself to the dust and the noise and anything and it's not that I'm losing my job. They're actually upskilling me and they're making a better person out of me. Yeah. So, I think management don't describe that process completely to the operators. That's why we experienced some pushback that after like I said two- or three-days training, then the operators do recognize this benefit and then we've got the time from them. And it's like, if you take a person that was on a manual, don't read the whole time and you start expressing between this environment, they're just getting more and more excited than you have seen. Listen, I want to, why do you waste time? Let's, let's get to the control and they start early, and we just have to stop them and say, hey, it's not that easy. We need to get through the theoretical part, and then there's a practical training part with the trainer on the drill. We normally go between 40 to 80 hours on one touch training, before you have 10 minutes to autonomous training, and once you have done that hours, then we take you to the control room, our instructor, our trainer, and he will do at least, I think it's 20 to 40 hours with you in the control room, and setting you up catching, you're skilling, you're giving you the skills by yourself the whole time, and then he will do the final assessment, and if he's happy, then you will get certified as a trained autonomous operator. Some of the clients do push us to say that hours are too much, and then we just, we don't give you, we push back and say, sorry, that's a minimum requirement, we're not gonna drop the standard.

Interviewer

Yeah, it's good idea. So yeah, in that case, I think you mentioned the buy -in from the operators, aside from that, what is it that the mind needs to have first before deciding to bring in auto? Like, what processes need to be in place? Not really technical processes, just general processes. What is it that the mind must have before they say they want autonomous training?

Participant 3

Okay, yeah, that's a difficult question, but if I can answer you on that, now if I can answer you on that, I mean, first of all, you have to go and do a business case study, and say, okay, currently, how are we performing? me? Do we meet target?

Do we, do we, does we not meet target? How many incidents that we had related to that? And when I say incidents, how many times that draws time into each other? How many times that draws time into HME cause that incidents are they, trust me? And some of the minds don't want to speak openly about it, but it is there. And I mean, you do a case study and say, okay, guys, we had a lot of damages on our adults, where they either turned into burns or they turned into something, or they collided with each other. Are we willing to continue like that? Isn't there something on the market? And that's, then obviously we're not the sole supplier of autonomous. There's a lot of companies doing it. And secondly, you have to look at your network setup because you need a strong. You need a strong network. What we prefer to work on is the LTE network, although on our agent and what the mesh network. Some of our clients do run on that and it's successful on that also.

Although we do experience some communication drops, like I explained to you, from the command center to the draw and back. So, you have to look and say, am I willing to invest? You have to look at all the powers and the cons and what it's going to cost you if your network is not up to standard to get it to standard for these draws to be able to communicate and make it a success. And then obviously another benefit for it that you have to look at is your survey manpower. Or as manual stacking is taking a lot of your manpower on the survey department. I mean, in the past, you're talking about five to six people that must go and stake a block. As we are autonomous, you just need one surveyor. To go out there, pick up the crest, design the blocks and then send the plan out. So also, there you're taking a lot of people exposed to any necessary hazards. And also on the crest, some of those needs to be staked two meters or 2 .5 meters from the crest. And you don't want to expose your employees to that. So that's also a huge benefit that I forgot to mention about it. But you have to look. And then obviously cost effective. I mean, if you've got a grow worth of 20 million rand, if I can make an example, it doesn't help you put on a 20-million-rand autonomous system on the other. You hear what I'm saying? It's the same as if you've got a second. car and it's your $15 ,000 and now you're going to spend $40 ,000 fixing it. It doesn't make business sense. So, you must also look at your equipment and the state of equipment that's in as it's fairly new. And if I say, look, we can, like I said, we can automate anything. There's not one room that we can't do.

Yeah. But it will not be fair to give the client those leading indications to say, okay, do not spend this. I'm taking examples that you're talking there. Spend this $20 million, but we know that dollar is only worth $10 million. You know what I'm saying? It doesn't add up. It doesn't add up, yeah. Right. I give the guidance and say, okay, guys, I suggest build them until they can buy more and then sell and invest in new equipment and the range of equipment from getting them install the system. We guarantee you will have less incidents collisions and trying to balance and anything because we've got systems in place that

will protect that road from going to that boundaries or whatever might be the case.

Interviewer

Oh no, I understand that one yeah and then just to so yeah, the next question is just more on the positive light and you just have two more questions one is on a positive light yeah you work with different sites. So can you just describe a situation where you felt positive about the site when you are introducing the internal autonomous drilling which sites do you feel more positive about and then what we do in private you need to mention the name of the site just describe what they were doing right and then yeah what did you like about how they were seeking in the internal link.

Participant 3

Okay so I'm not going to name the site yeah but there is one particular site that I worked on, and we managed to draw 80% and above in that certain year new autonomous.

But it wasn't a man one man show it was the buying from the GM down right to the operators everybody was involved and everybody wants to make the success of it and prove it and just to read the benefits of that but in that not only the GM your mining manager your section manager your miners yeah your foreman your production controllers your operators I mean the cost must be set up clearly. and everybody's buying into that and then you push and I mean everybody saw the benefits of it we didn't have instant uh instances we learned we're almost there anymore outflow stock everything and it's just fascinating to see it and it's fascinating to see when you can take an example one of our clients we did a study we we dropped almost the size of 22 rap issues in fully auto and the end of the project when it was measured the hint of that that level we had a x y and z of 99 .7 percent I mean we had very little details it's just the whole engineering team everybody was on board to set up these draws correct and just so this is how it's done and I mean it just makes you feel that you belong and most importantly people think to forget the operators and those are the guys and I always said it the operators will make me shine I will make my suits shine my super like my mining manager shine and my mining manager will make my GM shine and the GM will go to the port without any issues and say this is what we achieve and everybody's just but it's hard work it is hard work like I said everybody must be in there and you must go I have a firm hand on it and you must go and I was taught don't check up so much because you don't trust in your people it's not about not trusting in the people it's adding that piece of wine saying go into the box blocks regularly walk the blocks check the conditions is to add that piece of my mind when I go to bed tonight 10 11 I know I will not be called to say there was a incident on the door block whatever might be the case cause you set up your crew correctly to do the right thing at all times but it takes a lot of discipline and it's taking it from the GM down to the operator everybody must be on board and everybody must know

exactly what to do I don't know if that does answer your question your question down yeah I think the question just one last question then we're done one last question is just overall I think you've said a lot of things a lot of these things you might have said during the course of the meeting but just in a few words like what is your overall learning that you're gonna take forward from whatever experience that you had with the auto drilling now what's your overall learning when you gonna introduce it to the other side what leanings can you say you're gonna use okay so what I'm currently applying is number one I thought I knew anything I knew very little about autonomous my own company open up my eyes my own specialist I'm dealing with one now from Australia mm -hmm I thought I knew it all and he just opened up my eyes and appeared look at this is so much more and I said how did I manage to overlook this and it's a grounding it just shows again that you are never told to learn. Even with all the years of the experience that I have in the mining industry, I'm still learning everyday new things about autonomous.

The one thing that I've taken away is that when I started my mining career, I was against this. Honestly, when I was still working for a certain company, I didn't believe in autonomous drilling. I had quite certain engineers today where I said, I will prove you wrong, my operators will go and throw you away in one touch and all that. And I looked just in a productive eye because in the ground, stones blasted. And I got a real eye opening when I saw what autonomous can do.

Safety wise, efficiency wise, and environmental wise, remember, we tend to forget that aspect that if you push the strip, pipes are going to burst. I don't need pipes. This alliance is going to burst. We have the expertise. And that's also a huge benefit because your breakdown is very less. And one of my sites have proven it to me now, and I was actually bragging about it. They were starting up a drill, and we had a lot of breakdowns on the other girls, and they started up this particular drill in manual mode and free water. And for 48 hours, that drill didn't have one breakdown on it, not one. And the moment we went back to one touch of manual drilling, that drill was standing in the next two days, just on breakdown course. And this is the wrong way. This is wrong. Then it's running an hour or two, then you experience this problem. So, there's definitely that huge benefit. which I didn't believe in, but one of my previous companies that opened up my eyes and said but have a look at the bigger picture. Don't just think, yeah, you want to shine. You know, you're going to put with us, you know, you're going to get a man, but it's coming with a price. You're putting all these people's lives in danger, exposing them to that as it's, we could have done it even better, even faster. They're saying you won't teach an old dog new tricks. I was approved from there, honestly. And that was an eye opener for me. And I will, no matter what system it is, if it's our system, where there's another system, what the client can afford, if it's anything to do with autonomous, I will definitely tell them, go for it. Go for it. Invest in it. Because that is the future, whether we want to know it or not. I understand in some of the mines in Australia, the trucks, everything is running fully hotel. Yeah, it happens.

I would like to get to the point where I can be part of even autonomous trucks who say autonomous dices and not just the roads, but there's so much, I understand some of the buses is even automated, taking the people to the workshops or to the working area and back. I mean, we are South Africa, I'm not going to be negative against the country, but we are lagging a pet behind. But I think within the next five to 10 years, we will have catch up a lot in the autonomous world to say we are competitive concerning the rest of the world. It's not that they must just laugh and laugh now in South Africa, they don't know. We're miles ahead of them. I think we are catching up very quickly to the rest of the world. My learning is what I always tell my people, and I've done it recently also, on other sides also, is the fact that we're telling auto doesn't mean we have to lose the respect for that machine. It stays a piece of metal. We control it. If we don't respect it, it will either injure us or it will kill us. We must think we are the heartbeat now of that machine. Autonomous is the heartbeat of that machine now. If we're going to start relaxing, that heartbeat is also going to relax and then that's when it's going to catch you. We have to stay focused on top of it the whole time and just respect it and say, whenever we approach, it doesn't matter how we do it, let's respect, let's go. check and say confirm the status of this drill because it's got the potential that technology can fail, and the potential is there that it can hurt you or your fellow employees. So, we must just respect the autonomous process and implement as much as possible the rules and guidelines around it to safeguard the people that is not working directly with it. When I get exposed to it at the house I got it. We don't just let them work into a danger zone and we haven't kept it for that.

Interviewer

No, I understand. So now you just mentioned about South Africa being what do you think is the reason behind South Africa leaking behind? Do you think maybe something to do with the unions or why are we tricking behind?

Participant 3

My personal, my personal. Yeah, definitely with the unions, um, if your unions aren’t well -breathed and they are not onboarded from time one, we're going to have to keep that because I see this as, oh, one, the message sending to them is one operator can go to, can operate two or three rows at one time. So, what about these positions? And we went into negotiations and said that, you know, guys, we're not retrenching anybody here. We're selecting a few people. The other people will also be trained on that and addition on that, we will train them on other additional secondary equipment that you don't need to man always 24 seven. Now you've got the opportunity where instead of just making the one machine, you multiskill that operator, when he's not needed on that role, when there's enough, he can go and man a secondary piece of equipment that would have stand in any case because, uh, you don't have the budget to

man all that machines. So that's it. But like I say, the unions were under the wrong impression of years coming to a job cut years coming job, job losses, uh, we not for that cause they weren't properly engaged from the beginning of the process, and they weren't taken along the discussion right after the end. And that's where most of the clients made the mistake. Now they want to get the union on board it almost too late when it's too late. Yeah. Okay. As when you start with the process and have them on board it, let me see the benefits. Let me see the gains, let them see the upliftment of the labour skill, uh, and then they were buying it. But like I say, unfortunately it is a problem. We always leave the unions for losses. then we want to start negotiations when already we have taken a decision to implement. So just take them from the start of the project, add them on board that they also can give their inputs and everything. I think that's the reason why we've got so much pushback and then obviously uh cost saving. I mean most of the mines they want to put as much as many uh rounds into their pockets without spinning too much. It is a expensive project to take on but like I said your return on investment isn't immediately you will see it over a time lapse of saying two to three to four years and you will see okay yeah my return of investment is coming in now. Whereas most of the companies want to see it immediately yeah, I mean that's a that's a very That's not how you measure it. There must be a time frame on it, and you must, as a company, go and see goals and objectives and say, okay, by this time we wanted to achieve this, by this time we wanted to achieve this, by yet too we wanted to achieve this, and you must keep track of that progress. Okay, okay. Now it's mixed in.

Interviewer

No, thank you very much. I won't take any more of your time if you're tired. You want to stress now.

Participant 3

No problem. If there's anything that you want said in a bad way, you want more clarity, I'm still available tomorrow night. We can still make it six o 'clock again. If there's some questions, you can just pop me a WhatsApp and then I can have kind of a specialist engineer. This guy is really good, and he can elaborate a bit more of that. So, recap, if there's any questions, feel free to call me. Just send me a WhatsApp and then I'll put you around about six o 'clock again.

Interviewer

No problem. Thank you very much. I'll do that. Actually, yeah, on that I just needed, because like I need to have, for this time I need to have a lot more, a bit more people.

Masters interview 4

Interviewer

This is my master's interview. Then I applied for what's this? I did the ethics application. I got the certificate for it. And yeah, as to draw a got this data that we're discussing now, I'm going to use it to write my final dissertation just to let you know, but I won't name you or any of the companies you refer to. So that you'll have that sort of privacy. So only the rich data out of this will be in the report. Not the identities of anything companies or people or even you. So yeah. So, we can start. The first question is to do obviously with my data sample, I needed some criteria. So, it has to be someone with a degree or someone with 5 years or more of experience. So, this first question is just a qualifying question. It's just to state your level of education and your experience in mining in number of years.

Participant 4

Yeah, I'm in NQF level eight. Am I in engineering? And I've been in the industry for I think nine years. It's going to be 10 years. No, nine years. It's going to be nine years. I'm talking in the industry now.

Interviewer

Okay. Obviously in every research you need the bit of rationale to back you up into whatever, like whatever that you're starting, whatever that you're trying to investigate is worthwhile. So then one of the questions to just to qualify this research. Is just from your point of view. Yeah, on a high level, what would you say are motivations. What are the motivations for introducing new operational technologies in mining, like auto drilling, you can focus on the auto drillings perspective. So, what would you say the reasons are, why would mines want to introduce such a technology?

Participant 4

No, I think for high level, we just talk about the company strategy. Obviously, towards moving away from being labour intensive to capital intensive, that means you actually undersize, it becomes more data centric and controlled. Therefore, you have more control and visibility in what actually happens in your product and point of view. And then if I was to bring you to operational perspective, if you look in terms of your conditioning monitoring, and that relates to cost as well productivity, if you have more technologically advanced operation, you are able to actually do more reliability work and become proactive in managing your assets. So, these unplanned breakdowns and expenses can be managed easily or can be lend ahead of time. And the most important of your skills is going to be safety. You are actually minimising exposure to a point of elimination of exposure of people, which is very important for all

mining houses. And also, in terms of quality of whatever you're producing, you have more control in what you are drilling.

Your quality assurance and quality control are in place. So, your overall drilling process or overall process, the bad part of the value chain, you can you manage it proactively. So, it's about ensuring that you become proactive in your process and mitigating problems before they become a problem. Yeah, just sort of being proactive. It is true. So, I think when we discuss these things, they always make sense to us, right? I think the most important one would be to the people in the crowns, the people that actually need to use this. Like in your view, in general, what we just discussed now, because to someone it makes sense that we would want to do this.

Interviewer

But for the crews on the ground, do you think the message goes there so that the guys understand? Because I think for them to be the part of the journey and understand how this thing is meant to help them, they need to also understand such things. So why are we introducing such a system? It's not there to take their jobs, but to make it... get the job easier and get it saved. But do you think that does it fall the truth to the teams down or in general? Or just a follow up question on that.

Participant 4

No, I think at the end of the day, I think it goes back to you understanding where you're operating. So, if you are talking about implementation of this in Australia, I can say, Australia or South American operation compared to an African operation, the challenges we have are not the same because of the fact that are we labour intensive or capital intensive. So, if we understand that aspect and means that our strategy actually beyond the operational, actually when you get to the operational aspect, your strategy, everyone understands when you come to the technical level and operational level, the way we actually approach it has to vary because the climate is not the same.

So, if I'm to bring it to a South African context or a Southern African sub-Saharan Africa context, we are a labour intensive. We have in South Africa; we have issues in terms of economic stability and employment rates and such things. So, the way we communicate our message to the people who do the work will be different compared to someone who's in Australia because of those factors. So, we need to be very sensitive on how we actually picture it and make our numbers very clear that if we know this technology is not going to affect anyone’s employment. we can’t just say that we need to actually show numbers that it won't, what is the new labour strategy going to be? What is gonna be the additional requirements?

Like if you go and look at companies that don't do instrumentation, if you look at the C&I aspect, it's not that, there's no C&I department actually, but you go and look in companies. where there's mining companies, where there's technology. You have
a whole new leg within the engineering, drilling engineering called C&I. That was not there before. So, if you communicate such aspects to say that there'll be new high level employment opportunities. You don't have artisans then you have technicians. You don't have labourers there. You have people who are skilled. Skill levels of the labour force create opportunities, such things. If you look at the operators, you are no longer an operator or controller, it affects the salary to you in a certain way, depending on how the pay skills they've used before. So, if you actually package it in that manner and actually indicate the requirements that are in place and what we can use that card, the existing labour, obviously there is retraining in place required, and that requires time off for those people. And the implications there often to their finances. You communicate that really, you will not actually have challenges, but that has been our main challenge within South African operations. It is not clear in all operations that what the impact is it going to have. We just hear that we're not gonna cut jobs. Okay, I know you're not gonna cut jobs, but you're telling me this machine can drill, one person can operate up to eight machines. What assurance is there in place besides HR processes? What assurance is in place to ensure that I get upskilled to a point that even if I get to be moved to another department, I will still be effective. I'm not sure.

Interviewer
Oh, yeah, yeah, that makes sense. Yeah.
Makes sense, man. Answered fully. So, I think the other question, I think we just pocketed it. It was just a follow up question that I asked and then I think you dealt with it now. So, we're just gonna go to the next one. So, yeah, so this is just gonna be overall also. Yeah, high level one. So just an organizational one. So, in your experience, what do you think, what is your take on the relationship between maybe the overall setup of a mine or a site and the ability to sustainably adopt new technologies? Like, yeah, so what are those attributes of a mine or a site that enables it or disables it from being able to adopt new technologies and stuff like that? What's the relationship there?

Participant 4
I think this thing boils back down to operational readiness, having a very clear and capable operational readiness team that is going to hand over to operations at the end of the day, irrespective of how, you are in terms of technology. Remember when you're starting the implementation of any new thing at the mine you must run it as a project.

And with time gel in the existing labour strategy that's going to be taking over once you are done and ensure that once the project team detaches from the work, the team that is actually left on site can continue the work. So, I think in that space, in the operational readiness space, there's a change management aspect of it. There's an SIB aspect of it. There is a construction management aspect of it. And then there's the value chain management aspect of it or value chain integration aspect of it. And that requires you to be able to establish new management routines or modify existing management routines to centralize the technology. And to actually see overall in your project scope, or can you say maybe in your Gantt chart for exit or maybe... Once I done with commissioning and such to ensure that what is the critical path there? What is the main constraint there? Most sites, if you go and look into this, the main constraint is bench preparation. Once we have resolved all our technical issues in the technology and such, our main issue is bench preparation. So, before you bring a drill into site, have you identified what would be your bottleneck there? What would be your constraint there that you need to actually deal with? And once you have that as an entity, remember there's already existing processes at the mine. If you look at how mine planning is done or schedule reviews are done, that needs to be part of discussion. And it requires that project team to actually take charge or become present in that process to ensure that by that time we have actually ramped up in the steady state, we're not finding a certain situation where we have to ask for Favors for extra equipment or extra time to be spending prepping a pattern for autonomous compared to other drills you have on site. Because we do know that we don't have greenfield projects mostly in Southern Africa. What we do, we are doing this, is brownfield projects that we have to make it work within that. So, for me, I really believe that your operational readiness plan needs to cover everything. I can just give you an example that when we actually buy new machines or we're converting machines, if you look at your IT or IM readiness, if you look at the things that on site require network connectivity and the existing infrastructure, and if you look at the sensitivity of autonomous operations because it's live, it needs to be live. So, it's very sensitive. It's not like when your fleet management system works, you can operate offline, once it gets to your point where there's network, then it just back loads all information collected. This one, if there's one or two, it stops. Has that been considered in your expansion? Like if I know I'm going to have five drills this year, is my network capable to actually manage that traffic? It's my hardware for the infrastructure there. We found a certain situation where I can give an example where I work. We found a certain situation where that if we looked at our SIB checklist, every time we acquired a new drill or we acquired a new autonomous kit, because it doesn't need that. It can be an old drill that we actually just kit it with a new system if it's competitive or not.

We did not account for the fact that there needs to be a match between network trailers to the number of drills we have. There's a rule of thumb around the globe, but if you go and look at the cost or the budget for the next two years, it's not there. The only cost we have is for the hardware that is fitted on the drill.

And now you're finding yourself having intermittent breaks. Sometimes the world that is supposed to take 40 minutes to drill, it takes two hours because of things like that. And now that's where you find yourself, but the operation is actually losing money, is losing tons because of that. And then you're going to find yourself switching off the project because you didn't do your operational readiness right. You did not actually, when you did the budget for this thing, or five-year plan, you did not have the correct inputs put in place. So, it needs to be a holistic view.

You can't just be looking at it in terms of the drilling in the field and drilling. You need to look into what is it that are required to ensure this thing is consistently connected. Yeah, it gets to a point that when you're working with technology like this, it's you having to work with systems, having to work with your OEMs. Even your OEMs can let you down. The OEMs can let you down in this space because the safety features or the control access control into the system, you require to ensure integrity. Besides data, I can just talk about safety integrity to ensure no one can go and make changes that can kill people. If it's not there, you have problems. So that's the risk of having such sensitive technologies that need to be merged with existing mining processes because there's project to produce, so we'll bypass because we want to produce. So, you need to actually ensure your operational readiness plan is very clear and waterproof so that when we hand over, we actually minimize those gaps from existing.

Interviewer

Yeah, so like, yeah, I understanding you're saying and then Yeah, but what's your take on the people part of it?

Participant 4

So obviously, it's also, it's just that in the people part of it, I think that you need to be very careful. You need to, this thing of levels of work is very important in that space because at the end of the day, like I told you that once you have buy-in from a group or senior management, they want the things to work. You need to identify who are the people who are going to actually make your operational readiness plan work and work with those people, make them champions while you support them. Make them have ownership. And that is very important because those people already have existing KPIs. You are adding a KPI into there already bloated KPIs. Yeah. I can talk about operators. Operators is about you ensuring that there's their management, understand what they're doing, and the communication that actually gets transferred by that management is aligned with what the objectives of the technology are. So if we can actually ensure that the right levels of work, people who make the decisions, operational decisions at the right level and have influence, take charge of this, you have won the battle. Because it means there will be accountability. There will be accountability in that space.

People will take ownership. And if it requires us to train people, they will release people. If it requires us to ensure people are held to account for misbehaving when they know the right things, those things will happen. It will bring trust and will bring acceptance of the system into the mine. That's what I believe. You can't just be relying on having a mine manager or a GM buying into that thing and the section manager of the mine is not. You will not win. You won't win. Yeah, so it needs to be a holistic sort of a thing. Yeah, so, this is at a technical level. That's why you need to ensure that things get done and obviously the reports that get sent to senior management, high level and things are moving, there's ownership.

Interviewer

Yeah, so. That's what I'm getting from what you're saying. It's like you need to trickle down with levels. You cannot be a project team or executives from head office and then want to bypass the section managers and then go to get by in from operators without doing the section managers. You want to. Yeah, I think maybe a lot of times, I think that's done. We tend to think assume that they because they are learned and then they have experience. We just assume that they are on board. So, and then the people that we need to win at the ones on the grounds But like we leave the section managers out and then the tactical leaders like you said we leave them out.

Yeah I'll get you saying man Hey, I think I make sense and then yeah that makes sense and Yeah, so I Think we covered up most of the things because I was asking questions one by one, but I just asked them is for all questions so, yeah Yeah, obviously you work with a few few sides And then you don't need to name one you just need to describe the one where you you had a challenging time when you're trying to sort of get through to the operational teams.

Participant 4

All of them were challenging.

Interviewer

The most challenging. The most challenging and just unpack it and then what was the dynamics there and stuff like that. So, I'm just trying to get what would, in a normal day, what would be the challenges that you come across as a specialist trying to take this down to the teams and yeah, the side teams from managers to operators.

Participant 4

No, the thing is, as a specialist, I always like saying this, that you don't have a cost code, you are broke.

You don't have a cost code, you don't have people, you don't have machines. You're literally a broke person, you're a broke person, you're a consultant and you must remember that you have to be a consultant.

Yeah, you don't have influence. You don't have influence, and I think that's where most of this group led projects fail. People who actually have money are the people on site and those are the people whom you need to ensure they take ownership. So, and you know all sites have their own challenges and if you look at how some of the processes that like each and every mine within our company, each and every mine, the way they do things is different even within the same regime is different. Some of these things that are doing, they got special permissions from the DMR to do such things and some we just were just mining to make a profit because the geological and geotechnical issues, I just said a lot. So, the important thing for me, I can say before I answer your question is the fact that we need to remember that I can come with the technology, and I must not look into the technology as the holy grail. That technology must operate in a certain environment. And what are the consequences that I have within the environment. And what is my technology sensitive to? That can be a problem because of the existing environment.

So, I can give you an example that we are working with one of the sites I'm not gonna name, but you know site I'm referring to. We have water issues. It's like dynamic water that is permanently and technology of ours cannot operate in water because if you look at the algorithm of drilling, if I'm drilling in a place that has water, it requires an operator to feel the drill and then retract it to two, three meters, prevent it from getting blocked and then losing your rods. Or to actually ensure that, and also if you look at the spending time after you drill a hole in an area where there's water, you can actually, you're supposed to drill today in charge today so that you don't lose your hole.

Yeah, but if you look at technology because it doesn't require people there, you must actually be able to... Square off you pass by time you square up that area it requires redrills and if you look at some of the processes the mines some other mines are allowed to flush the holes. That is actually can increase the drilling cost by 40 to 50 percent by flushing and you're losing time, So this is the challenges that we found ourselves with that we know we're gonna have water here our technologies not capable right now.

It's in a waterlocked area How do you actually engage people who've been doing something in a different way, but this technology doesn't record, doesn't allow you to do it like that, to actually change that way. Remember you don't have you don't have money you don't have resources you don't have a cost code you have no people you are broke so that's where it goes back to the issue of fully going back to a technical space, your technical department going to engage geology department and going to engage your operational team. I'm talking about pit Sups, Operators, yeah, those people understand the pit and such things and now say we accept that in this part of the pit, for the current bench

we will not drill full autonomous because we are not ready.

If you look at the dewatering strategy, It's non-existent It's a new process.
So, you find that the holes missing then then so you can square off up until the drill must go and drill that hole you lost because of such you see the way we did it in other manual drills you can do that because you can flush It's quicker, but you can't flush with auto drills. So, there was no drilling sequence that was in place. We lost the whole pattern now you must go and present this to your senior management that We have to redrill the whole pattern. How do you allow such? How do you allow such things to happen? So that look at the planning process at the mine It was a very poor planning process. It didn't require it to be detailed to that extent because in the manual areas you can just bring a drill there, flush and then it could move. But you can't do that with auto drills. It damages the machine. Like if you flush with that auto drill, you're going to have all your sensors damaged. You have damages everywhere. Like you have issues. So now you have to go back and actually do an RCA to see how we actually handle for the next bench. We actually have that area we're actually going to have to drill one touch or manual in some patterns while we're figuring out how to actually become effective in that space. We discovered that actually I have to drill bore holes now, like three, four benches deep in and actually dewater from there. It reduced the water levels, but it didn't eliminate the water issue. So that requires you to be proactive. It requires that there must be a small drill dedicated to actually going and drilling dewatering holes for us because we know we have water. The water is there. It's permanent. Our software development was poor.
Like if you drill manual in it, we know that each and every two, three meters, you retract the drill and continue drilling to actually assist with the removal of the bearings. And we discovered the reason why we're doing this is because there's a mismatch between the drill string and the drill bit sizes. Yeah. So those are autonomous drilling. That's not the mine I've been operating for the longest time, but you, because you know your bailing force and such things are affected by the fact that you don't have clearance around that area. The program does not even have the capability of doing that because it's not the best practice to drill like that. The drill is supposed to actually adjust itself automatically while you... If you start seeing that it's grounding, it's supposed to increase the air pressure and such, but that was not happening. And then the question that we asked, we took a deep dive into the program. It had a lot of issues, the program itself. And now we're also having ground issues. We're at the back and actually established a technical, what do they call this, having a technical stay home where we're addressing program issues relative to our site issues. Because just because you do it like this in some other site in South America or even within South Africa, it doesn't mean that you must do it like this with us. I know we want to alter the program, but we will need addons because we have special problems. And that is the issue with our OEM. They were not willing. Also, you needed site -specific sort of... Addons, yes. There must be a menu to the program. There must be a menu. But even now it's an ongoing issue that we need addons for this site because we know we have water issues, our rocks are like this, the rocks are hard.

There are a lot of issues that we have that are not applicable to other sites. So, you can't tell me because the program is like this. You won't have addons for me. So those are the challenges that we have.

So, you find yourself in a process where I want to talk about it goes back to the foundation of operational readiness. So as a specialist, your job is basically operational readiness.

When you go back to that aspect, you go and review. How was our actual conversion and commissioning done? The way our C&I specialist was actually signing off the drill, did we look? Even if you look at our checklist of things that we're actually signing off in our commissioning, it evolved the time because we realized that there were some things we're not looking into, and we discovered that it became a problem on the result side. So, we had to add them to our checklist before the machine gets signed off by itself. It helped us in the process to say that we are mitigating the risk before the machine actually gets to production. But once the machine is operational, there's a checklist there. There are a lot of things you must check. And some of them, if you have never experienced those issues, they're not necessary. So, we will know when we're going to work in such conditions. So, we need to check those things. Look I am saying that you need, like for each and every department from engineering to operations, you need champions. No. The job is to look into this because if you don't have those specific people every week, you have someone new coming to represent the engineering or whatever. You will never address most of the issues that we have. And also, you won't be able to make amendments for the coming drill for the next drill for the next knowledge, whatever. You won't be able to. So, you have specific people whose job is basically automation, even though they have other responsibilities, but there are the people who communicate with when it comes to this thing.

We sit and discuss what happened the day before. Because there's a lot of finger pointing. Remember, if you look at your base machine, it's not just the mechanical issues, also the auto electrical stuff there, it can be from the base machine side. There's a lot of grey areas there where you can have a lot of finger pointing and not find the solutions. So, this becomes clear cut. It needs to become clear. One of the issues we had was the issue of sensors. Sensors, like I can talk about the rotation sensor. That sensor can be like a terrain. But we're losing hours. days because someone was pointing fingers at others. So, who's responsible for this? And then if you go back to the foundation, it was operations that was a problem. The other way, drilling was wrong. It was damaging that thing.

So, I'm just saying that in the nutshell, I know I spoke a lot, in the nutshell, you can't go there and think, I'm talking about technology and people and those things that you must manage. There's more to it. And that's why I think, that's why mining engineers are the right people to actually occupy those roles because you are able to understand the technical aspect of this. You can go and engage the MTS team.

You can go and engage the operations team. You can go and engage the SIB team. You can go and engage the engineering team to resolve the issue. And IIT team as well.

So, you need to have a holistic view and all of that must come from operational readiness play. And it must be, you must establish routines that are needed for the risk we have.

Like right now, the site where I think for the next two years, every day, they must have a meeting. They kind of have a meeting once a week. It's not enough. They probably will fall apart. So, they need to they need to baby because remember we have issues from the MTS side, issues from the system side, issues from the engineering side. Everyone I think is stable. IIT is always not stable. But if you look at Mine y, they can have a meeting once every two weeks to survive because the operational readiness plan when they established this thing was proper. So that's not the case where we are.

Interviewer

Oh, so it's better because of the operational readiness plan was done better?

Participant 4

Yes. The operational readiness plan for Mine y was better. Like right now, when they buy a new drill or you're converting a new drill, there's a formula. They maintain, if you look at the number of network trailers, they have on site. Like the example I used to you earlier, that you can't just be talking about the hardware to fit into the machine. You must buy the hardware to support the IT aspect of it. That is part of the budget for Mine y and it's not part of the budget for the mine I work at because there was a gap. Someone didn't identify that as a critical aspect. So every every two drills need one skid. So if I have 10 drills I need a minimum of five skids. And right now we have nine drills and we only have two skids and there's no money to buy additional skids. How do you expect this thing to be consistently stable because now you find yourself drilling in three patterns?

You need connectivity. You need video footage in all of them.

But it's not in the budget. There's no infrastructure. Yeah so we mustn't just talk about the people. I know the people are important. So that training aspect of operational readiness and change management aspect in terms of procedures and the people, you can have that and a lot but still fail because of all the supporting things.

Interviewer

So, the technical side is also important. Does that frustrate the people and then the people who are frustrated now push back?

Participant 4

If I'm just frustrated and know that I need a bonus, I will go out and put the operators in the machine. I'll take them from the control room and put them in the machine because I must blast.

And do you think my manager will stop me from doing that? They won't. He has targets as well. Remember I told you that existing KPIs, you are bloating these KPIs. If you're not providing the solution we revert back.

Interviewer

I think the next question you answered in the one that we discussed, there's just an inverse of that one. So, you discussed both aspects. So, it was just asking about the positive aspects. But like, yeah, I think when you are, I think when you discussed the negative ones, you gave alternatives, that's just answering the question. So, yeah, so like, let's say you are a, so you are a maybe site operational manager or something. And then you are saying, maybe the technology process, the technology adoption process is going well. So, what would your measures of effectiveness be? The KPIs that you're going to check, yeah, that to indicate to you that like, this process is going well, not at the final stage, the while it is in process that gives you confidence that this project is going to be a success. The things that you see you can track during the adoption process, the initial stages, that gives you that confidence that this thing is going to work out. What are those indicators? How would you measure like if you would come up with a set of measures of effectiveness to say what I'm going to track, what I'm going to track, what would it be?

Participant 4

Okay, for me, I think compliance to schedule, multiple schedules. The first one obviously is the conversion and the commissioning schedule. Yeah. And also ensuring that all the orders, so that involves supply chain obviously, all the orders actually, I don't actually get delayed work or delayed delivery because the PO was late. So, supply chain, my supply chain aspect of things needs to be on top of things, needs to be on top. I don't want to be actually getting a request, someone actually wanting me to give them permission to install something on a machine that doesn't have a PO because it's not even good governance. For me, that will be a critical KPI for me. So that's just conversion and the commissioning of the machine. And obviously the cost aspect of that, I don't want people to be working crazy over time, pushing work, we need to schedule work and then we stick to the schedule for that aspect of things. And then when it comes to the, when you start actually operating with the machine in the field, the people that are operating, I need to ensure that obviously, obviously based on the assessment we made and also in terms of the percentage of the drills that we'll have auto compared to manual, the amount of people that we committed to the train, I'm going to check that as well to ensure the people, the amount of people we committed to train, actually trained at that rate and also ensure the content of what they are trained at is relevant for our site issues. We need to actually audit the material as well or the outcomes. That is very important for me. My KPIs, so my other schedule is my schedule compliance of OM.

Yeah, schedule completion, schedule compliance. There are patterns that handed over to autonomous drills. I think what we've been promised is that this thing is actually around 20% more productive than manual drills. Obviously, as I ramp up, I'll put it on par with the manual drills. Initially, I'll put it on par with the manual drills. If the pattern is supposed to be finished in three days, it must be finished in three days.

We have had cases that we dealt with, where the pattern that was supposed to be finished in three days we finished in 15 days because there were just too many breakdowns. And so that would be very important. Yeah, so I will link the schedule compliance in terms of meters output from the drills, initially must be on par with the meters for manual and then afterwards when we are accountable I will increase it by that 20% that has been obviously when I mend the schedule from planning but I would have my private schedule that accounts for whatever has been promised for the system because it must deliver at the end of the day and then that would be my other key. Yeah, but at the beginning I will put it on par with the manual drills. It must at least minimum produce at the same level as the manual drills. My other KPI would be the issue of data integrity and system integrity and reliability for my machines. I need to actually get assurance that we get condition monitoring at some stage for the tech for the sort of money we are paying but we don't have condition monitoring. I can't be able to check the vibration on the machine and that machine is supposed to. I know x system has that option that you activate. Actually, every drill come with those sensors that it tells you the vibration levels and the machine must adjust the pressures, the rotation and the feed to ensure that you don't damage the power head. We've lost power heads at Mine y because we don't know what vibration levels we're getting. The system is supposed to show that, but it doesn't have that. So, for me all the aspects I know I'm going to be an operational readiness planner but remember that this is part of TMM so if you go and look at all the chapter 9 or chapter 8 of the MHSA regulations all those things that are required to actually ensure that we don't put people in danger. All those safety aspects by the time I hand over fully to production, those safety aspects must be in place. No one must be able to just log into my system from anywhere and do changes on my system no one must be able to just bypass my system. There must be a master user who knows the system properly like an automation engineer or maybe automation pit superintendent who are the master users for my site who give access control who are legal appointees as well. So, for me by the time this thing I hand over I need to ensure those people have control over the system. You can't tell me the operators are the master user can bypass whatever they want to bypass. So, those for me are major KPIs. I must ensure my safety aspect of things. Secondly because I'm paying so much money, I need to ensure I protect my machine. So, I want condition monitoring at the end. I must ensure this access control to my software.

I must ensure that in the mining planning process, all the requirements that are actually supposed to ensure we drill autonomously for those autonomous drills, they must be embedded, they must be part of the discussion, it must not be a favour. So it needs to be part of it, it must be a column, it must be a row that talks about all these things that are required for autonomous, if I require a berm and then when you talk about bench prep, if I go and look at the amount of time required for bench prep for autonomous patterns, it must include the placement of that berm and all these other things are required there. So, if I would say I was successful when I find that all those things get tracked and then if someone from different section didn't actually fulfil those things, it affects the schedule compliance for the week because they didn't do it. It's part of the process. It's not a favour.

Interviewer

No, I see. I see, man. Yeah, that's good, I think. Yeah, you answered that. So, the last question. In a nutshell, can you discuss just your overall learning, what did you take away from your job, from your overall learning? Can just be high level in a nutshell?

Participant 4

No, my overall learning from this job is the fact that you know when we talk about integration, we talk about value chain integration. I think it is one of the things that they would love talking about, value chain integration. It's very important. You can't be operating on a silo. Like, it goes to a point where if someone talks about conditioning monitoring, I understand if we're talking about studio 5000 what it does, I understand because I know it is an effect as a mining engineer, there's an effect on me. It means I can be able to see whatever's happening in my operation from wherever. If you're talking about algorithms and programs to ensure safety, protect just minimum safety requirements, I fully understand. At the same time, ensuring that we have a solid standardized process. It requires you to challenge the school for whatever's happening inside. So that's why I'm saying that you need to be a project manager in the midst of you being an execution person. You must be able to identify that you must do project management and must give myself timelines and finish. On one of the examples, I can just give you, we had to fight the drilling and blasting engineers. to create geofences because they didn't want to. But the standard says they have to. So that one, you have to make it your project. Within two weeks' time, I must have insured that these people are forced to do their job because it's a safety issue. At the end of the day, geofences, safety aspects, not just anyone must have access to do that. And but those people, because they're seeing it as an increase of the workload and understanding how the current operation works, the challenges they have in the operation, you understand to an extent, but you can't understand all the way because it has to be done and we must maintain our standards.

So overall, it's about integration. And when we say integration, don't talk. We tend to lean towards what we understand. You must get off your comfort zone. You must, you must actually go and engage the IM guys, must go and engage the SIB guys. Like I learned a lot about this thing of tendering processes and all that. Also, purchasing a, this thing of PRs, POs, the challenges we have, all the systems we have, challenges with the issues and how you make amendments to the checklist of things that must be bought.

Masters Interview 5 Interviewer

Interviewer
…and then you confirm that you are fine with me recording and yeah you find me that so that's cool and then you can answer the question to the best of your ability and what is whatever that you're not comfortable with you're allowed to say you're not comfortable with it and lastly, I'm gonna write a report at the end for first report and then you must just uh I must just keep a promise that I'm not gonna reveal your identity or any identity of the companies and people that you're gonna speak about so it is going to be anonymous and confidential. So, first question is just the easy one it's just uh just a qualifying question just give us a brief background of your experience your education and background of your experience.

Participant 5
Okay I'm a mining engineer by training I've practiced as a mining engineer both in operations strategy technology and leadership. I worked with different commodities both in underground and open cast mining.

Interviewer
and how many years of experience do you have now from when you graduated

Participant 5
This is going to be year 12.

Interviewer
You've obviously been involved with, as you said, you've trained as both operational and not only engineer and you're now in some sort of strategic roles, but you're also involved with technologies and stuff like that. I think you were exposed in both roles.

You were to some extent involved with technologies because given your term at Colomena, there was a bit of operational technologies that were introduced there also. I think you have an experience in that. So, with that, just from your side, Because this is more about this intro to automation and other technologies. So, from your side, why would we want to start introducing technologies such as automation? What's the need for the mines?

Participant 5

Yeah, I think for both underground and open costs, there's different benefits. For me, in open costs, I see the precision and being able to get as much data as you can from each hole, which enables your efficiencies and your productivity to increase. There's the benefit. And in underground, what I've seen is when you blast, you evacuate the entire mine, right? You've got a schedule time for blasting, but you're not necessarily blasting the entire section. So you lose six hours the whole mine. But if you've automated your systems or your equipment, you're able to continue drilling. Or in this case, you're able to continue drilling instead of losing six hours. You still drill in that six hours because you don't need to have someone underground when you're blasting. And the other thing I've noticed is in terms of how people approach problems in a technology environment or an automated environment versus in a conventional way, it's vastly, vastly different. You can see deeper thoughts, you can see deeper processing of information and data, and the conversations start to be different. And once you've automated, you are able to focus on other issues compared to in a conventional way. You have an automated, when there's no apparatus, you know, and I think for me, because of that, your power struggle leans more towards the operator which disadvantages the operation to be more effective if you spend a lot of time running after people to do their work instead of looking at how you can develop your mind and use whatever data or whatever systems that you have not only to benefit yourself but to benefit your operators as well. In South African context, I can't be using a handheld drill while my father was using the same drill. It shows that there's no development, it shows that the society is not moving or progressing forward. Also, if I'm using convention, that it means I can only stick to conventional minds in South Africa, so it also limits not only your employees but your leadership and your technical team as well if you've never managed an automation system or an automation section.

You can only apply your knowledge and your mind engineering skill in a non -auto environment. But if you've done both, it just cracks the world open for you. You're able to expand your skill, you're able to do a lot of things. So, there's a lot of non -tangible benefits and tangible benefits to the whole thing. I think that the thinking just needs to be a bit wider than that to say to the broader society and the communities within which we operate. What do we want to achieve? Do we want the same cycle over and over again? And what does it mean for not only your company, but your country and the people that you lead?

Yeah, that's cool. Okay, that's true.

Interviewer

I think it's true even for such as mine. When you look at the equipment, for example, when you're blasting radials for people, it might be a thousand meters and then for equipment it's just drain -wrapped.

Participant 5

So, you can safely put the equipment outside the drain -wrapped if you're working there. But if there needs to be a break, then it needs to stop. So, it defeats the whole people. But that gives outside the drain -wrapped, but it's automated. It can continue because it doesn't need to be a person in there. So, I think... Yeah, it's the same benefit. Yeah, I think it's a waste of what you just... Yeah, it's just a waste of what you're saying.

Interviewer

Thank you for that. And so obviously you've worked both on the division and now you are the one that's like responsible for some strategic planning towards introduction of technologies. And at Colomela maybe you were there when people... you I think there are people that did come and tried to introduce technology. So, what is your overall experience in trying, in engaging people when you want to introduce the technology and versus the time when someone was selling it to you when you were still in operation? Because I think those are the different heads to wear.

Participant 5

Yeah, when I was at operations, my thinking was that the people selling technology to us, you could hear that there was no operational experience. And hence it meant that there was always a friction because we felt that they don't understand our KPIs. and then they felt that we don't understand their KPIs. What I've seen is if you've been in operations and on the other side of strategy now like I am, you start to, you've seen both sides. So, you try to come with a common ground because for technology to be successful, you need the other person to see why it's important, why it will add value, and why it's important that you implemented. I've seen that operational people have the perception that oh no, technology is slow, why? You know, it's gonna do the screw that. Once you understand that and try to merge their current KPIs to make them see like you need to, when you sell it or whether when you implement it or when you introduce it to someone like, am I allowed to mention names? You can, I'm not gonna have them completely doubt.

I'm gonna give you an example of someone like x, right? x is a production person through and through. When you approach him, that's the thought that you need to go in with. Understand that he's main KPI, he wants meters on the ground. He is concerned about quality, but volume is more important than him, right? With every automation, there's always benefits. There are always the productivity benefits. And how you sell it to someone like him to say, you will still get your volume, you will get your volume even better, you'll get it this way and this way, and that's the approach you go in so that he understands and then he takes it to his people directly and say, hey guys, this is what's happening. Then you get other people that just don't understand technology at all. I think you start to understand your audience and then from a strategic perspective, you have a full view of what the capability of the technology is and you are able to say, okay, for this specific audience, this part of the capability will surely benefit everyone. We have a common interest with the ops team. We have a common understanding and a way to move forward together as a team. Compared to when you come with, you haven't done your background check to understand who your audience was. Like for example, I've done technology in Northern Cape, Postmasburg, Kattu, not a lot, Mochalla, Kowena and then, Venetia. They are all black people with a certain history. But the minds that they've operated in are completely different. For example, the people at Venetia, where they come from, they come from what do you call this mind in Northern Cape, which is completely and totally mechanized. So, they approach technology. Yes, Finch. So, when you don't have state of the art systems or technology, they actually shocked like, you know, what are we doing here? They would even tell you at Finch, we had a machine that you can do this yet. Then they're still black, right? They still carry certain legal seas in terms of a social way, in terms of acceptance. And then you get to like areas like Rustenberg, a way I don't know why technology is not catching in Rustenberg. The people from Rustenberg then go and work at Mohalla Goyne because it's platinum mine. So how you also approach those people, it's two different ways. And I've seen that it's a trust thing for people who've never worked in a mechanized or in a technology -friendly environment. The perception that technology is going to take our jobs is real. It's very, very real. It's not just the same. But to people like that, how do you now sell it differently to say, look, yes, it's going to replace you sweating there and sweating the whole day and physical labour. You're going to be in a control room. You're going to be in an air con. You're going to be able to operate this. On top of that, we're going to upgrade your skill. If you want to leave Mohalla Goyne, you can go to any other mine in South Africa, but you will have that skill. So it's how you sell it to different stakeholders. And being at one operation for a long time, it limits you to thinking that there's only one way to sell technology. I don't know if I've answered your question because I've been going on.

Interviewer

Now, you answered it fully. Just a bit of a follow -up. So now we talk of the benefits of technology and stuff like that. But do you think that information, that motivation, and then the benefits and then the objectives, of certain organizations, do you think they filter through to the people on the grounds, the people that you think have trust issues with technology? You think they have the full information? Are we doing a good job doing that?

Participant 5

I think the one thing that we need to learn is technology requires a learning culture, first and foremost, an organization that's able to say, this is year zero, I need to learn how to do this and it's going to take me five years, right? But currently we don't have those kinds of organizations that have a learning culture where you learn, you try, you test, you do this until you get it right. So, the problem with that is you want results today. And with technology, right? When you buy, let's say, a Sennvik machine, all it had done is it was tested at Tempere in Finland. It has never been applied at Colomela. When you bring it to Colomela, it's not that the technology doesn't work. It has never operated in that environment. So, what must happen? We must go through the learning process with the technology as well. Understand it until we realize the benefit. So because you don't immediately realize the benefit of technology, if you implement it today, you don't realize the benefit tomorrow. It's a learning process. Let's say, I knew it, when at the other day they were crying about, what were they crying about? I think it was the data or something, but they managed to fix it. And then the minute there's an issue, everybody's like, let's leave it, it doesn't work. But that's not the approach that we should have. We should say, okay, what is the problem? What can we do to make it better? If you visit Stendic Mines, European Mines, North South American Mines, like my boss, me and him were discussing about Kuala Vekho. I mean, from a perspective of technology, that was the strategy that it's gonna be this nice technology. But five years ago, nothing was working, TT. And the mine was even making a loss from a financial perspective. But if you look at where it is now and what they have achieved and what it, they've lost a lot, but what is ahead is way much better than what's at the, you know, what has passed.

Because why you've got leadership and teams that are willing to learn, that are willing to persevere, that are willing to grow in conjunction with the technology and the automation. So, it's not that people don't know the benefits, they just want it immediately. And even in your, in your home, right? If you buy something like a fridge or a bed or anything, you don't realize the benefit like from the get-go. It's like a machine tool cut along a lawn mower. That day's where maybe your grass is wet and then it trips.

And then you learn, okay, I mustn't cut my grass with this lawn mower when it's wet. I must wait until it's dry. Or it doesn't like this plug. There's a lot of learning.
There's a lot of things that you need to do before you get to an optimal stage. So they know the benefit. They are just quick to go back. Oh, I mean, they quick to go back when things don't happen.

Interviewer

Yes. As they expected. Yeah. They understood. So, the next question is just... So, I think we already unpacked this maybe in the book. what we discussed about now, but just now, just to make it clear, what do you think is the relationship between the setup of the mind and its ability to absorb new technologies and nature. I think we discussed this to some extent about the culture of the bed, but I just want you to single out those factors that you think are very important in distinguishing. If you look at an organisation, you spend maybe a month with them where you can see, okay, these people, this is where I can introduce technology, and it takes off. What are those attributes or traits that you can see that side have to cultivate? Yeah, you used to help grow technology that any technology that you can want to introduce there. Obviously, number one, I think number one, to start you off, you said like, they need to be in learning culture where people embrace that things are not going to, we're not going to realise things today. We need to grow with this thing and then, yeah, what else is the attributes that you can say?

Participant 5

Yeah, I think what I've learned is if you start with the technology from the get -go, it's much easier to implement. When someone comes to tell them, my boss calls it the bending the ships. So there's no return, there's no going back. Don't activate, don't say there's manual mode and auto mode. It just goes auto mode. Then everybody's on board. The engineers that must fix the operators, the leaderships. If there's no other way, then you have to do it. Because if you look at the endic in the European minds, why did they get it right? Yeah, I think. I went to the mine in where was it? Corona in Finland, right? You find a guy operating like five girls at the same time and he's got a bench press day. He's busy exercising at the same time as he's drilling for some reason. I mean, it's his benefit. He's watching the news. It was really like, you see, why doesn't someone want that? Why do they want to continue to operate in an unsafe environment instead of wanting that? And I think it's because they think that it won't work because they've never seen it. And I remember, I know with some point in them, they once did it. They took the section managers and the technicians, I think, on the trip to see what other people are doing. I was like, maybe we should have taken the operators. Just so they can believe it. Maybe the reason why it's because they don't think they don't believe it will work. you Yeah. Yeah, no. So, yeah, people need to, like, we need to be able to learn.

Number two, from a technical perspective, we need to make sure that the infrastructure and the equipment that we have is completely supportive of that, because you also can't slack from a technical perspective. For example, at Mine z, I mean, we had this set of the art technologies, but what we didn't have is the network backbone to support what we wanted to do. So, when you get to certain areas, you don't have network, so the equipment doesn't work, then people start feeling like, ah, you know.
So, you need to, from a leadership perspective, be as technically prepared as practically possible, equip the mind, accordingly, make sure that the resources are there to support the technology. But very important, if you have the opportunity, never buy a conventional machine, just go straight to auto. So, the transitioning, you know, cost you anyway, more, you know. Cool. I know the transition is crazy.

Interviewer
Okay. I think this one we discussed. Okay. Obviously, in your history of working with technologies now, in your current role, can you just describe for me the challenging situation that you faced in producing a technology at the mine, which was the most challenging? Yeah, I know it's difficult because you have a lot of people and a lot of sides.

Participant 5
I think Armilla remains the most challenging. It just felt like we never going forward. Like you take one step forward, two steps forward. back one step forward two steps back. But the one thing that scared me, there was a time it drilled burnt and it was a reportable. And the first thing the executive said was, why do we have people in autonomous machines? And that answer wasn't for the GM, it was for me. I mean that question wasn't for the GM, it was for me. So basically, the fact that I could have killed someone where the company has spent money to make sure that even in the event that a drill catches fire, there shouldn't be a person in there. So, I think that has remained with me my whole life. And I knew that night I couldn't sleep because I almost killed someone. Because I didn't implement. Yeah, I mean, what was I going to say? Because that was definitely what the message to the family was going to be. Yeah, the manager. There was an opportunity for this person not to be in there, but we have. And if he had died, probably they were going to fire me because what was going to be my reason for not using a block prep? What? Okay, so at the cost of someone. Oh, so more than anything, really, you know, number one technology is as a safety enhancer. It's a complete. And so, it removes humans from the face of danger. Yeah. And besides other benefits, I think for me, that's the biggest benefit. You work in a better environment. I mean, if you think about the conventional drill that we used to use underground, that rock can fall on top of you anytime. You know, and then on surface mines, you remember the time we had an unplanned detonation and there was a drill next to that area.

Yeah. Remember the time we truck a truck bent and it was next to the drill. There was a time where the drill itself caught fire. There was a time when the drill toppled over very since the adhesion. It's like there's so many incidents that I can give an example of way technology could have could have benefited us the most because if you've got a fatality, I mean, oh man.

I mean, even with an HPI, I remember it felt like a fatality. Yeah. No, it does feel like that a little time. just gets a bit scary. Yeah, but like, let's just go back to that. Can you answer that question that they asked you now? Why do you think we don't do that? We don't use the technology as it was intended? Yes, it was intended. Because we think there is a short time, like there's this perception that manual is quicker. You know, we've been doing manual. For me, I feel that there's a lot of incorrect perceptions around technology, and then a strong belief that conventional methods are quicker. And we're not able to absorb the pressure when it comes, when they say, why is this taking long? People will be like, it's because it's an auto mode, then you put a person, then you forget all about the benefits.

And what I've seen also, if you don't have good leadership by in like, for example, like given example of weight. It's not on his KPI. It's not part of his mandate. It's not part of his job. There's no way in his contract that says, right, I want meters, but I want quality meters. No, we just want meters. And that's what he's going to deliver, right? I mean, it's human. Why bother yourself for something that nobody asked you for this? If you bring quality, if you say, I didn't get the meters because I was looking at quality, who asked you for quality? We missed the blast because you want quality. So how we structure the organization is very important. We need to do. And then the other thing that I've noticed is when companies are in trouble, the first thing that they do is the cut spending on technology and the support around it. Like Englod just did now, the biggest department that was affected in TNS was the mine modernization department, and we're doing such great work. But when it's crunch time, that's the first department that they go to. And I've seen that without group, right now, case study mine automation collapsed. And then after a few years, you want to go back and you're confusing the culture. So just that consistency in application, I think will go a very long way.

Interviewer

Yeah, that's the truth actually. I think what you just said now, trickles down is just at a maybe at a higher scale, at a more global scale, but it just captures also what happens in the grounds. If we have an organization where when it hits a fan, they're cutting a lot of budgets and resources towards the technical side of things, like the innovation side, like you can see the cutting, the expenditure on the innovation wing, it just also shows on the ground, on the grounds that that's what they miss they send into the crown.

Participant 5

That's not important. It's not as important. So yeah, I think it's easier for even the side personnel to do that. Like x now I'm sure now he's he said, he says, why should we bother about this? Because they even cut the department that was supporting us. It's really, it's really dating his perception about technology. Yeah, about technology. It's just that thing. You know what? And I feel like Company y was going far, right? It was going very far.

Yeah, I remember. But what does it do? I'll see my set.

Interviewer

Yeah, one of my set years. Just remember, we had a lady from Company y head of his that came present to us and then she was presenting about Mine x was what's the drill? And I was like, wow. And then when I got a chance to go to Mine x, where I get so excited about that, and when I get there, the entire thing has

collapsed. And then, well, it's just like, wow. Cause it's like everyone was just doing, do you perhaps think that, perhaps, what do you think employee 10 over has that on? Obviously, you, you were there when it was introduced, now you're left Government, is someone else in your shoes. Do you think that employee 10 over also affects this? To say that like, we, yeah. We had these people that were doing very well in, in that department, now they've all left, we brought in new people and then we didn't capacity them with the knowledge and the training to do the same thing. We just assumed that, ah, Mine x we did, operation on readiness of Mine x we had done, but those people left and then now, it came new people, like you say, if they coming from Brachtenberg, where they were not exposed to technology, they had their own sort of attitude about technology, now they get to case study Mine.

And we think that we did, or back in 2011, we are fine. So, I think, yeah, something may, what's your take on that, when your employee 10 over, some fact on that?

Participant 5

Actually, I saw it at, at, Vinicia because they were showing me the amount of, automation that we're doing, and then it collapsed in October 2021, I remember very specifically and I asked them, how what happened? And they said, mama left. So, when you have someone driving technology, and that person perhaps does not have enough capacity to create an ecosystem that's sustainable above and beyond when they've gone, then definitely yes, you do have a problem. I've seen that also when they, especially what was like, for example, I don't know if you know x, x was a bit more, more towards the technology as a mind manager, then you get someone like y and z. I mean, yeah, yes, once in a while. It wasn't completely untied, but I think definitely that turn over when you have someone, um, because if you have someone say like, um, right as a section manager, even if the mind managers come and go and she's there when the mind manager comes, he tells them, this is the way we work around here. But if you've got 10 over, you know, you lose a lot of institutional knowledge. Someone, I remember when I was section manager, the reason why I was successful was because of everybody around me and specificity. They'll tell you in this on this year, this is what this is what happened. And this is how we solved it. That's all that history. That history and, you know, I remember there was a time the employees were complaining about pay. the autonomous and then be it was like, no, it's because when we went to auto, we said we're going to make them think. And for something or what was the number but those small things to make sure that this continuity people continue to work without disruption. It's almost like when you run right, you run from zero to 100 meters. But you want to get your goal is 1000 meters and then someone leaves you go back to zero meter. We go back then you start to gain.

I mean, you know, instead of gaining and understanding, OK, you know, there's a curve here when I get here, I must do this. So definitely that has an impact.

Interviewer

Yeah, yeah, it's cool. OK, so now another question. So, you in your current role, you introduce technologies, right? So, what is what is your measures of effectiveness? Like when you introduce technology to what what do you track normally? Like when you. Obviously, the I'm just this obviously hard things and the soft things. The hard things may be maybe a compliance schedule and the sort of things I don't know what might be like. What is your gauge there? What what would you look at to give you an indication that we are going the right direction when we hand over to operations? This is going to be a success.

Participant 5

That's a that's a very important question. For me, I look at now what I look at is the KPIs. Are they are they measurable? But can the normal men on the ground be able to measure? If we say that, for example, drilling is going to improve quality and then how does the operator measure quality? you Ah, I see. Because you keep screaming those things, but the operator can't see it, can't visualize it, can't touch it. So it's hard for them to grasp this thing. What we did when you started going underground, we started to say in simple terms, for the skill level that we're dealing with, quality is for example, if you've planned to drill five holes, and you plan to drill it at one, two, three, four, five, quality is one, drilling the exact number of holes that you said you're going to drill, number two is drilling them where you said you're going to drill them, right? And if you're going to measure it, does the operator wait another day to get a report? By the time it's too late. So what we did is we tried to look at those things that, Someone can be proud of someone can be kept engaged like I was playing five holes.

I draw five holes I was playing five holes at this area in this area and they just draw it there They get the immediate reports. They get a live report on the drill as they're drilling. They are able to correct You equip them you train them to understand that I don't want five holes I don't want five meters. I want five quality meters and This is how you do that and that end of your shift This is how you're able to you know to measure that this is what you've done because I've seen a lot of times where you know, we and it's easy for an operator to know how many like for example How operators used to measure like they would say a bench is 10 meters. I've drilled two holes So two times ten after 20 meters. Is it really 20 you get there? But for them their bonus they are everything their target is based on two holes ten meters whether it's One is short. Yeah, it really isn't So it's back to what I was saying as well to people in senior leadership roles if you're gonna measure him on quality I remember even x We I don't remember if in the contract we had a section of saying all your holes must be within 97% accuracy For them if you say I need 1000 meters and I'm gonna give you 1000 That's what they're looking for.

But if you say I want 1000 meters within a tolerance of 97% Anything below that I said as they penalizing you so you structure your organization To benefit your technology So and eventually if you continue like that after five years it becomes culture It becomes how we do things around here But if someone designs the person who was pushing that and then the new person just pushes meters. It's a problem again We understand Yeah, I think that you said it's very important about the operators understanding what your KBS are but sometimes a lot of times I don't think The KBS that we come up with the guys on the ground can understand that measure them They just hear you talk about them Then you're not doing well. So, if you talk someone that you're not doing well, it's like you if you're maybe Going to school if someone marks you wrong and then they don't doesn't leave your comment for you to understand where you are Pisses me off. Yeah, with interviews will be like, no, you didn't do it. Okay. What did I do wrong? They can't say It's the same thing so I think yeah, it's very important for them to understand the cause Yep so last question Yes, Samai Rebop to in your experience about technology and introducing technology to the operational teams, particularly when it’s difficult, people don't have the, oh yes, all people can have positive attitude to other technology.

Interviewer

So, what is your overall learning on dealing with those teams, like just an overall learning?

Participant 5

I think for me it's understanding why it's easy to start with, yeah, you guys need shoving it down their throats, but I think that's a very wrong approach and you realize as you go on that you actually isolate them more. So firstly, just making them understand, like for you to understand what is their beef with what is their beef with technology, you know, why do they not want it? And you realize that people just have fears. Yeah, yeah. Some real, some not, you know, but you need to come to a common understanding with people, number two, understand what motivates them and what drives them. Is it because what you are introducing is contrary to what they that drives them? And I'll give you an example. If you earn a bonus by the more meters you drill, the more bonus you make, right? For me personally, I plan to say, okay, on top of my salary, I want 10 ,000 bonus. From that bonus, I want to do this, this, this, this, this, this, this, this. Do you understand? That's what motivates me because I want more money. Yep. That's what drives me. And then if I come and I take that away from them to say, no, we're not, we're not giving you meters for money anymore, and then you don't replace it with anything, then they become aggressive. or hostile towards the whole thing and then you ask yourself how what happened you know No, you're taking like you're taking the you taking the bread away You're taking my bread and butter away Anything Most of the people budget with that You will be surprised you will be surprised So that's

what drives them and you as a person need to like already technology leader as you call yourself you need to You need to understand that what drives them So what you're basically saying is you need to find a way to integrate the technology into the into the incentive system Oh, I see. So I'm compensated. Yeah, yeah. Yeah, I think that's one of the things like we I think we expect a lot from these people. So the man just wants to make money for his family again. Yeah, and then you take it away. Then you take it away without saying anything. Without anything. Yep. I think they need to be there needs to be a sort of advice incentive system. To when you like you can choose a transitional one until you register your date. Blend the qualities in there and stuff like that. Yeah.

So, like you see that with the way like you're speaking about x, those guys, like they are nothing but your employee. If a x operational manager, even the regional manager is your employee. The fact that he understands, he understand that if he doesn't do this, he doesn't get this. Yes. And then the same thing I think means to apply to employees. They need to understand that if you don't do this, you don't get this. Then like that tell them, you know, yeah, obviously you need to engage them in time and stuff like that.

Interviewer

Yeah. Yeah. I think that's the end of our interview, ma 'am.

Masters interview 6

Interviewer

Now I started with a good thing, you see. Yeah. Have you started? Yeah. So young guy, this is just a bugging for my master's. So yeah, we spoke about this last year that this time will come for me to interview you. So, it's just a high-level sort of an interview about the autonomous thrilling introduction. You've been involved in this process for the past three or four years. So yeah, there's a background of the problem that Mine x there, they're struggling and then I was asked to do this project before I left. So, I just figured I must continue to do it for my master's. So yeah. No, that's good. That's all good. So, number one, the question number one is just going to be a high level one just for you to state your just academic and experience background.

Participant 6

Yep. So, I must do my academic background. So, okay. So, do I state my names as well? I feel like this one you have to start off by saying this is who I am. Okay. All right. So yeah. So, by trade, I'm a mining engineer studied at Wits from 2014 to 2017 and proceeded on with my master’s as well, which is still, you know, in a similar state as this. current one. So, but yeah, so that's as far as my, my, you know,

academic history goes and, yeah, and terms of experience, work experience, I started at Mine y in 2019. Yes, and I've managed to, you know, to climb, climb, climb up to where I am currently, still at Mine y, but as a Drill Automation Superintendent.

Interviewer

Ah, that's good, young man. And how long have you been working since you graduated?

Participant 6

I suppose it's five for last year, so we're stepping into the 60th year now. Yes, yes. Hey, it's a tough man. He's supposed to, we are supposed to be millionaires now.

Interviewer

Man, that's that was the plan, wasn't it? Yeah, that's cool, young man. So, chop, chop. The next question is going to be, what's this? So, this thing of drilling, English introducing it, you started for the male session, now it's a big thing at the Mine y. They're also going to Botswana there. So, on a high level, if I ask you, why do we need it? Why are we introducing this? So, one of the benefits from your experience, when you tell people, you try to get people to buy in into this, what would you say, why we're doing this? What are the benefits?

Participant 6

Yeah, so I think there is, I like to split it into three. The benefits, the major benefits of automation. Obviously, we know that with this automation project, I'll just call it a project now because it's not fully rolled out into the other sides of Company y. But yeah, I think firstly, we know that as Company y, we are very big on safety. So that's the core value that we live by. And that's the first thing that comes to mind. Or that's the first selling point when it comes to automation. Second being productivity. And the third, obviously, being the cost and the savings basically on the cost. So in terms of your safety, I'd say that obviously, due to the nature of drill automation, being that we are basically taking away operators from the field and taking them into a more controlled environment in terms of the command centre, we are reducing their occupational, if I may put it like that, occupational exposure limits to... Yeah, to environments that are very harsh to humans. And if you're looking at your productivity side, you're looking at having a more stable, sort of like predictable drilling outcomes, which ultimately improves your schedule and your plan, because obviously with that, you can already foresee what, I mean, you can already foretell or to predict exactly what it is that you want to do and where you wanna go, right? And then in terms of accuracy levels as well, I mean, you know that in Mohalla Gwena is, it finds itself in the middle of a lot of communities. So in terms of accuracies that assist a lot in terms of accuracy levels. And

obviously that gives confidence to operate within company set standards because after drilling comes blasting, which when not in control can be detrimental to an operation as a whole. Still within productivity, you get your improved, let's say maybe your improved meantime between failure for your machines because the operation of these machines at that point is completely into the hands of a system and it's away from operator or human intervention. So, we know that with set logics and everything like that, it is more reliable to, I mean, those shooting up the sky because you know that everything is preset, everything is predetermined. Even though there might be some, you know, occurrences here and there where now you have anomalies, but ultimately, we're looking at increasing our liabilities. Right? So, the third one, if we may look at the third one in terms of the cost and the savings thereof, like I said, if you increase your liability of equipment, then obviously you have to realize a lot more life on your consumables. You get to realize a lot more life on your machines, your strings, which is basically where most of our costs or most of our running costs go to.

You know, you get to, yeah, I mean, every movement is determined so you get to have, with automation, you get to have a process where maybe a machine is not operative for some type or whatever, instead of idling or doing some sort of things which would, yeah, which will, you know, otherwise impact your diesel costs or your whatever costs there that gets to be minimized in that manner. So, I think, yeah, I think there would be the three most obviously there might be more benefits to that, but like those are the three most outstanding sort of reasons why I would sell automation to everyone.

Interviewer

Okay, I'm right. So again, you say the benefits are threefold too, but because like a lot of times, this application, a lot of times we struggle with getting the teams to buy in this, because my experience, the teams by was poor. They would just get back to manual when they are frustrated. So do you think we do we're doing enough? in terms of taking the teams on the grounds along about what you just described. Do they know this to the core, why we're introducing these things? In your experience, do we do it already now? Do you think the teams on the ground?

Participant 6

Look, I don't honestly speaking, I don't feel like we like multiple sort of takings on the project or the automation space because firstly, with the automation, remember what we are trying to do. We are trying to minimize, at the end of it or at the core of it, we are trying to increase productivity and part of intervention. In future, we are going to be getting to a point where we are cutting down on the current way of doing things in terms of with operators and stuff. That is the first point that people don't quite understand that.

If we are going forward with automation and we're saying that we're going to have, for instance, two people or a person operating at some stage, three machines, which is our goal, what's going to happen with the other two. The issue of fear of job loss comes to mind. Number two, initially or maybe currently, there are other benefits which come with the way, the manner in which we are currently operating. So people are scared that some of those benefits will basically just, you know, So incentives like that because I mean you do get your we just call it your underground premiums whatever but you know basically being in the pit so if you are saying that we are removing you from the pit in the future we are basically saying that some of those who might not necessarily apply get yes high risk benefits like that so those are some of the things that people are looking at and thirdly I think it's the rollout itself in that we are we are not look we are intentional in rolling it out but there is still that technicality that comes with it you know when you get people that are still old I mean there are old in the industry and a lot really you know in and sync with WhatsApp and Inc currently. So, for instance, if I may take Mine y as an example. So if you are in the command centre, you want to trim it from one machine, I mean from one hole to the next. We obviously, you can either do it by way of waypoints on the system where a machine will trim itself or you can use joysticks, which are basically now more familiar with the younger and newer generation. So, an old person that has been in the industry will not necessarily, because they just know how to operate in the machine with those gears, those levers on the cap. So those are the three most discouraging points for them to say that firstly, it's highly technical and number two, it's taking away some of our benefits and number three, it might lead to job losses. So those are some of the things that make it very difficult for people to buy it. Yeah, to accept the movement if I may put it like that.

Interviewer

Okay, yeah man. That's understood very clearly. So the next one is just to package the important factors to take into account. Like what would you say, what makes or breaks the introduction? Like I don't know, we discussed some other things now, but like now with that knowledge, if you're going forward, what would the things that you want to look at before you introduce this new technology, how would you want to set up your site? Sure. With the latest. With the latest. First of all. Not technically, like I'm just maybe, I'm just going to buy in, but what we just discussed now, how would you get people, those challenges, how would you never get them knowing what you know now before you implement?

Participant 6

Yeah, so I mean, okay, so there's that different, I think in terms of the incentives one is quite an easier one to deal with because as much as as much as you do get a high risk sort of like incentive, you can have, I don't know, something as Yeah, something else to, yeah, in terms of, you know, to, to in place of that

particular incentive. So, I think you can have, I don't know, maybe as you operate, maybe the more machines that you are comfortable operating then, you know, something like that, or some sort of incentive that is going to be not entirely equivalent, but something to, you know, to slot in in that particular incentive space. That's number one. Number two, if we're dealing with them with the What's this? The old people now, this issue of old people are not being too receptive to it, to this thing and thinking that we are going to have job losses. I mean, there are obviously programs that you can come up with as a site to say that this is going to take care of people that are already in their toilet years of the mining career or whatever. Then you know that with these sort of skill sets, you upskill them to say that with these sort of skill sets, even beyond the mining career, they can still be able to do something other than being in the mine. The third and foremost is to basically, sometimes all it takes is making people understand. Because I feel like as much as we know what this could bring to the company or for the company, we sort of do not get that same energy or that same sort of understanding and knowledge down to the people and what this would mean for them. You need to understand people that are solely focused on making it work for themselves, don't necessarily see what maybe five years or six years from now and where the company as a whole wants to navigate to. So trying to show them maybe getting the bigger picture and how this is going to also improve their lives and making them understand that this is not only a business bias decision, it's also sort of like a project or a movement that's also seeking to look out for the both parties that will also enable us to get through to them and also make them feel like they're part of this and feel like they're also going to make a difference. Because I think that is the most important thing. To make people feel included and feel involved in making it a big thing. Because at the end of it all, we don't want people to suffer. We don't want to hurt any people here. And we want to make sure that we are always doing things that are going to improve their lives. So I think that those are a few things that in terms of the disadvantages or maybe the challenges, let me put it like that, the challenges that I told you, we are currently facing in trying to roll out this project. Those are some of the ways that you can address those. And obviously there's more other technical ones that you might want to put in place before you but yeah. Yeah, yeah. And all those things. Yeah.

Interviewer

Okay, I mean, I think the time is up. You're up for another meeting. Yeah, I mean, it's as short as possible. It's fine. Let me see. Yeah, I think I'll you. Are we covered? Most of the things except one question. I don't know if you have time to take it. Okay, let's go. Okay, now you are doing this implementation thing, this project that you're doing like you're doing it.

So, what would be your indicators that things are going well? The confidence during the project phase? What would be your indicators to say when we hand over to operations, this is going to be a success?

Participant 6

Yeah, I mean, obviously, it's like any other comparison study, if I may put it like that, because remember, and the most fortunate part of it all is that we're not starting it out in a sort of thing. So we're running it in parallel with what is currently, yeah, with what is currently or what was previously being used at the operation. So, for me, I need to ensure that we can prove that with this project, we can actually deliver the same value as what has been delivered in the past or do more than what is currently being done with the manually operated machines. So, if you can be able to surpass or maybe meet target on a monthly basis, if you can on all fronts really meet us, your utilization, which is supposed to be obviously, I mean, with utilization, we're not even supposed to negotiate. It needs to be up there because really, everything is just here and as long as the availability is there, then we know that. that we find, right? So the other issue or the other win is also going to be trying to get our mechanics or the people that basically look after the machines. Yeah, competent in trying to understand the functionalities and the way around the system number one and two, the machines and how to respond to whatever ills that they may go through in these machines. So those the availability, we can have those availabilities and also meet target on your production because I mean remember, as much as we are doing this, it's not, we are still in the business of producing. Yeah, so if that can be met and if we can do that and if we can prove that indeed, we have made people's lives firstly safer. And if we can ensure that or we can prove that we've actually made the operation and the manner of operating more easier for our operators, then I think that would be, that would be, that would have basically ticked all the objectives of the project. And yeah, that would have been us handing over and saying that we are capable of running the operation. Number one, the way it's being run and number two, at a much safer and yeah, in a way that can improve people's lives.

Interviewer

That's good, your man. I was in a problem. I think we answered everything. I just tried to put everything together so that you covered most of the things. I think I'm satisfied from my side. Thank you very much for your time. And yeah, now it's time for your meeting

1880