# THE VIRTUAL DICHOTOMY IN MINING: A Leap Forward or a Step Back?

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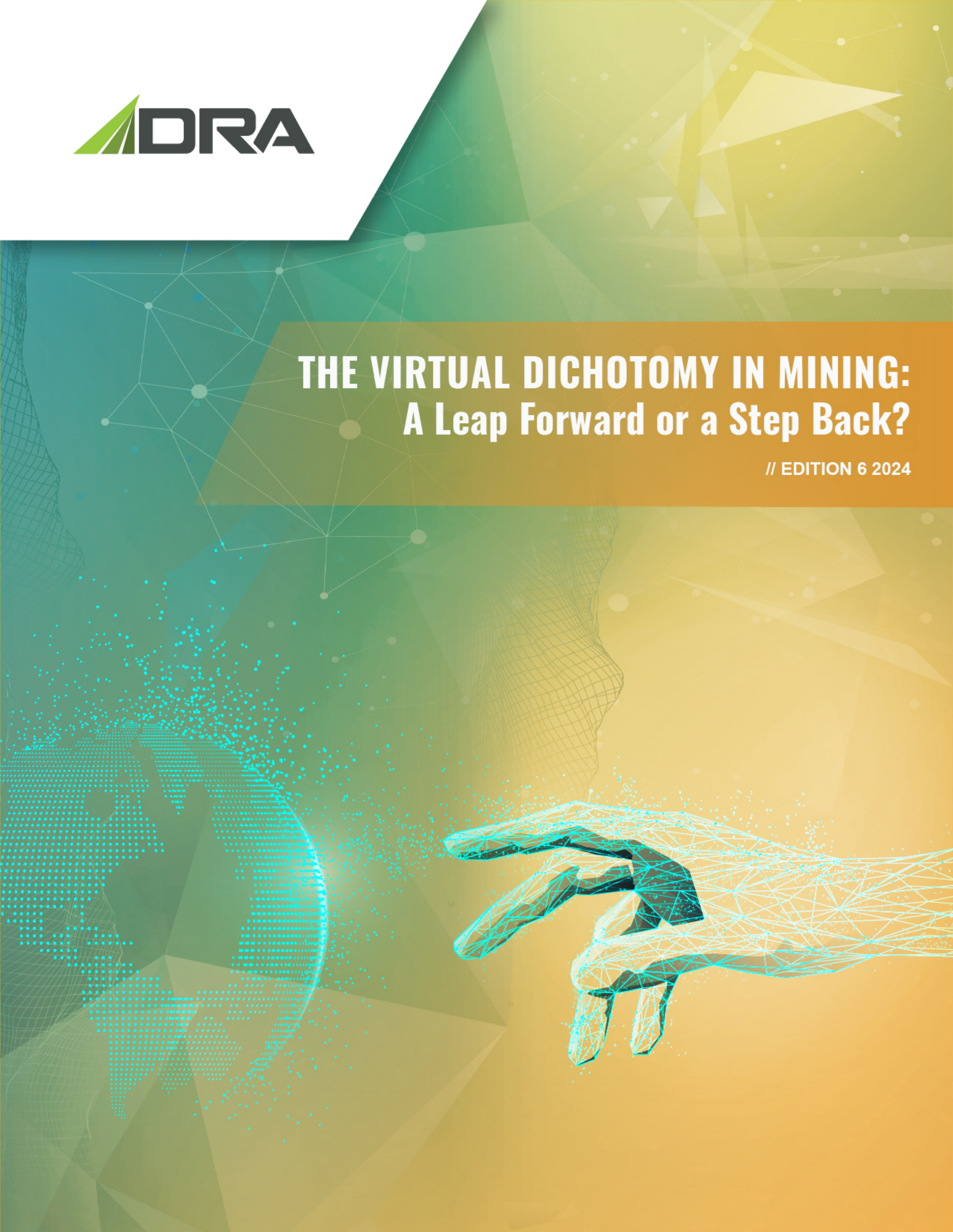


## ABOUT DRA'S FUTURE OF MINING SERIES

The mining industry is one laden with contradictions. On the one hand we must produce faster, smarter and more lucratively than before, and on the other we must consider the environment, sustainability and even the end consumer. Is there a common ground to achieve mutually beneficial outcomes on this unchartered and, often unstable, terrain?

We've seen accelerated strategies in environmental, social and corporate governance (ESG), digitisation and automation since the outbreak of the COVID-19 pandemic. Change has become business as usual and compared to a long history of using the past as our compass, the industry is now looking to the future as a driver of fundamental and sustainable change.

Disruptive technologies continue to shape and reshape our picture of the future. There's no clear or definitive image of what that will look like but we unpack some fundamental elements of what success might look like in our next horizon. Share our journey, as we imagine the workforce of tomorrow, explore socially conscious mines of the future, weigh up the risks, investigate new business models and get real with artificial intelligence.

In DRA's Future of Mining Series, we take a look at the challenges the industry is facing. We leverage the knowledge from our expert team of advisors to highlight some considerations for mining companies and its value chain to navigate the future with confidence. Join us as we step into tomorrow.

# Introduction

As the mining industry, steeped in tradition, collides with the digital age, a pivotal question arises: Is the metaverse a step forward or just an illusion from science fiction stories? The metaverse is a shared online space where the real world and digital world come together. It's a realm where avatars represent users, fostering interactions that transcend the limitations of the physical world. But what does this mean for an industry as ancient as mining?

The metaverse, once a mere concept, now infiltrates mining operations, suggesting a fusion of virtual and physical processes. Could this be the catalyst for redefining the industry's foundational practices? As we navigate the metaverse, we encounter digital twins—virtual replicas that not only mirror but also amplify real-world mining environments. With such advancements, we gain unprecedented oversight and planning capabilities. But at what cost?

Blockchain technology becomes indispensable in this new domain, ensuring the integrity and traceability of each virtual element. We might ask ourselves: is this digital record reliable in keeping our online activities authentic?

This evolution is not merely a step in a new direction; it's a complete overhaul of reality as we know it. The metaverse in mining blurs the lines between the tangible and the virtual, where miners, equipped with virtual reality (VR), can delve into the earth's depths from afar. Machines, guided by blockchain's unwavering rhythm, execute tasks with unerring precision. But will this harmony of technology and tradition enhance the industry, or will it lead to unforeseen complexities?

As we stand at the threshold of this digital frontier, we must challenge the status quo and consider the implications. Will the metaverse and blockchain synergise to forge a new era of efficiency and safety in mining, or will they disrupt the delicate balance of an industry slow to change? This article is not just a reflection on potential futures; it's an invitation to critically examine the role of the metaverse and blockchain in mining's next chapter. What will the future hold for an industry at the crossroads of reality and virtuality?

# A digital revolution or a virtual mirage?

The metaverse, a continuum of virtual and physical realities, offers an exciting vision for the future of mining. It promises to create a digital twin of mine sites, enabling real-time monitoring and control of equipment and personnel[1]. This integration of virtual and physical operations could lead to a comprehensive view of the mine site, improving situational awareness, productivity, and efficiency[1].

The power of Augmented Reality (AR) and Virtual Reality (VR) in mining is staggering. These aren't just tools; they're game-changers, tackling the sector's toughest challenges head-on. Think safety transformed, training reimagined, and operational efficiency skyrocketing. VR isn't just a simulation; it's a risk-free battleground for miners to master emergency maneuvers. AR doesn't just inform; it transforms maintenance and strategic decisions with layers of critical data[2].

Globally, the mining sector has seized these innovations, turning economic and operational hurdles into relics of the past. They're protecting workers in the farthest corners of the earth and rewriting the rules of collaboration and expertise transfer, which are essential in an industry facing a widening skills gap and an aging workforce[2].

The adoption of AR and VR in mining is a global phenomenon, with varying degrees of implementation. In regions with advanced technology infrastructures, such as North America and Australia, mining companies are leading the charge, integrating AR and VR into their operations to drive innovation and maintain a competitive edge[3]. These regions serve as benchmarks for the rest of the world, showcasing the practical applications and benefits of these technologies.

Yet, this revolution has not reached every corner of the globe. In developing nations, where traditional mining still prevails, the leap to AR and VR is met with barriers – infrastructure gaps, financial constraints, and a lack of expertise[4]. Despite these challenges, the potential for AR and VR to revolutionise mining practices in these regions cannot be overstated, offering a path to modernisation and improved safety standards.

## Challenges of implementing the metaverse

The journey towards full integration of the metaverse is laden with obstacles. Establishing a consistent virtual world that is accessible to many users simultaneously is a sophisticated undertaking. It demands meticulous coordination of the metaverse's numerous elements and realms to guarantee its long-term viability[5], elements such as interoperability, scalability, security, user experience, content moderation and economic systems.

Some industries are embracing the metaverse and leveraging its potential, while others face significant challenges. The mining industry must grapple with the significant shift in skillsets necessary to support new digitally driven operating models. Traditional approaches to talent acquisition and development may no longer suffice, and the most sought-after skills may be in short supply[1].

The ethical considerations of introducing the metaverse into mining also warrant attention. The aim is to achieve a fully sustainable mining process that is beneficial to society, optimises resource utilisation, and avoids adverse legacies. Yet, it remains to be seen whether the metaverse can fulfill these ambitious objectives and if the mining industry has the appetite to invest in the sustainable practices, upskilling initiatives, ethical AI, collaborative platforms and training and support needed to advance in this space.

There is also the concern of creating a disconnect between the virtual and the physical. As remote operations become more prevalent, the essence of mining – its connection to the earth and its resources – may become obscured by a layer of digital abstraction.

In this context, the concept of a 'digital twin' becomes pivotal. A digital twin is a virtual model that mirrors a physical object or system. In the mining industry, creating a digital twin of a mine site could revolutionise the way we interact with and manage resources. It would allow for real-time monitoring and adjustments, bridging the gap between the virtual enhancements and the physical operations, and ensuring that the essence of mining remains grounded in reality. This digital counterpart could be the key to harmonising the metaverse's potential with the industry's enduring values.

## The dichotomy of digital twins in mining: a leap forward or a step back?

In the realm of mining, the concept of the digital twin has been heralded as a revolutionary leap forward, promising to usher in an era of unprecedented efficiency and safety. Yet, as with any technological advancement, the journey is not without its pitfalls.

One shining example of digital twin success is Rio Tinto's Autonomous Haulage System. In a groundbreaking trial, Rio Tinto collaborated with Scania to test autonomous mining trucks with a 40-ton payload[7]. This initiative is a testament to the power of digital twins in enhancing operational precision and safety in mining. By simulating and monitoring every aspect of the mining process, from equipment health to ore transportation, digital twins like Rio Tinto's are setting the standard for the industry's future. The mining giant also pioneered the use of digital twins for key assets at their iron ore mines in Australia, resulting in a significant increase in equipment health and haul truck availability[3]. The success of such projects not only showcases the practical benefits of digital twins but also paves the way for their broader adoption across the mining sector.

These successes underscore the potential of digital twins to enhance operational efficiency, improve safety, and optimise resource management. By creating a virtual replica of physical assets, systems, and processes, mining companies can monitor and analyse data in real-time, predict equipment failures, and streamline procedures – failing fast to ensure long-term success.

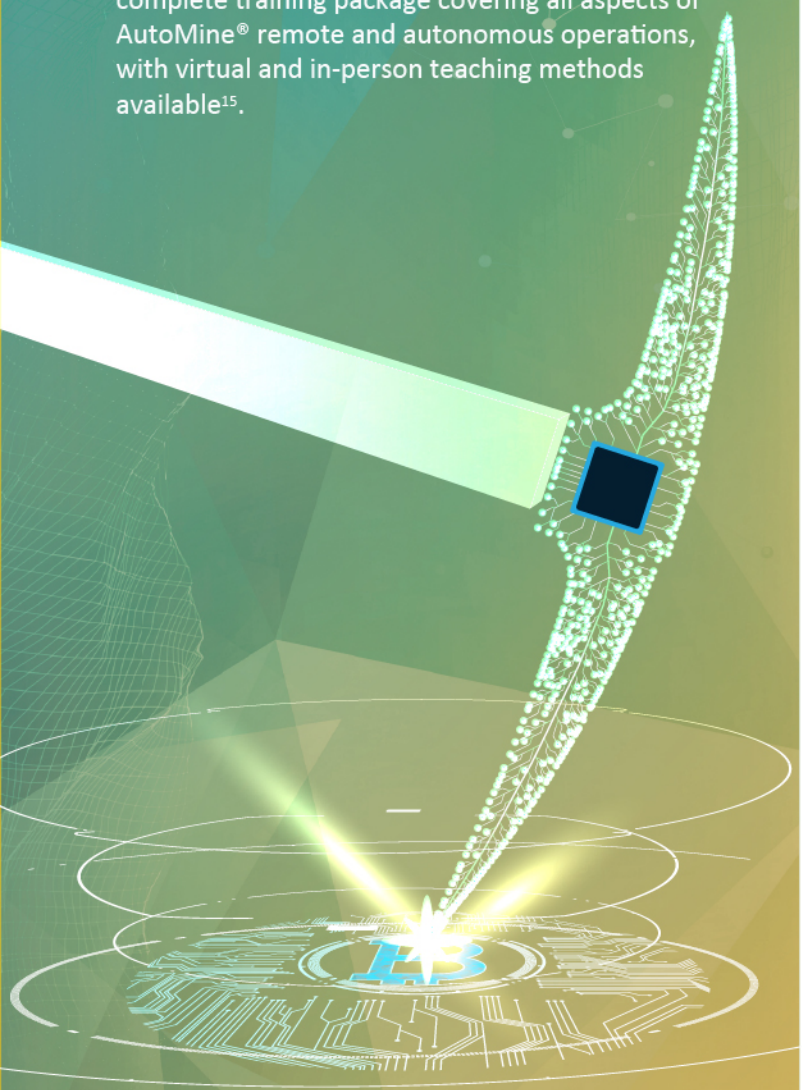
Bridging the gap between the virtual and the physical, digital twins serve as the strategic backbone of mining innovation. They are not just about preventing failures but also about pioneering success in the digital age. As we adopt these virtual models, we set the stage for the next breakthrough in technology, one that extends beyond the simulation capabilities of digital twins and brings the precision of virtual planning into the real-world execution of mining tasks.

Remote control machines represent a quantum leap in mining technology. They embody the transition from passive monitoring to active control, marking a significant stride in the industry's march towards a safer, more efficient future. It is here, in this nexus of digital and physical, that we find the true essence of

modern mining – a harmonious blend of data-driven foresight and hands-on expertise. These machines allow operators to perform tasks from a safe distance, away from the immediate dangers of the mining site. Whether it's excavating, drilling, or transporting materials, remote control technology enables precision and efficiency without compromising on safety. In the face of unstable terrain, blast areas, or high-risk zones of falling debris, remote control machines stand as the first line of defense, ensuring that human lives are safeguarded[8].

The integration of remote control technology in mining operations is a testament to the industry's commitment to safety. Glencore utilises automation technology at its George Fisher Mine (GFM) in Queensland, Australia, with a fleet of new underground loaders as part of an automation project[12]. BHP has installed autonomous drills at its Spence copper mine in Chile and usses autonomous haulage fleets at the Boddington gold mine in Western Australia[12]. By removing laborers from hazardous environments, the risk of accidents is significantly reduced. Yet, these machines require skilled operators who can manage them effectively, ensuring that the human element of intuition and decision-making is not lost in the mechanisation of mining but begs the question of available skills.

The mining industry faces a skills gap due to an aging workforce and historical disinterest. However, the larger challenge is the shortage of new talent to replace retiring workers. In Chile, the world's top copper producer and second-largest lithium miner, more than 34,000 new workers will be needed by 2032[13]. Surprisingly, despite automation, the demand for human capital is expected to rise by over a third in the next nine years[14]. Three-quarters of this demand will be concentrated in five types of specialists, with mechanical maintainers topping the list, followed by mobile equipment operators and fixed equipment operators[14]. Companies have also begun with training initiatives to address this critical shortage. RCT offers courses for Line-of-Sight, Teleremote, and Guidance Automation solutions, tailored to suit both operators and maintenance personnel[15] and Sandvik Automation Learning Solutions is a complete training package covering all aspects of AutoMine® remote and autonomous operations, with virtual and in-person teaching methods available[15].



The adoption of VR and remote control machines is not a matter of choice but a necessity as is embracing change in a traditional industry. The question is not if these technologies will be accepted but how quickly they can be integrated into everyday mining operations and how fast the workforce and be upskilled. While machines may take on the brunt of physical labor, the human element remains irreplaceable. Maintenance of sophisticated VR and remote control equipment will still require human expertise.

VR's potential in high-risk mining environments is profound. By simulating real-world scenarios, VR provides a risk-free platform for training and skill development. It's a realm where miners can hone their abilities to respond to emergencies without the threat of actual harm. For instance, VR can train miners to spot a potentially at-risk situation, such as equipment failure or structural collapse, before it escalates into a disaster. This preemptive approach to crisis management is invaluable in an industry where every second counts.

Moreover, VR can ease the pressure of high-risk training, reducing the resources needed and the time taken to prepare workers for the complexities of mining operations. It offers a cost-effective solution to the industry, slashing training budgets while enhancing the quality of training provided. The immersive nature of VR ensures that miners are not just passively receiving information but are actively engaged in learning, leading to better retention and application of skills.

The integration of VR and remote control machines in high-risk mining environments are more than an upgrade; it's a revolution. These technologies offer a beacon of safety in the inherently dangerous world of mining, providing workers with the tools they need to navigate and manage risks effectively. As the industry moves forward, it must shed its conservative skin and embrace these innovations, for the safety of its workers and the sustainability of its operations hinge on this pivotal transformation.

The nuanced understanding of machinery, the ability to troubleshoot complex issues, and the hands-on repairs are tasks that machines cannot replicate. The future of mining will see a symbiotic relationship between technology and human skill, where each complements the other to create a safer, more productive mining environment.

As mining companies begin to explore this digital horizon of artificial intelligence, robotics and automation driven by analytics, the question of data legitimacy is underscored. Blockchain technology ensures that the data used to create and operate digital twins is secure and reliable. It also allows for the creation of a decentralised marketplace within the metaverse, where virtual mining assets can be bought, sold, or traded.

Blockchain technology is carving out a significant niche in the mining industry, offering a robust framework for enhancing transparency, efficiency, and traceability. It provides an immutable record of transactions, which is crucial for tracking the origin and movement of minerals from the mine to the end consumer. This traceability is essential for verifying the ethical sourcing of minerals and combating illegal mining practices.

Smart contracts automatically execute when certain conditions are met, streamlining operations such as sales agreements, royalty payments, and joint venture operations. Smart contracts minimise the need for intermediaries, reducing delays and disputes.

Blockchain enables the tokenisation of physical assets, including minerals and mining rights. This process allows for fractional ownership and easier transfer of assets, potentially opening up investment in mining to a broader range of investors.

The integration of blockchain in mining offers numerous opportunities, such as enhanced operational efficiency, improved stakeholder trust, and the potential for new business models. The metaverse, supported by blockchain, could also revolutionise training and simulation, making it safer and more cost-effective.

However, challenges remain, including the need for significant investment in technology infrastructure, the requirement for a skilled workforce to manage blockchain systems, and potential resistance from stakeholders accustomed to traditional mining practices. Additionally, regulatory uncertainty around blockchain and digital assets could pose hurdles for widespread adoption.

Blockchain's role in mining and its connection to the metaverse present a landscape rife with opportunities for innovation and growth. Yet, the industry must navigate the challenges of adopting these technologies to fully realise their potential. In parallel, the advent of autonomous mining technologies is revolutionising operational efficiency and safety standards, paving the way for a more automated and intelligent future in the sector.

## Is it the rise of the autonomous mine?

Autonomous mining refers to the use of advanced technologies to operate mining equipment and systems without human intervention. This can include self-driving vehicles, drones, and remote-controlled machinery. The goal is to improve efficiency, safety, and productivity in mining operations by leveraging robotics, AI and the Internet of Things (IoT). The maintenance of autonomous mining equipment will undoubtedly retain a human element. While AI plays a critical role in predictive maintenance, humans are essential for overseeing operations and addressing complex issues that AI cannot resolve. The future will likely see a hybrid model where autonomous systems handle repetitive tasks, and humans focus on higher-level analysis and decision-making.

While technology has advanced significantly, there are still limitations to what autonomous systems can achieve. They may not be able to handle complex, unpredictable situations as effectively as a human operator could. While significant progress has been made, there are still technological gaps that need to be bridged. Current technology cannot fully automate mining operations, and human intervention remains necessary for decision-making and predictions. The industry needs advancements in AI that can handle complex, dynamic environments and make autonomous decisions with the same nuance and understanding as a human operator. Moreover, the integration of IoT and seamless communication between machines is crucial for a fully autonomous operation.

The cost of implementing autonomous systems can be prohibitively high, especially for smaller mining operations. This includes the expense of purchasing new equipment or retrofitting existing machinery with autonomous technology[7].

One of the main concerns is the potential impact on employment. The shift to autonomous mining could lead to job losses, as fewer workers would be needed on-site. This could have a significant social impact, particularly in regions where mining is a major source of employment. The design of a fully autonomous mine requires a diverse set of skills, primarily centered around science, technology, engineering, and mathematics (STEM). The mining industry must cultivate a workforce adept in AI and machine learning (ML), as these technologies are the bedrock of autonomous systems. However, there is a gap in the current skill set, particularly in the specialised knowledge needed to develop, deploy, and support advanced autonomous systems. Industries such as aerospace and defense, which have made significant strides in automation, can serve as a blueprint for the mining sector to accelerate its skill development.

Even with a fully skilled workforce, the use of autonomous technologies in mining raises regulatory and liability issues. Questions arise about accountability when an autonomous system fails and causes accidents[7]. Ethical concerns emerge in situations where human lives are at risk, as machine decision-making may not align with human values, especially during emergencies[7]. Industry resistance to adopting autonomous systems may stem from trust issues or worker fears about job security[7]. Additionally, as mining operations become more connected, they face increased vulnerability to cyber-attacks due to heavy reliance on technology[8]. While autonomous mining can reduce environmental impact, there's a risk that heightened efficiency might intensify mining activities and worsen environmental degradation[9].

Some argue that the best we can do is assisted mining. Assisted mining refers to the use of technology to enhance human capabilities in the mining process. Unlike autonomous mining, which aims to operate without human intervention, assisted mining involves a collaborative approach where humans and machines work together. This method leverages tools like robotics, sensors, and data analytics to support and augment the miners' tasks[10].

Assisted mining allows for human oversight, which can be crucial in complex or unpredictable situations where human experience and decision-making are invaluable[10]. Humans working in tandem with technology can adapt to unforeseen changes or challenges more flexibly than autonomous systems, which may require extensive reprogramming to cope with new scenarios[10]. Additionally, the implementation of assisted mining technologies can be less costly than transitioning to fully autonomous systems, making it a more accessible option for many mining operations[11].

Assisted mining maintains employment opportunities by enhancing the workers' roles rather than replacing them, which can be important for communities dependent on mining jobs[11] and mining companies can introduce assisted mining technologies gradually, allowing for a smoother transition and the opportunity to address issues as they arise[11]. Perhaps assisted mining is the first step forward for the industry?

## Conclusion

Facing the imminent reality of fully automated mining operations, the metaverse emerges as a powerful catalyst for transformation. Its promise lies in revolutionising safety, efficiency, and talent development within the industry. However, this digital frontier also casts shadows – ethical dilemmas, cybersecurity risks, and the need to balance technological progress with human expertise.

Assisted mining, positioned between tradition and full autonomy, offers a pragmatic compromise. By harnessing technology while retaining human oversight, we can navigate the challenges associated with removing humans from the equation. The mining sector's success hinges on effective data utilisation, optimising operational efficiency, safety, and sustainability.

The journey toward fully autonomous mines demands collaboration across disciplines. It's not merely about technology; it's about culture, skills, and industry evolution. As machines and humans collaborate, we shape a safer, more efficient, and sustainable mining future – one that respects our heritage while embracing innovation.

In this metamorphic landscape, the metaverse beckons. Its digital solutions can redefine exploration, planning, and execution. But let us tread carefully, mindful of both promise and peril. The metaverse could be our key to a brighter mining future, casting light into the depths of our industry.

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