4TH DIGITAL TRANSFORMATION IN MINING CONFERENCE 2025

Putting digital technologies to work

Sustainable Mining: Leveraging Multidisciplinary Solutions

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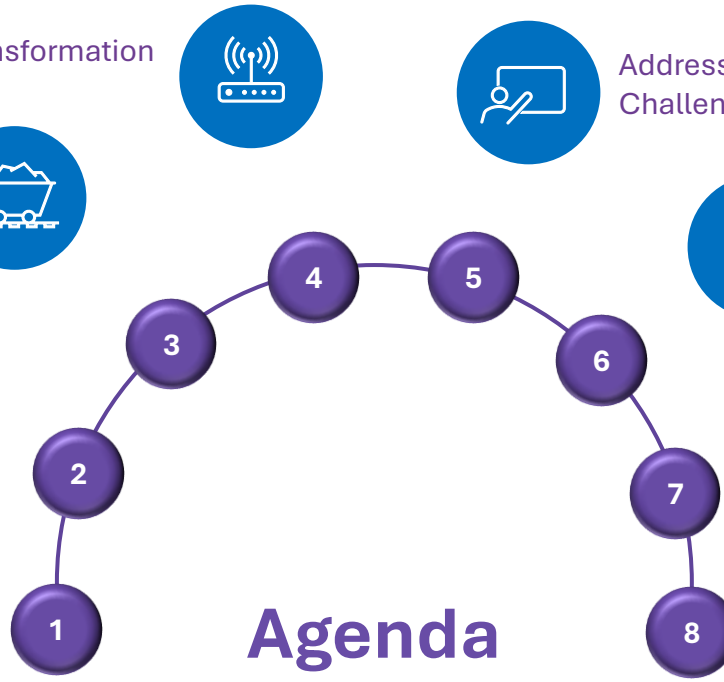

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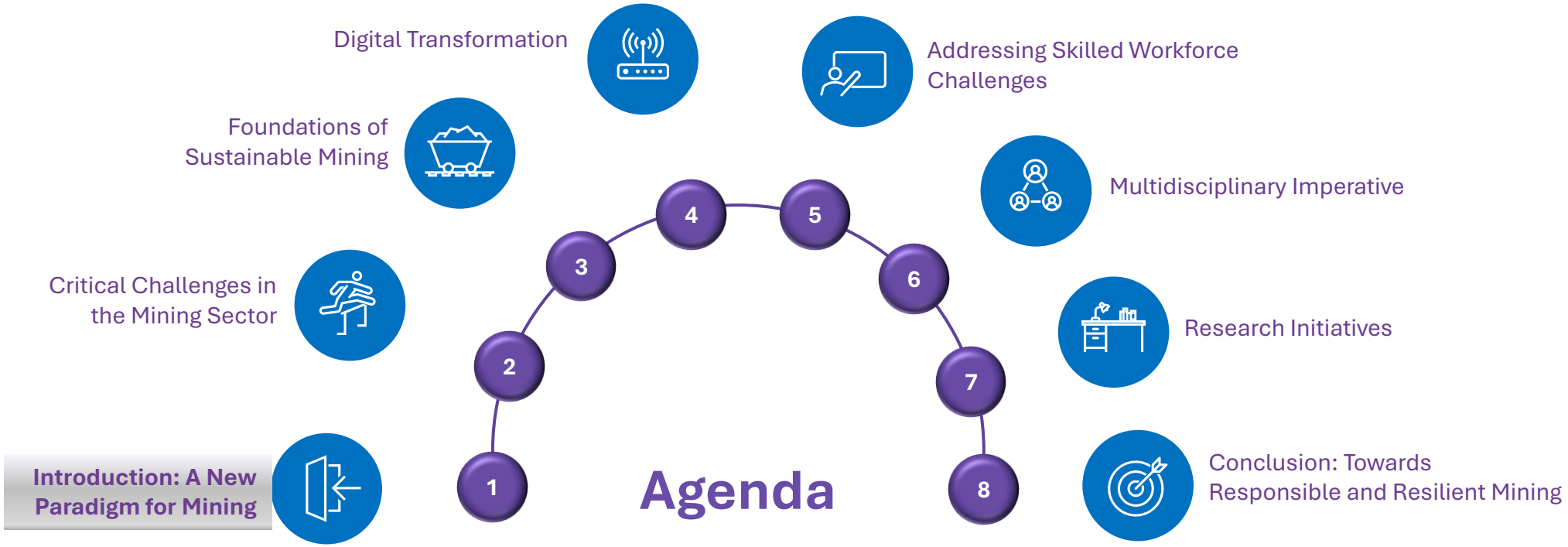
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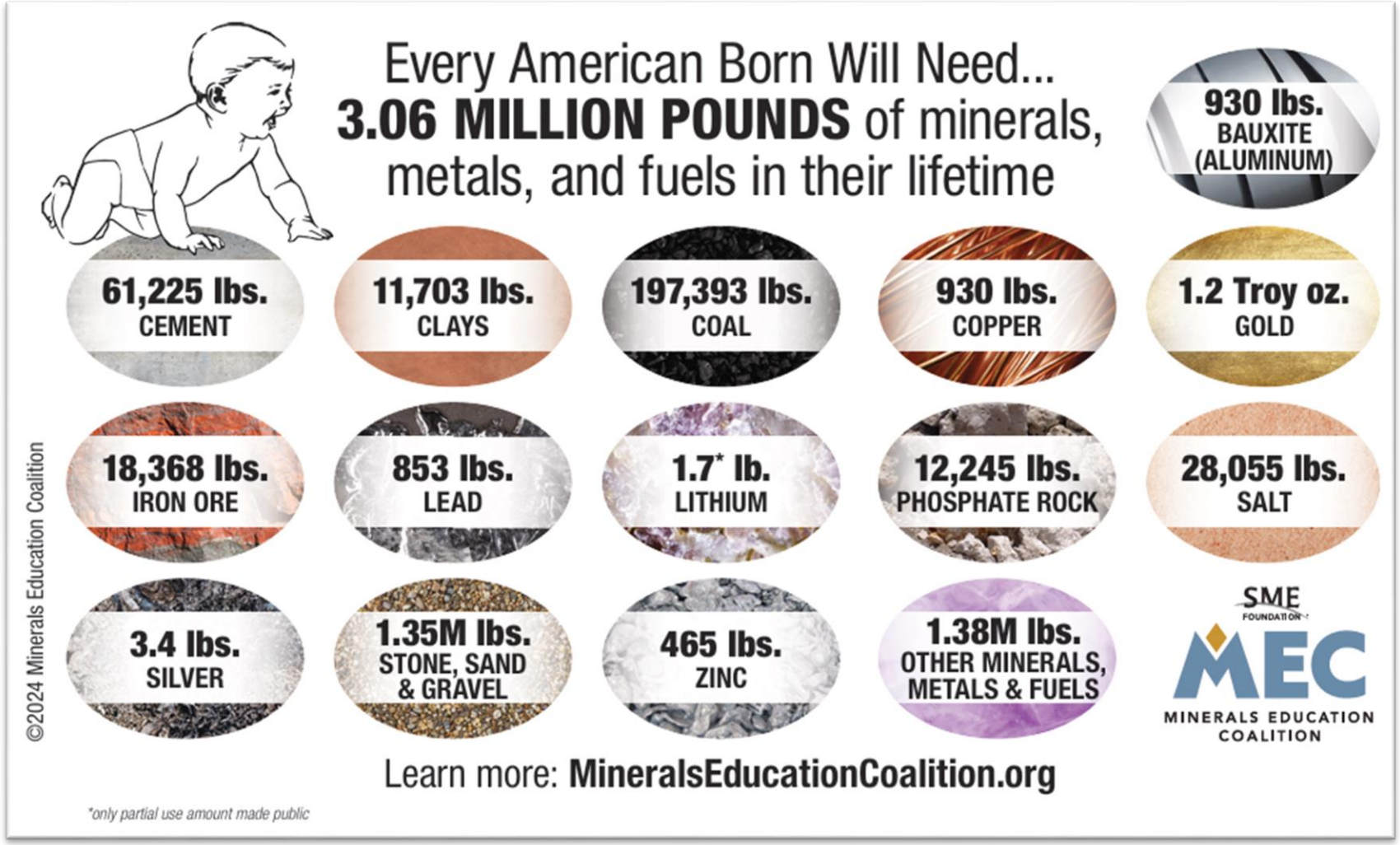
Introduction: The Need for Mining

The MEC Mineral Baby report outlines the estimated quantity of **minerals, metals, and fuels** that an American born this year will consume over their lifetime. In 2024, this figure was projected to be about 1,387 tonnes.

Mining will remain essential in the future just as it has been in the past. However, the specific **minerals that are in critical demand** will continue to evolve.

This trend is clear as the demand for coal, lead, and asbestos decreases, while the need for **rare earth elements and other modern battery materials** rises.



Source

Introduction: A New Paradigm for Mining

Mining directly impacts numerous Sustainable Development Goals (SDGs), particularly the following:

- SDG 6: Clean water and sanitation
- SDG 7: Affordable and clean energy
- SDG 8: Decent work and economic growth
- SDG 9: Industry, innovation and infrastructure
- SDG 12: Responsible consumption and production
- SDG 13: Climate change
- SDG 15: Life on land

United Nations adopted the 2030 Agenda for Sustainable Development

Source

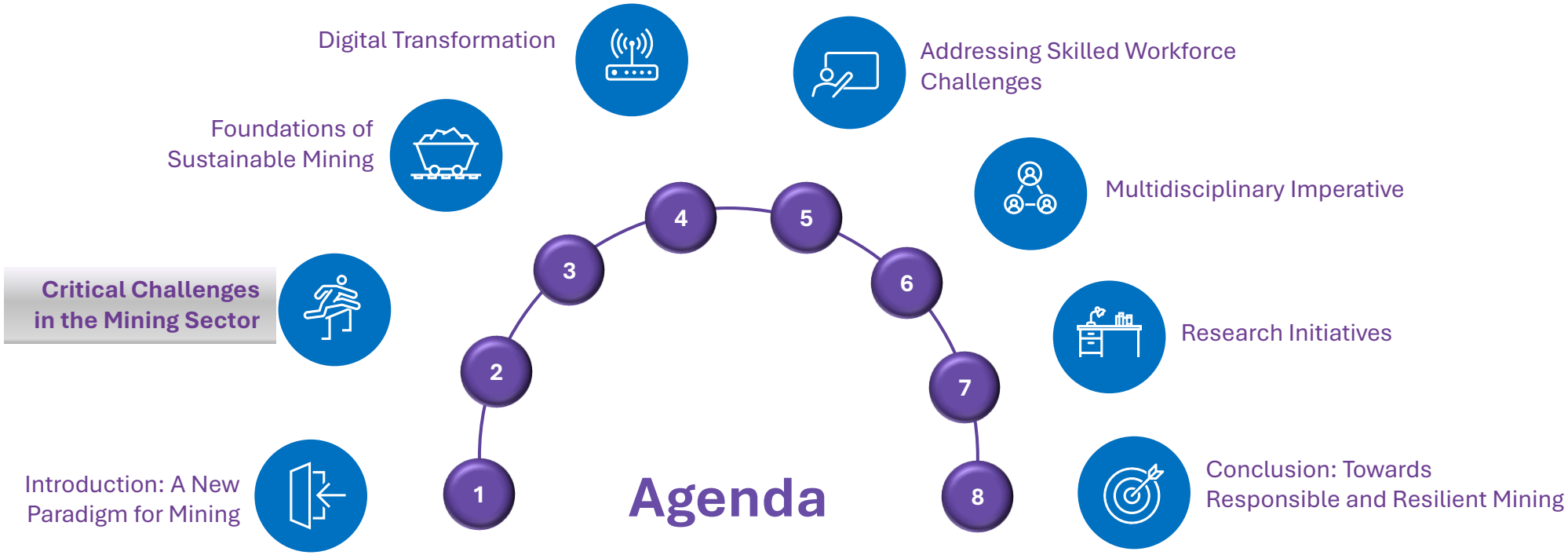
Introduction: A New Paradigm for Mining

The global mining and metals sector faces unprecedented challenges and opportunities.

As demand for critical minerals grows, vital for renewable energy, electric vehicles, and infrastructure, the industry must address environmental, social, and economic pressures.

Embracing forward-thinking strategies, particularly digital transformation and multidisciplinary solutions, is essential for long-term resilience and sustainability.

Responsible, technology-driven mining is not only a matter of ethics but crucial for **supply chain security and maintaining economic viability** in the transition toward a low-carbon economy.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Critical Challenges in the Mining Sector

Before we explore opportunities for innovation and transformation, it is important to acknowledge the critical challenges confronting the mining sector.

Environmental Footprint

Mining's legacy includes significant environmental impacts such as **emissions of greenhouse gases, waste generation, and pollution of air & water resources**.

Skilled Labour Shortage

Digital skills shortage undermines sustainability and competitiveness (IoT, Automation, AI, and data analytics)

Social License to Operate

Maintaining SLO is fundamental for mining business. Issues stem from **displacement, human rights concerns, and conflict with employees and communities**, particularly indigenous people.

Economic Resilience

Economic viability in mining hinges not only on resource extraction, but on the stability of supporting systems – **energy, infrastructure, and governance**.

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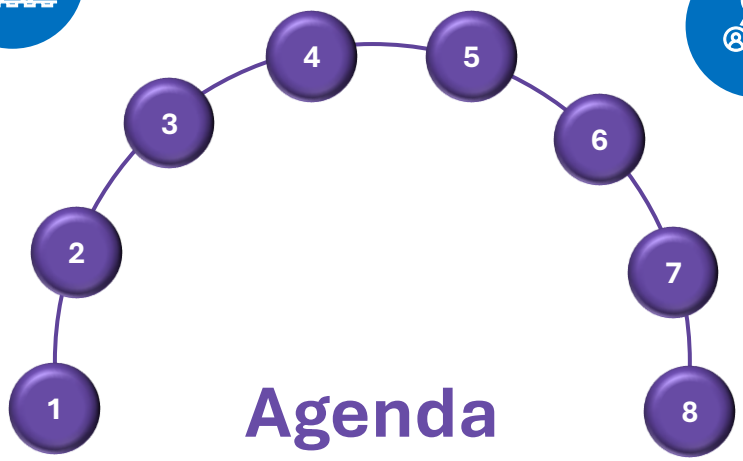

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Foundations of Sustainable Mining

Sustainability: the practice of meeting present needs while safeguarding environmental, social, and economic systems so future generations can thrive.

It requires balancing resource use with long-term stewardship, ensuring progress today does not come at tomorrow's expense.

Sustainable mining refers to **responsible resource extraction** that minimises environmental impact, promotes social equity, and ensures economic viability.

By integrating eco-friendly technologies and practices, the sector can mitigate these negative environmental effects, preserve biodiversity, and ensure responsible resource management for future generations.

Prioritise social responsibility by engaging local communities, ensuring fair labour practices and promoting transparency.

This will foster trust, mitigate conflicts, and supports the social fabric.

Prioritise long-term economic viability by reducing environmental impacts and promoting resource efficiency.

By integrating innovative technologies and practices to enhance productivity, reduce costs, improve safety, and ensure stable supply of minerals.

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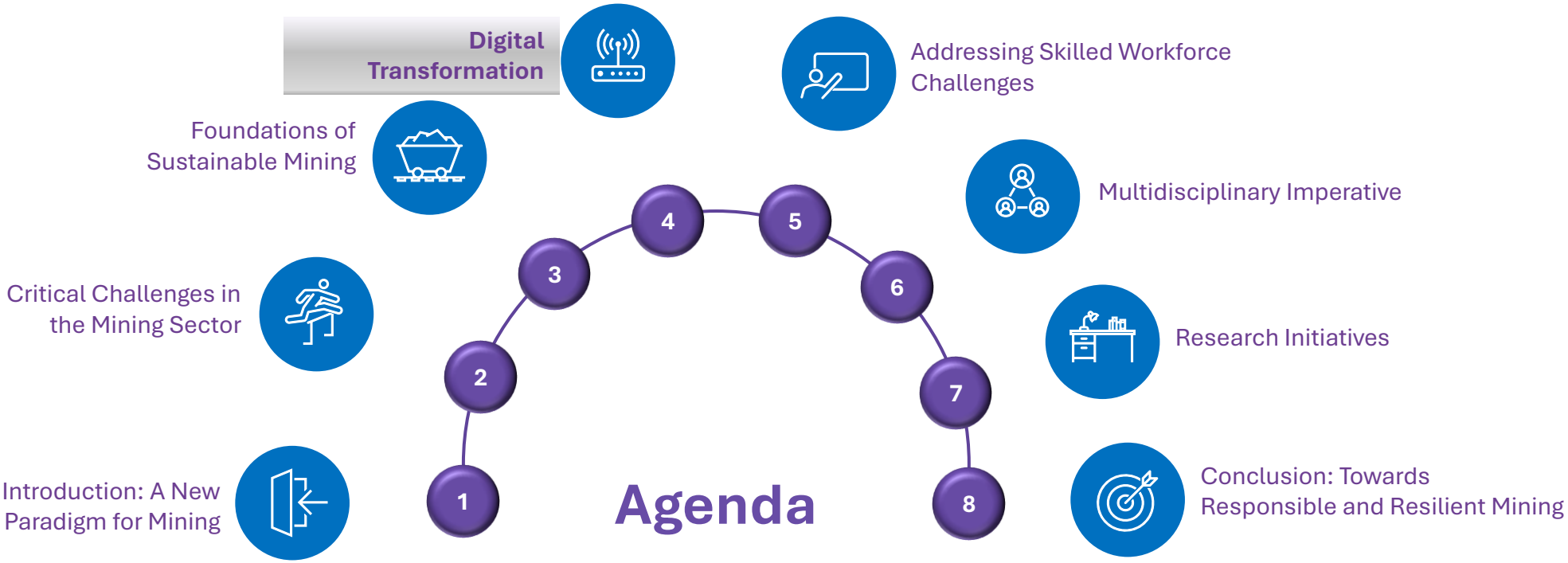
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Digital Transformation

Intelligent mining systems enhance worker safety, environmental stewardship, and operational performance by integrating the mining value chain with technologies such as IoT sensors, wearable devices, cloud computing, and other digital tools.

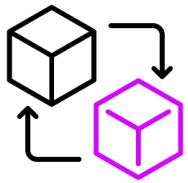
Digital technologies are revolutionising mining by integrating real-time data, automation, AI, and virtual modelling. These enable proactive safety measures, resource optimisation, and transparent supply chains.

- Real-world benefits include reduction in environmental incidents, improved worker safety, lower emissions, and more efficient use of water and energy.
- The true power of digilitisation lies in the compatibility of technologies, transforming mining from a reactive to a predictive and preventative industry, with quantifiable gains in productivity, safety, and sustainability.

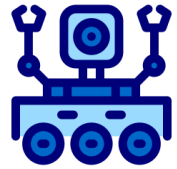
Key Digital Technologies

Internet of Things

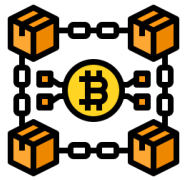
Artificial Intelligence



Digital Twin



Autonomous Systems & Robotics



Blockchain

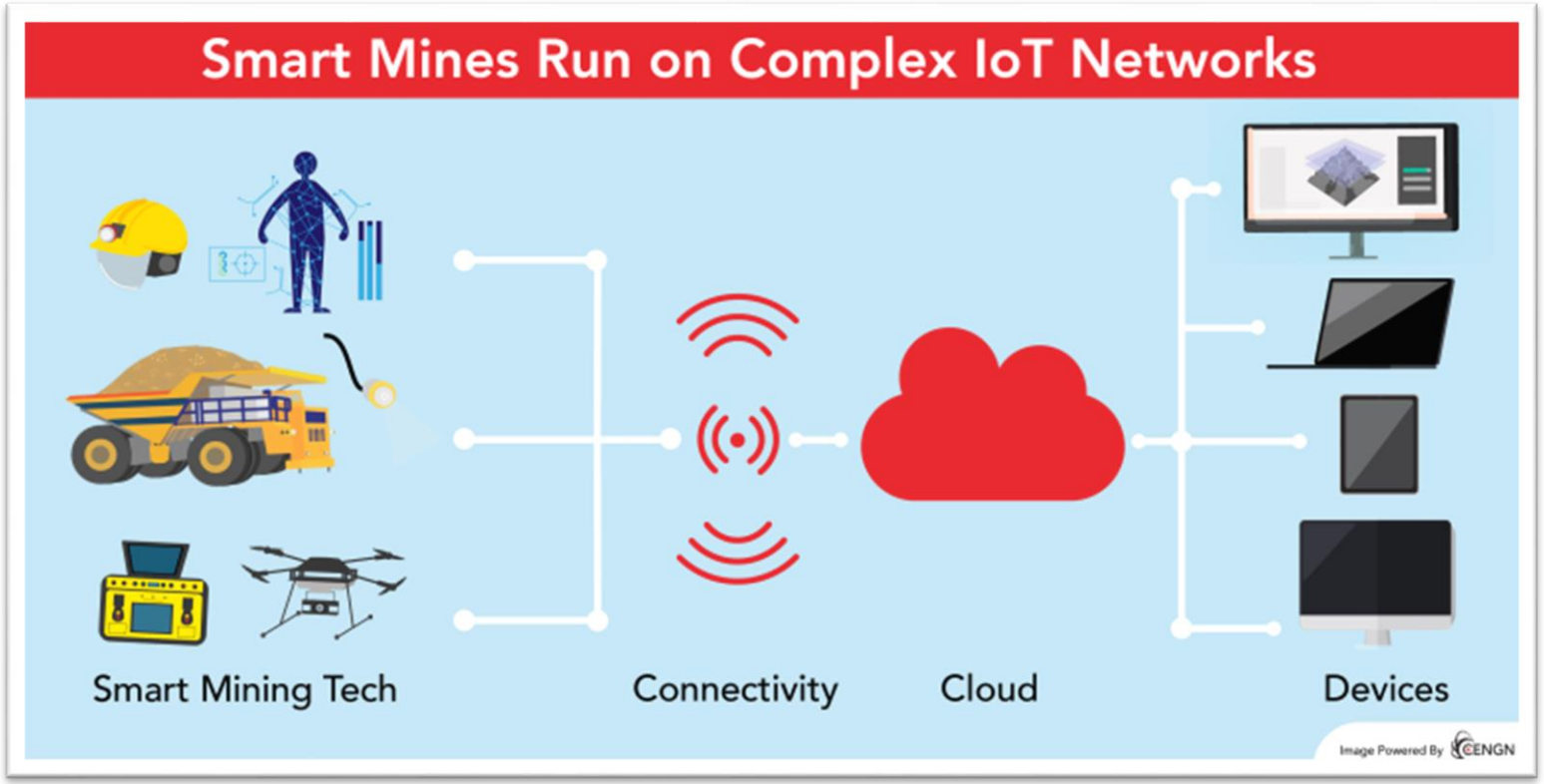
Digital Transformation: IoT

- IoT is revolutionising mining by using connected sensors and systems to collect and analyse data for smarter, more efficient operations.

- Some application areas:
  - Operations management
  - Worker safety
  - Asset management
  - Logistics and transportation

- IoT devices enable real-time monitoring of equipment, and safety parameters, which can reduce environmental incidents by up to 44% and enable predictive interventions.

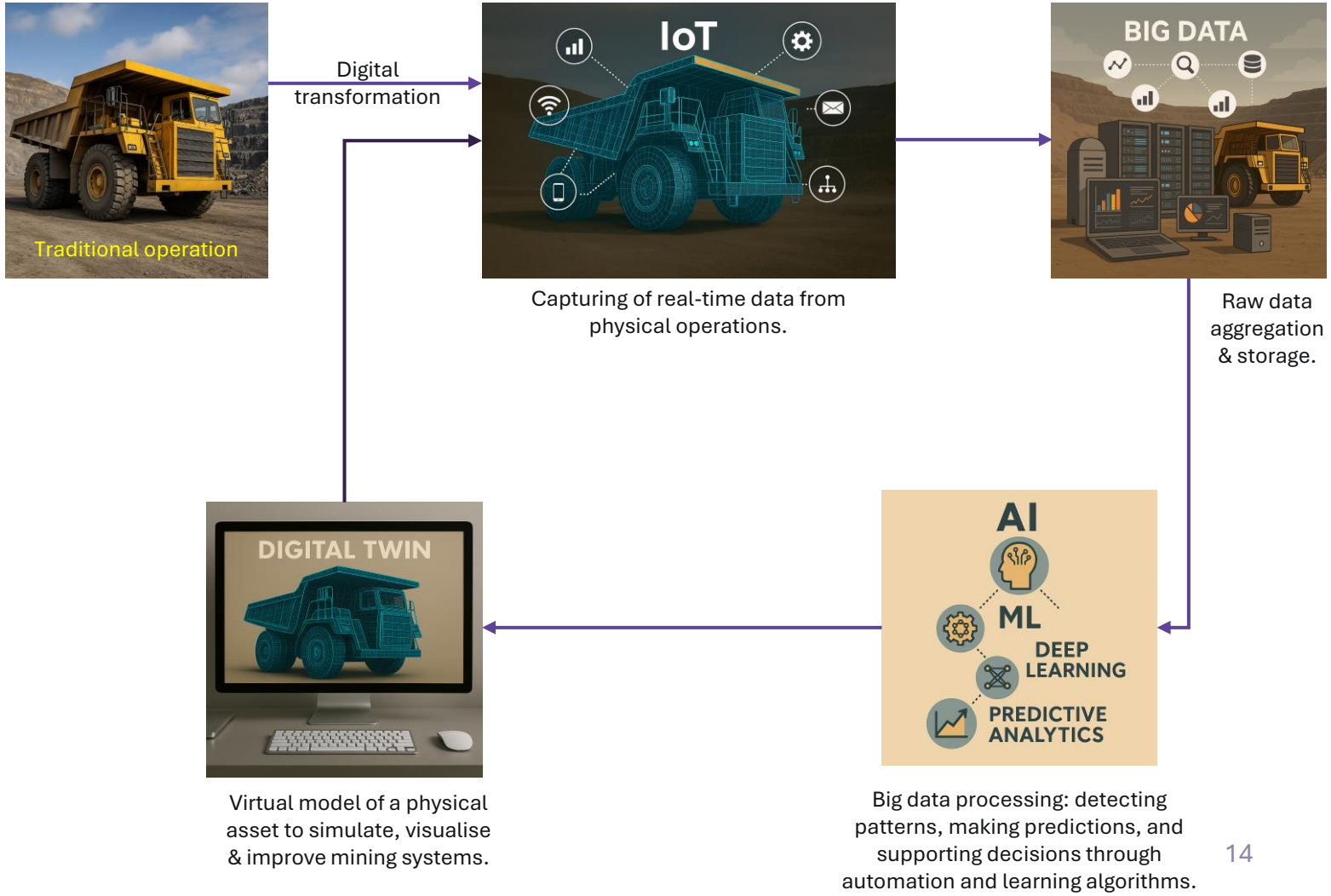
- Real-time analytics turn data into actionable insights, minimising risks and improving efficiency.



Digital Transformation: AI & Digital Twin

From real-time sensing to intelligent prediction: how digital technologies converge to optimise mining operations.

- AI optimises extraction, ore sorting, and energy use, increasing resource yield by 20-30% and reducing costs.
- Digital twins (virtual models of assets) allow **scenario testing**, **predictive maintenance**, and support strategic decision-making that optimises safety, costs, and ecological impacts.



Digital Transformation: Autonomous Systems & Robotics

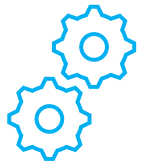
- Self-driving **trucks**, robotic **drill rigs**, and **drone**-based monitoring and surveying redefine safety by removing workers from hazardous activities, reducing injury rates and increasing productivity.

- Precision automation also reduces waste and emissions.

Screenshot from “Simulated Coordination of Autonomous Mine Vehicles” (Neya Systems)

Digital Transformation: Blockchain

- Blockchain is used t secure traceability across the mineral supply chain.
- It ensures authenticity, ESG compliance, and transparency.
- Reduces fraud and building stakeholder trust.



Transparent Supplier Management

A complete transaction record ensures openness and accountability throughout the bidding process.

Fraud Detection

Unauthorised entries are identified by missing or invalid hash values, ensuring the authenticity of every transaction **(Once info is entered, it cannot be deleted/altered).**

Automated Smart Contracts

Smart contracts are self-executing programs stored on a blockchain that **automatically enforce terms once predefined conditions are met.**

End-to-end Supply Chain Visibility

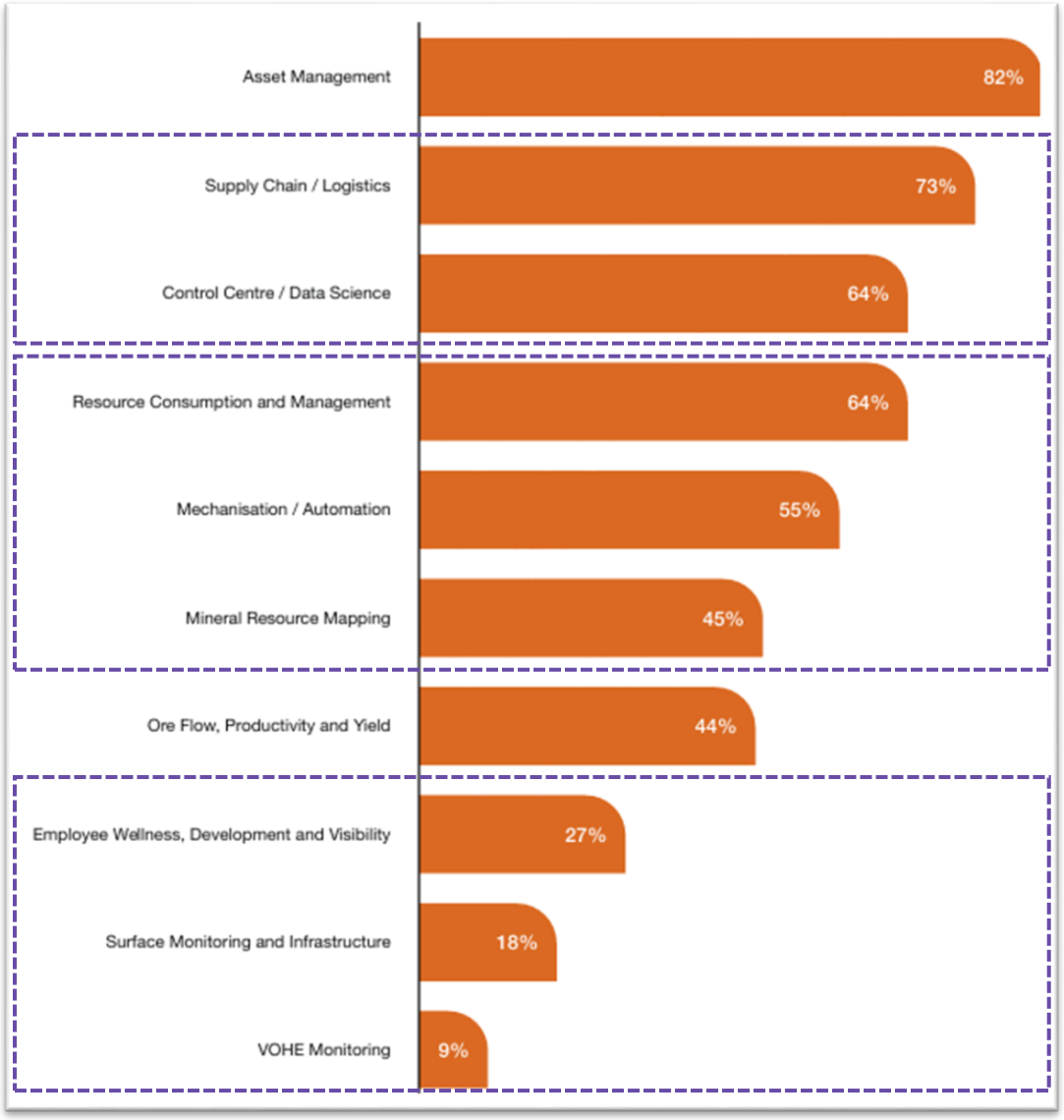
Traceability enables organisations to **monitor the journey of goods** from raw materials to final delivery.

Ledger Assurance

A distributed ledger provides a **tamper-proof, transparent record of all transactions**, enabling multiple parties to independently verify data.

Digital Transformation: Applications

Figure 3: What are the dominant value drivers that are being measured?



Operation coordination and data-driven decision-making.

Emphasis on efficiency and technological integration.

Potential underinvestment in people and environmental monitoring.

PwC, 2023

Figure 5: To what extent have you implemented the following technologies within your company?

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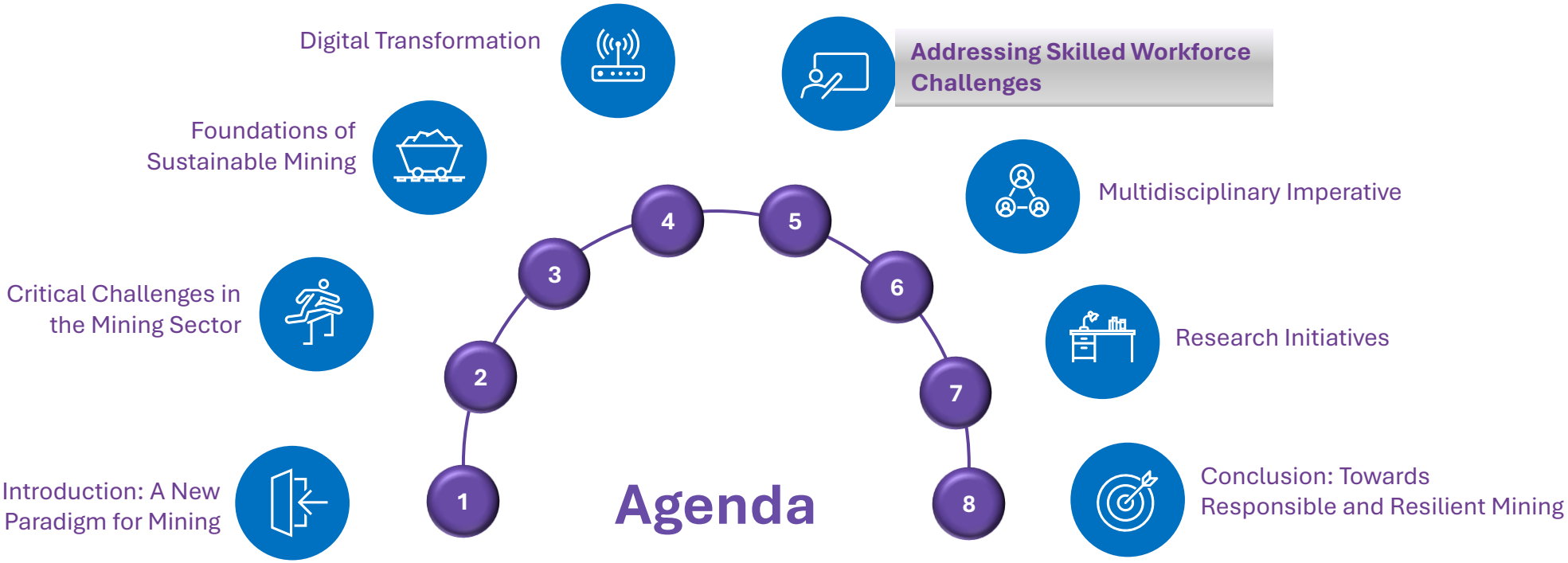
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Addressing Skilled Workforce Challenges

Upskilling & Reskilling

Internal training
New digital skills and refine existing ones.

Collaboration with academia
Develop customised curricula focused on data analytics, automation, IoT, etc.

Digital literacy initiatives
Build foundational digital skills across all levels of the workforce.

Focus on STEM education
Strengthening STEM subjects at primary and secondary school levels.

Human-centric Approach to 4IR

Employee engagement
Involving employees in the digital transformation journey .

Adaptation to change
Guide workers through technological transitions, minimising disruption and maximising adoption.

Just transition frameworks
Develop policies and initiatives that ensure a fair transition for workers impacted by automation.

Strategic Partnerships & Investment

Government-industry collaboration
Address skills shortages, improve educational quality, and ensure regulatory alignment for digital transformation.

Investment in digital infrastructure
Robust IT/OT systems and connectivity to support advanced digital technologies.

Leveraging technology for training
Use VR & AR for immersive and interactive training experiences

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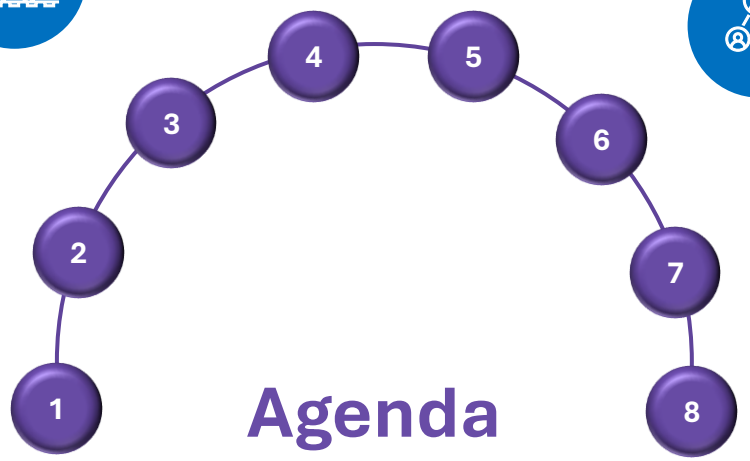

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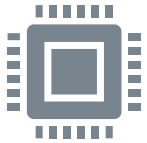
Multidisciplinary Imperative

Successful digital transformation in mining requires a holistic & structured approach. It is not just about technology; it is about integrating strategy, operations, and people.

Multidisciplinary solutions are essential for addressing the **interconnected challenges** facing mining industry.



Collaboration among **engineers, scientists, social scientists, health practitioners, community representatives**, etc., fosters innovation and holistic problem-solving.

Integrating diverse perspectives and knowledge bases ensures that **solutions are tailored to local contexts and address the needs of the stakeholders**.

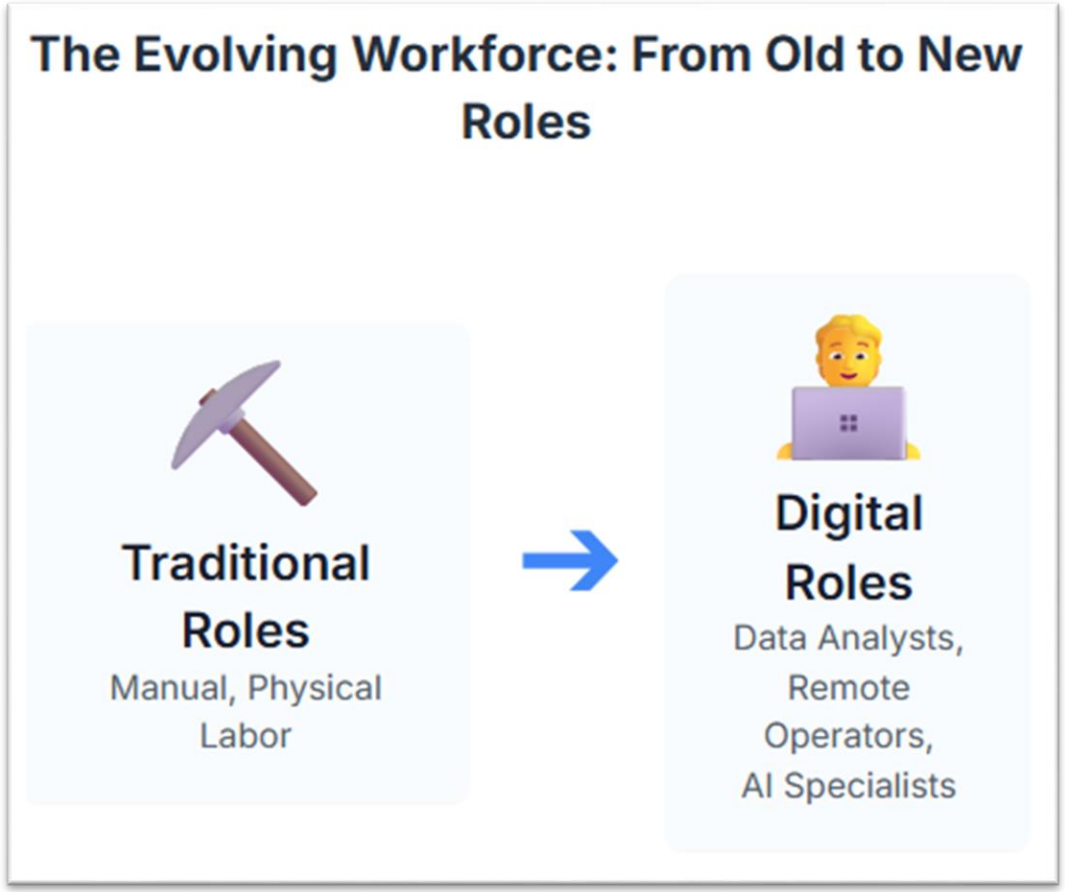
Promoting cross-disciplinary research and development **accelerates the development of innovative technologies and sustainable practices**.

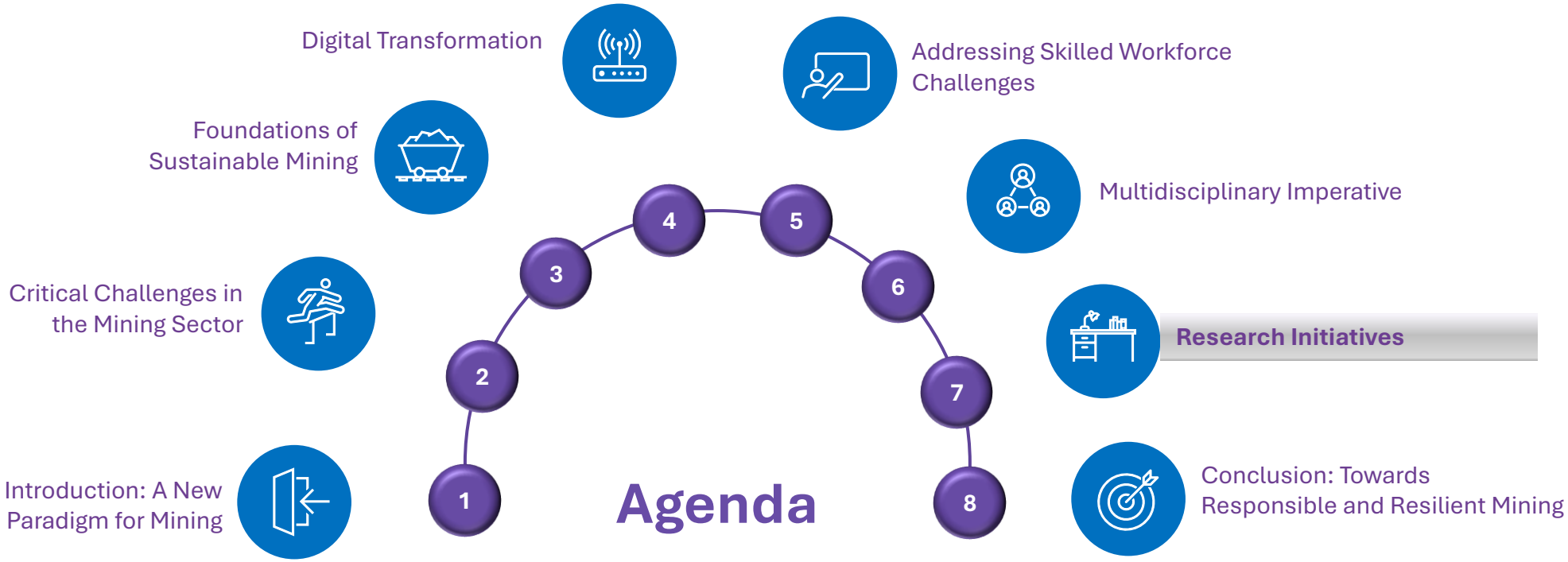
Investing in education and training programmes that promote multidisciplanry thinking and collaboration **equips the workforce with the necessary skills**.

Multidisciplinary Imperative

Digital transformation core

- Achieving successful digital transformation in the mining industry, is not just a technology shift. Its demands a **holistic and integrated approach**, uniting diverse expertise across disciplines.
- Multidisciplinary teams foster holistic assessments and innovative solutions, enhancing resilience, and reducing unintended consequences.
- As technology becomes more embedded, the **required skill set in mining will shift** accordingly.
- Miners and data scientists contribute distinct expertise – effective collaboration hinges on **mutual domain understanding**.

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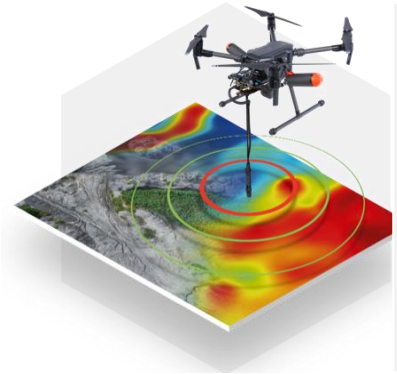
Research Initiatives: Intelligent Systems for Sustainable Mining

Digital technologies, automation, and artificial intelligence (AI) are transforming various aspects of mining, leading to **improved resource efficiency, enhanced safety, and reduced environmental impact**.



UAVs in Exploration: Utilise drones equipped with sensors to conduct geophysical surveys, capturing high-resolution data efficiently and with minimal environmental disruption and reduced time and costs.

UAVs in Survey and Mapping: Drones can capture high-resolution images and topographical data over vast, hard-to-reach areas, providing more accurate geological mapping (e.g., open pits, tailings dams, waste dumps, water courses, etc.).

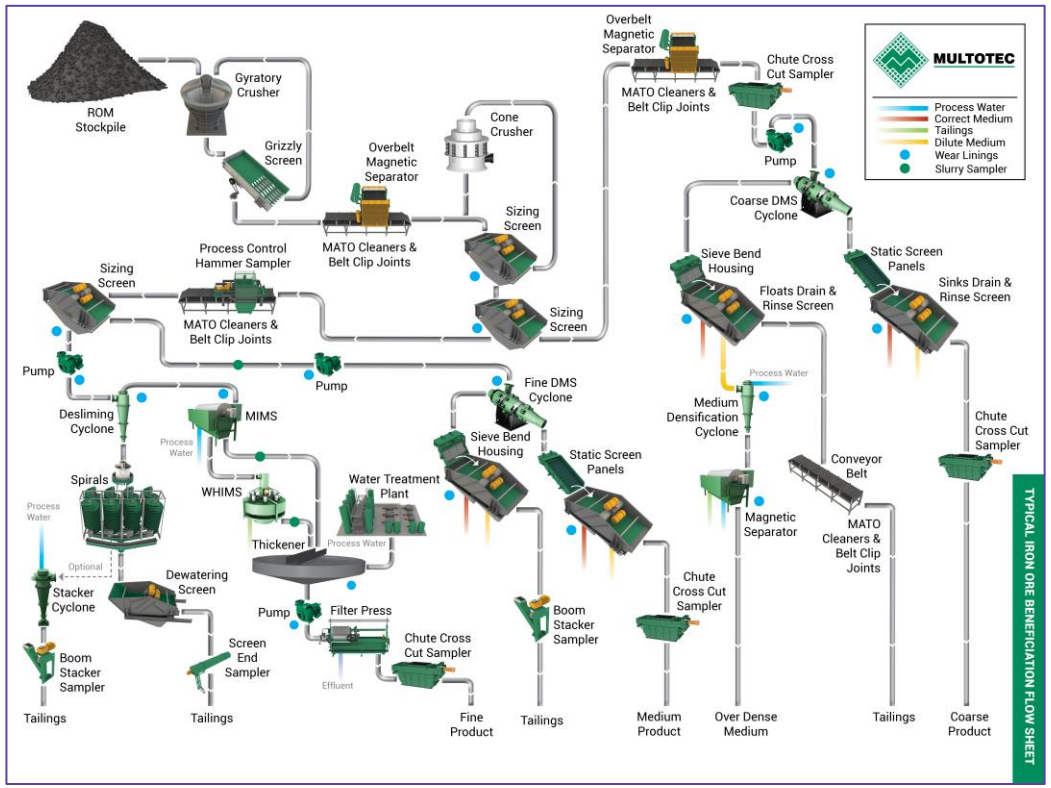
Traffic Management and Dispatching: Develop advanced fleet management systems that enable efficient traffic management and dispatching, integrating real-time collision avoidance to maximise productivity and safety.

Condition-Based Maintenance (CBM): Maintenance is performed based on the real-time condition of equipment or machinery**.** Prevent unexpected failures and reduce operation interruptions and costs by performing maintenance when it is needed, rather than on a fixed schedule.

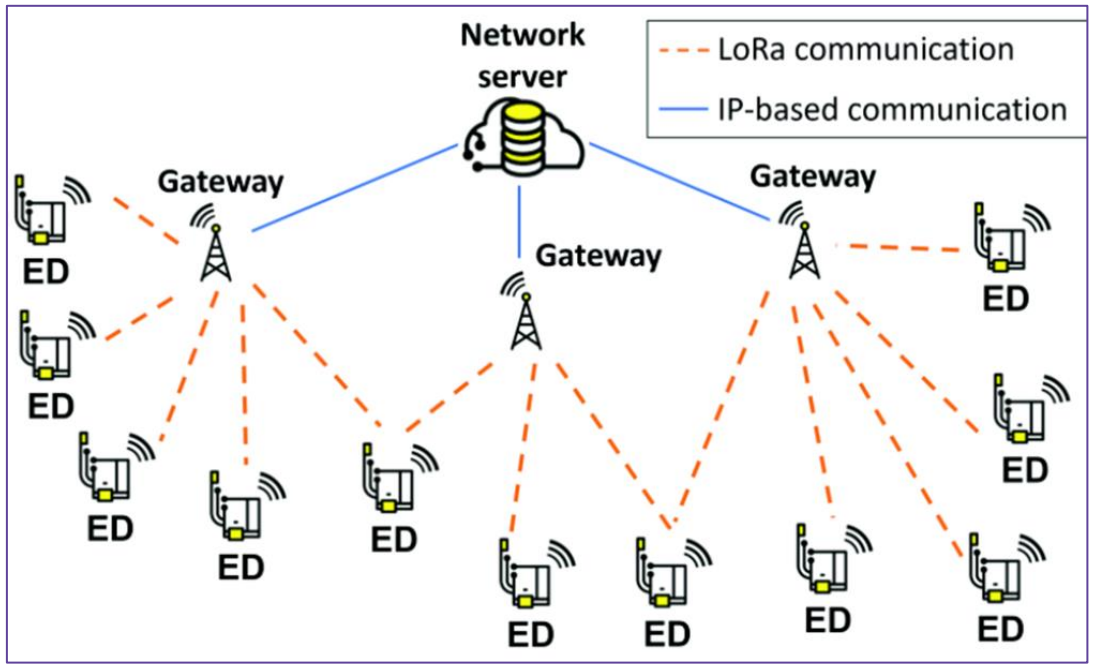
Predictive Maintenance (PdM): Uses advanced data analytics, machine learning, and predictive modeling to forecast when equipment is likely to fail. Predict potential failures before they happen, allowing for proactive maintenance scheduling and planning.

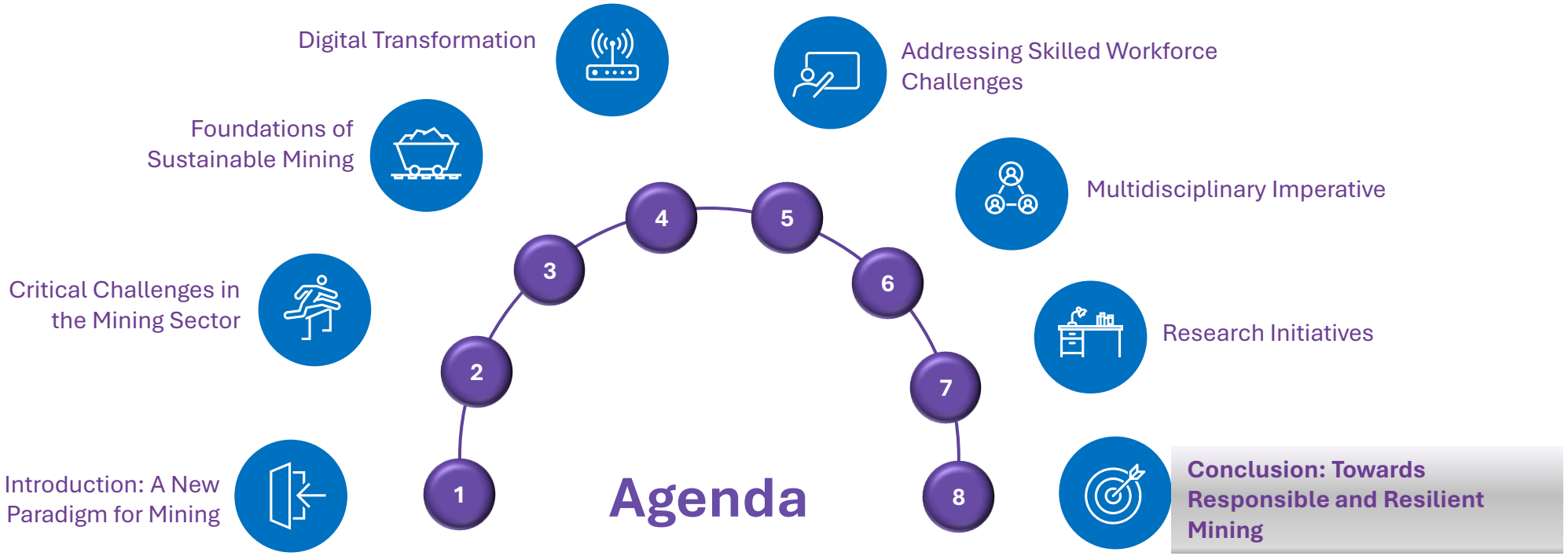
Research Initiatives: Intelligent Systems for Sustainable Mining

Control of Mineral Extraction Processes: Use AI and ML solution to dynamically adjust mineral extraction processes based on ore richness, minimising chemical agent usage for optimal output and cost savings.



Long-range (LoRa) Technology: LoRa technology is promising to provide reliable communication in mining environments due to its long-range, low-power, and deep-penetration characteristics (e.g., u/g sensors).

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Conclusion: Towards Responsible and Resilient Mining

Sustainable mining is achievable and vital for global climate goals.

Continuous investment in **digital infrastructure, workforce development, and collaborative culture positions mining** as a key enabler of a sustainable, low-carbon future – elevating its role from a climate problem to an essential partner on global development and decarbonisation.

By strategically integrating digital transformation with multidisciplinary collaboration, the mining industry not only reduces environmental and social impacts but also **secures economic and operational advantages**.

At its core, digital transformation is driven by people – not by technology itself. Success depends on how individuals adopt, adapt to, and innovate with digital tools to create real value.

Enkosi, Hi khensa, Thank you, Re a leboga, Siyabonga, Dankie, Siyathokoza, Ro livhuwa!