

ANNUAL REPORT

20/21



mining3



Celebrating 30 years of transforming mining

A 30th anniversary special edition of the CMTE Development Ltd Annual report

Mining3 is a world-leading research organisation, directed by its global mining industry members to develop and deliver transformational technology to improve the productivity, sustainability, and safety of the mining industry.



WE ARE

mining3



Annual Report FY 20-21

A review of CMTE Development Ltd's operations in the 2020/2021 financial year.

Mining3 (CMTE Dev Ltd.) was established and supported under the Australian Government's Cooperative Research Centre's Program in 1991. It brought together, for the first time, Australian and international leading mining organisations in a cooperative effort to develop innovative mining and processing techniques as well as supporting equipment for the industry.

Today, it is a world leading, entirely industry funded not-for-profit organisation focussed on delivering novel solutions to the mining industry's leading issues. 2021 marks our 30th year of operations and with this we celebrate our past successes and our vision of the future.

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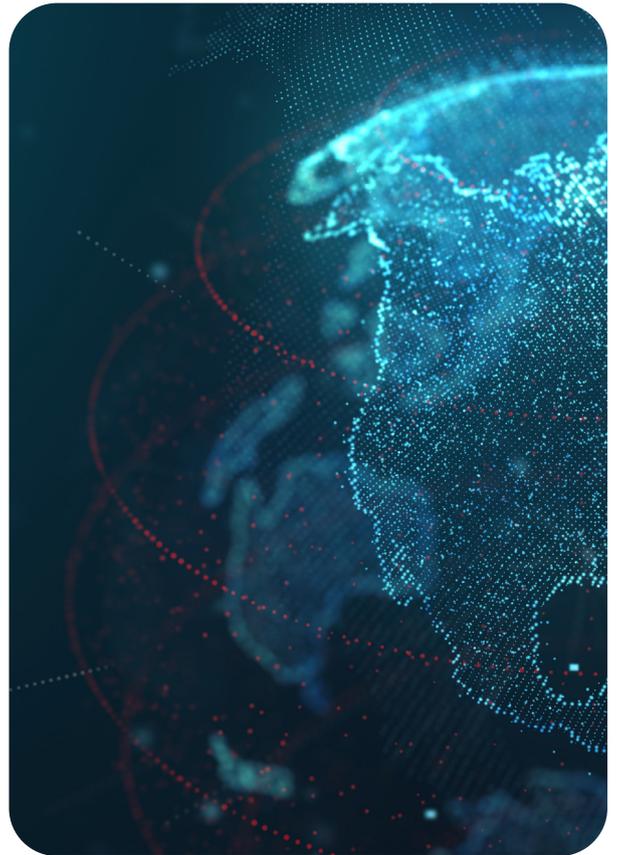
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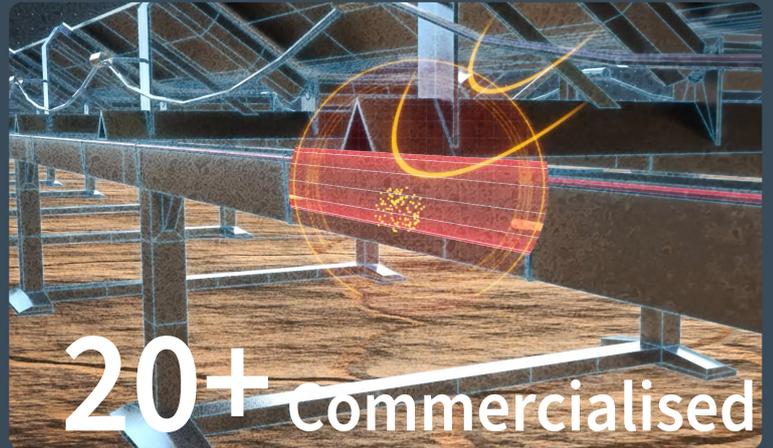


OVERVIEW

Mining3 at a glance



100+
Patents



20+ Commercialised
Technologies



8 Spin-off
companies



1000+
Technical Papers

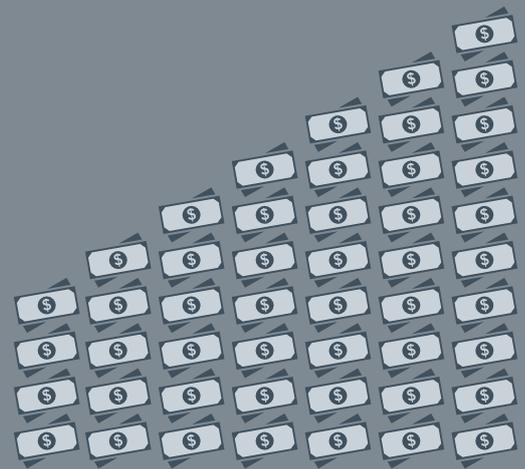


Consistently industry
funded / supported
for **30 years**



Research contributions
saved the mining
industry over

\$1B



Collaborated with over
60 organisations

\$14M
re-invested into
SEED research since
2014



OVERVIEW

2020-21 A review

July 2020

Launch of the online sensor technology capability toolkit to provide free, unbiased information on Proximity Detection System sensors. The **PDS Toolkit** is part of the Mining3 ACARP funded project titled “PDS Validation Framework – Phase 3”. The easy-to-use interface provides a high-level summary of the six most prevalent Proximity Detection System (PDS) sensors available to the market. This information has been extracted from the PDS Sensor Capability Assessment document developed by the PDS Project Team comprised of Mining3, University of Pretoria and The University of Queensland. The document in its entirety will also be published and made available to industry.

April 2021

Mining3 and ENGIE announce the **commencement of the Hydra Consortium**. The Hydra Consortium is now actively working on validating the business case of utilising a hydrogen fuel cell-based powertrain for heavy-duty mobility within the mining sector. This will enable heavy-duty mining mobile equipment to run on renewable hydrogen, displacing diesel, and as such decarbonize the mining sector. The Chilean Economic Development Agency (CORFO), was the first to support the project, since then, Mitsui & Co.(USA) Inc., Thiess, Ballard Power Systems, Hexagon Purus and Reborn Electric Motors have joined to support the research and development of the prototype.

July 2020

Mining3 **welcomed ENGIE, a global energy company, as its newest member**, fast tracking the development of solutions to major industry issues, such as mining decarbonisation. ENGIE joins Mining3 in its next phase of hydrogen research to co-create hydrogen solutions and help reach carbon neutrality for the mining sector in the coming decades. “Mining3 has already identified a number of projects that align with both ENGIE’s strategy as well as the mining industry’s current and future needs. We believe that these only scrape the surface of what can be done in this space, and are looking forward to developing a diverse and forward-thinking energy roadmap for our members,” stated Mining3 CEO, Paul Lever.

May 2021

Mining3 entered **phase 2 of research for the development of remote sensors capable of withstanding extreme operating environments**. We’re working closely with project partners and members, Newcrest Mining to develop a series of sensors focussed on obtaining reliable real-time through-ground data to ensure accurate mine planning and blasting processes in extreme geothermal environments. Recent site tests have shown the ability to operate at over 150 ° Celsius within a range of 120 metres. Once developed, these sensors could have a wide range of applications from measuring tilt, movement, water pressure, temperature, geochemical properties including pH and conductivity, and more.

August 2020

ENGIE and Mining3 received **funding from the Chilean economic development agency CORFO for the Hydra project**. The 252 million Chilean pesos, or the equivalent of \$460,000 AUD funding will finance part of a project to design and supply a new powertrain for mining vehicles to run on renewable hydrogen instead of diesel. The Hydra project will work through Mining3's partnership with CSIRO and CSIRO Chile to accept the CORFO funding.

August 2020

Mining3 and CR Digital are pleased to announce a partnership with the next phase of development in **Top of Coal** technology. This announcement comes on the back of promising new results delivered from the most recent Bowen Basin trial, where the technology was tested over 12 weeks and collected downhole data from over 250+ boreholes. With support from ACARP, Mining3 has been developing a measurement while drilling (MWD) system that detects the top of a coal seam while routinely drilling blast holes. CR Digital, part of the global CR Group, is now working with Mining3 on the commercialisation of the technology, and the integration of the Top of Coal technology into their technology portfolio.

May 2021

SmartCap acquired by Wenco International Mining Systems. This fatigue technology was developed by Mining3 with supporting funding firstly from ACARP, then from Anglo American to bring the technology to commercial reality. SmartCap assesses real-time fatigue levels and monitors for oncoming microsleeps that create safety hazards. The Brisbane based company's device has over 5,000 users globally in mining, trucking, and other industries. This acquisition adds a strategic, fatigue monitoring capability to Wenco's safety solution portfolio. Safety is of paramount importance at mines and other industrial sites, where operators must perform long hours of repetitive work while paying close attention to their surrounding environment.

June 2020

Mining3 **Industry Forum and 30th Anniversary Celebration moved to early 2022**. Our annual industry forum has been displaced due to the Global COVID 19 pandemic. We now intend to host a hybrid event early 2022, inviting members and interested parties to learn more about our current research and take part in the stepping stones of what's next.

Chair's address

This year marks the 30th year of CMTE Development Limited, also known as Mining3. In my second year as chair of your board I would like to acknowledge this impressive milestone and recognise the contributions made by many of you.

We celebrate with past and present staff, members and partners, all the achievements over these years. Our contributions to the mining industry are impressive and they have had a significant global impact on improving safety, productivity and sustainability practices for the future.

In the near future I look forward to meeting in person to celebrate our history, reflect on our strong heritage and shape our vision for the future.

We mark this momentous occasion during a global pandemic, and like you, Mining3 felt the effects of the crisis. The work of our key stakeholders was heavily disrupted, especially in the early stages of the COVID19 outbreak and we experienced project deferrals, cancellations and fewer pipeline conversions than expected.

Mining3 was able to adapt to ensure we continued to operate in this new, isolated world. Travel was restricted, many of our planned on-site tests were postponed and work was completed predominantly from our homes. Despite these roadblocks, the staff of Mining3 rose to the occasion as we navigated this new landscape. New testing locations were identified in Queensland within closed state borders, and our face-to-face meetings were replaced with videoconferencing. Staff continued to work on industry-funded research and develop new pipeline projects while keeping our financial position strong. I would like to congratulate our team on all their hard work during this unprecedented time.

Our intellectual property from commercialised technologies and shares in a spin-off company continues to inject funds into our operations, most notably the recent sale of SmartCap to Wenco International Mining Systems. These successes underline the value of our contributions to the industry and highlight the importance of our continued investment into fundamental research for future solutions.

Our research

In the context of Glasgow COP26, many countries and companies have committed to net-zero by 2050. Now, more than ever, we must align our research to help reduce the carbon footprint of not only Mining3 members, but the mining industry as a whole. This goal is integral to our research projects. Sustainability is at the heart of many of our projects. For example the Alternative Explosive projects aim to reduce the environmental impact of blasting.

We are facilitating these global objectives through other key research areas. This past year the HYDRA consortium – focussed on investigating the business case for a hydrogen-fuelled drive train – has grown significantly. The consortium welcomed several new members, and its research is well into the second phase with the development and testing of a prototype. We are also developing various sensors and tools to improve the safety of tailings dams and spoils, ground control, condition monitoring and more.

Several projects have come to fruition during the year. Some to note are the collaborations with CRC ORE, in which our research in Grade Engineering Simulation and Blast Design contributed to successful intellectual property transfer to the industry. The Proximity Detection System validation project was also finalised, with a report published by sponsors ACARP and a free to use online toolkit made available. Both successes can be seen later in this report.

Our business

We are pleased to report that Mining3 gained certification to ISO 45001 occupational health and safety management standards in July 2021, with zero non-conformances. Ahead of its final release earlier this year, Mining3 completed a three-year program to update our work health and safety management system to suit these new standards. We are an organisation with projects across the world and it is important that we ensure health and safety of our people is at the highest standard.

On a strategic level, I am very aware that our current member agreements expire on 30 June 2022, and we are working hard on developing a proposal for new agreements. We recognise that the industry has changed in the past eight years since we evolved from a CRC to become an industry-funded research organisation.

To prepare for this, late last year the Board commissioned a governance review to look at board effectiveness. Early this year the Board held a number of internal strategy sessions with management and hired an independent consultancy firm Threeby3 to conduct a stakeholder engagement survey. Current, past and prospective members and partners and external industry experts contributed many hours of confidential feedback, and we value the time invested. The resulting report has been presented back to stakeholders and is being considered by the board and staff in developing our new strategy and operating model. The feedback highlights that Mining3 has great value to our stakeholders, whilst identifying opportunities for realignment and some areas where we can improve our performance. The presentation is available if you missed the feedback sessions. I am humbled by the willingness and commitment of our stakeholders to contribute feedback in support of Mining3.

I will be continuing these discussions personally with you all over the next 2 months as we prepare options for our next iteration which we will bring to an Extraordinary General Meeting (EGM) in February 2022 for your endorsement/approval.

Our Board and leadership

At our AGM, we acknowledge the retirement of Brad Nielson as an independent non-executive director and thank him for his long-serving contribution as a member of our board. We also thank Professor Neville Plint for his service and will continue working with him in his capacity as Director of the Sustainable Minerals Institute at The University of Queensland. In his place we welcome Professor Michael Bruenig back to our board and reappoint Tony Sprague, our Chair of Audit and Risk committee.

We also acknowledge the recent leadership changes at Mining3. Ms Susan Grandone, our Chief Operating Officer and Managing Director of Mining3 Canada has resigned, we thank her for her dedication and enormous contribution in leading the delivery of our roadmap and programs.

Our Chief Executive Officer and Managing Director, Professor Paul Lever, is currently on a leave of absence and your board has appointed me as Interim Executive Director until further notice. The senior leadership team, including project leaders Erik Isokangas, Ewan Sellers and Ray Wiedmaier, our operations manager Ray Nelson and finance manager John Hood are running the projects and I am working closely with them on strategy, intellectual property and commercial negotiations with the strong support of our new in-house legal counsel and company secretary Karesse Biggs. I thank our former company secretary John Lemon for his service to the board in recent years.

As we approach 2022, I reflect on my enthusiasm taking on the role as Chair last year and look forward to working with you all to transform Mining3 into our next exciting phase.

Finally, I warmly thank my fellow board directors, management, staff and all our members and partners for your unwavering support for Mining3 as we work across the mining industry towards a vibrant and sustainable future.

Sincerely,



Leanne Bond

Chair of the Board, CMTE Development Ltd.

ABOUT



Who we are

Mining3 is a world-leading, member-based research organisation.

We work collaboratively with our mining industry members to research, develop, and deliver transformational technology to improve productivity, sustainability, and safety.

Leveraging our 30 years of industry experience, extensive networks, and foundation of knowledge, our researchers develop solutions to industry-identified challenges using fundamental and applied research.

Based on the premise that collaboration is the most powerful instrument of innovation, Mining3 and its members work together to identify key industry challenges, focussing our research into areas that deliver the greatest value.

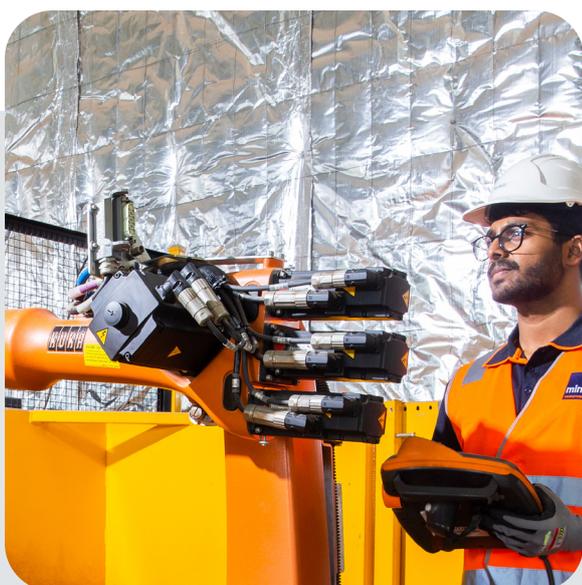
Mining3 membership is open to Mining

Companies, Original Equipment Manufacturers (OEMs), Mining Equipment and Technology Services (METS) companies, and Universities.

Our membership provides a conduit into research and technology guided by an active cohort of thought leaders working to resolve the mining industry's biggest challenges.

By combining industry and research expertise, the delivery of solutions is accelerated, ensuring rapid and effective market availability—benefitting our members and the global mining industry.

Our 'three pillar' vision for the mining industry focusses our activities on: Lean Mining, In-Place Mining, and Sustainability through Technology.



Capabilities

In Place Mining • Energy • Green House Gas Reduction • Operating in Extreme Environments • Modelling • Mine Sustainability & Closure • Deposit Characterisation • Rock Breakage & Cutting • Geotech • Autonomous Systems • Interoperability • Bulk Handling Systems • Robotic Maintenance • Reliability • Safety

Vision

To transform mining globally through collaborative and innovative industry-driven research and technology.

Our Culture

As a creative research organisation, we foster innovation, education and collaboration. Our culture is underpinned by:

- Our people being our greatest strength
- Strong and lasting relationships
- Leadership in its knowledge and expertise
- Continuously driving value by successfully responding to changing member industry needs
- Utilisation of robust research methodologies in providing leading industry solutions

Our Mission

To deliver transformational innovation to existing, planned and future mines that maximise productivity, and or enhance resource utilisation, safety and sustainability.

Our Values



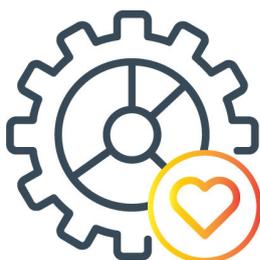
Drive innovation



Invest in strategic partnerships



Demonstrate expertise, excellence and rigour



Work with passion



Build collegial relationships



Sustainable business model

Board of Directors

The Mining3 Board of Directors sets overall policy, determines the strategic direction and oversees technology transfer and commercialisation activities through quarterly meetings. In consultation with the Research Committee, the Board directs the research focus of Mining3.



Leeanne Bond

Chair of Mining3 Board

Appointed March 2020

Leeanne is a professional company director with a portfolio of board roles. In addition to her role as independent non-executive chair of Mining3, Leeanne is a non-executive director of ASX listed Synertec Corporation Limited (ASX:SOP), Aurecon Group, Snowy Hydro Limited, Clean Energy Finance Corporation and QADO Group. Leeanne retired from the board of The University of Queensland's JKTech Pty Ltd in 2018 in order to take up the role with Mining3.



Prof Paul Lever

CEO and Managing Director - Mining3

Appointed May 2012

Paul has extensive research experience in the fields of robotic and automated mining systems, smart mining machines and systems and intelligent data analysis techniques. He held several positions at Mining3 prior to becoming CEO that included Research Director, Vice Present for Business Development and Program Leader. Before joining Mining3 in July 2000 he was head of the Mining and Geological Engineering department at the University of Arizona.



Jonathon Law

Executive Director - CSIRO Growth

Appointed November 2016

Jonathan and his leadership team bring together research with global partners in academia, government and industry to tackle short and longer-term challenges to the sustainability of the Australian minerals industry. He is a geologist by training and has worked across the value chain of the mineral resources industry and in many countries around the world. A major focus of his working career has been managing the interface between research and practical applications in industry.



Jim Callahan

General Manager - Resource Industries Asia Pacific, Caterpillar Inc.

Appointed November 2019

Jim has been an employee of Caterpillar Inc. for over 25 years. The bulk of his career at Caterpillar has been in the mining industry with responsibilities and experience spanning from Engineering, product development, research and development, manufacturing, supply chain, dealer development, mergers & acquisitions, marketing & sales, technical support, training and mobile equipment consulting.



Luke Sandery

Power, West Musgrave and Carrapateena Expansion Package Manager - OZ Minerals

Appointed March 2019

Luke has over ten years of experience as a mining engineer, including five years in Iron Oxide Copper Gold deposits. With half a decade of experience in managerial positions, Luke previously acted as the Principal Advisor to the CEO at OZ Minerals and now manages the Power, West Musgrave and Carrapateena Expansion Package.



Neville Plint

Director - The Sustainable Minerals Institute (SMI) at The University of Queensland

Appointed November 2019

Professor Plint's extensive background focused on delivering improved operational performance on mining sites by developing and implementing new technologies, whilst establishing a global network of research professionals in academic institutes, mining companies and research organisations.



Peter Salditt

President - Underground and Hard Rock Mining at Komatsu Mining Corp.

Appointed January 2019

Peter has spent his career working in the mining equipment supply industry. His experience includes general management and executive leadership positions in all facets of mining and civil tunnelling, including exploration, underground hard rock and surface mining, as well as underground soft rock mining. He has been based in multiple assignments across the USA, as well as Sweden, France and Australia. Peter is based in the USA.



Tony Sprague

Group Manager - Directional Studies & Innovation, Newcrest Mining Ltd.

Appointed January 2019

Tony brings a wide variety of experience in surface and underground mining projects gained in both Australian and international mining operations. He currently leads a team of internal experts, consultants and contractors in a number of mining transformation projects across Newcrest's global operations. These projects are focused on the use of new technology and innovative thinking to achieve step-change improvements in safety, costs and productivity.



John Lemon

Company Secretary

Appointed January 2019

John, formerly a solicitor with Clayton Utz, has worked as an in-house lawyer for several companies including M.I.M Holdings Ltd. and General Electric and was the company secretary and head of the legal department at the Bank of Queensland. He is an experienced company secretary and company director within a variety of organisations including ASX and international stock exchange listed companies, unlisted public companies, private companies and not for profits across a range of industries and activities. John will retire as Company Secretary on the 25th of November 2021.



Karesse Biggs

General Counsel and Company Secretary

Appointed October 2021

Karesse has more than 20 years-experience as a lawyer in private practice and in-house roles in Queensland. Karesse is a practicing solicitor of the Supreme Court of Queensland and the High Court of Australia, a Fellow of the Governance Institute of Australia, Chartered Company Secretary, Chartered Governance Professional and Graduate of the Australian Institute of Company Directors. She has spent 15 years in the energy and resources industry in senior leadership and Executive roles responsible for corporate governance, legal and regulatory compliance, insurance, integrity and fraud management, corporate strategy, internal and external audit management, risk management, organisational resilience and business continuity and land and mining tenement management.



OPERATIONS



Corporate Governance



Approach

Corporate Governance for Mining3 means the system by which the organisation is directed, managed and held to account. The Board is accountable to its members for the successful operation of Mining3; ensuring the strategies and goals of Mining3 are established and agreed; the key risks to Mining3 are identified and managed; and ethical values and behaviours and responsible decision-making. Mining3's Board, with the support of the Board committees, is responsible for the oversight of Mining3's governance approach.



Key areas of focus and achievement for 2020/21

This year, the Board and its committees have undertaken key strategic, governance and oversight activities, including:

- Conducting two Board Strategy workshops focused on the long-term success of the organisation
- Reviewing and discussing Mining3's risk tolerance, risk management approach, risk management plans and reporting requirements;
- Providing oversight of the implementation of Mining3's values and supporting behaviours across the organisation
- Regularly discussing and having oversight of Mining3's response to the COVID-19 pandemic
- Reviewing Mining3's governance processes for the preparation of the financial statements
- Undertaking Audit and Risk Committee effectiveness evaluation
- Undertaking and overseeing the outcomes of the employee engagement survey
- Transforming Audit and Risk Committee to People and Culture Committee and appointing a new Chairman
- Conducting, with external expert support, a comprehensive governance review
- Stakeholder engagement survey conducted by independent consultant Threeby3

Committees of the Board

The Board has established two committees: the People and Culture Committee and the Audit and Risk Committee. These committees assist in the execution of the Board's role and allow detailed consideration of complex issues. Committee members are chosen for their skills and experience. The roles, responsibilities and delegated authorities of each committee are set out in their respective committee charters. Each year, the charters are reviewed and, where appropriate, updated to take account of changes and other developments in the committees' areas of responsibility. Each committee meets throughout the year, depending on committee workload requirements.

The Board also has an industry member based Research Committee to support the Mining3 Board in reviewing and overseeing its research activities. The Research Committee considers activities undertaken by the Technical Committees.

Avoidance of conflict of interest

The Board is conscious of its obligation to ensure that directors avoid conflicts of interest (actual, potential or perceived) between their duties as directors of Mining3 and their other interests and duties. All directors are required to provide written disclosure on appointment of any business or other relationship that he or she has directly, or as a partner, shareholder or officer of a company or other entity that has an interest in Mining3 or another related entity. At least annually, or when relevant changes occur, directors are required to update these disclosures. The Company Secretary ensures that copies of all disclosures, including updated disclosures, are provided to each director. Any director with a conflict of interest in a matter being considered by the Board must declare their interest and, unless the Board resolves otherwise, they may not participate in boardroom discussions or vote on matters in respect of which they have a conflict.

Executive team

Mining3 is led by a strong leadership team with diverse backgrounds in research, technology transfer, financial, and legal expertise.



Paul Lever

Chief Executive Officer and Managing Director - Mining3

Prof Paul Lever was appointed the CEO of Mining3 in May 2012. He is also the Professor of Mining at the University of Queensland.

Paul has extensive research experience in the fields of robotic and automated mining systems, smart mining machines and systems and intelligent data analysis techniques. He has worked on projects that include intelligent control algorithms for an automated (robotic) excavator and developing the science of bucket/material interactions to improve the performance of large excavators.

He held several positions at Mining3 prior to becoming CEO that included Research Director, Vice President for Business Development and Program Leader. Before joining Mining3 in July 2000 he was head of the Mining and Geological Engineering department at the University of Arizona.

 **BSc Mining Engineering - The University of Witwatersrand, Johannesburg**

 **MSc Mining Engineering - Colorado School of Mines**

 **PhD Mining Engineering - Colorado School of Mines**



Susan Grandone

Chief Operating Officer Mining3

Managing Director, Mining3 Canada

Susan was appointed as the COO of Mining3 in August 2018 and the Managing Director, Mining3 Canada in January 2018. Susan is responsible for Mining3's day-to-day operations, reporting directly to the CEO and Managing Director.



John Hood

Financial Manager

John joined Mining3 as a Finance Officer in 2007 and was appointed Financial Manager in 2018. He has completed a professional accounting certification and gained experience in the financial management of a research services organisation. John has over 10 years' experience in budgeting and the implementation of budgets, helping Mining3 to monitor project progress and other operational metrics. He is responsible for preparation of all financial reporting materials presented to the board, management and auditors.



Karesse Biggs

General Counsel and Company Secretary

Karesse has more than 20 years-experience as a lawyer in private practice and in-house roles in Queensland. She has spent 15 years in the energy and resources industry in senior leadership and Executive roles responsible for corporate governance, legal and regulatory compliance, insurance, integrity and fraud management, corporate strategy, internal and external audit management, risk management, organisational resilience and business continuity and land and mining tenement management. Karesse was appointed as General Counsel and Company Secretary in October 2021.



Dr Erik Isokangas

Program Director

Erik leads research in mine process modeling and simulation, integrated mine process design and implementation, and the development of technologies for future mining systems. Erik previously worked for Metso, a global equipment supplier to the mining industry, most recently as the Director of In-pit Solutions supporting mining customers in the design and feasibility of in-pit crushing and conveying systems. Prior to this, he led a consulting team in Finland, focused on process integration and optimization for mines in Europe, Russia, the Middle East, and Africa. Erik was appointed Program Director at Mining3 early 2017.



Dr Ewan Sellers

Research Leader

Ewan Sellers is a specialist in rock mechanics with broad experience in numerical modelling, instrumentation, seismology and blasting. He joined Mining3 in early 2017 with his most recent position being Research Leader, as well as having an overarching role as the Research Director within the Mineral Resources division at CSIRO. Ewan has worked in the mining industry for over 30 years focusing on hard rock mining. Ewan has led a similar research group in South Africa and worked as a consultant involved with improvements across the value chain in several mining companies.



Dr Ray Wedmaier

Program Director

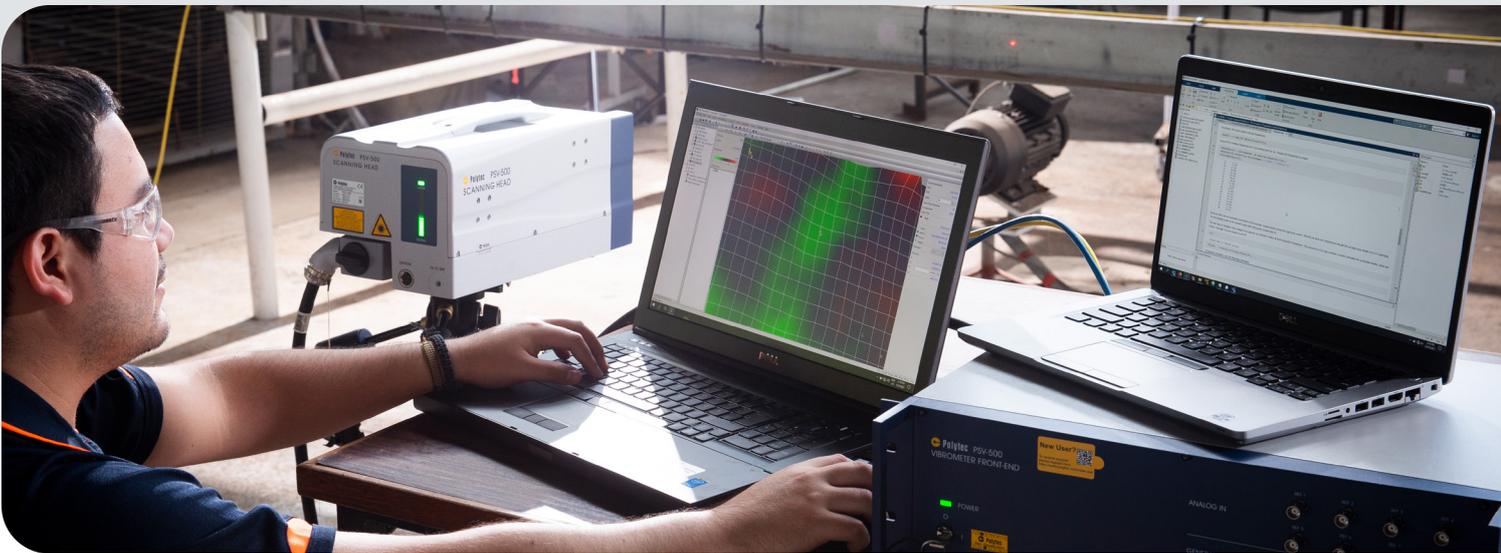
Ray Wedmaier is a mining engineer with over 35 years working experience in the mining industry. He has had direct involvement in mine operating, technical and corporate roles as well as worked with industry partners as consultant, supplier and mining researchers. Ray was appointed Program Director at Mining3 in 2021. He leads research in the areas of automation and sensing technologies. Ray has held a number of leadership roles across the mining industry. He has supervised teams in finance, technical and operations capacities, lead multi-disciplinary study teams on international joint venture projects and has a demonstrated capability for influencing projects and strategies.

Working at Mining3

Mining3 has a unique operating model. It consists of members from mining companies, OEMs (original equipment manufacturers) and Universities. Collaboratively, members identify the key challenges facing the mining industry and allocate funding to research areas which will deliver the highest return.

Our significant advantage over our competitors is as a result of our:

- Collaboration model with mining companies, mining services providers and researchers
- Scalability of operations globally
- Acceleration of innovation to market
- 30 years of experience in delivering new technologies
- Access to highly-skilled industry specialists and researchers



Mining3 Expertise

Our people are drawn from many fields and backgrounds, including university researchers, and leading experts in the mining and related technology manufacturing industries.

Our world-class researchers are highly experienced in understanding the needs of the Mining industry and collaborating with all the necessary stakeholders to achieve innovative and viable solutions.

Students at Mining3

Mining3 provides its research partners with a unique opportunity to engage with a large number of companies in the minerals industry to conduct collaborative high value and challenging research. It provides research opportunities and funding for a wide range of graduate students.

Research

Mining3 works with its members to provide research and technology to solve industry identified challenges.

- **Members steer research towards real-world applications**
- **Industry committees test and challenge all research initiatives**
- **Collaboration filters out ineffective use of research resources/funding**
- **Focus on the right problems and best opportunities**

For the mining industry to operate profitably and sustainably in the future, it must transform across several fronts. The Mining3 strategic research vision for this transformation is focused on three key pillars as shown below in Figure 1. *Note, during 2021 Mining3 has conducted both stakeholder and employee engagement surveys and the Board has begun developing a proposal for future strategies.*

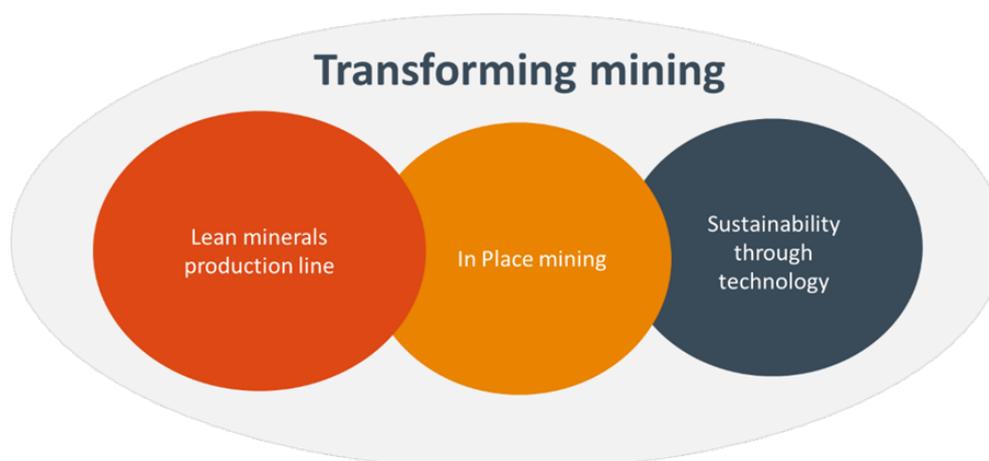


Figure 1: Strategic Research Vision for Mining3

The lean minerals production line pillar refers to our focus on precision mining and bringing control as close to the face as possible. As mining processes evolve, we've discovered that the sooner we identify the value of the ore, the higher the return on investment. This pillar underpins the requirements for mining methods and processes to be precise and controlled and mining systems to deliver to their design specifications. For current mining operation this means applying measurement and control strategies to drive optimal operation performance (rated performance), often through continuous improvement approaches. This applies across the full mining value chain.

Approaches used by this pillar include:

- Control and optimisation of the mining value chain
- Complete connectivity
- Delivering the right information at the right time and location
- Integrated automation
- Sensors and data analytics for dynamic mine control
- Interoperability
- New measurement systems



Figure 2: In Place mining research pillar

The in-place mining pillar drives the need for radical approaches that deliver new thinking about how mining happens. This means the development of new fundamental mining methods and processes that encapsulate the characteristics of both the “Lean minerals production line” and the absolute requirements proposed by the “Sustainability through Technology” pillar. The In Place mining approach proposes new thinking about mining through three sub techniques (see figure 2 above).

All these encompass the following characteristics:

- Significantly reduce surface footprint
- Reduced mine transportation infrastructure – waste material remains in the mine
- Smaller processing plant size due to high grade feed and processing in place
- Significant reduction in tailings dam footprint
- Modular production units with the ability to scale and reduce as required
- Reduced energy need

All these approaches attempt to adhere to the primary concept of designing a tight coupling between Discovery – Mining – Processing.

The sustainability through technology pillar looks to transform mining by placing sustainability (economic, environment and social) requirements at the heart of the mine planning process and developing significant new technology innovations and operational designs to accomplish this.

The following are sustainability issues that must be addressed.

- Right to mine
- Social - positive, clear and transparent engagement with community
- Energy, water, materials and waste use – reduction and recycling’
- Removal of people – potential high level of automation
- Small footprint mining
- Adopting a lifecycle approach – integrating community benefit, supply chains and performance criteria

Project List

Mining3 is a world class research institute focussed on delivering transformative solutions to the mining industry. We do this through a combination of industry, government and self-funded (Mining3 funded – Seed funded) projects in line with our strategic research roadmap. Each project, however small contributes to a larger picture of how we and our members envision mining in the future. Note: fully confidential projects are not listed or described here but governance is still through Mining3’s technical committees and research committee.

● Active Projects

ACARP C27024 - Blast performance evaluation of production-scale trials using hydrogen peroxide-based explosives

This project aims to demonstrate the manufacture and delivery of Hydrogen peroxide (H₂O₂)-based explosives using a specialised Mobile Manufacturing Unit (MMU) and evaluate blast performance in surface mine-site operations with increasing scales of production. This progresses the research plan for H₂O₂-based explosives from confirmation of first viable formulations meeting sleep-time and detonation performance towards implementation and adoption by focussing on manufacture and delivery procedures to meet mine-site operational requirements.

Surface Technical Committee

ACARP C28025 - Integration of DAS conveyor monitoring into SCADA

The objective of this project is to develop the current DAS monitoring system from a scheduled reporting system, to real-time monitoring system capable of being fully integrated with mine-site operator stations (SCADA), which can be queried by maintenance staff whenever required. This advancement would facilitate integration into business enterprise database packages (such as SAP) to enable smart, autonomous and objective scheduling of maintenance activities.

Automation Technical Committee

ACARP C29031 - Acoustic Sensing for Mobile Machinery using Laser Vibrometers

Project Spotlight: This is a feasibility study to see if this proven signal processing technology can be adapted to other purposes. It is about providing a tool that would assist in improving maintenance practices. The technology is essentially a remote point sensor, aimed to improve the methods in diagnosing machine faults in difficult to reach areas. This enables quick and frequent diagnostics without the need to remove machine components, when the machine is parked in the field, while working, or to avoid personal contact with hot surfaces. Non-contact “point-and-measure” sensing offers safe measurement of the conditions of any or all



locations of interest on a mobile machine, quickly and simply. It could be done in-situ while the machine is operating, similar to the way conveyor condition monitoring does now. In the future, it may be possible, using a robotically guided laser, to measure machine vibration on a machine working under load, such as a loaded haul truck climbing an incline.

Automation Technical Committee

ACARP C29052 - Autonomous Sensors for Evaluation of Groundwater Pressures in Spoil Dumps and Tailings Dams - Phase 2

The geotechnical integrity and stability of a mine spoil dump or tailings dam can be weakened, by factors including abnormal pore pressures and movement induced by ground water permeating the embankment or the foundation of these structures. These factors greatly affect the design, layout, safety and potential for slope failure to affect surrounding areas. The objective of the second phase of the project is to

- Continue the development and validation of an autonomous sensor system
- Create a geotechnical model from the field data to provide information and certainty on spoil dump or tailing dam stability, and develop a reporting and alarm system to notify of increased or high risk.
- Perform a long term trial to monitor the pressures and movement of a spoil pile and predict instability

Automation Technical Committee

ACARP C33041 - Demonstrations of larger production scale trials using H₂O₂ based explosives using a specialised MMU

The objective of this project is to utilise a prototype Mobile Manufacturing Unit (MMU), built during project C27024, coupled with the project learnings, to expand the demonstration and address technical hurdles of Hydrogen peroxide (H₂O₂) explosives beyond the limited trials of C27024. We propose to conduct a series of displays of large-scale production blast trials that have not been achievable until the completion of C27024. This project will push the H₂O₂ explosives closer towards commercialisation.

Surface Technical Committee

Anglo-Measure While Drilling (MWD) Sishen Stage 2

This project aims to evaluate Measure While Drilling (MWD) systems on the reverse circulation (RC) drill rigs and apply the data to improve blasting processes at the Sishen mine. Data collected by RC drills at the Sishen Mine can then be used to inform blast designs to improve fragmentation outcomes and plant performance predictability, further improving mine planning capabilities.

Surface Technical Committee



Automated Inspection of Mobile Machinery Through Remote Optoelectronic Imaging and Point Sensing

Building off work in the ACARP C29031 project, the goal of this research is to provide technologies that could increase the availability of mobile equipment from a maintenance perspective. The vision is to deliver a product that would automate the maintenance troubleshooting process, through hard or easy to reach components without touching it. This is done via the application of the Laser Vibrometer and applying various signal analysis techniques to identify possible maintenance needs.

Automation Technical Committee

CRC-P Mineralogical and hydrometallurgical testing and characterisation in support of the Kapunda in situ recovery project

Working with ISR mining specialists, Environmental Copper Recovery, on a Commonwealth Government CRC-P (Cooperative Research Centre) grant which funds a 2.5-year research program to better understand and resolve key ISR mining challenges— particularly in relation to environmental, social and economic impacts.

Surface Technical Committee

DAS - Extending the DAS Conveyor Monitoring Service at Moranbah North

It is proposed that the DAS sensing fibre cable, already installed at the Moranbah site as part of the ACARP project, is continued being utilized for the detection of failing rollers and that this fibre is extended to further include the monitoring of additional conveyors.

Automation Technical Committee

DAS Conveyor Monitoring Trial - Vale

This project consists of a trial and further develop a distributed acoustic sensing (DAS) monitoring system, using fibre optics, for autonomously reporting on the operating conditions of mine conveyors, while running. It is expected that Vale could improve the efficiency of conveyor maintenance by using DAS technology. In addition, as the technology develops into the future it is possible, and indeed intended, in the context of the current research, to extend the application of DAS from conveyors to other machinery that comprise rotating parts, such as drive motors, gear-trains, apron feeders, and so forth. This proposal seeks to test the current industrial prototype assembled by Mining3 and further develop and adapt its functionality to suite Vale requirements. Mining3 will also train Vale personnel in the usage of the DAS system, as developed.

Automation Technical Committee

Efficient Haulage - Towards a Zero Carbon Mine

This project aims to investigate the opportunities to make significant impacts on the efficient haulage or movement of material in mining, working towards supporting the industry towards their net-zero carbon emissions targets. More specifically, the project considers the impact and tradeoffs of replacing current diesel fleets, with various scenarios involving manually operated or autonomous electric trucks with different capacities for selected mining operations. Mining3 has been actively researching electric haulage systems, working on case studies such as satellite and open pits. We also have experience in evaluating IPCC and trolley-assist solutions. Through this process, Mining3 has developed methods and tools for modelling, simulating, and assessing the impact of new technologies on mining processes.

Surface Technical Committee

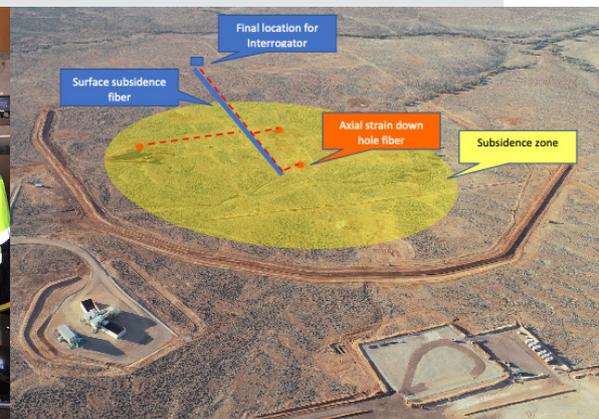
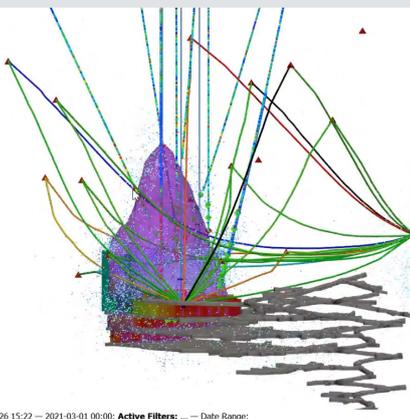
Fibre optic monitoring for ground control (Extension with Carrapateena Site)

Project Spotlight: Successful ground control is an integral part of any well managed surface or underground mining and the geotechnical conditions that exist in the rock mass, together with the influence of mining activity, should be well understood and monitored during operation. Depending on the type of operation, the ability to influence ground behaviour movement can be very limited as it is in cave mining operations.

The aim of this project was to showcase the application of distributed fibre optic sensing technologies for ground movement monitoring. It included the installation and commissioning of 3 x 500m Fibre Optic Axial Strain Gauges downhole and a fibre optic subsidence monitoring system at the OzMinerals Carrapateena mine in SA. These installation have been used to determine the distributed strain in the rock mass surrounding the cave for over a year now. Further, a short-term trial of a fibre optic seismic monitoring system has been conducted utilising the already installed fibre network. This trial demonstrated that the technology is capable of observing micro-seismic activities in the rock caused by the mining operation.

The ongoing support from Oz Minerals for field installs and trials has been excellent so far. Great appreciation goes to the OzMinerals Carrapateena Team led by David Cox.

Automation Technical Committee



Fibre Optic Sensing (FOS) – Smart Composite Cable

Project spotlight: The FOS Smart Composite Cable project is a joint Research and Development project with ConneC to develop and commercialise the next generation of High Voltage (HV) Coupler Systems. The aim is to enhance the availability of fibre optic networks in mines in general and in underground coal mines in particular through the integration of fibre optic networks into HV cables and connectors.

Underground coal mines often have limited network capacities due to the environmental constraints and the need to utilise only Intrinsic Safe equipment. As a consequence automation and/or remote operation is less common than in metalliferous mines. Providing a fibre optic network throughout the mine, even to mobile machineries, i.e. to Continuous Miners through trailing cables, will enhance the available bandwidth (up to Gbps) and so act as an enabling technology for automation and remote tele-operation.

Furthermore, the Mining3 Fibre Optic Sensing team sees a significant opportunity to utilise this network in the future for distributed mine-wide sensing applications. The project is a key activity towards the strategic task of developing “Reliable high-bandwidth UG comms anywhere & anytime” and the visionary task of “Mine wide high-bandwidth comms connecting all mine systems” in the “Mining Systems” -> “Communication” stream of the Mining3 roadmap.

In addition, it is an enabling technology towards the strategic “Mine Safety Systems” enabling the “Emergency location of personnel with distributed sensing” and many other distributed sensing applications, e.g. temperature and ventilation condition, as well as equipment specific monitoring tasks, e.g. Bretby condition monitoring for long-wall shearers.



Automation Technical Committee

Mine-to-Mill-to-Mine (M2M2M)

In this project, a software application will be applied to track material flows at Newcrest’s Lihir gold mine by linking mine data through the CSIRO VoxelNET data fusion engine with the Outotec HSC SIM code to allow material flows to be tracked or simulated from the blast through the mill and, most importantly from mill back to the mine, to provide suitable blends of material as required for production, selected breakdown or shutdown scenarios. The combination of codes will provide a closed loop of information from Mine to Mill to Mine (M2M2M). This software will allow users to track material flow in real-time through a three dimensional digital twin of their mine.

Underground Technical Committee

MRIWA M499 - Establishing the in-situ rock bolt behaviour underground in order to model and design improved rock bolt support systems

Inherent uncertainty associated with geotechnical engineering, particularly in cave mining, means that it is necessary to install monitoring equipment to verify the performance of mining stability of selected areas in the mine. This research develops rockbolts with fibre optic sensing to monitor ground movement and enables the miner to respond appropriately with improved design and operational procedures. Essentially, the technology aims to enhance the engineering best practice for ground control and safety through embedding novel fibre optic sensing technologies in the geotechnical engineering toolset.

Underground Technical Committee

MRIWA M519 - Broadening the opportunity for In-situ Recovery (ISR) of value from mineral deposits

The objectives of this project are to consider, in an interdisciplinary manner, the key technical challenges related to:

- The measurement, creation/improvement and sustainability of target mineral liberation and access in an in-situ mineral system.
- The design, introduction and control of new and improved lixiviants for more efficient and selective extraction of values with a reduced environmental risk.

Underground Technical Committee

MRIWA M522 - Physics Models for ore tracking in surface mining

The main objective of the project is to develop the physics of material tracking in parts of the mining value chain where physical processes change the material shape and hence obscure the original grade distribution. The main areas of complex material movement and potential mixing include blast movement, digging, dozer push, truck loading, truck dumping, stockpile stacking and depletion, surge piles and feeders. This data is expected to improve mine design and processes as well as feed into current and future mine modelling tools.

Underground Technical Committee

MRIWA M529 - Lixiviant access creation in impermeable hard rock mass for the in-situ underground leaching of metals from ore

This PhD study aims to understand the impact of cryogenic liquids, microwaves and high-voltage pulses on access creation in impermeable hard-rock mass, from the perspective of rock properties, permeability and their effect on leachability. Access will be created in samples using the techniques mentioned above and the extent or success of the access creation will be tested using a variety of tools. Outcomes from this work will be used to evaluate the potential for the use of these alternative (micro-) access-creation methods in an in-situ environment and their effect on the metal recovery by leaching.

Underground Technical Committee

MRIWA M545 - Evaluation of ISR in-situ barrier technology for risk mitigation and extraction optimisation

Mining3 is sponsor of this project for evaluation of in-situ barrier technology for risk mitigation and extraction optimisation for in situ recovery operations. The project will involve 2 PhDs at Curtin University. The research will further Mining3's understanding of the in-situ mining process and improve future applications with improved lixiviant formulas.

Underground Technical Committee

Microbial carbonate precipitation dust suppression

The overall aim of the Project is to develop a novel dust suppressant technology based on microbial carbonate precipitation for AngloGold Ashanti's tailings storage facilities in South Africa. This technology may also improve geotechnical stability and reduce trace element mobility.

Surface Technical Committee

Mining development at great depth

This research will test an excavation damage hypothesis used to develop a global methodology for safe (and most economical) development construction at depths not yet reached by the current mining operations. This will enable the sustainability of underground mining even in conditions of very high stress, where failure can occur very soon after the construction of the underground openings.

Underground Technical Committee

Remote Borehole Temperature Sensing (Phase 2) - Newcrest

This project involves research associated with a remote borehole preblasting sensor system that can provide real-time feedback on rockmass characteristics, such as temperature, to aid in the risk mitigation process during blasting activities. Phase 2 of this research is focussed on the pre-production and manufacture of the current prototype sensors, second generation research and development to improve performance, longevity and reliability, and the development of end user software. This will allow minesite staff and other stakeholders the ability to deploy the sensors, gather and analyse sensor data, comply with governance and reporting and most importantly feedback to minesite personnel the effectiveness of current geothermal cooling strategies.

Automation Technical Committee

Assessing the feasibility of an in-line mining approach for South 32's Hermosa Mine

The fundamental objective of this project is to assess the potential for innovative in-place mining solutions for creating additional value of Hermosa project and Cannington mine. Specifically, the project will quantify the characteristics and value proposition for an in-place mining solution for the deposits through an engaged desktop study. The first phase of the project will derisk the study by determining the amenability of the ore to leaching with new "green" lixiviants. The second objective is to assess the feasibility and quantify the risks (technical, financial, implementation, etc.) associated with the proposed concepts.

Underground Technical Committee

Tailings dam wall movement monitoring using strain, creep, etc using Fibre Optic Sensing

This project aims to determine the feasibility of utilising fibre optic sensing technologies to measure the tailing dam wall movement and 3D ground deformation and then correlate them with existing models to generate an early warning system.

Automation Technical Committee

Top-of-coal Detection Algorithm Development

The aim of this project will be to develop algorithms to recognise approaching coal seams from the Top-of-Coal sensor system. This project has two phases. The first is cleaning data for further analysis. The second phase will be detecting and tagging the location of coal seams in the dataset and then using that data to build predictive models. This will support future commercialisation of the Top-of-Coal system with partners CRDigital.

Automation Technical Committee

Uncrushables

This series of projects aim to develop an In-Pit tramp metal detection system for wheeled loaders. The capability to detect, in real time, tramp metals or “uncrushables” in material payloads during digging or loading would provide significant benefits to mine operators through increased productivity, and reduced maintenance and repair costs.

Automation Technical Committee



● Initiatives and Collaborations

Adv Qld PTP grant: Enabling the Queensland Power System of the Future

Mining3 is working with the researchers in the AQ-PTP targeting reduced energy and carbon intensity focus on increased adoption of renewables in mining operations as well as increasing efficiency and reducing energy usage of mining equipment. Enabling a high penetration of renewable and other alternative energy sources with a focus on mining's unique energy needs requires knowledge based on modelling, simulating and emulating existing supply and augmentation systems as well as current state of the art renewable energy technologies and distributed generation.

Strategic business innovation leads to improved firm performance, productivity and growth. By focusing on enhancing innovation through strategy, mindset, structure and environment, the Research Centre will lead to improved performance of METS businesses and therefore higher productivity and sector growth.

Mining3 provides seed funding for this project and members can participate in their studies.

Cave Mining 2040

Cave Mining 2040 was developed as an international consortium that advocates for the collaboration to develop and accelerate innovations and new knowledge to ensure cave mining remains a technically viable, sustainable, safe and profitable business. The objective is to facilitate the development, validation and demonstration of new technologies and concepts through Horizon 1 projects each with its own scopes of work for the corresponding study areas to be identified, delineated and approved. It aims to engage stakeholders in supporting Cave Mining2040 collaboration and in particular projects leading to transformational technologies. The current five projects are:

1. Total deposit knowledge
2. Numerical optimisation based decision support tool for cave mining operations
3. Designing block cave interactions for high recovery
4. Cave front tracking using active and passive microseismic data
5. Review of global sublevel cave best practice

Centre for METS Business and Technology Innovation – Mining3, Qld government and University funded

The research centre has a METS focused research program aimed to build the capabilities of METS firms for strategic innovation and inform industry development initiatives delivered by industry associations and government organisations. The research centre will have a strong focus on industry engagement, communication and research impact pathways.



CRC TiME Foundation Projects

A national consortium led by The University of Queensland and University of Western Australia has secured \$30 million from the Federal Government to help regional communities transition to a sustainable future after their local mines have closed. Currently Mining3 has three projects in CRC TiME's foundational projects portfolio which focus on bringing groups together to understand what knowledge exists on key topics at the moment (from multiple perspectives); define the problem and articulate what will transform the area; and determine whether this is something the CRC should invest in or if it is being addressed by other means.

Hydra

Project spotlight: The Hydra Consortium is working on validating the business case of utilising a hydrogen fuel cell-based powertrain for heavy-duty mobility within the mining sector. This will enable heavy-duty mining mobile equipment to run on renewable hydrogen, displacing diesel, and as such decarbonize the mining sector.

To achieve this target, several workstreams will be executed, including a pre-feasibility and engineering study of a powertrain and the renewable hydrogen value chain. This includes designing, manufacturing and testing of a 200kW fuel cell plus battery powertrain prototype under mining

conditions (altitude, dust, temperature, etc.). The test outcomes will provide valuable information to optimise the overarching design that could replace the traditional diesel powertrain.

In addition, the project will support government entities in Chile and beyond by establishing safety protocols for hydrogen use at scale within the mining industry, which will be critical for the successful deployment of this hydrogen solution.

Finally, the project will complete with an analysis for validation of the business case.



Sponsors of the Hydra consortium are: **Mining3, ENGIE, Mitsui & Co. (U.S.A) Inc., Antofagasta Minerals, Ballard, Hexagon Purus, Reborn Electric Motors and Thiess, with support from CORFO and CSIRO Chile.**



● Recently completed projects

ACARP C26035 - DynaCut™ Fundamental Development Phase 2

This project followed directly from the ACARP Project C25041 - Dynacut fundamental development and capability testing for high capacity mining of coal overburden, which completed excavation trials at a sandstone quarry at Helidon, QLD. This was the first time that Dynacut had been tested in soft/medium/high-strength sandstone with purpose-built cutters in an in-situ environment. It produced encouraging cutting rates and demonstrated very low levels of cutter wear, indicating significant performance potential for application to overburden removal. Phase 2 established key design criteria and developed an advanced design for an up-scaled test machine. This up-scaled machine will demonstrate the scalability of the Dynacut technology via site testing in a subsequent Phase 3.

CRC ORE P2-008 - Heterogeneity Index for Ore Mixing

This project developed a proof-of-concept for a novel (sensor) data driven computational platform for transporting ore property information through the extraction and handling stages of minerals production. The framework accounts for the unavoidable mixing and segregation of ore as it is extracted and hauled prior to processing. This enables tracking of ore and ore property evolution throughout the whole of mine process.

CRCORE P2-009 Elastic Limit Blasting to Maximise the Grade Engineering

This project investigated whether it would be possible to preferably control and optimise the blasting to fragment the soft ore materials to fine particles and not to break the harder gangue minerals. This would imply that a sieve/screen-based approach may be used to separate the fine ores from the coarse waste, based on Grade Engineering theories.

Having identified the opportunity to influence natural department by applying selective fragmentation to a synthetic blast design, further research would be required to consider how the relevant rock mass parameters can be measured in the field, and develop a selective fragmentation blast design workflow.

CRC ORE P2-010 - Valorisation of Grade engineering by-products

Grade Engineering (GE) offers the potential for the early separation of gangue from ore. This would reduce net volume of material being sent to tailings and increase the volume of engineered dry waste rock dumps. This coarse dry material (called GE by-products) has the potential for utilisation to create new value (valorisation). This review assessed the implications of grade engineering on waste streams emerging from mining. The objectives of the project were to study and characterise GE by-products, assess the alternative application of GE by-products, study socio-environment impacts of GE, and provide inputs and strategies for the evaluation of GE stream impacts on waste associated cost profile within the scope of short term mine planning.

CRCORE P2-011 - Variable particle size separator

Grade Engineering creates an opportunity to unlock additional value in ROM production by utilizing early stage separation of gangue from ore. Separation based on particle size using screens is already an established technique. The value-add of a size-based separation technique could potentially be significantly enhanced with the ability to alter the mass pull by dynamic manipulation of the cutoff particle size for every truckload.

CRC ORE P-012 - GESim Value Modelling (GESim Ph 2)

Application of the Grade Engineering Simulation (GESim) models and methods for a recent Grade Engineering project. Aim is to demonstrate the value of the models for medium-term mine planning of GE solutions. This project further developed Mining3's capabilities in modelling and simulation of complex mining operations, to forecast the performance of new mining technologies as inputs to business value models.

CRCORE P2-013 - DAS for vertical spindle crushing machine control

This research was completed to demonstrate how acoustic measurements can be used for the control and maintenance of the new generation of vertical spindle crushing machines. This has led to a follow on project focussed on developing an early stage prototype.

Discrete Event Simulation development for GESim

This seed project supported the development of further capabilities in Mining3 in the area of discrete-event simulation modelling; supporting projects such as CRCORE GESim, V3 development, Energy simulation, etc.

MRIWA M487 - Actuated undercutting disc project

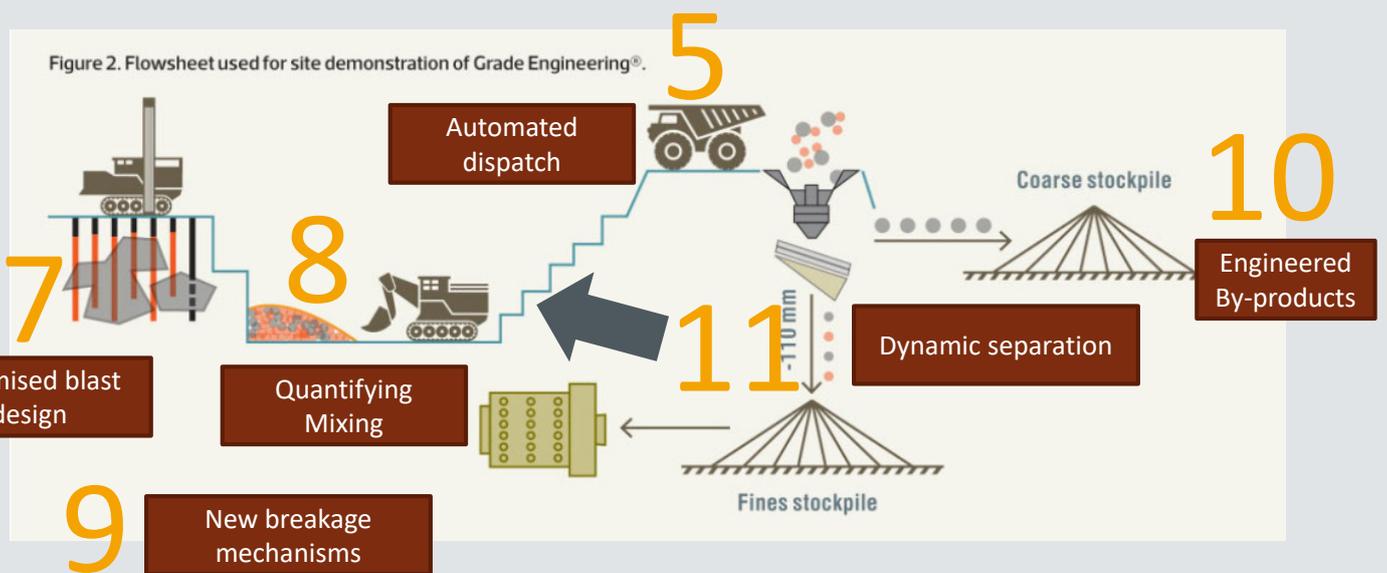
The overarching objective of this project was to make mechanised fragmentation a viable method for breakage and extraction of minerals in hard rock mining. Focusing on Actuated Undercutting Disc technologies, the project aimed to achieve this goal through understanding and optimising rock breakage mechanism, and reducing the energy required for rock fracture. Investigating the mechanics of cutter/rock interaction, associated rock failure mechanism and the role of the controlling parameters, the project provided strategies to enhance the effectiveness and efficiency of the mechanised breakage method for developing controlled and stable excavation technologies. Ultimately, the research outcome facilitates development of potent and energy efficient tools by preventing the energy loss in processes that are not required, opening new avenues for design and optimisation of hard rock technologies.

Proximity Detection Systems (PDS) Validation Framework - Stage 3

Proximity detection systems (PDS) for mobile equipment, people, and other structures are increasingly being used to establish effective collision management strategies. However, there are so many proximity detection systems and multiple sensing technology categories that it is difficult to select the best PDS for specific applications. In this project researchers conducted a critical review and assessment of PDS technology types, application, constraints, and implementation requirements; developed a testing methodology to verify and assess proximity detection systems; and produced a set of measureable, objective metrics to describe performance criteria. This project aligned and built upon the EMESRT PR5A body of work to develop a set of standardized functional, performance, and technical specifications with an associated testing regime for validating PDS system capability relative to control levels 7, 8, and 9 in open-cut mining.

V3 Energy & Processing Module Development

Mining3 has developed V3, a value driver tree modelling framework that leverages Mining3 research to provide clients with a technology value assessment tool that spans the entire mining value chain. V3 utilises several modules in a plug-and-play framework that provide customizable levels of detail depending on the area of focus along the mine value chain, and takes into account the up and downstream impacts of modifications to activities at a given process. The objective of this project is to develop detailed energy and processing modules to incorporate into the existing V3 framework. This work will include development of base case assumptions around common current energy generation, storage, conversion, distribution, and usage, as well as typical processing plant flow sheets for ore types that are common amongst Mining3 members.



CRC ORE and Mining3

Similar to Mining3, CRC ORE was born of an idea to deploy innovative world-class technologies to influence a change in value across the mining industry. Their goal was to 'Optimise Resource Extraction' (ORE) through site implementation of innovative methods to improve overall productivity. It was because of this alignment in thinking that Mining3 became its largest collaborative contributor with a series of research projects worth over \$3M which facilitated a number of the centre's outcomes.

One aim of CRCORE's renewal phase was to implement Grade Engineering® (GE) concepts into the industry and further develop the technology required for future implementation. Grade Engineering® is an integrated approach to coarse rejection that matches a suite of separation technologies to ore specific characteristics and compares the net value of rejecting low value components in current feed streams to existing mine plans as part of a system-view.

Mining3 provided mining researcher expertise with projects across the whole GE value chain. Upon completion of these projects and closure of CRC ORE, we look back at our recent contributions and the value created for not only our members, but the mining industry as a whole.

Our four projects in the blasting space contributed to the understanding that GE for selective mining required new ways of looking at the rock mass properties so that relative hardness of the ore, ore content, and waste can be identified prior to drilling. When the mine has a good model of the rock strength, structure, density and ore content it is possible to customise the GE blast design for each zone.

The fragmentation predictions for hundreds of scenarios of hole spacings and explosive content are run through a plant simulator to find the optimum throughput and profit. Then

the most profitable design can be selected. This model was then expanded to consider multi metal operations.

Having improved the blast design it is important to have measures of the heterogeneity of the output material and determine how the mixing caused by blasting and haulage can reduce this. A simulation was developed to model the process from blasting to crushing. We identified a Heterogeneity index that can measure how much a stream of trucks or the crusher output is mixing the material. This is very useful for enabling mine planners to sequence muckpile excavation by areas of similar GE heterogeneity for optimum processing value.

One project also looked at the operational solutions for managing haulage across the mine, leading to the development of GESim .

GESim was developed to test impacts or run simulations to find the optimal combination of equipment and technologies for a given mine plan (factoring in a variety of operating scenarios and control parameters). The models forecast the behaviour of the mining system, helping identify potential bottlenecks, resourcing and sequencing issues. This reduces implementation risk and increases the success of deploying new GE solutions.

The models can be imported into the Integrated Extraction Simulator (IES), allowing mine planners to regularly simulate scenarios during the operation of a mine, with a view to maximising mineral extraction value.

Mining3's project work with CRC ORE has aided in the commercialisation of Grade Engineering with Hatch, while Orica plans to take the reins on the IES technology. All of this while still improving our expertise and understanding of mine planning, modelling and design for our members.

OPERATIONS

Safety



OHS 603887

Mining3 gains certification to ISO 45001

In July 2021 Mining3 gained certification to ISO 45001 with zero non-conformances.

Mining3 has maintained a certified safety management system since 2007 to demonstrate the organisations ongoing commitment to the health and safety of our staff. In 2018, a new international standard, ISO 45001:2018 — Occupational Health and Safety Management System — Requirements with guidance for use, was released and subsequently adopted within Australia as the Australian Standard for health and safety management systems.

Ahead of the final release of new standard, Mining3 entered a three-year program to update the work health and safety management system (WHSMS) which was certified to ‘AS/NZS 4801 Occupational Health and Safety Management Systems — Specification with guidance for use’ to being suitable to be certified to the new ISO 45001.

The review started with re-setting the Mining3 safety Goal to ‘Safety Always’ and then building four key objectives to drive the safety system, these objectives are embedded in the Health and Safety Policy and are measured through our annual strategic plan:

- Implementing the right systems for continual improvement
- Engaging with our Members and workers
- Controlling our WHS Risks
- Demonstrating Due Diligence

Implementing the right systems for continual improvement

- Framework & mapping
- Policies
- Procedures
- Tools
- Resourcing

Engaging with our members and workers

- Awareness campaigns
- Competency training
- On-the-job training
- Consultation
- Meetings & forums

Controlling our WHS risks

- Standard operating procedures
- Audit & inspection programmes
- Safe work instructions
- Project safety plans & risk assessments

Demonstrating Due Diligence

- Management review
- Performance reporting
- Risk registers & tools
- Audit programmes



Members

Mining Companies



Original Equipment Manufacturers & Suppliers



Research Organisations





Members of Mining3 participate in the Mining3 Research Committee, Technical Committees, and Board. Members will have the capacity to steer long-term visionary research, as well as be first to the opportunity to commercialise and implement transformative technologies. With cash or in-kind contributions, membership solidifies your organisation's commitment to fast-track real-world solutions to market.

Why be a member?



Reduced research risk



Leveraged R&D



Access to world-class mining researchers, scientists and engineers



Access to certain Mining3 IP



Enhanced ability to target major mining challenges



Build lasting relationships with industry representatives



Participation in peer group meetings to identify key areas of focus



Participation in the development of roadmaps for the future of mining



Commercialisation and IP opportunities

From time to time, Mining3 will partner with non-members on a specific research or commercialisation project. This arrangement falls out of the membership structure and is necessitated by a specific need of either the commissioning mining company or the required expertise to produce a commercialised product or technology.

Organisations Mining3 has partnered or collaborated with in the past include:

ACARP • Anglo American • Australian Research Council • AVA Group • Barmenco • BHP Billiton • Codelco • CR Digital • CSC Australia • DSI • Elexon Electronics • Environmental Copper Recovery • ESCO Group LLC • Escondida • Glencore • MMG • MPS • MRIWA • Newmont • Northern Star • Peabody Energy • Rio Tinto • Roy Hill • Sandvik • The University of Newcastle • Theiss • Yakum Consulting

Financial Report

During the year, total income earned from Mining3’s project activities was \$10.3m. The adverse impacts of Covid 19 were felt by industry participants, delivering flow on effects to Mining3, leading to project deferrals, cancellations, and less pipeline work coming on line. However, Mining3’s future project pipeline (\$7.3m) and financial position (\$9.7m) remains strong.

Industry funded projects reduced by 23% (compared to FY2020) to \$5.6m. This includes work done by our Research Partners CSIRO, University of Queensland, Curtin University, Queensland University of Technology, and staff directly employed by the Mining3. Notwithstanding the reduction in total income, operating expenses remained under budget resulting in a \$352k net surplus for the year.

Whilst the impact of Covid 19 has impacted our project delivery, research staff have been focussed on funded project work, with the remaining time spent on project development seed research projects, funded by Mining3 itself. During the year, Mining3 received royalty income of \$318k as a result of the intellectual property rights flowing from the Cave Tracker agreement with Elexon.

Other grants include a positive \$673k adjustment to the Net Present Value of the Smartcap advance as a result of the \$1.3m repayment received during the year. Mining3 holds \$521k in share investment assets in Smartcap and Ezymine. As a result of these income streams further enhancing Mining3’s strong financial position, no future material impairments of Mining3 assets are expected, including work in progress, share assets, and plant & equipment.

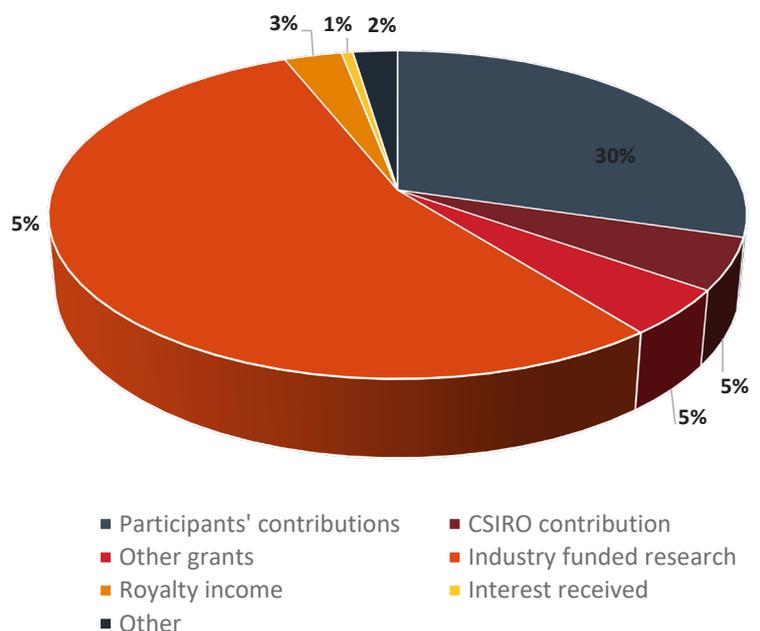
Investment in research programs remained steady at 84% of all operating expenditure.

Participants’ contributions represent the membership fee payable by both university and industry partners. Members develop the Centre’s research strategy while supporting projects through allocation of the Centre’s cash resources, and provision of external funding.

The net profit margin of 3.4% will preserve the Mining3’s financial position. Due to this position, future profit margin targets aim to achieve a sustainable surplus while delivering outcomes for our members and industry.

Total equity is \$9.7m. Current assets exceed current liabilities by \$8.8m. There is sufficient capital to meet the ongoing needs of the company in FY2022 and beyond.

Total Income 2020/21



Income Statement	2020/21	2019/20
	\$000's	\$000's
Income		
Participants' contributions	3,050	2,791
CSIRO contribution	529	585
Other grants	478	923
Industry funded research	5,627	7,282
Other revenue		
Royalty income	318	475
Interest received	63	116
Other	246	216
Total income	10,311	12,388
Expenditure		
Research programs	7,095	7,424
Research overheads	1,194	1,174
Work, health & safety	93	80
Total research spend	8,382	8,678
Administration	850	702
Business development	159	298
Technology transfer	409	367
Communications	176	159
Operating expenses	9,976	10,204
Share of (profit) losses and write-downs in respect of associated companies	(17)	(447)
Surplus/(deficit)	352	2,631
Staffing (full time equivalents-FTEs):	FTE	FTE
Research	22.8	26
Administration	7.6	8.5
	30.4	34.5
Research spend per FTE (\$000's)	311	286
Balance Sheet Summary		
Net current assets (liabilities)	8,864	7,648
Total assets	14,713	14,876
Total equity	9,657	9,305



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