MI4
MINING INDUSTRY 4.0
CRC
Prospectus
Delivering a step change in value for METS\(^1\) and Miners

From siloed value chain components to trusted systems integration

The MI4 CRC aims to achieve a step-change in the adoption of Industry 4.0 principles by the mining sector. Research will address challenges associated with mining systems integration, implementation, integrity and intelligent decision making in order to move the mining value chain to a trusted integrated-systems approach. This is expected to greatly assist in enhancing the conversion rates of Australia’s ‘mineral resources’ to ‘ore reserves’.

Successful implementation will require profound social and technical change and has the potential to transform the mining and METS sector.

Mining Industry 4.0

Industry 4.0 refers to the fourth industrial revolution:\(^2\):
- First industrial revolution – mechanisation through water and steam power
- Second industrial revolution – mass production and assembly lines using electricity
- Third industrial revolution – adoption of computers and automation
- Fourth industrial revolution – smart and autonomous systems fuelled by data and machine learning

Mines differ from manufacturing plants in that ore and energy minerals are extracted from highly heterogeneous, finite resources. Decisions made to extract ore today impact on future possible extraction sequences and overall Net Present Value. In addition, manufacturing businesses are constantly investing in new product development and associated retooling/reconfiguration of manufacturing processes. In mining, significant capital investment in plant is required upfront and there is limited scope to significantly change extraction and comminution processes once a mine starts producing. Thirdly, autonomous equipment in mining involve unique field robotics command and control challenges operating over wide geographical areas or in deep underground spaces.

Disruptive processes and technology present a high risk given the current capital and personnel intensity of operating mines. The MI4 CRC will address the challenges associated with adapting Industry 4.0 principles to the mining value chain by providing de-risked, enabling solutions. This will deliver significant reductions in both capital (CAPEX) and operating (OPEX) costs compared with current approaches. Step change reductions are achievable based on experience from other industries. This offers the potential to make current uneconomic deposits viable and make existing mines more competitive.

1. Mining Equipment, Technology and Services
MI4’s Vision

To achieve a step change in the adoption of Industry 4.0 principles across the value chain by Australian mining companies. This will be achieved by sharing the collective experience of mining and METS companies engaged in the implementation and support of such principles. Improved integration, implementation, integrity and intelligent decision making associated with Industry 4.0 will minimise downside losses, enhance the financial competitiveness of Australia’s Mining and METS sectors and position “brand Australia” as a world leader. Rapid take-up of Industry 4.0 principles by more mining and OEM companies will enhance conversion rates of Australia’s ‘mineral resources’ to ‘ore reserves’.

MI4 CRC research will focus on:
- Formulating an OEM-agnostic, open platform for interoperability
- Developing and providing life-cycle support for trusted autonomous mining systems
- Enabling utilisation of Industry 4.0 IP across small, medium and large Australian Mining and METS companies
- Preparing an Industry 4.0 competent workforce and facilitating informed, value-based decisions, and
- Researching policy and regulatory environment to help facilitate the industry changes.

Research outcomes

- Improve safety outcomes and reduced environmental impacts through precision mining
- Significantly reduce capital and operating costs for greenfield and existing mines
- Increase the conversion of Australian mineral Resources to Reserves, creating new mines, new jobs and unlocking significant value
- Grow the Australian METS sector by supplying to the Australian and international mining industry and growing international export opportunities, and
- Prepare the workforce of the future.

The MI4 CRC will create new opportunities and value for the METS sector and miners by re-imagining the mining value chain.

Developing the prospectus

This prospectus has been developed following extensive consultation with METS and miners throughout 2018, undertaken via workshops and a series of one-on-one interviews. The industry feedback suggests that there is a large amount of research to be carried out before potentially significant gains can be realised.

We seek your engagement to further refine the research programs outlined here. Expressions of interest to participate in this CRC bid are sought from the mining & METS sectors and other key stakeholders, with programs tailored for organisations of all sizes and positions in the value chain.
Context – Why the MI4 CRC?

Challenges to Australia’s position as a global mining leader

The first wave of digital technologies applied to the mining industry have largely focused on the automation of existing equipment and processes, together with improved data collection and analysis. This has allowed for important but incremental improvements to be made. The MI4 CRC is based on the premise that step changes can be achieved through the adoption of Industry 4.0 principles. This will allow for radical process re-design and operation. The MI4 CRC will work with METS companies and miners to achieve these gains.

Australia is a global powerhouse in the mining sector and home to a modern and growing export-focused METS sector. Together Australia’s mining and METS sector contributed some $133.2B in gross value to the Australian economy in 2015-2016, with an estimate of $10B to $40B contribution directly from the METS sector.4

The METS sector has been designated as an area of high priority by the Commonwealth government and in Australia is recognised as a key industry ‘high tech’ growth sector. The global demand for Australia’s mineral and metal exports is strong, with continuing growth predicted resulting from ongoing urbanisation particularly in China and India. The growing trend of electrification in transport and industry to reduce greenhouse emissions is further fuelling metal consumption.

While a global leader, the Australian mining and METS sectors faces a range of challenges:

• Increasing scarcity (and complexity) of the in-ground resource base, coupled with the challenge of finding large, high quality mineral deposits at or close to the surface
• Increasing community expectations, and challenges with respect to social license to operate and end of life mine rehabilitation
• Adoption of the UN Sustainable Development Goals
• Increased pressure to reduce energy consumption, greenhouse gas emissions and waste
• Increasing global competition through consolidation of service and equipment providers present challenges to the Australian METS industry, and
• Having a workforce prepared for Mining Industry 4.0.

Initial proponents of the Mining Industry 4.0 (MI4) CRC

5. www.sustainabledevelopment.un.org
Australia is not reaping full value from the global ‘Digital boom’

The pace of global technological development in a range of industries (for example manufacturing, defence, health, and oil and gas) has been rapid over the last decade, and particularly in the application of Industry 4.0 principles. The mining industry in Australia has not been exempt from these changes. Many mining companies are some way behind in the race to adopt equipment automation, remote operating centres and data analytics. This has the effect of a ‘digital divide’ within the Australian mining industry. According to McKinsey, “mining is in the bottom quartile of digitisation compared with other industries”6. Many millions or even billions of dollars in resource potential could potentially be unlocked through bringing METS and mining companies up to the level of industry leaders.

Mine sites are becoming increasingly flooded in a sea of data but turning data into decisions is problematic. To be successful, Mining Industry 4.0 principles need to be embraced and supported by key stakeholders. The MI4 CRC aims to encourage a suitable culture of collaborative innovation to support METS companies and miners to address the barriers to entry of new technology.

Learning from other industries

The mining industry can learn from other industries while recognising there are important contextual differences. A key premise of manufacturing is to closely control the quality and consistency of the inputs and to minimise variation. Mines, however, are typically highly heterogeneous with the composition of ore in the ground varying greatly at the macro (hundreds of meters) through to the micro (sub-micron) scale. Like manufacturing, the aim is to manage variation and to produce a uniform input into the mineral beneficiation process. Other industries that could contribute to the development of the minerals sector include defence, manufacturing, agriculture, oil and gas, and medicine to name a few.

$133.2B gross value added to the Australian economy in 2015-2016 from the mining and METS sector

The case for Australia

Why now?
Minerals are becoming more difficult to find, are generally of lower grade and more challenging to process. Deeper mines are being developed posing additional safety challenges and productivity hurdles. Government regulations and policies need to keep pace with technology and social changes.

The mining industry also faces challenges related to social operating license and the need for improved environmental performance. Mining Industry 4.0 offers great potential to assist.

The imperative for ‘action now’ is compelling:
• Australian mining industry can gain significant benefits by using rapidly developing approaches to integrate the value chain
• Australia is at risk of falling behind other countries (notably Canada, Chile and Sweden) in the digital mining space. The MI4 CRC aims to build a long-term framework while delivering short term outcomes
• The depth and breadth of skill sets required, including Australian and international researchers, METS companies and miners, means a CRC is an ideal collaboration and delivery platform, and
• Mining Industry 4.0 has the potential to transform Australia from a high-cost jurisdiction to a low-cost producer.

What it means for the mining industry:
The MI4 CRC will provide solutions that directly help integrate the value and supply chain by:
• Creating an OEM-agnostic, open platform for interoperability and integration. We are aware of initiatives being conducted by the Global Mining Guidelines group in Canada, and work sponsored by the Chilean government. Given that 70% of the world’s mining software is created in Australia, there is a need for an Australian-based initiative that will work with Australian METS and mining companies to complement, inform and influence existing initiatives.
• Developing and providing life-cycle support for trusted autonomous mining systems. This research program aims to develop tools and techniques for off-line testing of the integrity of software and sensors prior to live download. It also aims to address how maintenance strategies are impacted by automation systems designed to operate without human intervention over defined periods of time via the use of digital twins.
• Ramping up adoption of Industry 4.0 principles across small, medium and large Australian Mining and METS companies and through the value chain. Much of the success involved in implementing Industry 4.0 technologies comes by careful attention to how the technology will impact people. The MI4 will outline what changes in work roles, business rules, responsibilities and organisational structure and culture will provide best value in an integrated value chain. Mining Industry 4.0 offers great potential to enhance inclusiveness, flexibility and diversity in the mining workforce. The aim is to position Australian METS and mining companies with a competitive advantage in this area.
• Preparing an Industry 4.0 competent workforce and providing informed, value-based decisions. The digital world necessitates large volumes of data being collected and analysed over the mining value chain. The challenge is to sift and process this data in order to present the right information to the right person at the right time so as to facilitate decision making. MI4 will provide a platform for the education and training of an Industry 4.0 literate workforce. It will also experiment with machine learning and visualisation tools and techniques to process data to facilitate value-driven decision making. These tools will differ from those already applied in the manufacturing sector because of the NPV implications of exploiting finite resources.
• Engaging with Government at all levels so policy and regulation develop in sync and supporting Industry 4.0 implementation.

For the METS sector specifically:

The Australian METS sector has been a leader in the development of new technologies for the mining industry. The creation of projects within a CRC environment offers many benefits:

- Access to operational mining sites and data enabling the acceleration of development and deployment of new technology solutions
- Promulgation of industry standards to assist with interoperability
- The ability to work with multiple end users rather than one customer, thus expanding and accelerating the range of commercialisation opportunities, and
- Exposure to MI4’s network of researchers, industry partners and end users, including access to the best approaches and technologies from other industries in Australia and globally.

The value proposition

The Australian METS sector is a key provider to the Australian mining and resources industry and has a global reputation for innovation. Global demand for commodities continues to increase. When coupled with low discovery rates and a long-term decline in the grade of future resources, a step change in approach is critical to improve profitability. Current mining technology is limited to converting an estimated 30% to 40% of Australia’s mineral resources, which have been identified as having reasonable prospects for economic extraction. At this conversion rate most already identified resources will not be developed and remain as “stranded assets”.

MI4 Value proposition

The step change reduction in capital intensity and operating cost in mining has, over the next 10 years, the potential to deliver in excess $320 billion for the mining & metals sector (equivalent to 2.7% of industry revenue and 9% of industry profit), to eliminate more than 600 million tonnes of CO₂ emissions and the potential to save lives by removing people from harmful energy through automation.

9. Based on Measured and indicated Mineral Resources and Ore Reserves as aggregated per commodities by Australian Geosciences. Definitions of Mineral Resources and Ore Reserves as per the JORC Code 2012.
10. World Economic Forum (WEF, 2017) “Digitalisation could generate >$320B industry value over the next decade, $190B mining + $130B metals sector (2.7% of industry revenue & 9% industry profit), reduce CO₂ emissions by 610Mt; and improve safety - 1000 lives saved (10% decrease in fatalities), 44,000 injuries avoided (20% decrease in injuries)”.
Reimagining the mining value chain –
the Surgeon’s scalpel

The application of Industry 4.0 principles provides the opportunity to fundamentally redesign the mining value chain. From a precise knowledge of what minerals lie under the surface and how they are best processed, the objective is to minimise the amount of waste material that is mined, processed, transported, and then ultimately discarded. In short, precision mining. Modern keyhole surgery provides a useful analogy.

**Keyhole surgery** is a minimally invasive surgery. It provides accuracy and allows more rapid patient recovery and rehabilitation.

The application of digital and industry 4 principles will allow “Precision mining” to occur.

Like keyhole surgery, digital mining offers the potential to pinpoint and selectively extract the minerals and metals of interest. The aim is to:

- Maximise the extraction of valuable ore and leaving as much waste material in the ground.
- Thereby minimising disruption to the landscape and making rehabilitation quicker, easier and more complete.
- Provide a safer working environment by minimising the contact between people and machines.
- New mines can be designed in a very different way, with lower CAPEX and OPEX by removing human contact.

For new mines, digital mining will unlock previously uneconomic ores. For established mines, the application of digital technologies has the potential to increase NPV, ROI and increased cash flow.

No one individual miner, METS company or researcher has the scale, breadth or expertise to fully develop and capture these benefits. The MI4 CRC will harness both contextual mining knowledge with broader technology related opportunities to create value. Unleashing the potential of Industry 4.0 will require:

- Mining contextual knowledge
- A deep understanding of Industry 4.0 principles
- Organisations prepared to accept and maximise the benefits (a combination of innovation culture, training and capabilities), and
- Appropriate government policy settings and regulations.

Previous efforts have faltered where one or more of these enablers has not been present. All are critical.

The MI4 CRC will deliver a safer, more environmentally acceptable and productive solution to the world’s growing demand for minerals by enabling fully autonomous and integrated mining operations along the entire value chain.

This will grow the Australian mining sector through enhanced competitiveness, enable new orebodies to be mined thereby increasing reserves, and enable the METS sector to deliver mine automation and integrated mining platform solutions.
**Themes**

Detailed project outlines will be developed in close collaboration with industry partners to ensure maximum alignment and impact. At this stage four cross cutting and interrelated research themes (the four “I’s”) are proposed to stimulate engagement:

1. **(Systems) Integration: Creating an OEM-agnostic, open platform for interoperability**
   - Open platforms and architectures for data, processes and insights
   - Systems integration
   - Inter-operability solutions
   - Value chain driven decisions (dynamic resource models)
   - Encouraging entrepreneurial METs companies

2. **(Systems) Integrity: Developing and providing life-cycle support for trusted autonomous mining systems**
   - Trusted autonomous mining systems (enabling autonomous mining)
   - Systems engineering (system of systems) with new age mining equipment and plant
   - Risk management and measurement
   - Maintenance support for autonomous systems
   - Cyber resilience – bringing technology from other sectors to mining to secure handling of increasingly large volumes of data

3. **Implementation (& Deployment): Ramping up successful adoption of Industry 4.0 technologies across small, medium and large Australian Mining and METS companies**
   - Agile change management
   - Business process modelling
   - Systems re-design & rapid deployment
   - Organisation model structures to support transition
   - Government regulations & frameworks to promulgate change

4. **Intelligence (& Co-learning): Preparing an Industry 4.0 competent workforce and facilitating informed, value-based decisions**
   - Fostering the workforce of the future
   - Human machine interfaces & digital twins
   - Artificial intelligence & human-machine co-learning
   - Targeted training programs & skills development
   - Social adaptation to Mining Industry 4.0 (meeting sustainability goals)
   - Postgraduate programs for future employees
   - Providing tailored training programs for existing employees
Exemplar projects

The following are selected projects that could be undertaken in each theme. They are provided by way of example only, with the full project listing being determined in close collaboration with industry participants.

Integration
Planning, execution and measurement reconciliation
Mining companies currently use specialised planning tools for long, medium and short term planning. When it comes time to execute, separate fleet management systems are used to control production. In many surface mines, measurement of this production is done via weekly drone surveys. At present, the mine planning software does not easily communicate with the fleet management software, nor with the drone survey data. The MI4 CRC will investigate OEM-agnostic platforms for systems integration that could lead to more agile planning decisions, enabling “precision mining” and eliminating costly inefficiencies.

Implementation
Remote decision making
Industry 4.0 principles have the power to transform the way in which work is conducted. Lower resolution, routine decisions can be handled by Artificial Intelligence and machine learning techniques, leaving higher value-add decisions to be made by human experts. These experts can be located anywhere in the world. However, in order to facilitate good decision making sometimes necessitates collaboration with other experts and/or with on-site personnel. Managing these human relationships over distance can be challenging. MI4 CRC will investigate practices adopted by mining and other companies in this regard, with the intention of developing best practice guidelines for implementing remote decision-making facilities.

Integrity
Software integrity testing
Mining is increasingly becoming dependent on the integrity of software systems as it adopts automation and harnesses big data analytics. Much work has been conducted related to software integrity in the nuclear power industry, where catastrophic system failure is to be avoided at all cost. The MI4 CRC will investigate the integrity processes used to test software and sensing systems in failure critical industries with a view to developing guidelines and procedures to guide the integrity testing of software for mining automation applications.

Intelligence
Social adaption to mining automation
Mining companies are facing significant challenges regarding the social acceptance of mining projects:

- Mines are driven to maximise returns which incentivises investment in automation technologies. However, perhaps the greatest incentive for local communities to host mines relates to the employment opportunities that the project will generate. The MI4 CRC will investigate how such investment decisions are managed in other industries. This collaborative work will inform government policy.

- The MI4 CRC will not only enable smaller mining footprints with the use of Industry 4.0 technologies – smaller, made-for-purpose and scale plant and machinery, but also focus on education and training from pre-tertiary levels to vocational training to re-train the current workforce and ensure the future workforce is MI4 ready. This collaborative work will also inform government policy.
How do I participate?

What is a CRC

CRCs are independently run entities which are jointly funded by industry participants, research organisations and the Federal Government for up to 10 years. Since the inception of CRCs in 1991, 210 have been funded. Over the ensuing years, CRCs have undergone several independent reviews, all concluding that the CRC program has delivered significant economic, environmental and social benefits to Australia.

The Australian Government’s CRC program is a proven model that supports industry-led collaborations between industry, researchers, government and the community within Australia and internationally to develop new technologies, products and services. In 2018, there were 31 active CRCs in Australia.

There are many advantages for companies (small, medium and large) participating in the CRC process, including access to leading research providers, greater insights into the mining value chain, learning’s from other industries, funding leverage and networking opportunities.

The CRC bid process is highly competitive. The MI4 CRC will bid into the 2019 Round 21 Federal Government call for CRC submissions.

Next steps

By participating in the MI4 CRC bid process and subsequent formation, organisations will be able to provide input into the research areas, so they are aligned with their needs. Given sufficient industry support, the intent is to submit an application for the MI4 CRC in the Round 21 CRC bid phase, occurring from March 2019 through to March 2020.

We actively encourage Australian (research, industry and government) and international organisations to participate in the bid phase to influence and drive the bid strategy and content. Activities during this phase include:

- Establishing a bid team to prepare deliverables required for the Stage 1 bid
- Engaging with industry, government and research institutes to refine the scope and confirm the participation agreement
- Preparing research project agreements with core research institutes and industry participants to build a CRC budget, and
- Preparing a bid phase budget.

Participants can join the MI4 CRC bid at any time during the bid phase. Proponents contribute an equal share to bid costs, notionally $20,000 to $30,000, depending on the number of proponents.

Once funding has been announced the CRC is set up, this includes establishing initial governance structures (appoint Chair, Board and CEO) and working with government to finalise the funding agreement to start in July 2020.
Term and participation levels

The term of the MI4 CRC is proposed to be seven years. Overlaid on this timeframe the MI4 CRC will adopt a project horizon of three years or less, in order to provide timely impact and match the pace of change in technology development. This will balance the need for readily adoptable industry solutions and recognising the profound nature of the industry transformation required.

Four participant levels are contemplated as follows (all cash contributions p.a.):

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<th>Level</th>
<th>Contribution Range</th>
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<tr>
<td>Core participant</td>
<td>$300,000 p.a. and above</td>
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<tr>
<td>Key participant</td>
<td>$150,000 – $299,999 p.a.</td>
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<tr>
<td>Associate participant</td>
<td>Up to $150,000 p.a.</td>
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<tr>
<td>Affiliate participant</td>
<td>Project by project basis</td>
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In addition, participants will be encouraged to provide in kind resources to strengthen the technology transfer process.

Indicative Timeline

The following dates are indicative, and subject to confirmation by the CRC program.

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<tbody>
<tr>
<td>Collect expressions of interest and define research programs</td>
<td>Lodge round 1 Expression of Interest</td>
<td>Further refine bid, value proposition and finalize partners</td>
<td>Lodge round 2 Full submission including business case</td>
<td>Interview process</td>
<td>Funding outcomes expected</td>
<td>MI4 CRC commences</td>
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Contact

To participate in the MI4 CRC bid please contact

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