

TRANSFORMING MINING

2013/14
ANNUAL
REPORT



MINING

TRANSFORMING MINING

OUR VISION

To transform mining globally through industry-driven research, collaboration and innovation.

OUR MISSION

To deliver step-change innovations to existing, planned and future mines that maximise productivity and enhance resource utilisation and sustainability.

OUR VALUES

INNOVATIVE – We are leaders in mining research innovation.

CREATIVE – We push the boundaries and search for new horizons.

DRIVEN – We are focused on developing solutions for mining's grand industry challenges.

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2013-14 MEMBERS

ANGLO AMERICAN
 ANGLOGOLD ASHANTI
 BARRICK GOLD
 BHP BILLITON
 CATERPILLAR
 CSC AUSTRALIA
 GLENCORE
 HERRENKNECHT TUNNELLING
 SYSTEMS
 JOY GLOBAL
 NEWCREST MINING
 PEABODY ENERGY
 SANDVIK



GLENCORE



JOYGLOBAL



UNIVERSITY MEMBERS

CURTIN UNIVERSITY
 UNIVERSITY OF NEWCASTLE
 UNIVERSITY OF QUEENSLAND
 UNIVERSITY OF WESTERN AUSTRALIA



PROJECT PARTNERS

BARMINCO
 ELEXON ELECTRONICS
 RIO TINTO
 RUSSELL MINERAL EQUIPMENT
 SHELL
 VALE AUSTRALIA



RioTinto



CHAIRMAN'S REPORT



DR LAURIE HAMMOND
Chairman

This time last year I suggested that 2012-13 had been the most pivotal in the then 22-year history of the company. The Centre for Mining, Technology and Equipment (CMTE) Development Limited (which trades as CRCMining) had reached a point where the Board had confidence in the commitment of Members to its long-term operation after its planned exit from the CRC Program.

That confidence was not misplaced, but it was tested by the substantial effort that was required during 2013-14 to finalise and turn those commitments into an executed new Member Agreement. It was another object lesson in how the deepening downturn in commodity prices adversely affected the companies that comprise CRCMining's membership.

However CRCMining, which has long and widely been regarded as a standout product of the national Cooperative Research Centres program, continues to receive accolades for being one of the few CRCs that has successfully transitioned from the program. Much credit is due to Chief Executive Paul Lever and his management team, who have worked both hard and smart to ensure a successful transition. The Board backed management's judgement during some periods of significant uncertainty.

The very visible re-branding and corporate communications work done in 2013 will stand the organisation in good stead, but will need to be revisited in the future in the light of foreshadowed changes to the CRC Program and their possible effect on the value and utility of the CRCMining brand.

The company starts its new life with a comprehensive long-term research program developed and signed off by its Members. The process by which that was achieved has been noted by people outside of the organisation as a great example of the mining industry's capacity to take a long-term strategic view of its innovation requirements. For example, it provided inspiration to those developing the ResourcesQ 30-year strategy for Queensland, a joint initiative between the industry and government.

I thank the Members for their continuing high level of engagement, a hallmark of successful industry-driven research and development organisations.

After June 2014, CRCMining will be a somewhat smaller operation than it has been in recent years, but we have good reasons to believe its membership base will soon start to grow again; this would be consistent with the pattern we have observed previously when the company went through re-funding bids. Historically our Members have taken the view that additional mining companies should always be welcome to join if they commit to the collaborative model, and that OEM companies are similarly welcome provided the competition that naturally exists between them can be managed and does not unduly affect existing OEM members.

On behalf of the Board I thank the Members for their continuing high level of engagement, which is a hallmark of successful industry-driven research and development organisations. I also thank Paul Lever for his effective leadership of a very committed management team.

My thanks are also extended to my fellow directors, who comprise an effective board that achieves high quality standards of governance.

I look forward with unabated enthusiasm to continuing success for CMTE Development Limited.



CEO'S REPORT



PROFESSOR PAUL LEVER
CEO, CRCMining

This year, 2013-14, brings to an end the Centre's successful partnership with the Commonwealth CRC program that started in 1991. Twenty-three years later, we are excited and enthusiastic about our new life from July 1, 2014 as a fully industry supported collaborative research centre.

Going forward, our vision and its associated ideals and motivations remain essentially the same as they have been for the past 23 years. We continue to strive to contribute to the sustainability of the mining industry by partnering and collaborating with the world's leading mining companies, original equipment manufacturers and universities to deliver transformational research and innovation.

As we go forward as a new entity, we see many opportunities for new types of collaborations and partnerships, and for improving the value we deliver to our members and the mining industry as a whole. We would like to thank the CRC Program for its support of the Centre over the past 23 years.

Despite being buffeted by the stresses of a depressed resources industry, the Centre enjoyed another fruitful year. All but a few of our research and commercialisation milestones to complete the CRCMining2 program have been achieved this year and these will be completed in the first half of the new financial year (2014-15).

The year contained a number of significant achievements starting with the **Cave Tracking System** that has now been installed in two major mine sites, including Rio Tinto's Argyle Diamond Mine in Western Australia. This technology monitors in real-time the 3-dimensional position of cave material for block caving operations. The underground trials to date have shown good results in detection range and accuracy, which should deliver significant gains for industry. Testing shows that the detectors can detect and track beacons up to 200 metres away through rock. This 3-year project is fully industry funded (\$4M by Newcrest, now supported by Rio Tinto) where our commercialisation partner is Exelon Electronics, a Brisbane-based SME.

Nitrogen oxide fumes (NOx) from blasting appears to be an industry-wide problem that occurs in a variety of geological conditions with the use of a variety of bulk ammonium nitrate based explosive products.

The Centre's members have prioritised as a key safety target, the elimination of the NOx hazard from blasting. The current project aims to develop and trial an **alternative explosive formulation** that eliminates the use of ammonium nitrate (AN) as the main oxidising agent, which will completely eliminate the potential of NOx fumes. Initial trials are very promising.

Professor Ross McAree and his team at the University of Queensland (UQ) have been focussed on demonstrating the **Shovel Load Automation Program (SLAP)** technology on a rope shovel at an operational Queensland coal mine. This project aims to semi-automate the swing and return components of a shovel load cycle. The benefits of SLAP span safety, availability, productivity and maintenance through two technologies, TruckShield and AutoLoad. The major components of the technology have now been tested at the mine site and the integrated demonstration will follow shortly.

The Centre's spin-off company **EdanSafe Pty Ltd** is now commercially delivering our **SmartCap Fatigue Monitoring** technology to a growing number of major mining companies around the globe. This Brisbane-based technology company is profitable and has a very bright future.

The spin-off company **Odyssey Technology Pty Ltd** holds the intellectual property associated with the novel method for cutting hard rock, **Oscillating Disc Cutting (ODC)**. In 2006, this technology was licensed to Joy Global and branded as **Dynacut**, which combines a number of innovative rock breakage concepts into a single technology – enabling the excavation of hard rock using comparatively small and lightweight equipment as a continuous mining process, in both surface and underground mining applications. Underground trials of the technology will occur in the near future.

The Centre is collaborating with Australian Coal Association Research Program (ACARP) and German institute Physikalisch-Technische Bundesanstalt (PTB), to develop an alternative to the electro-mechanical Spark Testing Apparatus (STA) that has been the standard for 50 years. The new **Electronic Spark Tester (EST)** provides a more reliable, more informative and versatile test method, and an intrinsic safety approach that will deliver better risk management in explosion protection. The EST measures both the transient and steady state performance of an energy device (power supply) and then provides an indication of spark energy that could be developed and compares this to an explosive limit. The information collected from the EST provides much greater value in terms of design validation, and quantifies the margins of safety for devices being certified. The objective is for the EST to become the standard for Intrinsic Safety testing and certification.

During the year the Centre worked with its members to finalise the new member agreement for membership beyond 1 July 2014 as a fully member-controlled organisation. Considerable effort has focused on successfully transitioning from the CRC program with signed-up

members and a required project portfolio in place. A strong focus continues around member engagement that has been strengthened by the appointment of Stephen Powell as Director of Industry Engagement. The position was created as a direct request from members. Stephen Powell is a mining engineer with more the 35 years mining experience, most recently as the Manager Mining Innovation at Newcrest Mining Limited.

Improved project management and performance has been a focus for the Centre this year. This has been achieved by implementing a number of new and improved processes that include:

- Updated project proposal template documents;
- A more rigorous process for checking/approvals of project proposals;
- New project initiation procedures for project leaders to ensure that projects start well and project leaders have a well defined project plan and understand their responsibilities;
- Regular meetings every two weeks for project leaders with their Program Leader to report project progress over the past two weeks and define project tasks for the next two weeks;
- New detailed and regular review of project budgets by program leaders and the CFO;
- CRCMining Project Management Guidebook to assist project leaders;
- New project reporting template for final reports; and
- Project management training opportunities for project leaders.

The Centre continues to support 15 postgraduate students at its four partner universities. We also maintain a vibrant six week summer undergraduate vacation work program, which provides 3rd and 4th year engineering students with hands-on, practical project experience.

As planned, CRCMining has now successfully transitioned from the CRC Program. Despite the worldwide slow-down in the resources industry we are confident that we have put in place an effective, sustainable collaborative organisation. The Centre is well placed to work with the mining industry as it goes forward to address a number of upcoming grand challenges. The opportunity to collaborate to overcome these grand challenges is at the core of the value the Centre delivers to its members. Transition is just the start of this new and rewarding phase for the Centre and its members.

We continue to strive to contribute to the sustainability of the mining industry by partnering and collaborating with the world's leading mining companies, original equipment manufacturers and universities to deliver transformational research and innovation.

BOARD OF DIRECTORS



Laurie HAMMOND
BSc, PhD

DIRECTOR, IQ CAPITAL
MANAGEMENT PTY LTD
(APPOINTED DECEMBER 2007)

Dr Laurie Hammond became a director and independent Chairman in December 2007. He is Chairman of the Commonwealth Government's Commercialisation Australia Board and a member of the Innovation Australia Board.

He is an investor in many start-up and early-stage technology ventures through inQbator and iQ Capital Management, investment management companies which he co-founded, and is currently a director of several investee companies. Previously, he was a research scientist and chief executive of several statutory bodies in Australia and New Zealand. Dr Hammond also chairs the A&R committee.



Paul LEVER
BSc, MSc, PhD

PROFESSOR, CEO - CMTE
DEVELOPMENT LIMITED
(APPOINTED 1 MAY 2012)

Professor Paul Lever became the CEO of CRCMining in May 2012. He joined in 2000 as the Program Leader for the Mining Systems Program, and held several roles within the Centre before becoming the Research Director in 2009. He is also a Professor of Mining and holds the CRCMining Chair at The University of Queensland (UQ).

Prior to joining CRCMining, Professor Lever spent 10 years as a faculty member in the Mining and Geological Engineering Department at the University of Arizona and was Department Head from 1996 through 2000.

He is an internationally recognised expert in the fields of mine automation, excavation and loading technologies and mining systems. He was awarded a PhD in Mining Engineering from the Colorado School of Mines in 1991.



Gordon DUNLOP
BE (Metallurgy), MAsc, PhD

SPECIAL ADVISOR
BUSINESS DEVELOPMENT,
THE UNIVERSITY OF
QUEENSLAND
(RESIGNED 13 NOVEMBER 2013)

Professor Gordon Dunlop was the Research Member representative on the CMTE Board of Directors. Professor Dunlop has 40 years' experience in research, education and commercialisation in the fields of metallurgy and materials engineering and holds degrees in Engineering and Applied Science.

He was awarded his PhD from the University of Cambridge in 1974. He is a former CEO of the CAST CRC and is currently Chairman of the Queensland Division of the Academy of Technological Sciences and Engineering.

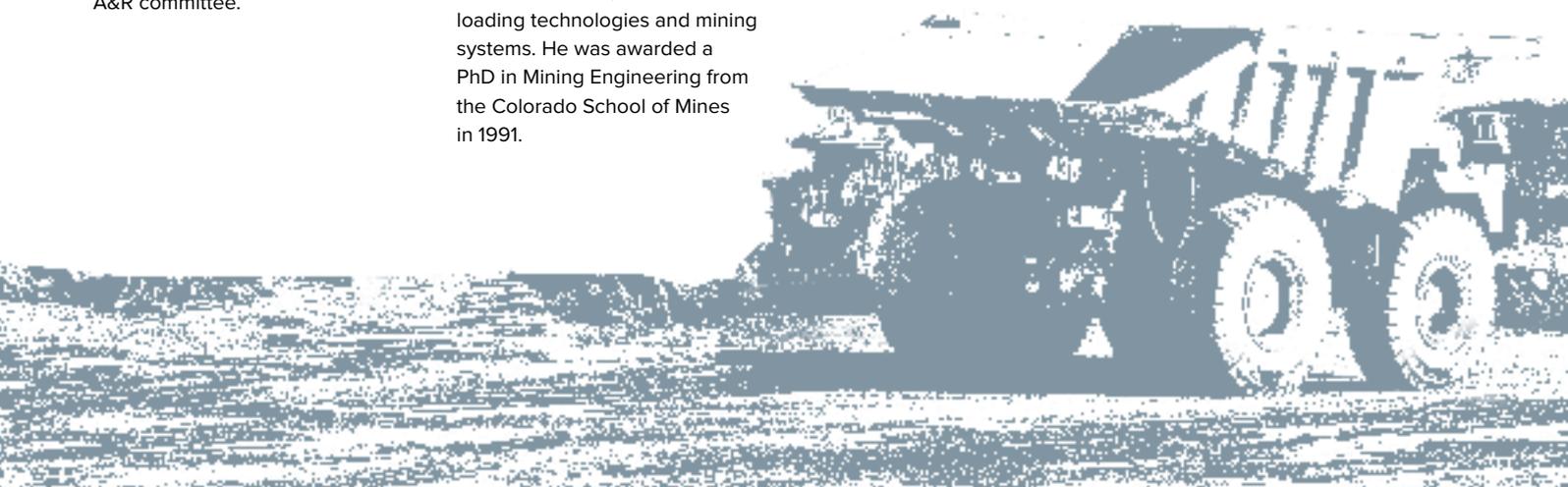


Andrew RANSLEY
B.Eng (Mechanical) (Hons)

GENERAL MANAGER, ASIA
PACIFIC CATERPILLAR
GLOBAL MINING
(APPOINTED 29 MAY 2012)

Andrew has over 30 years' experience in the mining industry. His career includes positions at mine sites with Consolidated Goldfields Australia in Tasmania and New South Wales and with Metals Exploration Ltd in Kalgoorlie, WA. Andrew also has experience in manufacturing at Dale B Elphinstone Pty Ltd as Operation Manager and was also the Group Plant Manager at Thies Contractors.

Since joining Caterpillar in 1995, he has held the positions of General Manager, then Managing Director for Caterpillar Underground Mining in Burnie Tasmania and Product Manager for Large Tractors in Peoria, Illinois.





Graham EHM
BSc (Metallurgy), MAusIMM,
MAICD

GENERAL MANAGER
OPERATIONS – AUSTRALIA
ANGLOGOLD ASHANTI
AUSTRALIA LTD
(APPOINTED 12 MAY 2011)

Graham Ehm is the Executive Vice President Australasia for AngloGold Ashanti and briefly held the same position in Tanzania in 2009/10. Graham has a background in mine operations and management, covering the nickel, copper, uranium and gold sectors. He holds a Bachelor of Science (Hons) and is a member of both the AusIMM and the AICD.



Alex HATHORN
BSc (Mining Engineering)

MANAGING DIRECTOR –
COAL, HATCH
(APPOINTED 28 AUGUST 2011)

Alex Hathorn has over thirty years of mining industry experience in senior roles with Gold Fields of South Africa, Anglo American, Peabody Energy and latterly Hatch. He has been involved in mining in many global resource provinces and with a wide diversity of commodities - gold, platinum, iron ore and coal, amongst others. He has held a number of directorships; notably, he was on the Board of AMIRA for eight years, and is also a past director of both Australian Coal Association Low Emissions Technologies (ACALET) and Australian Coal Research Ltd (ACARP).



Kellie McKENZIE
BBus (Hons), CA

PARTNER – ERNST & YOUNG
(APPOINTED 15 SEPTEMBER 2011)

Kellie is a Partner with Ernst & Young who specialises in the resource industry.

Her experience includes providing audit, due diligence and transactional advice to clients both in Australia and Europe.

Kellie is a Chartered Accountant and chairs the Audit Committee.



Rowan MELROSE
BE (Hons), M.App.Sc., MBA

PRESIDENT, SANDVIK MINING
ASIA PACIFIC
(APPOINTED 30 NOVEMBER 2011)

Rowan is responsible for the Sandvik Mining operations in the geographical area bounded by India to the West, Mongolia and China to the North and New Zealand and the Pacific Islands to the East. Rowan is an Engineer with over 25 years' experience in the resources sector covering operations, manufacturing, supply and finance.



BOARD OF DIRECTORS



Professor David MEE

PhD, BE (Mech) Hons 1st Class

HEAD OF SCHOOL,
MECHANICAL AND
MINING ENGINEERING,
THE UNIVERSITY OF
QUEENSLAND

(APPOINTED 13 NOVEMBER 2013)

Professor David Mee is the Research Member representative on the CRCMining Board of Directors.

He has a background in leadership and personnel and financial management in a research environment. He has previously been Head of the Division of Mechanical Engineering and Head of the School of Engineering. Professor Mee is also a member of the Board of the CRC for Rail Innovation. Professor Mee is an Associate Fellow of the American Institute of Aeronautics and Astronautics and is actively involved in the Queensland Division of the Australian Acoustical Society for ten years.

DURING THE YEAR THERE WAS A CHANGE IN DIRECTORS. PROFESSOR DAVID MEE WAS APPOINTED TO REPLACE PROFESSOR GORDON DUNLOP AT THE AGM ON 13 NOVEMBER 2013. IAN HARRIS WAS APPOINTED AS AN ADDITIONAL ALTERNATE DIRECTOR.



ALTERNATE DIRECTOR

Andrew DOE

BEng (Mining), MAusIMM

VP TECHNICAL & BUSINESS
IMPROVEMENT, ANGLOGOLD
ASHANTI AUSTRALIA LTD

(APPOINTED 30 JULY 2013)

Andrew Doe is the VP Technical and Business Improvement for AngloGold Ashanti Australia. Andrew has 19 years' experience in metalliferous mining in a range of operational and technical roles. Andrew has a degree in Mining Engineering and is a member of the AusIMM.



ALTERNATE DIRECTOR

Ian HARRIS

BSc Agr, Grad Dip Admin,
MEd, GAICD

DIRECTOR, RESEARCH
PARTNERSHIPS, UQ
RESEARCH & INNOVATION,
THE UNIVERSITY OF
QUEENSLAND

(APPOINTED 13 NOVEMBER 2013)

Ian is the Director of Research Partnerships, UQ Research & Innovation at The University of Queensland, with responsibility for research partnerships, including CRC's. Previously Ian was COO for the ARC Centre of Excellence for Integrative Legume Research. He has also held senior management roles at several Australian universities (including The University of Sydney and The Australian National University), establishment of the IDP Education Australia office in the Philippines and business development in the community health and aged care sector in Queensland.

He is a Graduate member of the Australian Institute of Company Directors and a Board Director of the Living with Autism Spectrum Disorders CRC, and the CRC for Optimising Resource Extraction (CRC ORE).



COMPANY SECRETARY

Jane SEAWRIGHT

BA.LLB (Hons), MBus
(Marketing), FAICD

Jane Seawright is an experienced corporate and commercial lawyer, marketing professional, company director and company secretary, with wide experience across a range of professional services and other sectors. She has practised in Brisbane at a number of national and local firms, and is currently a consultant to Tobin King Lateef.

In addition to her role as Company Secretary and General Counsel at CRCMining, her current directorships include the Residential Tenancies Authority, and Energising Communities Limited, a not for profit company.

Jane has also served as a director of City North Infrastructure Pty Ltd, as chair of the Queensland Institute of Medical Research Trust and most recently independent chair of Fisher Adams Kelly, patent attorneys.



SENIOR EXECUTIVE TEAM



Paul LEVER
CHIEF EXECUTIVE OFFICER

Professor Paul Lever is the CEO of CRCMining, and also the CRCMining Chair and Professor of Mining at the University of Queensland. Prof Lever held several positions at CRCMining prior to becoming CEO that included Research Director, VP for Business Development and Program Leader.

Before joining CRCMining in July of 2000, Professor Lever was Associate Professor and the Head of the Mining and Geological Engineering Department at the University of Arizona. He received his MSc and PhD in Mining Engineering from the Colorado School of Mines in 1991, and is qualified with a BSc in Mining Engineering from the University of Witwatersrand in Johannesburg, South Africa.

Professor Lever's research interests include the fields of robotic and automated mining systems, smart mining machines and systems, and intelligent

data analysis techniques. He has worked on many mining industry step-change research projects, including intelligent control algorithms for an automated (Robotic) excavator, developing the science of bucket/material interactions to improve the performance of large excavators, and cave-tracking technology to monitor and understand the caving process.

He has authored and co-authored 70 research publications, and also developed a number of innovation patents. In 2011, he authored the "Automation and Robotics" section of the Third Edition of the SME Mining Engineering Handbook.

Professor Lever has won several prestigious awards, including the Australian Coal Association Research Program (ACARP) Research Excellence Award in 2004, and two University of Queensland Awards for Programs that Enhance Learning in 2009.



Charles GOLDING
CHIEF FINANCIAL OFFICER

Charles Golding is an experienced financial and operations manager and is also currently responsible for the maintenance of the Centre's Intellectual Property (IP) register and all IP protection and patenting procedures.

Charles' experience includes more than 18 years at Price Waterhouse plus six years as Finance Director at LSE listed Meikles Africa Ltd. Charles has worked in Zimbabwe, South Africa, Hong Kong and the United Arab Emirates.

Charles has been with the Centre since 2004 and has held the positions of Business Manager, Commercial Manager and is currently Chief Financial Officer and also in charge of the Administration Team. Charles is also the CEO of GeoMole Pty Ltd, a Centre spin-off company.

Charles is an Australian Chartered Accountant and has a Bachelor's degree in Commerce from the University of Natal.



Kevin GREENWOOD
CHIEF OPERATING OFFICER

Kevin Greenwood is responsible for ensuring CRCMining's research activities result in effective outcomes and industry impact, including research operations, engagement of industry members, and effective commercialisation of intellectual property with industry partners.

Kevin's experience includes more than 15 years mining industry experience, including 5 years with WMC as an engineer at Olympic Dam and Kambalda, and 10 years in senior executive roles with Leica Geosystems' mining business in Brisbane and Denver. He was previously involved with Beeline Technologies, a start-up company focused on agricultural technology.

Kevin is a director of Mineware, Acumine, Ezymine and EdanSafe. He has a Bachelor of Engineering from University of Queensland (Power and Control Systems), and a Masters in Business Administration from Deakin University.



Jane SEAWRIGHT
COMPANY SECRETARY AND
LEGAL COUNSEL

Jane Seawright is an experienced corporate and commercial lawyer, marketing professional, company director and company secretary, with wide experience across a range of professional services and other sectors.

She has practised in Brisbane at a number of national and local firms, and is currently a consultant to Tobin King Lateef.

In addition to her role as Company Secretary and General Counsel at CRCMining, her current directorships include the Residential Tenancies Authority, and Energising Communities Limited, a not for profit company.

Jane has also served as a director of City North Infrastructure Pty Ltd and as chair of the Queensland Institute of Medical Research Trust and most recently independent chair of Fisher Adams Kelly, patent attorneys.



Erica THOMAS
MARKETING AND
COMMUNICATIONS
MANAGER

Erica is a specialist in strategic marketing, business planning and governance, and human resource management, with over 15 years experience working with private commercial and public sector organisations across a diverse range of industries in South Australia and Queensland, including mining, infrastructural engineering, agriculture, finance and tertiary education.

She has held board directorships with Bendigo Bank at state and national levels, and The Epilepsy Centre SA/NT.

Erica's professional expertise is supported by a strong academic background. From 2006 to 2012 she lectured and tutored business and marketing undergraduate courses at the University of South Australia (UniSA), and was also involved in developing the UniSA Business School's Marketing course curriculum.

Improved project management and performance has been a focus for the Centre this year. The opportunity to collaborate to overcome the industry's grand challenges is at the core of the value the Centre delivers to its members.

PROGRAM LEADERS



Professor Ross MCAREE

AUTOMATION PROGRAM LEADER

Professor Ross McAree is Professor of Mechanical Engineering at the University of Queensland (UQ), Head of the UQ Mechatronic Engineering program, and Director of Research for the UQ School of Mechanical Engineering and Mining Engineering.

His research interests are in robotics and automation: automatic control systems, constrained predictive control, state and parameters estimation, data analysis, dynamics of mechanical and electro-mechanical systems and real-time computing.

Professor McAree received his PhD from the University of Melbourne in 1993. From 1993 to 2000 he was a research fellow in the Robotics Research Group at Oxford University and a Stipendiary Lecturer in Engineering at Trinity College, Oxford.

He joined The University of Queensland in 2000 as a Senior Lecturer in Mechanical Engineering in 2000 and was promoted to Associate Professor in 2006 and Professor in 2007. He currently holds the P&H Chair of Mechanical Engineering in the School of Mechanical and Mining Engineering.

Professor McAree has served at various times as UQ's Program Director for Mechatronic Engineering (2002-2005 and 2007-2011), Chair of the School of Engineering Teaching and Learning Committee (2007) and Chair of the School of Mechanical and Mining Engineering Research Committee (2009-on going).

In October 2013 Ross was elected a Fellow of the Australian Academy of Technological Sciences and Engineering (ATSE).



Dihon TADIC

HARD ROCK AND SURFACE MINING PROGRAM LEADER

Dihon Tadic has been working with CRCMining since 2000. He holds Bachelors and Masters Degrees in Mining Engineering from the University of Queensland. Following completion of his Masters thesis, which involved applied research across a series of Centre projects investigating high-pressure water jet technology for rock drilling and cutting, Dihon has played a key role in designing and developing novel drilling and rock breakage technologies. These include blast hole drilling and automation tools, measurement-while-drilling technology, and water jet drilling and rock breaking systems for application in coal and hard rock mining.

Another principal research interest – and focus area for CRCMining is the assessment and optimisation of materials handling systems. Dihon's work in this field expands the unique capability of the Centre to conduct accurate scaled dig testing and analysis of

rock excavation systems for equipment selection, design and optimisation purposes. This work is inherently linked to developing technology for improving control and consistency of rock fragmentation, and understanding the effect of fragmentation performance on the mining value chain.

In 2012, Dihon was appointed to lead the Centre's Hard Rock and Surface Mining Program. A core responsibility of this role, in addition to providing technical expertise and guidance to a broad range of applied research projects, is to ensure that these projects are developed to collectively address the longer-term challenges facing the future of mining, whilst delivering a stream of tangible short- and medium-term outcomes for the industry.



Scott ADAM

UNDERGROUND COAL
MINING PROGRAM LEADER

Scott Adam is a world authority in water jet drilling technology and flexible continuous drilling systems.

Scott has extensive experience in mining research, and is qualified with a Bachelor Degree in Mechanical Engineering from the Queensland University of Technology (QUT). He has played a central role in the development of revolutionary step-change drilling technologies at CRCMining since 1997, including water jet drilling systems, novel coil tube drilling systems, and advanced geophysics sensing systems. He is an inventor of several breakthrough drilling technologies with several patents, and leads the development of the Tight Radius Drilling (TRD) system.

In 2012, Scott was appointed to lead the Centre's Underground Coal Mining Program. His team of mining research experts is pioneering the development of distributed fibre optic sensing technologies for coal mining applications, including borehole gas flow monitoring, asset monitoring and machine sensing. The group is also active in drilling technologies and longwall condition monitoring tools.



Professor Peter KNIGHTS

PERFORMANCE AND
RELIABILITY PROGRAM
LEADER

Professor Peter Knights is BMA Chair and Professor and Head of the Division of Mining Engineering at the University of Queensland. He specialises in mine maintenance management, mine operations and process control, mining simulation and mining equipment automation. In addition to this role, Peter is Executive Director of Mining Education Australia – a joint venture involving the four largest mining engineering programs in Australia sponsored by the Minerals Council of Australia.

From 1996 to 2004, Peter was employed as an Assistant Professor with the Faculty of Engineering of the Catholic University of Chile, based in Santiago, Chile. He was subsequently named as Associate Professor and Canadian Chair in Mining.

Peter holds a Bachelor's degree in Mechanical Engineering for the University of Melbourne, Australia, a Masters degree in Systems Engineering from the Royal Melbourne Institute of Technology and a Ph.D. in Mining Engineering from McGill University, Canada.

For the past 25 years, Peter's research work has focussed on maintenance and reliability engineering. He is best known for promoting the now widespread use of logarithmic scatter plots (also known as jack-knife diagrams) to characterise and prioritise downtime events for his industry training courses on Root Cause Failure Analysis and for developing pragmatic approaches to RCM.

His recent work has focussed on mine data analytics and the reliability and planning issues associated with novel mining systems. He has a number of maintenance publications in prestigious international journals such as the Journal for Quality in Maintenance Engineering and the Journal of Reliability Engineering and System Safety.



PROFESSOR BOB BETZ

ENERGY AND POWER
PROGRAM LEADER

Professor Bob Betz is the Head of the School of Electrical Engineering and Computer Science at the University of Newcastle. He has had a long and successful career with the University of Newcastle since 1982, with 202 research publications to date, and he has taught a broad range of courses in Electrical and Computer Engineering. His areas of research expertise include electric machine control, power electronics, real-time computer systems, computer operating systems, software, industrial electronics – digital and analogue.

Bob undertakes extensive industrial consulting, usually involving project related work. In 2004 Bob became the Chief Technical Consultant for ResTech Pty Ltd, a joint company between the University of Newcastle and Ampcontrol Pty Ltd, a Newcastle based electrical equipment developer and manufacturer. In 2008 Bob won the Don Nicklin Award for most outstanding paper at the 2008 Australian Mining Technology Conference, 16-18 Sept, Twin Waters Resort, Queensland, Australia. Paper titled "Multi-level Statcom – Power Quality Control in Mining Applications".

TECHNOLOGY TRANSFER STRATEGY

The goal of technology transfer activities is to actively commercialise new and existing intellectual property (IP) developed by CRCMining based on the following strategy:

- Ensure the IP generates successful outcomes (products and / or services) as quickly and reliably as possible to the maximum benefit of our members and the mining industry; and
- Ensure that the IP generates value (\$) and reputation) to CMTE but not unreasonably at the expense of the first point above.

In order to generate successful outcomes from its IP, the Centre's approach for its commercialisation pipeline is:

- To establish independent governance of spin-off companies, with the goal of supporting and guiding those companies toward an appropriate exit, enabling CRCMining to realise value from its shareholdings;
- To support licensees as required, either as knowledge transfer or funded research projects, in order to best ensure the success of the resulting products, and to realise ongoing revenue streams from the licensed IP.

While providing valuable leverage for research funding, the organisation's business strategy does not hinge on receiving returns from IP for the following reasons:

- A Centre business plan that relies on the funds from its IP commercialisation to remain viable means that these decisions may be driven by greatest benefit to the Centre and not that of the members.
- The magnitude of revenue generated by Centre IP back to the Centre is significantly impacted by mining industry cycles.
- Small start-up technology spin-off companies need to re-invest profits to ensure growth. Extracting these funds in the spin-offs early years threatens their viability, or encourages a premature exit from those companies.

COLLABORATION

CRCMining operates differently to other research centres, as a joint venture between:

- Mining companies and OEMs that identify industry and technology needs;
- OEMs and SMEs that commercialise and deliver the technologies; and
- Top ranked universities that conduct research to solve industry problems.

The Centre ensures that research outputs deliver significant value to the industry. Our world-class researchers understand the needs of the mining industry and are experienced in collaborating with all the necessary stakeholders to achieve innovative and viable solutions. CRCMining has synergistic ties with a wide group of research providers, and the capacity to grow its research program through mutually beneficial agreements with Australian and international research bodies.

2013-14 COLLABORATIVE ACTIVITIES

Internationally, the Centre's researchers collaborated with professional staff from world-leading mining organisations and institutions in Germany, Chile, South Africa and the United States.

On a national level, the Centre continued to collaborate with non-member companies, including Rio Tinto, Newmont, Vale, Russell Mineral Equipment, Barmenco, Surtron Technologies, Elexon Mining (Cave Tracking), Gas Field Services and many others, as well as other bodies including Standards Australia and the Sustainable Minerals Institute (UQ).

In total the Centre participated in eighteen national and eight international collaborations during the reporting period. These collaborations are fundamental to the success of CRCMining and a large portion of its efforts annually are directed to developing them. In the last four and a half years the Centre has managed to secure over \$42 million of industry and participant funding, \$13 million more than its original application amount. All of this additional cash has gone directly towards research, development and technology transfer.

CRCMining operates differently to other research centres, as a joint venture between Mining Companies, original equipment manufacturers and top ranked universities.

CORPORATE PROFILE

The Centre relies heavily on its Communications Strategy to promote CRCMining's work in mining technology research and development.

A detailed Marketing and Communications strategy and activities plan is formulated and reviewed yearly.

During the 2013-14 year, communications initiatives included:

- The CRCMining Industry Forum
- CRCMining member and partner seminars
- Staff team building events
- Targeted national and international media coverage
- Quarterly newsletters
- The Centre's website and social media
- National and international conference presentations
- A presence at conferences and trade shows including SME 2014, and CRC Association / CRC Program showcases

CRCMINING MEMBER PORTAL

The CRCMining Member Portal provides a secure, online unified knowledge system that integrates the core functions of stakeholder, project, customer relationship management, geographical information and document management systems. The Portal houses more than 1000 CRCMining research reports and technical papers, and enables members to collaborate on projects 24-hours a day, from any location around the globe.

STRATEGIC COLLATERAL FOR MEMBERS

CRCMining's unique Roadmap for Members details the Centre's research vision and strategy, research roadmaps, industry outcomes to be delivered in the next 1-20 years, key benefits to members, the Centre's operating model, and terms of membership. The highly confidential Roadmap document is provided to existing and potential members and partners, and accompanied by CRCMining's large format Roadmap poster, and Project Outcomes document that showcases over 50 of CRCMining's research projects.

2013 CRCMINING INDUSTRY FORUM

The Centre held its annual Industry Forum on 13 November 2013 at the Queensland University of Technology (QUT) Gardens Theatre in Brisbane, with a theme of Research Solving Industry Grand Challenges and Transforming Mining. The 2013 CRCMining Industry Forum was quite different from previous CRCMining conferences. The industry-focused program, targeted to CRCMining members and partners, highlighted break-through research outcomes that solve the mining industry's Grand Challenges.



RESEARCH STRATEGY

The CRCMining Research Strategy focuses on the following overarching themes:

- Developing human resources to meet industry technology needs
- Growing the Centre's intellectual capacity to solve current and future industry challenges
- Undertaking fundamental research aimed at addressing key industry grand challenges
- Delivering applied research that demonstrates technology implementation
- Managing effective technology transfer to ensure industry outcomes

The Centre prioritises the delivery of ongoing incremental industry outcomes including continuous improvement generated through the opportunities within the research roadmap that maximise short-term benefit to members operations, as stepping stones toward longer term, step-change impacts.

RESEARCH VISION

CRCMining works with its members to develop a common research vision with a 20 year timeframe, with a rolling 8 year roadmap to achieve major research outcomes for meeting the vision. From the roadmap we continually identify and deliver solutions that have immediate impact to our members' businesses.

RESEARCH MISSION

Our mission is to develop industry solutions, which provide both incremental, and step-change productivity increases for the five Grand Industry Challenges.

EFFECTIVE TECHNOLOGY TRANSFER

The goal of our technology transfer activities is to actively commercialise our new and existing IP to ensure that it generates successful outcomes (products) for the maximum benefit of our members and the mining industry.

A secondary requirement is that IP generates value (\$ and reputation) to the Centre but not unreasonably at the expense of the members and industry.

FOCUS ON INDUSTRY CHALLENGES

CRCMining members drive the research strategy, to achieve priority outcomes to address the global mining industry's Grand Challenges:

• SURFACE AND UNDERGROUND MASS MINING

- o Step-change and Next Generation technologies, equipment, methods and processes to increase productivity, safety and sustainability

• SELECTIVE MINING

- o Low-cost, highly productive and safe methods and technologies to selectively mine large deposits

• RAPID MINE DEVELOPMENT

- o High-speed, safer access to mine deposits for rapid profitability

• MINING IN CHALLENGING ENVIRONMENTS

- o Productive, safe and highly profitable techniques to work in problematic locations

OUTCOMES FOR EXISTING AND FUTURE MINES

- Improved health and safety
- Reduced mining costs
- Increased productivity
- Reduced infrastructure and low capital cost
- Increased recovery, less dilution
- High productivity transport systems / logistics
- Lower geotechnical risk
- Stretch challenges – new concepts / paradigms

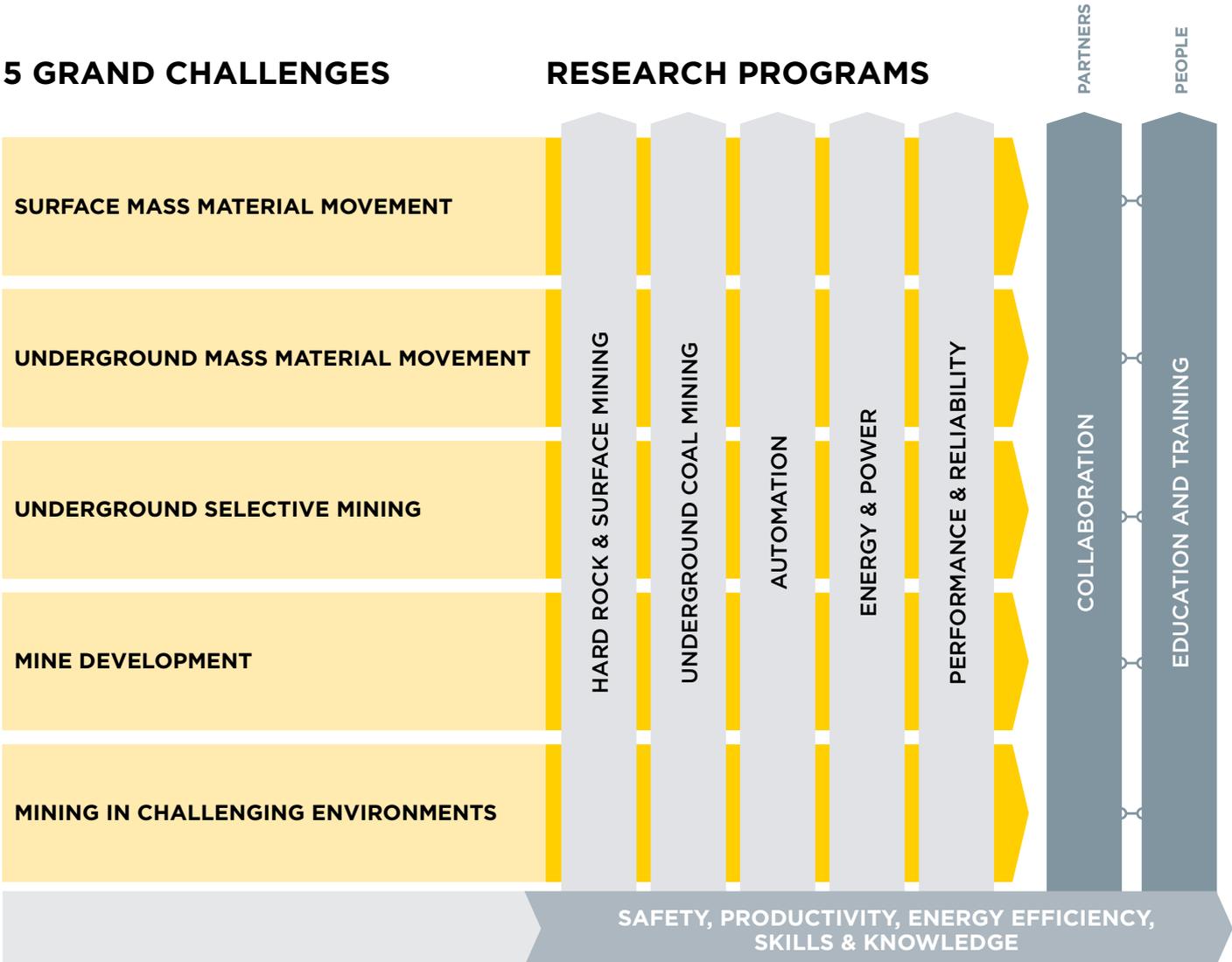
CRCMining members drive the research strategy, to achieve priority outcomes to address the global mining industry's Grand Challenges.

RESEARCH DELIVERY STRUCTURE

During the 2013-14 reporting period CRCMining’s research projects were restructured into five Program areas that focus on the five Grand Industry Challenges.

Under the direction of our members, CRCMining ensures solutions to the industry Grand Challenges are achieved. Our world-class researchers in the Centre’s research programs collaborate with other organisations across the world to generate the required research outcomes.

The figure below details the future matrix structure to be used by CRCMining to describe its research activities.



RESEARCH PROGRAMS AND INDUSTRY OUTCOMES

Outlined below is a summary of the research activities undertaken during the reporting period, with a program and outcome level summary of major research activities.

AUTOMATION PROGRAM

PROGRAM LEADER: PROFESSOR ROSS MCAREE

PROGRAM MISSION

- Develop innovative automation technologies that provide step change improvements in multifactor productivity and safety in open-pit and underground operations of the future.
- Facilitate global industry acceptance and implementation of step change automation technologies.
- Provide a measurement of multifactor productivity and safety of step-change automation technologies.
- Capture the value of step-change automation technologies.

PROGRAM STRATEGY

The Program's strategy to achieve this mission is to:

- Manage a carefully selected portfolio of automation technology projects defined, classified and ranked by value.
- To develop a reference architecture able to characterise automated mining systems using a common industry-accepted language and method;
- Be the custodian and purveyor of methods derived from the reference architecture e.g. collision avoidance, and interoperability standards.

The research challenges being addressed by the program are focussed on addressing five gaps that limit the ability to deploy sophisticated automation technologies in mining:

- The implementation of technology in mining;
- Control strategies that enable automated machines to operate interdependently with other equipment, both manned and automated, in semi-structured environments;
- Optimisation algorithms that find the most efficient way to break a high-level task description into a detailed action plan;
- Situational awareness capabilities that are able to replace the many and varied functions performed by human operators; and
- Perception systems that enable effective remote operation of machines over potentially long distances where communication bandwidths are limited and also may be significant latency.

PROJECT MANAGEMENT

The expertise and major projects of key personnel in the Automation Program include:

Professor Ross McAree: Shovel Load Assist Program; Perception Requirements for Teleoperation of Bulldozers; Mining Automation

Reference Architecture; Perception Sensor Evaluation for Mining; Skills requirements for Mining Automation; Functional Safety Implementation of Automated Drills; Track Protection for Mining Shovels; Payload Estimation for Mining Shovels; Energy Modelling for Mining; Ore Car Dumper Safety System.

PROGRAM CAPABILITIES

The Automation Program has capabilities in the following areas:

- The application of functional safety in automation systems
- Machinery productivity trials
- Perception and control systems for automation and teleoperation of machinery
- Mechanical and electrical design for equipment automation
- Novel sensing and instrumentation

N641 SHOVEL LOAD ASSIST PROGRAM (SLAP)

This project is being conducted with Joy Global (previously known as P&H) and is financially supported by CRCMining, the Australian Coal Association Research Program (ACARP), and Joy Global. The project is developing operator assistance technologies that will help operators of electric mining shovels load trucks more efficiently and safely. The project has developed two technologies:

- TruckShield: A layer-of-protection that prevents metal-on-metal collisions between the shovel and truck that might injure truck drivers or damage the truck or shovel.
- DozerShield: prevents collisions between the shovel, and the shovel dipper, and clean up equipment operating around the shovel.



Shovel Load Assist Program (SLAP)

- AutoLoad: A semi-automation swing technology that automates the swing, dump and return phases of the shovel loading cycle.

The benefits of SLAP technology span shovel safety, availability, productivity and maintenance through faster shovel cycle times, lower machine duty, improved material distribution in trucks, fewer impacts between truck and shovel and lower operator workload.

The project:

- Employs a functional safety lifecycle to iterate the prototype TruckShield, Dozershield and AutoLoad systems to achieve tolerable risk of operation.
- Has developed and proved a fit-for-purpose truck positioning technology to enable TruckShield and AutoLoad to establish the relative position of the shovel and trucks.
- Has successfully trialled TruckShield in a production environment with a manned truck at Bracalba Quarry, demonstrating the integrity of the system and its component technologies.
- Conducted a human factors analysis of shovel operation to identify areas that operators find difficult, where SLAP technologies can assist operators, and what gaps remain.
- Extended the understanding of various sensing technologies that can be used to perceive the shovel work area (including terrain and equipment units).

The project has shown that TruckShield, Dozershield and AutoLoad have the potential to help operators by addressing some of the main avenues for human error in shovel operation. The current work of the involves deploying the SLAP technology to an Australian coal mine and the associated evaluation of the benefits of this technology suite.

N655 MINING AUTOMATION REFERENCE ARCHITECTURE (MARA)

This project is developing a methodology to facilitate technology implementation in mining by promoting consistency, integrity and coverage in the design, evaluation and deployment of technology. This project is being funded by CRCMining, Anglo American, BHP-Billiton, Sandvik and CSC Australia.

This MARA project has:

- Developed a holistic methodology for risk driven implementation of mining technology that lays bare the key metrics relevant to design and evaluation (i.e. risk, cost, value, flexibility, compatibility, etc.) to ensure that, when followed, the implementer maximises the likelihood that a technology will deliver its promised benefit within a given context.
- Established a framework that can be used to capture and represent knowledge generated in the process of implementing technology using this methodology so that common elements may be reused in subsequent related work.
- Developed a software tool that actively supports the process of implementing technology in line with the vision described above.
- Demonstrated use of the tool by application to two example problems the introduction of autonomous blast hole drills and automated load haul dump vehicles.
- Applied this methodology to the introduction of Automated blast hole drills in collaboration with Centre Members Sandvik and BHP-Billiton.

N656 PERCEPTION CAPABILITY

This project has completed experimental investigation that has sought to understand the capability of perception sensors applied to tasks relevant to the automation of mining equipment. Perception is the ability to become aware of something through the senses. Automated mining machines require the ability to sense their surrounds. This project is being funded by CRCMining, Caterpillar and Anglo American.

This project has assessed the performance of two candidate RaDAR sensors and four LiDAR sensors as perception sensors to mining automation. The methodology of the project has had three streams.

- Stream 1 has been to identify categories of perception tasks, establish the requirements of a perception system needed to perform these tasks, and assess the performance of candidate sensors against these requirements. Perception tasks explored included (i) terrain mapping around mining excavators; (ii) perception of haul road surface quality; (iii) estimation of volume of material moved during excavation; (iv) perception of volumes and distribution of materials in the truck; (v) detection of berms and dump zones from truck mounted sensors; and (vi) detection of static obstacles. The outcomes of the work provide an evaluation of commercially available sensors for mining automation.
- Stream 2 has established the impact airborne materials such as dust and rain on the ability of the sensors to scan terrain. This project has developed an experimental dust facility to allow testing of LiDAR returns within a controllable dust environment. The control parameters are the dust cloud length, the range distance to target and transmittance through the dust cloud. The study has for the first time provided a characterisation of returns from commercially available LiDARs at different ranges and transmittances.
- Stream 3 has been to integrate data from machine (excavators and truck) mounted sensors into a mine-wide information system at Bracalba Quarry including the maintenance of terrain maps.

The outcomes of this work have advanced understanding of the capability of commercially available sensors when mounted on mining machines for providing fit-for-purpose perception for mining automation applications.

N662 ORE GRADE PERCEPTION

This project has scoped the feasibility of using a hyperspectral imaging spectrometer mounted on an excavator. The purpose of the instrument is to measure the reflected spectra from the bench face to determine ore grade during the dig-load cycle. It is intended to be used as an aid to the operator and is envisaged as an enabling technology for the automated excavator. A two dimensional map of the ore grade would be presented in real-time to operators, allowing them to select the next portion of the bench face to be excavated. The instrument is required to operate continuously, day and night, in all weather conditions.

The project has identified the performance requirements for the spectrometer during a typical excavator dig-load cycle. Commercially available optics have been identified that meet all of these requirements. A short list of commercially available spectrometers that meet all of the requirements has been established and the optimal mount position determined.

A conclusion from the project is that that a hyperspectral imaging spectrometer could be used to provide maps of mineral and ore grade distribution of the mine face, even under artificial lighting at night. However, it would require horizontal scanning rates of order minutes per metre and would have to be mounted separately from the excavator.

HARD ROCK AND SURFACE MINING PROGRAM

PROGRAM LEADER: DIHON TADIC

PROGRAM MISSION

- To develop innovative technologies that improve the productivity and efficiency of equipment and processes for hard rock mining and surface coal operations.
- To specifically consider the effect of rock fragmentation performance on the entire mining value chain to produce pioneering advances in:
 - o Excavation design
 - o Methods for assessment of rock masses
 - o Equipment and systems for fragmentation, loading and transport of materials
- To provide a stream of technologies that benefit existing operations, whilst developing step-change solutions for mines of the future.

PROGRAM STRATEGY

The Program's strategy is to deliver technology through a combination of fundamental and applied research and development projects, focussed on four key areas:

ROCK MASS CHARACTERISATION AND RESPONSE

- Developing innovative sensing, measurement and modelling techniques for improved characterisation of geological conditions and rock mass properties.
- Investigating the response of the rock mass to mining, assessing and improving the design of (and requirements for maintaining) suitable and stable openings.

ROCK FRAGMENTATION

- Improving fundamental understanding of rock breakage mechanisms to develop pioneering technologies for primary excavation and secondary rock breakage.
- Advanced blasting technologies, mechanical and water jet-based rock cutting and breakage, and drilling technologies to improve fragmentation control.

MATERIALS HANDLING

- Developing new performance assessment methodologies, and equipment selection and optimisation capability for materials handling systems.
- Utilising state-of-the-art technology and processes for scaled testing of digging and loading equipment to optimise equipment selection, improve digging efficiency and reduce energy consumption associated with the loading and transport of broken materials.

INNOVATIVE MINING METHODS AND PROCESSES

- Identification and development of innovative mining techniques and related mine design, equipment and operational considerations that exploit the capabilities offered by new characterisation, fragmentation and materials handling technologies.
- Driven by the increasing need for innovative solutions to economically mine challenging deposits in challenging environments with low-skilled personnel.

PROJECT MANAGEMENT

The expertise and major projects of key personnel in the Hard Rock and Surface Mining Program include:

Dihon Tadic - Blast hole drilling and automation tools; Measurement-while-drilling technology; Water jet cutting, drilling and rock breakage systems; Materials handling system characterisation and optimisation; High-pressure water jet fundamentals; Pulsed water jet rock breakage; Blast hole slotting; Water jet assisted blast hole drilling; Rock recognition; Bucket and dipper sizing, design and optimisation studies; Water jet cable bolt hole drilling; RC drilling reef detection.

Italo Onederra - Blast design, analysis and continuous improvement with emphasis on fragmentation, damage modelling and blast performance monitoring; Explosive performance testing; Mine to mill studies; Development and delivery of open pit and underground blasting courses/workshops; Advanced blasting engineering; Blast preconditioning assessment and modelling.

Ernesto Villaescusa - Rock mass characterisation, planning, design and ground support for underground mining methods ranging from shallow to deep cut-and-fill mines, sublevel open stoping, room and pillar, sublevel caving and block caving.

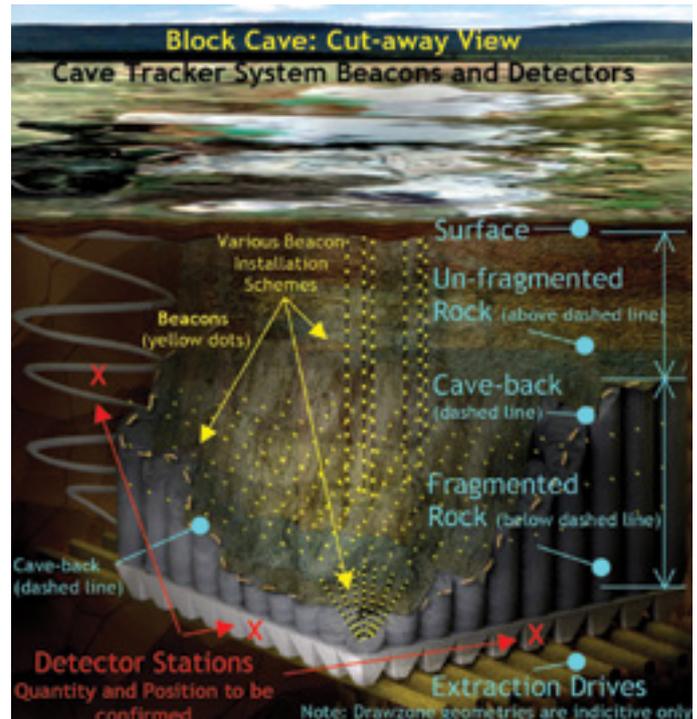
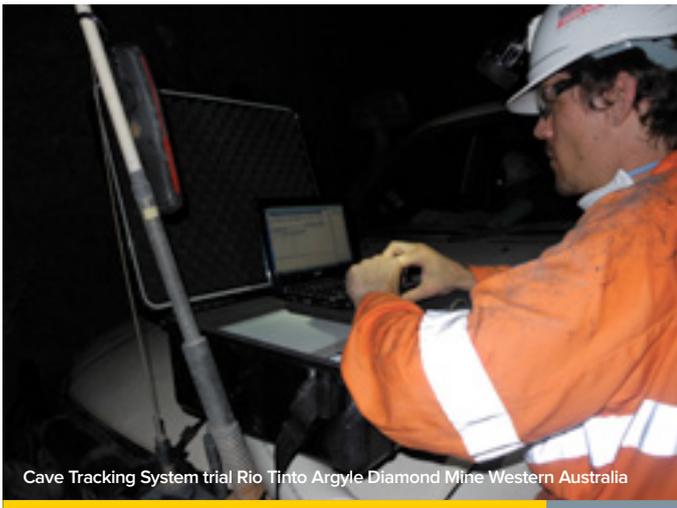
PROGRAM CAPABILITIES

The Hard Rock and Surface Mining Program conducts a range of research activities in a laboratory setting, and through various site investigations and equipment trials at mining operations.

Key capabilities are in the following areas:

- Sensing, measurement and analysis tools for rock recognition during mining
- Intact rock mass characterisation methodologies and modelling
- Performance assessment of mining excavations and ground support systems
- Characterisation of broken rock masses
- Blast design, implementation and monitoring
- Fundamental rock mechanics and rock fragmentation
- Novel mechanical excavation technologies
- Digging performance assessment and optimisation
- Materials handling equipment and system design
- Innovative mining methods and processes





G232 CAVE TRACKING SYSTEM

In a breakthrough for global mining, the world's first real-time flow monitoring technology for block caves has been developed, enabling real-time measurement of in-cave ore flow. The project has been a collaboration with Newcrest Mining and Elexon Electronics, with Rio Tinto joining the partnership in 2013. The 3-year project is industry funded and builds on previous work conducted by CRCMining that indicated potential for this technology in material flow monitoring.

The Cave Tracker technology uses ruggedised beacons and detectors deployed in and around the ore body, enabling real-time 3D tracking of cave material. A rotating magnetic field is used to determine the range between the detectors and beacons dispersed within the caving rock mass. Ranges from multiple detectors are used to locate beacon positions, allowing their 3D movement to be tracked.

With capability of monitoring every few days for over 10 years, the system will provide a detailed, time-lapsed view of underground rock flow, as the beacons travel with the caving rock mass during mining.

Solutions and benefits for mining include:

- Real-time mapping of caving material movement during cave production;
- Rilling, dilution entry, cave propagation and cave back position measurement;
- Minimise dilution and maximise recovery from caves;
- Test validity of existing caving models and develop new models; and
- Design better cave layouts and extraction sequencing using improved models.

Prototype systems were installed at two major mine sites, including Rio Tinto's Argyle Diamond Mine in Western Australia. Underground trials have shown good results in detection range and accuracy. Testing of the Cave Tracker system showed that detectors can identify beacons up to 200 metres away, with accuracy not affected significantly by material type or the structure of the underground rock mass.

G614 RAB DRILL RIG TOP OF COAL MEASUREMENT WHILE DRILLING

Ideally, blast holes in open cut mines would stop at a depth just above the top of the formation to be mined. Currently, the depth of blast holes is determined by expensive survey drilling on a coarse grid, interpolation between those points and drilling blast holes periodically into the seam. This results in significant losses due to mixing of the overburden and the material to be mined.

This project aims to develop a Measurement While Drilling (MWD) system that can accurately detect the top-of-coal interface while drilling blast holes in open cut mines. It follows on from a previous project that showed that high-frequency radio signals would propagate along the inside of the drill string and that resistivity measurement could provide an indication of the approaching top-of-coal interface. The benefits of this capability include increased coal recovery due to reduced damage to the coal during blasting; improved seam mapping during production drilling; and provision of information to assist with drilling automation.

Phase 1 of this project demonstrated that when drilling with air rather than water/oil/mud it is possible to have a high frequency, high bandwidth wireless communication link between a down hole sensor package and the surface using the drill string as a waveguide. This enables the measurement of a wide range of parameters with real time display and recording. Resistivity was chosen as the parameter to measure as there is a large contrast in resistivity between coal and the overburden.

The next stage of the project will involve a field deployment at Jellinbah mine, with preparation of the apparatus for deployment in Q1 2015.



Pulsed Water Jet test rig

G613 PULSED WATER JET ROCK BREAKAGE SYSTEM

This project is developing a high-pressure pulsed water jet system for secondary breakage of hard rock boulders at draw points of block caving operations. The 3-year project was a collaboration with Newcrest Mining and Russell Mineral Equipment, and it received a \$1M funding grant from the Queensland Government Research-Industry Partnership Program. Significant funding was provided by Newcrest as the key Industry partner for this work.

The technology delivered by this project will provide a step-change improvement in the efficiency and flexibility of secondary rock breakage. The immediate application for this technology is in underground mining, where costly delays are introduced by current methods requiring drilling and blasting/splitting to process oversize boulders.

The project comprises three Phases: 1) Laboratory test device development and lab testing; 2) Laboratory test device modification and field testing; 3) Commercial prototype development.

The project initially developed a prototype water jet device capable of testing on mine rocks in a laboratory setting. A number of refinements and modifications then allowed manufacture of a mobile system suitable for site testing to finalise the specific operating parameters for the first target mine's rock conditions. A site testing program at a Newcrest mine site was conducted in June 2014 to complete the project.

This project has significantly extended CRCMining's knowledge in the area of water jet rock breakage. The technology has generated much interest amongst the industry, and shows good potential to be adapted and further developed in future projects targeting specific applications and constrained operating environments.

G638 ADVANCED BLASTING ENGINEERING TO OPTIMISE GEOTECHNICAL AND MINING REQUIREMENTS

The overall objective of this project was to evaluate and improve blasting practices at Antofagasta Minerals' Esperanza Mine, with the view to increase mining efficiencies and overall productivity. The project involved two stages of targeted on site monitoring campaigns utilising the latest instrumentation and measurement techniques available to industry. As part of this project CRCMining constructed fit for purpose instrumentation using both triaxial accelerometers and gas pressure sensors. Dr Italo Onederra and Mr Joji Quidim visited Esperanza Mine and supervised the installation of sensors and conducted the monitoring and analysis work. The scope of work involved two stages of monitoring in 2013 which included the following:

- Measurements of peak particle acceleration, particle velocity and gas pressure behind presplit lines to evaluate the effectiveness of wall control and production blasting activities. Results from this monitoring stage were complemented by detailed geotechnical evaluations conducted internally by Esperanza Mine
- Development of data collection procedures for the application of high resolution laser scanning to measure "whole of muckpile" run of mine (ROM) fragmentation
- Development and application of algorithms to process high resolution laser scanning data to quantify fragmentation from specified production blasts
- Analysis of blast performance monitoring data to provide site specific design recommendations

The measurement of Run of Mine (ROM) fragmentation using high resolution (HR) laser scanning data was conducted by Dr Matthew Thurley of Innovative Machine Vision Pty Ltd. Dr Thurley was commissioned to develop improved algorithms to process laser scanning data, which was collected using the I-Site Maptek system available at Esperanza Mine. Aspects of this work have already been jointly published in a highly respected international mining technology journal.

The overall project was completed in December of 2013 and the final report issued in January of 2014. Specific recommendations were provided to Esperanza Mine which have now been implemented. A similar project is now being considered by Antofagasta Minerals to be implemented at another one of their operations in Chile.

G626 BUCKET / MATERIAL DATABASE TO DESIGN ENERGY EFFICIENT BUCKETS

The objective of this project is to generate and collate digging data to better understand the effect of material properties on bucket performance. This will facilitate optimisation of bucket designs for specific material types and conditions. This project relies on the outcomes and findings of a suite of studies related to material excavation and handling. The majority of these studies are industry-funded and executed in close engagement with the Centre's OEM Members to address specific design improvements for current and future bucket and GET components. Projects are also performed for mining company members to identify application-specific machine and operational requirements for loading blasted material.

The ultimate benefit of this work is improved productivity and efficiency of material handling equipment through a scientific understanding of the effects of blasted material properties and machine component design (buckets, GET etc.) on digging and loading performance.

The material and digging data for this project is compiled from studies being conducted with various machines at different mine sites. This year (2013-14 FY), several studies were performed on Cable Shovels and Hydraulic Excavators. Each study has unique measurement and equipment challenges. The key technical challenges have been developing appropriate hardware and software for the scaled digging facility.

Scaled testing in the Pinjarra Hills laboratory is ongoing for various digging studies. This work in material handling is complemented by the Centre's increasing capability in blasting performance assessment and design, which provides new opportunities for evaluation and optimisation projects associated with blasting for materials handling efficiency.

G816 GROUND SUPPORT TECHNOLOGY

CRCMining is collaborating with Curtin University's Western Australian School of Mines (WASM) to conduct investigations into the response of ground support systems to dynamic loadings. Extensive testing at WASM's unique test facility was completed for a large number of different reinforcement systems and steel wire mesh. Industry partners include Codelco, BHP, Newcrest, MERIWA, Lightning Nickel, DSI and Geobrugg.

The aim of this project is to characterise the energy dissipation of the most widely used reinforcement elements and their combinations with mesh and shotcrete. A large scale punch test method has been developed to evaluate various mix designs at different curing times. The force-displacement responses of the mesh have been measured and then characterised by various performance indicators such as rupture strength, displacement to rupture and energy absorption.

The database of test results provides a practical, accurate and simple tool that may be used to compare the performance of different mesh configurations and to assist with design of appropriate ground support for static and dynamic loading applications.

This work allowed development of a design methodology to enable selection of appropriate ground support schemes on a site-specific basis.



Scaled robotic testing facility for digging characterisation and bucket optimisation

PERFORMANCE AND RELIABILITY PROGRAM

PROGRAM LEADER: PROFESSOR PETER KNIGHTS

PROGRAM MISSION

To evaluate, develop and trial:

- Innovative approaches for consistently achieving 8000 hours per year average physical availability for fleets of mobile and semi-mobile mining equipment (8000 hours challenge).
- Technologies and skills likely to be available and necessary for maintaining mining equipment in 2020 (Future maintainer challenge).

PROGRAM STRATEGY

The program's strategy to achieve this mission is to develop a suite of step-change projects, carefully selected and ranked according to potential value, cost and risk, to:

- Develop approaches for enhancing overall equipment effectiveness (OEE), including:
 - o Reducing the time required to refuel, wash, maintain, and repair equipment (MTTR).
 - o Enhancing the reliability of equipment components (MTBF)
 - o Enhanced equipment scheduling
- Develop maintenance tactics aimed at addressing the root causes of equipment defects
- Assess, develop and trial technologies and training programs for the remote support of maintenance technicians.

The research challenges being addressed by the Program are focussed on addressing five gaps that limit the ability to deploy new approaches to maintenance in mining:

- What are the major impediments to performing equipment support tasks concurrently? How might these barriers be overcome?
- What are the root causes of component defects and how do these vary according to equipment application? What can be done about them?
- What sensing systems are needed to quantify machine health and operating conditions in cases where we cannot currently measure conditions?
- What algorithms can be employed to better predict and schedule operations and maintenance/support activities?

PROJECT MANAGEMENT

The expertise and major projects of key personnel in the Performance and Reliability Program include:

Professor Peter Knights: 8000 hours availability program; Emerging support technologies for future maintainers; Water truck scheduling; Quantification of truck bunching production losses in surface mines; Value tree development.

PROGRAM CAPABILITIES

The Performance and Reliability Program has capabilities in the following areas:

- Maintenance and repair processes
- Condition-based monitoring and diagnostics
- Data analytics
- Systems and reliability engineering
- Development of competence frameworks for reliability professionals
- Scheduling algorithms
- Machinery productivity trials

MAINTAINER OF THE FUTURE

The 'Maintainer of the Future' study, by Professor Melinda Hodkiewicz and William Jacobs, examined how the evolution of technology and asset management will change the training and role of the modern mining maintainer.

This study looked at drivers of change, including those that are expected to asset design, technical support equipment and organisational processes in the next 15 years, and how these developments affect the role of maintainers and their tasks. The training of maintainers in Australia is also assessed to identify the key enablers and barriers, to ensure a suitably matched maintenance workforce for the changes expected.

The findings of the study have significant implications for the mining sector, with recommendations to improve productivity, safety and skills management.

8000 AVAILABLE HOURS

The "8000 Hours" study by Professor Peter Knights examined the barriers and opportunities to sustain 8000 available hours of operation for fleets of mobile mining equipment. Currently, leading practice related to truck fleets is around 7000 hours availability, with 6000 to 6,500 of these being utilised hours.

The study identified operator-induced failures as a major source of downtime. In one fleet of rope shovels suboptimal operator practices were clearly linked to 16% of all failures. Thus fleet availabilities should benefit as then mining industry progressively transitions to fleets of autonomous equipment.

In terms of enhancing fleet availability the introduction of robotic PMs performed concurrently with other activities such as tyre changes was identified as a significant opportunity. This, however, necessitates the development of a fit-for-purpose "Future Truckshop". Other opportunities identified include the use of: automated truck washing; data analytics through the supply chain; the integration of condition based maintenance with cumulative damage models.

TRUCK BUNCHING SOFTWARE

A Beta version of a software has been developed to calculate congestion losses in deep open-pit mines. The current software is limited to fleets of Caterpillar 793D trucks, commonly used in such operations. The inputs to the software include; haul route specifications (lengths, incline of road segments), material characteristics (bulk density) and the payload distribution (mean and variance). Heavily loaded trucks are slower at travelling up ramp and cause congestion or "bunching" of trucks carrying rated payloads. The software calculates these hidden production losses, and estimates the associated opportunity to reduced diesel fuel consumption and emissions. Work is currently underway to validate the software predictions against real operating data.



The “8000 Hours” study by Professor Peter Knights examined the barriers and opportunities to sustain 8000 available hours of operation for fleets of mobile mining equipment.

ENERGY AND POWER PROGRAM

PROGRAM LEADER: ROBERT BETZ

PROGRAM MISSION

- Minimise greenhouse gas emissions and energy consumption, by enabling the electric mine.
- Develop understanding, tools and technologies around integration of alternative energy sources.
- Improvements in power quality and the minimisation of energy in mining environments.

PROGRAM STRATEGY

The key strategic areas to be focused on by CRCMining's Energy and Power program are:

- Alternative energy sources
- Increased energy efficiency
- Safety and reliability

THE PROGRAM'S STRATEGY FOCUSES ON:

- Interoperability – to enable high penetration of renewable and other alternative energy sources by modelling, simulating and emulating existing supply and augmentation issues as well as current state of the art renewable energy technologies and distributed generation.
- Weak grid augmentation – the ability to use grid connected power at whatever quality level available and augment this with locally generated and controlled energy to provide stable mine precinct distribution.
- Islanded operation – where no grid connection is available, the challenge is to maximise electrical energy production and stability while minimising the requirement for classical generation fuels.
- High renewable penetration – moving beyond established safe limits of 15% renewable mix in a highly dynamic system. Aims to provide 50% “free energy” while maintaining system stability.
- DC mines – to avoid stability issues associated with DC to AC conversion, with direct use of DC power in mining.
- Energy storage – aiming to supplement and eventually replace the non-renewable technologies currently required in renewable energy solutions.
- Pumped storage of water using renewable sources – will minimise the use of carbon based energy supply.
- Machine efficiency – migrating current diesel equipment and systems to new, smaller energy footprint, lower maintenance electric equipment – primarily focussing on replacement of diesel engines with electric or hybrid solutions, and associated electrical systems.
- Load scheduling energy reduction – where existing processes are time independent of other mining operations, fossil fuel based energy consumption can be reduced to virtually zero based on the integration of compact stand-alone renewable supplies.
- Demand management of dewatering and water purification processes through the use of renewable energy sources.
- Duty Meter projects – producing mathematical models that predict machine life and condition of large electric machines, with sensed data.



- Power Quality – achieving understanding of transients and voltage stability, and their effect on electrical system reliability and efficiency.
- Voltage Stabilisation using Power Electronics - applying power electronics to solve transient voltage stability problems via the use of a STATCOM based technology.

PROJECT MANAGEMENT

The expertise and major projects of key personnel in the Energy and Power Program include:

Professor Robert Betz: Program Leader

Dr Terrence Summers: Interoperability of Distributed Energy Assets

Dr Galina Mirzaeva: DC Duty Meter, AC Duty Meter

Dr Steven Mitchell: Wireless Charge Electric Mine Vehicle

PROGRAM CAPABILITIES

The Energy and Power Program has capabilities in the following areas:

- Renewable energy and storage
- Electrical machines
- Power electronics
- Power Systems
- Condition monitoring and diagnostics
- Control and automation

E703 DC MOTOR RELIABILITY

The concept of the on-line Duty Meter is based on monitoring parameters that influence the motor life and, based on a model of their influence, determine the reduction in the motor life time.

An extensive experimental study has been previously performed on full scale DC motors used in electric rope shovels of brush wear mechanisms. From this study, the fundamental mechanisms behind the brush and commutator wear have been devised.

A specialised laboratory test rig has been constructed for this project, which allows to test a lab scale DC motor under any loading conditions (such as hoist or crowd cycles) and to reproduce other conditions (such as ambient temperature and humidity). Sensors installed externally and internally with the motor, provide information about its condition.

By measuring the brush wear associated with certain loading conditions, the Duty Meter models for DC motor in electric rope shovel application have been developed. Such testing can be extended to match any other conditions of interest.

The end goal of this project is to develop an advanced condition monitoring tool ready for installation with critical DC motors in mining applications. A prototype Duty Meter has been developed using National Instrument CompactRIO system, with the advantages of rugged design and convenient Human Machine Interface. The draft prototype is currently being tested and improved. The hardware and software of the DC Motor Duty Meter have been designed with the view of possible extensions to other motor applications.

E707 AC MOTOR RELIABILITY

The project goal is to develop an innovative condition monitoring tool for AC motors used in mining applications. This tool will combine the best of the existing AC motor diagnostics methods with the innovative Duty Meter concept previously proven with DC motors in E703.

The project uses the same test facility as the related E703 project. The specialised facility includes two mechanically coupled motors (DC and AC), both with full 4 quadrant drives, which allows any of the two to be the “test” or the “load motor” (to provide programmable loading to the motor of interest). In this project, the induction AC motor is the motor of interest.

Via extensive laboratory experiments, the following fault mechanisms have been studied: stator winding shorts; broken rotor bars; static and dynamic eccentricity; and bearing faults. With special instrumentation (including internal Hall effect flux sensors) it was possible to not only detect but also to localise, quantify and predict the development of the named faults. Techniques used in this project are particularly suited to inverter driven AC motors.

The project is progressing towards the prototype Duty Meter development. It has great potential and importance for mining industry, due to the continuing shift towards using AC motors in various applications.

E717 RENEWABLES INTEROPERABILITY FACILITY

The CRCMining Interoperability Laboratory project based at The University of Newcastle provides the mining industry with the ability to model and emulate increasing penetration of renewable energy sources, aimed at reducing energy costs and GHG emissions.

The facility is specifically designed to model mine power systems. The project will provide the mining industry with tools and methods to design and operate electrically isolated power systems with increasing penetration of renewable energy sources, by examining problems in mine electrical power systems due to weak and isolated power supplies, and investigating solutions in a relatively low cost and low risk environment.

The project will enable CRCMining industry members to mitigate the effects of weak grids on mine productivity through the introduction of researched and understood technologies into brown field sites with a minimum of risk. The industry benefits will be significant: effective reduction of energy costs and greenhouse gas emissions; maintaining reliability of supply; less reliance on utility power supplies; and capacity to run critical systems such as ventilation fans during power outages.

From this project, mine planners will be able to draw metrics for the development of power systems, and researchers can focus on issues

effecting operational capabilities to provide new and innovative solutions to optimise energy delivery and cost.

E719 MAXIMISE RENEWABLES PENETRATION IN ISOLATED PRECINCTS

This project will use real-mine data to model mine power systems, and use the Interoperability Laboratory at the University of Newcastle to understand the limits of renewable penetration, and develop tools and methods to increase this penetration.

The project will provide the mining industry with tools and methods to design and operate electrically isolated power systems with increasing penetration of renewable energy sources. It will enable them to make use of many mine’s unique opportunities to exploit their access to renewable sources, especially solar, reducing energy costs and GHG emissions, while maintaining reliability of supply.

Project outcomes include:

- Knowledge of current limits of renewable energy mix
- Knowledge on alternative energy storage systems for mining
- Preliminary software tools to evaluate system’s viability and effectiveness.

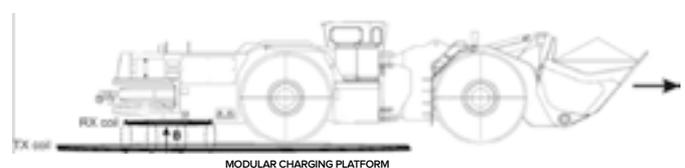
E722 WIRELESS CHARGE ELECTRIC MINE VEHICLE

This project is developing an innovative modular energy transfer system that will wirelessly charge the batteries of electrically enabled underground mining vehicles whilst in both static and dynamic operation. The approach will eliminate the range limitations and maintenance issues associated with trailing cables and productivity losses due to the battery interchange. A wireless system has the potential to work continuously.

The Centre’s current project also aims to develop a framework for an open systems approach, in which wireless charging is compatible across multiple platforms, machines and manufacturers, providing a common charging interface. The project is being carried out in conjunction with leading mining stakeholders.

The potential benefits to the mining sector are enormous. Wireless charge technology will require no battery change-out, trailing cables or connector brushes. Machines will be able to operate with all the flexibility of diesel powered machines but without generating carcinogenic particulates, operating with much higher energy efficiency and with much higher reliability. The system will have immunity to dirt and water, be electrically isolated, and will require significantly less battery capacity when compared to existing battery powered machines.

LOADER WIRELESSLY CHARGING WHILST IN MOTION



Wirelessly charged mining vehicle concept drawing

UNDERGROUND COAL MINING PROGRAM

PROGRAM LEADER: SCOTT ADAM

PROGRAM MISSION

Contributing to a viable and sustainable underground coal mining industry by focusing on:

- Addressing topical and emerging OH&S issues affecting mineworkers, staff, management and OEM
- Reducing mine operating costs
- Incremental and step change productivity improvements

PROGRAM STRATEGY

A significant portion of this research work supports the ACARP research priorities developed each year. The current priorities identified for the underground coal sector are developed annually by the representatives of the mining companies.

The research challenges are focused on the following areas:

- Enhanced mine safety through improvements to IS power supplies, remote, distributed sensing, gas drainage technologies.
- Improve equipment utilisation through incremental improvements to longwall system uptime.
- High Integrity Rock Mass Characterisation from a suite of geophysical logging tools compatible with surface to in seam and underground gas drainage drilling.
- Improving the effectiveness of Ground Support Systems through step change drilling and bolting technologies.
- A step change in mine sensing technology as an enabler for data driven mining and automation.

PROJECT MANAGEMENT

The expertise and major projects of key personnel in the Underground Coal Program include:

Scott Adam: Continuous drilling systems, Tight Radius Drilling, Coil Tube Drilling, UIS Cross Panel Water Jet Drilling

Dr Saïied Aminossadati: Distributed Fibre Optic Sensing – Gas Sensing, Conveyor Systems

F129 SPARK TEST APPARATUS

The Electronic Spark Tester (EST) project, sponsored by ACARP, is a new concept for assessing the arc ignition risk posed by an electrical energy source in an explosive atmosphere. It will aim to develop a new methodology of accurately testing electrical circuits in order to establish the IS properties without using explosive gas mixtures or causing actual explosions.

The work is being done in close collaboration with German metrology institute Physikalisch-Technische Bundesanstalt (PTB). The project also involves collaboration with coal mining industry representatives and manufacturers of intrinsically safe power supplies.

The first phase of the project was completed in early 2013, with the second phase scheduled for completion in January 2015. The results of this research have led to better understanding of the spark energy required to ignite hydrogen and methane mixtures at low voltages and have shown that the energy required to ignite methane at low voltages is significantly higher than was previously understood.

The proof of concept, Phase 1 EST is being improved by making the hardware more linear and incorporating the latest research findings into the software. The intent is for the EST to eventually provide an alternative to the STA as the standard for testing.

The proposed third phase of the project (Phase-3) will further the development of the experimental design and research prototype EST to an integrated unit with improved software to a standard operable by testing authorities and 3rd party experts.

F303 ADVANCED LOGGING SYSTEM

A measure while tripping directional logging tool has been developed and deployed in a number of surface to in-seam boreholes. The results were positive and enhanced the geological model.

CRCMining are currently developing a Measure while drilling resistivity module for use in underground in-seam drilling. The system will provide rig operators and geologists valuable information about the proximity of the roof and floor interfaces while drilling in seam.

F309 IN SEAM WIRELESS DRILL STRING

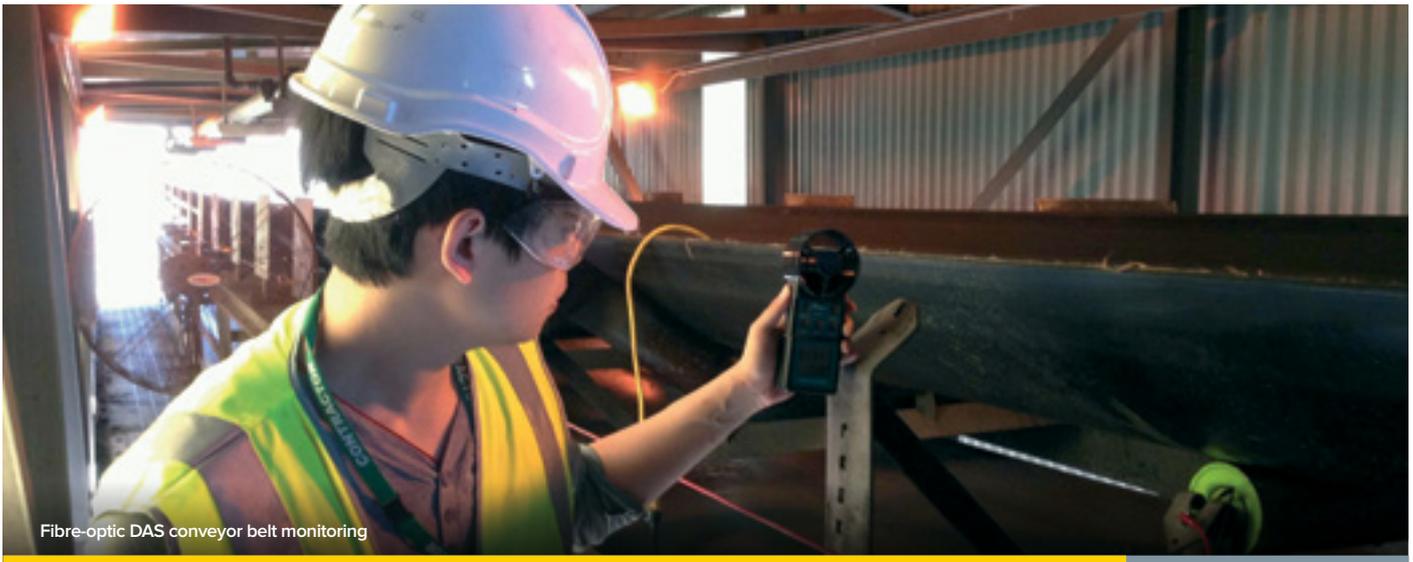
This project, funded by ACARP and CRCMining, aims to develop a high speed, hazardous area compliant wireless communication technology that provides communication between the BHA and drill rig operator for UIS drilling. This will provide an alternate to the existing wired drill pipe technologies that would enable standard drilling rods to be used, provide a path for a wider range of enhanced geological surveying technologies to become available, provide the necessary safety that the industry requires, and reduce operating and capital costs significantly.

This project builds on previous work conducted by CRCMining that demonstrated the potential for this technology. The existing work is being conducted with strong support and collaboration with various companies, including BHP Billiton's Appin West coal mine and Glencore-Xstrata's Tahmoor mine as well as several SME's involved in drilling technology.

This project has concluded successfully with a field trial conducted at Glencore's Tahmoor minesite in Q2 2014. The results demonstrated a strong and robust bi-directional communications signal between the drill string and the drill rig.

F312 TIGHT RADIUS DRILLING (TRD)

This project has developed a step change coal seam gas stimulation technology for improved underground mine safety and fugitive gas capture. The project is a fully industry funded research and development project, in collaboration with BHP Billiton Mitsui Coal. It builds on previous work conducted by CRCMining in which the Centre's unique water jet drilling capability has evolved to the point of pre-commercial demonstration and gas productivity assessment trials.



Fibre-optic DAS conveyor belt monitoring

A five well pilot gas drainage project was conducted by BHP Mitsui Coal in 2013-14. CRCMining's TRD system was successfully deployed with outstanding drilling results, drilling productivity and no safety incidents. Subsequent gas production rates have exceeded modelling.

The TRD system is currently being prepared for deployment onto an Arrow energy site for a 3 well trial. This work will demonstrate the system on a Coal Seam Gas property, working under the Petroleum and Gas Safety Act for the first time.

F323 FIBRE OPTIC TECHNOLOGY ROADMAP

In recent years CRCMining has conducted a number of studies involving new and emerging fibre optic sensing technologies. This year the CRCMining Underground Coal Mining Technical Committee commissioned a review of the capabilities and opportunities in applying fibre optic sensing to underground coal mining.

This paper identified a wealth of new and emerging technologies which can play a role in providing accurate, real time data to support a new wave of data driven decision support tools which are set to revolutionise how mines are operated. The review confirmed that the simple, long range and stable nature of fibre optic sensing is particularly compatible with the constraints of the mining environment in general. The ability to sense complex parameters such as gas content, noise, temperature, air velocity without electrical power is particularly advantageous for the hazardous gas environment in underground coal mines.

The outcomes have informed CRCMining's strategy in the Underground Coal Mining Program.

F324 WATER JET CABLE BOLT DRILLING TOOL

A continuous water jet drilling technique was developed to improve the safety and productivity of underground cable-bolting. Water jet drilling uses a high-pressure water jet cutting head for rapid and continuous drilling of holes of varying length, connected via a flexible hose,

removing the need for manual adding or removing of drill rods as part of the cable bolt installation process.

A phase one pre-feasibility investigation in 2013 sponsored by ACARP determined that the flexible drilling system could continuously drill sandstone at economic rates.

As at June 2014, a prototype drilling apparatus is in early stages of design. The rig will be deployed into an underground coal mine, nominally Peabody's wambo mine, in Q2 2015. The rig will be capable of drilling up to 12m vertically up using a continuous drill string.

F319 DAS CONVEYOR BELT MONITORING SYSTEM

Following on from the previous investigation of conveyor monitoring using a Distributed Temperature Sensing (DTS) system, CRCMining in collaboration with UQ, Mining Automation and Robotics (MAR) and Distributed Acoustic Sensing (DAS) OEM have conducted a successful pre-feasibility of DAS technology for conveyor monitoring.

The results of the site trials and laboratory experiments demonstrated that the fibre optic-based DAS system is a suitable monitoring system for conveyor belts that can accurately and in real time identify the faulty idlers that generate noise as they fail.

F330 HIGH SPEED CROSS PANEL DRILLING

ACARP has recognised the highly successful outcomes of the Tight Radius Drilling (TRD) project and has funded a field deployment of the same water jet drilling technology into an underground mine for the purpose of continuous cross panel drilling. The project aims to demonstrate that extended drilling range can be achieved, survey accuracy and steering control are adequate, and that the borehole quality improvement developed in the TRD project translate to the cross panel application.

The project will deploy to the field in the same trial as the water jet cable bolt project in Q2 2015.

CORPORATE GOVERNANCE REPORT

Whilst CMTE Development Limited, trading as CRCMining, (referred to in this report as Company or CRCMining) is not a listed company, it is committed to ensuring that its policies and practices reflect good corporate governance and endeavours to comply with the relevant corporate governance requirements applicable to Australian listed companies as set out in the ASX Corporate Governance Council Principles and Recommendations (3rd edition).

The Company's corporate governance policies and procedures are reviewed on a regular basis and updated where appropriate.

MANAGEMENT AND OVERSIGHT

CRCMining's Board of directors is responsible to its Members and other stakeholders for the Company's overall performance. The Board's composition, functions and responsibilities are set out in its Constitution and Member Agreement. The Board is responsible for the overall management of the Company and determines the policies, practices, management and operations so as to carry out its objectives. The Board is responsible for approving the Centre's strategies and for monitoring management's implementation of those strategies. It considers and sets the Company's goals and performance targets, appoints and removes the CEO, oversees succession plans and approves the accounts, budgets, risk management processes (including internal control and compliance), Code of Conduct, corporate policies and major capital and operating expenditure decisions.

The Chairman is responsible for leading the Board in the performance of its duties. The full Board meets at least quarterly for scheduled meetings. Other meetings are called as and when necessary. At each Board meeting, the non-executive directors meet for a period without management or any executive directors present. Throughout the year, the Board itself and its sub-committees have regular, scheduled discussions on various aspects of the Company's strategy.

ROLE OF THE BOARD AND MANAGEMENT

There is a clear distinction between the role and responsibilities of the Board and the role and responsibilities of the CEO as set out in the Member Agreement. The CEO is responsible for the efficient and effective operation of CRCMining on a day-to-day basis, oversees the implementation of the strategies approved by the Board, and is accountable to the Board for all authority delegated to the senior executive team.

Notwithstanding these delegations by the Board, the CEO must consult the Chairman on matters that are sensitive, extraordinary or

of a strategic nature. The CEO must also keep the Board informed of all the activities of the Company. The balance of responsibilities between the Board and the CEO is reviewed on a regular basis so as to ensure that the division of functions remains appropriate to the needs of the Company. The senior executive team briefs the Board regularly to keep the Board up to date and to assist the directors with monitoring the Company's operations. Each quarter, directors receive operating reports prepared by senior management, covering each research program and function.

COMPOSITION AND ELECTION OF DIRECTORS

The Company's Constitution requires that the Board include:

- two persons elected by a vote of the mining company members;
- one person elected by a vote of the research members;
- two persons elected by a vote of the members who are not mining company or research members;
- the CEO; and
- an independent chairperson. In addition the directors may appoint an additional director whose skills are required by the Board.

As at 30 June 2014, the Board comprised seven non-executive directors (including the Chairman) and one executive director, the CEO. The directors consider that, as a group, they possess the necessary skills, knowledge and experience to allow the Board to perform its duties appropriately. Between them, they bring to the Board scientific, academic, technical and financial expertise, as well as extensive local and international business experience. Summaries of the relevant skills, experience and expertise of each director are set out in this report.

The policy for appointment of directors and the selection process are outlined in the Constitution. The Appointments and Remuneration Committee assesses the necessary and desirable competencies of candidates for directorship.

New non-executive directors are provided with an induction program specifically tailored to the needs of individual appointees. That program includes a briefing on the current research activities, one-on-one meetings with members of the senior executive team and visits to key functional areas. Directors participate in continuous improvement and education programs from time to time, as considered appropriate. The Company's Constitution requires a director to retire from office at the conclusion of the second annual general meeting after the director was elected or appointed. Retiring directors are eligible for re-election. A review of the performance of the Board, its committees and individual directors is performed at least every two years, with the most recent being undertaken in 2012.

INDEPENDENCE

An independent director is a non-executive director who is not a member of management and who is free of any business or other relationship that could materially interfere with, or could reasonably be perceived to materially interfere with, the independent exercise of their judgement.

The Board has assessed the independence of the non-executive directors in light of their interests and relationships and considers that all Directors are independent. Although five non-executive directors are employees of Member companies and represent the three member colleges they are regarded as sufficiently independent within the meaning of the Principles and Recommendations in that the Company is a company limited by guarantee and therefore does not have any substantial shareholders.

Each year, the Board assesses the independence of directors in light of the interests and circumstances disclosed by them.

BOARD RENEWAL

The Board believes arbitrary limits on tenure may cause loss of experience and expertise that are important contributors to the efficient working of the Board. The Board believes that none of the current non-executive directors have served on the Board for a period that could materially interfere with, or could reasonably be perceived to interfere with, the independent exercise of the relevant director's judgement. The date of appointment of each director is disclosed in this report. Currently, no director has served longer than 7 years on the Board.

With the consent of the Chairman, individual directors may seek independent professional advice, at the Company's expense, on any matter connected with their responsibilities. No individual directors exercised this right during the year.

DIRECTOR COMPETENCIES

The Appointments and Remuneration Committee role (see below) has been established to assist the directors in ensuring that the Board is comprised of individuals who are best able to discharge the responsibilities of a director, having regard to the law and the highest standards of governance, by:

- assessing the skills, knowledge, and experience required on the Board and the extent to which each is represented;
- establishing processes for the review of the performance of individual directors and the Board as a whole;
- establishing processes for the identification of suitable candidates for appointment to the boards of CRCMining and its subsidiaries;
- reviewing skills required to be maintained by existing directors; and
- overseeing succession planning for the Board.

DIRECTOR COMMITMENT

As a part of the appointment process, prospective directors must disclose existing and proposed directorships, as well as any other commitments they have. These commitments are assessed to determine whether the prospective director has adequate time to perform their duties. The Committee assesses the time commitments of the Chairman and all other non-executive directors on an ongoing basis so as to ensure that adequate time is available to discharge Board duties. The current members of the Board are all considered to have sufficient time available to them in order to discharge their responsibilities to CRCMining.

DIRECTORS' MEETINGS

The number of directors' meetings (including meetings of committees of directors) and the number of meetings attended by each of the directors of the Company during the financial year are:

Director	Board of Directors		A&R Committee		Audit Committee	
	HELD	ATTENDED	HELD	ATTENDED	HELD	ATTENDED
Dr L Hammond	7	7	2	2	3	2
Prof P Lever	7	7				
Prof G Dunlop	2	2	1	1		
Prof D Mee	5	4				
Mr G Ehm	7	4	2	2		
Mr A Hathorn	7	7	2	2		
Ms K McKenzie	7	7			3	3
Mr R Melrose	7	6			3	2
Mr A Ransley	7	5			3	2
Mr A Doe	1	1				
Mr I Harris	1	1				

The Board met on 30 July 2013, 25 September 2013, 14 November 2013, 26 February 2014 and 28 May 2014.

BOARD COMMITTEES

The Board has established three permanent committees to assist in the execution of its responsibilities. Each committee reports to the Board. Each committee is governed by terms of reference under which authority is delegated to it from the Board. Committee meeting agendas, papers and minutes are made available to all members of the Board.

The Chair of each committee is free to use whatever resources they consider necessary to discharge the committee's responsibilities.

With the exception of the Research Committee, all members of the committees are non-executive directors.

The composition and role of each committee are set out below:

Audit Committee

The Audit Committee Charter includes terms of reference which set out its role and responsibilities, composition, structure and membership requirements.

The Audit Committee meets at least twice a year and consists entirely of non-executive, independent directors. As at 30 June 2014, the Committee was chaired by Ms Kellie McKenzie, with the other members being Dr Laurie Hammond, Mr Rowan Melrose and Mr Andrew Ransley. The Board considers that the Audit Committee is of a sufficient size and independence and possesses sufficient technical expertise to discharge its mandate effectively. The external auditors, the CEO and the Chief Financial Officer (CFO) and other executives are invited to the meetings at the discretion of the Committee. At each Committee meeting they attend, the external auditor reports on the outcome of their audit and other work.

The Committee meets with the external auditor in the absence of members of management at every meeting that the external auditor attends. Summaries of the Committee members' technical expertise are set out in the Directors' Report.



The principal role of the Audit Committee is to advise and assist the Board in relation to the reporting of financial information and the management of risk. The Committee's primary responsibilities include:

- ensuring the Company adopts, maintains and applies appropriate accounting and reporting processes and procedures;
- facilitating the independence of the external audit process and addressing issues arising from the audit process; and
- ensuring the Company maintains effective risk management and internal control systems.

The directors are committed to the preparation of financial statements that present a balanced and clear assessment of the Company's financial performance, position and prospects. Accounting and financial control policies and procedures have been established and are monitored by the Audit Committee. The Committee approves any new material accounting policies. Compliance with these procedures and policies is subject to review by the external auditors. The Committee provides a link between the external auditor and the Board and monitors compliance with statutory responsibilities. The Audit Committee is responsible for making recommendations on the appointment, evaluation and dismissal of the external auditor, setting fees and ensuring that the external auditor reports to the Committee and the Board, and reviews the performance, independence and objectives of the external auditor on an annual basis. Details relating to the selection and appointment of the Company's external auditor are included in the Audit Committee Charter.

Auditor independence

CRCMining is committed to auditor independence. The CMTE audit engagement partner must rotate every five years, with the next rotation occurring in July 2016. The Audit Committee reviews the independence of the external auditor at each of its meetings. All non-audit services provided by the Company's external audit firm must be approved or ratified by the Audit Committee.

The Company has a structured, quarterly reporting process, culminating in Board approval of financial statements. The CFO provides a written

statement to the Board that the Company's financial reports present a true and fair view of the Company's financial position in all material respects and that the Company is financially sound and able to meet its liabilities.

A written statement is also obtained from a director of each of the Company's subsidiary and associated companies that the subsidiary or associated company is solvent.

The number of committee meetings held during the year and the attendance at these meetings by members is set out in the Directors' Report.

Appointments and Remuneration (A&R) Committee

The A&R Committee meets at least twice a year, and more frequently as necessary. As at 30 June 2014 the Committee was chaired by Dr Laurie Hammond, with the other members being Mr Graham Ehm and Mr Alex Hathorn. All members of the A&R Committee are non-executive directors. The A&R Committee is structured so as to comply with the Principles and Recommendations. As the need arises, the CEO and other executives are invited to meetings at the discretion of the Committee.

The A&R Committee Terms of Reference sets out the Committee's role and responsibilities, composition, structure and membership requirements.

The Committee's responsibilities include making recommendations to the Board in relation to the Remuneration Policy and the amounts and composition of remuneration for the CEO and other members of the senior executive team. This includes short and medium term performance requirements and incentives. Remuneration levels are set at competitive levels to attract and retain qualified and experienced staff. Independent advice is taken on the appropriateness of remuneration packages. The Committee's role includes responsibility for the remuneration and incentive policies (including the Performance Appraisal Policy) for the Chairman and other non-executive directors as well as for CRCMining generally. The Committee also approves the recruitment, retention and termination policies and practices as well

as superannuation arrangements and makes recommendations to the Board in accordance with the CMTE Development Limited Share Plans.

Diversity

CRCMining respects and values the competitive advantage of diversity, and the benefit of its integration throughout the organisation, in order to enrich our perspective, improve performance, increase member value, and enhance the probability of achievement of our goals and objectives.

The organisation's guiding principles with respect to diversity are:

- To treat all employees, prospective employees, contractors, consultants, members and suppliers, fairly and equally regardless of their gender, age, sexuality, culture/ethnicity, language and religious beliefs, and regardless of any disability or flexible workplace practices.
- To value diversity by maintaining a safe work environment and by taking action against inappropriate workplace behaviour including discrimination, harassment, bullying and victimisation.
- To promote an organisational culture that values diversity and tolerates differences by developing and offering work arrangements that help to meet the needs of a diverse work force.
- To promote the recruitment of employees and directors impartially from a diverse field of suitably qualified candidates.
- To provide learning and development strategies and opportunities that will develop the knowledge skills and experience of all employees.

The guiding principles will be realised by:

- Being aware of diverse strategies and organisational and market opportunities and utilising a range of tactics to achieve our goals and objectives;
- Adding to, nurturing and developing the skills and experience of employees; and
- Developing our culture, management systems, processes and procedures to be aligned with our guiding principles and promote the attainment of diversity.

Ongoing strategies, initiatives and programs promote diversity across the organisation.

Senior executives' remuneration policy

The performance of senior executives is evaluated in accordance with the evaluation process determined by the A&R Committee. All employees, including senior executives, participate in annual performance reviews, where achievement of key goals is discussed and assessed and future goals are agreed upon. A performance evaluation for senior executives took place in the reporting period and was carried out in accordance with the evaluation process.

Remuneration for CRCMining executives includes both fixed and variable incentive components.

Non-executive directors' remuneration policy

Directors representing Members are not paid directors' fees.

Fees for independent, non-executive directors are based on the nature of their work and their responsibilities. In determining levels of fees, survey data on comparable companies is considered. Non-executive directors' fees are recommended by the A&R Committee and determined by the Board. The structure of independent, non-executive directors' remuneration is clearly distinguished from that of executive directors and senior executives. They do not receive any performance related remuneration and receive only the statutory superannuation awards.

Research Committee

The Research Committee Terms of Reference sets out its role and responsibilities, composition, structure and membership requirements.

The Committee oversees the strategic direction of the Company's technology research and product development programs with an emphasis on priority and resource allocation in line with the Company's agreed corporate strategy. The research conducted by each of the four research programs is overseen by its own, program-specific Technical Committee which in turn reports to the Research Committee.

The Research Committee is comprised of an Industry Member Chairperson, the Chairs of each of the Technical Committees and a representative of each Company Member not represented by a Technical Committee Chair. One Research Committee member may also be a Board member.

The CEO and each of the Program Leaders also attend committee meetings in an ex officio capacity. Other Company staff are invited to meetings at the discretion of the CEO.

As at 30 June 2014, the Research Committee members were:

Andrew Scott	Co-chair, Barrick Gold
Ken Stratton	Co-chair, Caterpillar
Bob Betz	University of Newcastle
Jeremy Davies	CSC Australia
Andrew Doe	AngloGold Ashanti
Steve Hall	Curtin University
Brad Nielson	Joy Global
Thys Greyvensteyn	Anglo American
Charles Howarth	Herrenknecht
Pasi Julkunen	Sandvik
David Mee	University of Queensland
Mike Onsager	Caterpillar
Jim Sandford	Glencore
Tony Egan	Glencore
Mark Stickells	University of Western Australia

As at 30 June 2014, the Committee was chaired jointly by Ken Stratton and Andrew Scott.

Promote ethical and responsible decision-making

All personnel, including the directors and the senior executive team, are expected to act with the utmost integrity and objectivity, striving at all times to enhance the reputation and performance of CRCMining. CRCMining's values are enunciated in the Code of Conduct and are reflected in CRCMining's mission statement and strategic plan. The Company also has documented policies on grievance resolution, fraud and corruption management, sexual harassment, equity and diversity, and occupational health and safety which are communicated to employees at the time of employment and are reinforced by continuous performance management and employee training programs.

These policies guide the directors, the senior executive team and all employees as to:

- the practices which are necessary to maintain confidence in the Company's integrity;
- the practices necessary to take into account their legal obligations and the reasonable expectations of their stakeholders; and
- the responsibility and accountability of individuals for reporting and investigating reports of unethical practice.

The policies require strict compliance with high standards of honesty, integrity and fairness in all conduct relating to CRCMining

and its business. The policies outline formal procedures relating to anticorruption, confidentiality/privacy, trade practices, documentation management, workplace and other compliance issues for the purpose of ensuring that the Company meets best practice in these areas. They also provide for clear and confidential reporting mechanisms concerning any potential breach. The policies also incorporate a policy to ensure that the confidentiality, investigation and reporting of any allegations relating to improper conduct are properly maintained.

These policies are internal documents and are available to Directors and staff only on the CRCMining website.

Timely and balanced disclosure

The principal channels of communication with the Company's Members are the provision of the annual report, the annual Industry Forum, periodic reports from the CEO, the distribution of specific material covering major research initiatives and events, Company newsletters and announcements, the Company's website and the AGM. CRCMining offers its Members and stakeholders the ability to receive distributed materials in either electronic or hard copy format. The Board's philosophy is to encourage full participation of Members at the AGM to ensure a high level of accountability and identification with CRCMining's strategy and goals. The Company provides a forum to address individual Members' questions at each AGM. The external auditor attends the AGM and is available to answer questions about the conduct of the audit and the preparation and content of the Audit Report. In addition, Members may at any time direct questions or requests for information to the Company Secretary, the CEO or the Chairman. Members can also gain access to information about CRCMining, including annual reports and the Terms of Reference of its Board committees through the CRCMining website.

Recognise and manage risk

CRCMining views risk management as integral to its objectives of effective management of Company assets and the protection and maintenance of the company's value. The Board has established a Risk Management Policy which provides a framework for the oversight and management on a continuing basis of the material business risks associated with CRCMining's activities. The Risk Management Plan puts the Risk Management Policy into effect. The Risk Management Plan was designed and is implemented so as to provide a comprehensive risk management system which identifies, assesses and appropriately manages CRCMining's material business risks. CMTE focuses on effective management of material strategic, business, operational (research), financial, human resources and legal risks.

Within these categories, specific identified risks arise from matters such as technological developments, government policy changes and the economic environment. The Risk Action Plans are compliant with the Australian and New Zealand Standard of Risk Management AS/NZS 4360. The Board, Audit Committee and Risk Management Committee of the senior executive team are together accountable for monitoring risk and implementing the Risk Management Plan however the Board oversees implementation of the Risk Management Policy and the Risk Management Plan. The Audit Committee advises the Board and reports on the status of major risks to the Company through the integrated risk management programs. Day-to-day implementation of the Risk Action Plans is delegated to senior management.

The Health, Safety and Environment (HSE) Manager advises the Board on all matters related to work place health and safety (WH&S) risk management. The Audit Committee advises the Board on all non WH&S risk management and is responsible for reviewing the effectiveness of the organisation's approach to this area of risk management and the establishment and maintenance of internal compliance and control systems within the risk management framework. This includes the scope

of the external audit function. The Audit Committee is responsible for the appointment and removal of the external auditor and for ensuring that the auditor is independent. The Audit Committee approves the external audit plan for each year and the effectiveness of the function is kept under review. All reports issued by the external auditor are tabled at Audit Committee meetings.

The Risk Management Policy is an internal document and can be viewed on the CRCMining Staff Centre website by Directors and staff only.

Remunerate fairly and responsibly

The A&R Committee has a responsibility to recommend to the board and management, appropriate remuneration policies which are designed to enhance corporate and individual performance.

CRCMining's remuneration policy and practices are designed to attract, motivate and retain high quality people.

The remuneration policy is built around principles that:

- remuneration be linked to CRCMining's performance and the creation of its value;
- directors' remuneration be competitive and reflect good corporate governance;
- executive and employee rewards be competitive in the markets in which CRCMining operates;
- executive and relevant employee remuneration be an appropriate balance of fixed and variable reward;
- variable remuneration for senior management be comprised of short and medium-term components; and
- a proportion of executive and employee reward be dependent upon performance assessed against key business measures, both financial and non-financial.



Expert bucket design for digging optimisation

SPIN OFF COMPANIES

Mineware Pty Ltd markets sophisticated electrical and software monitoring equipment (**Pegasys** for draglines, **Argus** for rope shovels) for large mining equipment that provide information in real-time to mine personnel on the productivity and health of these machines.

- Pegasys improves operational efficiency, safety and productivity by accurately measuring the performance of dragline operations, and offers superior functionality with more advanced tools and features than any other system on the market.
- Mineware's Argus Shovel Monitor is an advanced monitoring system that addresses key issues of managing shovel payload, real-time truck loading, operator performance, and machine positioning.

CBM Innovations Pty Ltd was established to develop and commercialise the Tight Radius Drilling (TRD) system, which is targeting extraction methane gas from coal seams. This technology has application on mine sites, making coal seams safe to mine, and also in the burgeoning coal seam gas industry.

EdanSafe Pty Ltd has been established to market SmartCap, an exciting technology for monitoring the fatigue level of machine operators. SmartCap is a baseball cap with integral sensors that monitors and analyses the wearer's brainwaves to determine their state of fatigue.

Odyssey Technology Pty Ltd has licensed to a major equipment manufacturer its Oscillating Disc Cutter (ODC) technology for cutting very hard rock with lightweight mining equipment. Mining machines based on the ODC technology are being developed by Joy Global.



Tight Radius Drilling (TRD)



Oscillating Disc Cutter (ODC) – Dynacut, Joy Global

The **Unidig** companies are intellectual property owning companies. The Universal Dig and Dump (UDD) technology enables a step-change improvement in the productivity of draglines through higher bucket payloads and more efficient bucket control. Six BMA draglines in Australia have been retrofitted and operated more productively with the UDD technology.

Ezmine Pty Ltd owns and earns royalties from IP through joint venture partner (and CRCMining member) Joy Global, from marketing of systems for measuring payload, protecting tracks, protecting trucks and the semi automation of electric mining shovels.

Acumine Pty Ltd was established to develop and market a world-leading system for avoiding collisions between vehicles on mine sites. The company is progressing with its plans to license the Acumine technology to the industry.

Geomole Pty Ltd markets a novel method for “seeing” through a rock mass to determine ore body boundaries using a slimhole borehole radar system.

INTELLECTUAL PROPERTY MANAGEMENT

CMTE Development Limited maintains an intellectual property (IP) Register. Key pieces of IP currently held by the Company are detailed in the schedule of patent families below:

Patent Family Name	No of Countries		
	Granted	Pending	Other*
Universal Dig and Dump Technology			
Dragline bucket rigging and control apparatus	9	1	PCT
Dragline dump position control	8	1	PCT
Dragline bucket	4	1	PCT
Tight Radius Drilling			
Fluid drilling system	10	0	PCT
Erectable arm assembly	9	0	PCT
Fluid drilling head	9	0	PCT
Drill-head steering	9	0	PCT
Fluid drilling head with sliding gauging ring		9	PCT
Fluid drilling head nozzle design		9	PCT
Shovel Automation			
Payload estimation system and method	3	3	PCT
Collision avoidance for electric mining shovels	4	2	PCT
A real time method for determining the spatial pose of electric mining shovels	3	4	PCT
A method for position-calibration of a digging assembly for electric mining shovels	4	3	PCT
A collision avoidance system and method for human commanded systems		6	PCT
Oscillating Disc Cutter			
Rock Boring device	6	1	PCT
Rock cutting machine	11	1	PCT
Controlling bearings	14	0	PCT
Rock sampling apparatus	5	4	PCT
Other			
Automated drill string position survey	5	2	PCT
Blasthole slotting	0	0	PCT
Cap mounted brain monitoring system	0	0	PCT
Coiled tubing drilling system	2	0	PCT
Flow tracking in cave mining	6	2	PCT
Improved explosive composition	0	3	PCT
Measuring scalp potential	7	5	PCT
Measurement of bulk density of the payload in a dragline bucket	1	2	PCT
Spark testing apparatus			Prov.
TOTAL	129	59	

*PCT – Patent filed under the Patent Cooperation Treaty

Prov – Provisional application made in Australia

IDENTIFICATION, PROTECTION AND OWNERSHIP OF IP

In order to adhere to the National Principles of IP Management for Publicly Funded Research:

- Processes exist to identify inventions early and to ensure that any inventions with commercial potential are protected;
- All staff, seconded staff and students are required to sign undertakings in respect of CRCMining's intellectual property to the effect that all inventions, discoveries and novel designs are assigned to CRCMining and no confidential information will be disclosed without its consent;
- Instructions on the use and maintenance of laboratory notebooks are given to staff; and
- A publication policy is in place to protect IP from being published before it is protected.

Processes exist to identify inventions early and to ensure that any inventions with commercial potential are protected.



Water Jet Cable Bolt Drilling

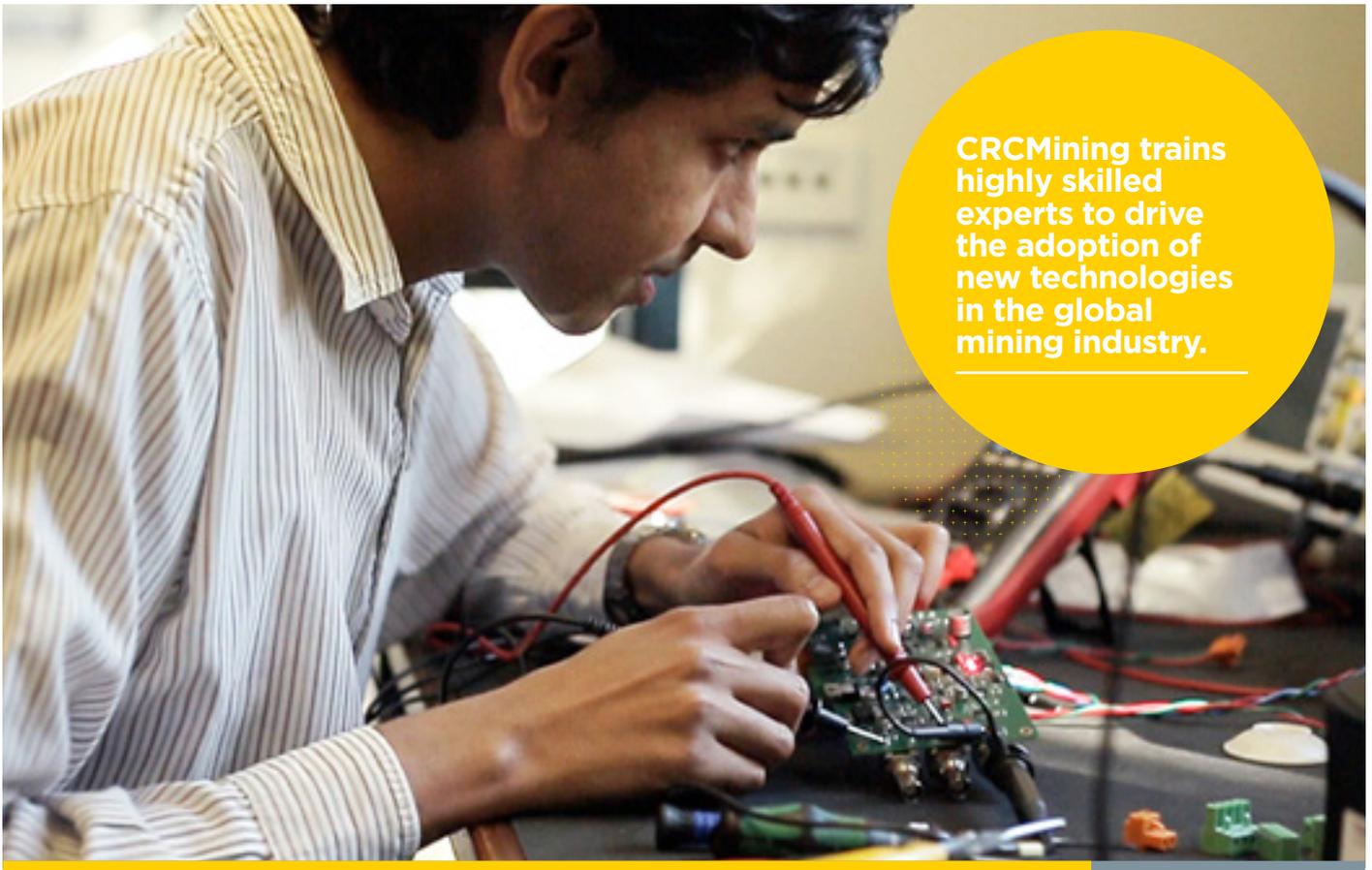
EDUCATION AND TRAINING

CRCMining trains highly skilled experts to drive the adoption of new technologies in the global mining industry. Supervised by Professor Peter Knights, the Centre's educational program research is conducted on commercially viable projects that tackle the technical challenges facing the mining industry now and in the future.

The key elements of the program are to support postgraduate studies and develop undergraduate and professional staff. CRCMining also works with industry to identify skills needs to successfully maintain automation technologies.

Seven students completed their PhD studies and four students completed their MPhil studies during the reporting period. CRCMining has achieved all of its student milestones and utilisations by 30th June 2014.

Student	Degree	Topic	Institution	Supervisor(s)
Peter Beasley	PhD	Theoretical framework for planning near optimal dig sequencing	UQ	Ross McAree
Juan Londono	MPhil	Systems Modelling of Parallel conveyors in IPCC Systems	UQ	Peter Knights Mehmet Kizil
Pablo Pinto	PhD	Organisational Structures in collaborative Research Groups	UQ	Damien Hind Peter Knights
Iain Williams	PhD	Dynamic Terrain Mapping for Collision Avoidance in Mining Applications	UQ	Ross McAree Paul Siegrist
Matthew Green	PhD	Automation of truck and shovel interaction for surface mining	UQ	Ross McAree Peter Jacobs
Mohammad Amanzadeh	MPhil	Investigation of All-Fibre methane sensors for Underground Coal Mines	UQ	Saiied Aminossadati Paul Lever
Chris Townsend	PhD	Control of Multilevel H-Bridge Converters	Newcastle	Terry Summers Bob Betz
Nathan Marks	PhD	Statcom systems for mining	Newcastle	Terry Summers Bob Betz
Hla Aye Saw	PhD	Early strength of shotcrete	WASM	Ernesto Villaescusa
Cesar Pardo	PhD	Back analysis of rock mass damage during block caving at El Teniente Mine	WASM	Ernesto Villaescusa
Ellen Morton	PhD	Seismic behaviour of large scale structures	WASM	Ernesto Villaescusa
Ayako Kusui	M Phil	Laboratory Testing of scale-down tunnel structures	WASM	Ernesto Villaescusa
Mark Ho	PhD	A shared reliability database for mobile mining assets	UWA	Melinda Hodkiewicz
Tyson Phillips	PhD	Perception Sensor Reliability from a risk based engineering perspective	UQ	Ross McAree
Pisan Kulkaew	M Phil	Optimal Mission plans for Autonomous agents	UQ	Ross McAree
Ben Yang	M Phil	An Innovative Fibre optic based Conveyor monitoring system	UQ	Ross McAree
Ali Soofastaei	PhD	Investigation of Energy Efficiency in Haul Truck Operations	UQ	Saiied Aminossadati
Xin Lang	M Phil	Genetic Algorithms for Dragline Sequencing	UQ	Peter Knights
M G Jahromi	PhD	Microgrid for Mobile mining equipment	Newcastle	Steve Mitchell Galina Mirzaeva



CRCMining actively contributes to undergraduate teaching programs at its partner universities. During the 2013-14 financial year, the following CRCMining staff had teaching responsibilities at their respective institutes:

UNIVERSITY OF QUEENSLAND

Professor Ross McAree, Professor Peter Knights, Ben Upcroft , Dr Kevin Austin, David Cusack, Dr Italo Onederra.

UNIVERSITY OF NEWCASTLE

Professor Bob Betz, Dr Steven Mitchell, Dr Terrence Summers, Dr Galina Mirzaeva

UNIVERSITY OF WESTERN AUSTRALIA

Melinda Hodkiewicz, Kerrie Unsworth

CURTIN UNIVERSITY OF TECHNOLOGY (WESTERN AUSTRALIAN SCHOOL OF MINES)

Ernesto Villaescusa, Chris Windsor, Alan Thompson

Many of the Centre's research staff supervise undergraduate theses and CRCMining postgraduate students provide extensive support in tutorials and practical classes.

At the start of the reporting period, CRCMining sponsored eight undergraduate students for the summer vacation period. These students worked on various research projects being conducted by CRCMining,

and were supervised by academic project leaders. This scholarship period culminated in an internal seminar, with each student presenting to and receiving feedback from CRCMining research staff.

STUDENT INVOLVEMENT IN CRCMINING'S ACTIVITIES

All students receiving CRCMining scholarships work directly with CRCMining research projects. Undergraduate students are tasked with an element within a project and challenged to produce solutions to problems. As shown in the table above, postgraduate students base their thesis topics on current projects.

SUPPORT STRUCTURES

All postgraduate students are supported in their studies, through the CRCMining Research Coordinator and respective faculty administration staff. All administrative aspects, from scholarship agreements to the coordination of reviews and assessments are conducted.

Funds are allocated to research projects to ensure the students receive adequate support and resources to conduct their study.

Students from different programs have the opportunity to interact through postgraduate seminars conducted through University members.

FINANCIAL REPORT

The 2013-2014 financial year is the last year in which CRCMining will receive funding from the Australian Government's Cooperative Research Centres program. Accordingly it has had to transition to a smaller Centre in the short term to accommodate the future loss of \$2.4m per annum in CRC Program funding which has unfortunately meant down-sizing. In addition it has been necessary to make a profit to enhance the Centre's balance sheet to mitigate for the additional financial risks the Centre will face as an independent research organisation. At the same time the mining industry has continued its down turn over the past year which has impacted significantly on our mining and OEM members making the sourcing of research funding difficult.

Total income has fallen \$2.5m from \$13.8m in the prior year to \$11.3m, a decline of over 18%.

Research expenditure has been reduced by \$5.8m, nearly 50%, primarily by reducing the research staffing FTE from 49 to 30.

Administration represents 21% of total expenditure, up from 12% last year because management has needed to spend an extraordinary amount of time ensuring a successful transition.

A surplus of \$2.9m was recorded which includes \$850k of dividends.

Participants' contributions represent the membership fees payable by both university and industry partners. The CRC Program grant comprises the cash received from the Australian Government's Cooperative Research Centres program.

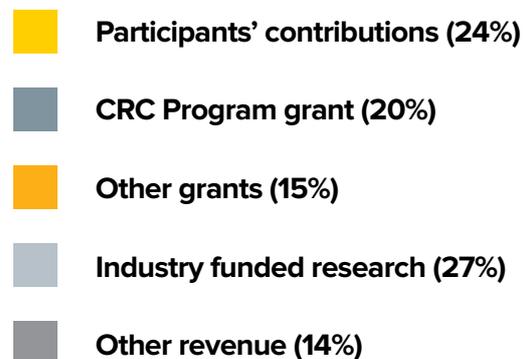
Participant contributions and the CRC Program grant are not tied to specific research projects and are used firstly to run the Centre and secondly are applied to the Centre's research programs as directed by the Centre.

Other grants comprise funding received from state governments and industry groups directed to specific projects. Industry funded research revenue is money received from mining companies and OEMs which is also directed to specified projects.

Expenditure on research programs comprises 83% of all expenditure and represents both the direct and indirect (overhead) costs of conducting the Centre's research.

Administration costs comprise Centre management expenses as well as the costs of the education program, technology transfer, intellectual property protection and business development.

In-kind contributions represent the non-cash contributions to the Centre by participants and comprise the use of their people, equipment and facilities.



	2013/14	2012/13	2011/12	2010/11	2009/10
	\$000's	\$000's	\$000's	\$000's	\$000's
INCOME					
Participants' contributions	2,920	3,230	3,153	2,590	2,475
CRC Program grant	2,400	2,400	2,400	2,400	2,400
Other grants	1,832	1,633	2,318	1,808	1,077
Industry funded research	3267	5,573	4,710	2,610	3,802
Other revenue	1788	980	88	97	35
	12,207	13,816	12,669	9,505	9,789
EXPENDITURE					
Research programs	6,649	12,547	9,923	7,799	7,639
Administration	1,811	1,728	2,447	2,534	2,375
	8,460	14,275	12,370	10,333	10,014
Surplus/(deficit)	3,747	(459)	299	(828)	(225)
In-kind contributions	2,191	4,792	4,697	13,753	11,143
STAFFING (FULL TIME EQUIVALENTS):	FTE	FTE	FTE	FTE	FTE
Research	29.7	48.9	54.0	42.6	43.5
Administration	8.3	8.2	6.9	9.2	8.0
	38.0	57.1	60.9	51.8	51.5
Research spend per FTE (\$000's)	224	257	184	183	176

APPENDIX A - PUBLICATIONS

JOURNAL ARTICLES

Aminossadati, S. M., Amanzadeh, M., Prochon, E., Kok, J. and Adam, S. (2014) Step change approaches in coal technology and fugitive emissions research. *International Journal of Mining Science and Technology*, 24 3: 363-367.

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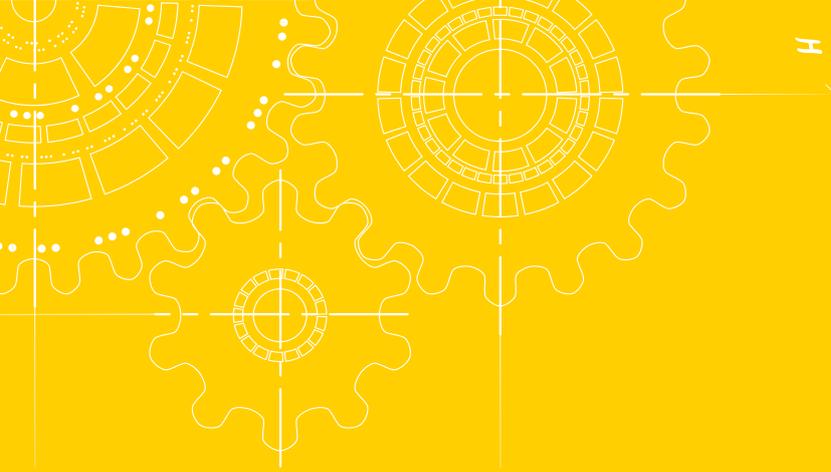
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