



MINING

TRANSFORMING MINING

2014/15 ANNUAL REPORT



CRCMINING 2014/15 ANNUAL REPORT

TABLE OF CONTENTS

CRCMining industry Members	1
Chairman's Report	2
CEO's Report	4
Board of Directors	5
Senior Executive Team	7
Program Leaders	9
Technology Transfer Strategy	11
Collaboration	11
Communications	12
Research Strategy	13
Research Delivery Structure	14
Research Programs and Industry Outcomes	15
- Automation Program	15
- Hard Rock and Surface Mining Program	17
- Energy and Power Program	22
- Underground Coal Mining Program	24
Corporate Governance Report	26
Intellectual Property Management	31
Spin Off Companies	32
Identification, protection and ownership of IP	32
Education and Training	33
Financial Report	35
Appendix A - Publications	36

CRCMining is the trading name of CMTE Development Ltd. These two names are used interchangeably throughout this report.

TRANSFORMING MINING

CRC MINING IS A WORLD-CLASS INDUSTRY-DRIVEN CENTRE FOR GLOBAL MINING RESEARCH AND INNOVATION.

We have a proven track record of collaborating and partnering with leading mining companies, original equipment manufacturers and universities, to deliver transformational research and innovations that maximise mining productivity and enhance resource utilisation and sustainability.

Since 1991, the Centre has directly commercialised technologies that have had significant impacts on industry, and also provided the foundational knowledge and pioneering research that has led to the development of technologies and equipment used widely in industry today.

We are committed to developing highly-skilled people who will be future leaders that drive the adoption of new mining processes and technologies critical to the future success of the mining industry.



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.



2014-15 INDUSTRY MEMBERS

ANGLO AMERICAN
 ANGLOGOLD ASHANTI AUSTRALIA LIMITED
 BARRICK GOLD CORPORATION
 CATERPILLAR
 JOYGLOBAL
 SANDVIK
 KOMATSU
 VALE



UNIVERSITY MEMBERS

CURTIN UNIVERSITY
 THE UNIVERSITY OF QUEENSLAND



PROJECT PARTNERS

BARMINCO
 BHP BILLITON
 CSC AUSTRALIA PTY LTD
 ELEXON ELECTRONICS
 GLENCORE XSTRATA
 HERRENKNECHT TUNNELLING SYSTEMS

NEWCREST MINING LIMITED
 NEWMONT
 PEABODY ENERGY
 RIO TINTO
 RUSSELL MINERAL EQUIPMENT
 SHELL

CHAIRMAN'S REPORT

The tenor of my report last year was one of cautious confidence in the success of CMTE Development Limited's transition from being a national Cooperative Research Centre to a fully industry-supported centre.

However, the challenges it had to overcome, and will continue to face, were more substantial than we first thought. The sustained downturn in most mining commodity prices and the end of the intensive investment phase in new assets by the mining companies created a difficult and uncertain operating environment for companies all along the value chain, from which CMTE Development Limited has not been sheltered. It is a mark of the commitment of our member companies to the value proposition offered by the Centre, and a product of the indefatigable efforts of the CEO and his senior management team, that the transition has been an unequivocal success.

Difficult times often bring forth opportunities, and that is certainly the case now, as possible new initiatives emerged on both the supply and demand sides of mining research and technology development.

An opportunity to create an alliance with CSIRO and bring its considerable research capabilities to bear on mining industry problems, as defined by the member companies of CMTE Development Limited through their "grand challenges" and technology-roadmapping process, is exciting and of potentially great benefit to innovation and productivity in the mining industry. The close engagement between the Centre and the industry, and the clear strategic direction provided by the industry, have been seen as critical reasons to enter into the envisaged alliance. While there is more work to be done before it can be signed-off, the parties are optimistic that agreement will be reached before June 2016.

On the demand side, industry members have encouraged a broader engagement with them on projects and problems in other jurisdictions in which they operate. They have proposed that CMTE Development Limited utilise its collaborative innovation model, adapted to circumstances as appropriate, to enable it to have a presence in some key mining jurisdictions, perhaps initially in USA and Chile. These ideas will be explored in the new strategic plan being developed during the coming months.

Other opportunities may be presented by the national METSignite organisation (the Federal government's METS Growth Centre initiative), which was announced during the year and has since been established in Brisbane. While METSignite's work program and priorities are not yet clear, CMTE Development Limited will remain open to engagements that clearly offer new benefits to its members.

The benefits to member companies and the broader mining industry of CMTE Development Limited's research program are most often delivered through joint development projects with one or more members. Less commonly they are delivered by establishing a new venture. This year, several of the spin-off companies from previous years (CBMI Pty Ltd with tight-radius drilling technology; SmartCap Pty Ltd with fatigue management systems; Mineware Pty Ltd with dragline and shovel control systems) have taken significant steps towards commercialisation of their products and services and achieving business success. Each has had its difficulties and delays, highlighting why CMTE Development Limited's strategic objective of shortening the innovation cycle is so important.

CMTE Development Limited has retained the right to use the CRCMining name post-transition, but as new opportunities and initiatives are taken, the relevance of the brand will be re-examined.

I thank the directors of the company for their commitment and professionalism, and particularly Kellie McKenzie, who resigned in June, and Rowan Melrose and Alex Hathorn who will retire at the forthcoming AGM.

On behalf of the Board I thank the members for their engagement and commitment, which is what makes a collaborative innovation model work. I also thank Paul Lever for his leadership, and all the management team and staff of CMTE Development Limited for their efforts and achievements over the last year.



DR LAURIE HAMMOND
CHAIRMAN

“WE ARE IN IT TOGETHER
TO DRIVE TOWARDS AN
INNOVATIVE FUTURE.”

ANGLOGOLD ASHANTI,
GRAHAM EHM

CEO'S REPORT

For the mining industry and CRCMining, the 2014/2015 fiscal was another challenging year. As we transitioned out of the CRC program and emerged as an independent, fully industry funded organisation, our first year wasn't without its trials and tribulations. However, while some elements of our operating model changed, it did not impact our continuing focus on the delivery of innovative technology for our members and the mining industry.

With mining continuing to battle low commodity prices and high costs, the innovation imperative has never been so pertinent. Mining companies are approaching the productivity challenge from multiple fronts and innovative technology is emerging as an opportunity which can no longer be ignored.

The work undertaken by CRCMining and its members is critical to this transition and will play a major role in leading the industry into the future. We are already making a difference through our collaborative model and we will continue to advance the development of innovative technology and equipment.

Some of our accomplishments this fiscal year include:

- Confirmed industry support and commencement of the development of an alternative explosive formulation
- Continued close collaboration with Joy Global on the research and development of the ODC-based DynaCut™ hard rock cutting system
- Initiation of the uncrushable (tramp metal) detection technology
- First field deployment of the Tight Radius Drilling (TRD) technology at a CSG well
- Successful field demonstration of the SLAP project – the world's first semi-automated mining shovel
- Continued positive operational performance from MineWare and SmartCap Technologies
- Sound financial performance in our first year without CRC program funding

Skills development remains a high priority at CRCMining and our education program continues to provide work experience to students from our research member organisations. Students are a vital part of entrenching innovative thinking into the industry, developing their technical and work skills and ensuring a strong future work force.

In closing, I would like to acknowledge our Chairman, Laurie Hammond and our board of directors who have provided strong strategic direction over the transition period. We also thank our mining partners for their continued leadership and our research partners who deliver world-class expertise and knowledge – The University of Queensland, Curtin University and the University of Newcastle.

I look forward to the challenges and opportunities the next fiscal presents.



PROFESSOR PAUL LEVER
CEO, CRCMINING

BOARD OF DIRECTORS



Laurie HAMMOND
BSc, PhD

DIRECTOR, IQ CAPITAL
MANAGEMENT PTY LTD
(APPOINTED 6 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 CRCMining 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.

Prior to 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. Professor Lever obtained a BSc in Mining Engineering from the University of Witwatersrand in Johannesburg, and was awarded a PhD in Mining Engineering from the Colorado School of Mines in 1991.



David MEE
PhD, BE (Mech) Hons 1st Class

PROFESSOR, 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 a member of UQ's Centre for Hypersonics, an international centre of excellence in the field of hypersonic aerodynamics. His research contributed to the development of the world's first flight test of supersonic combustion, the process used in scramjets. He 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.



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

COMPANY SECRETARY

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. Jane 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 the Australian Festival of Chamber Music; and Energising Communities Limited a not-for-profit company. Jane has also served as independent chair of Fisher Adams Kelly, patent attorneys, as a director of City North Infrastructure Pty Ltd and as chair of the Queensland Institute of Medical Research Trust.



Andrew RANSLEY
B.Eng (Mechanical) (Hons)

GENERAL MANAGER, ASIA PACIFIC CATERPILLAR GLOBAL MINING
(APPOINTED 7 DECEMBER 2012)

Andrew Ransley has a Bachelor of Engineering (Mechanical) with Honours from the University of Queensland and has over 30 years' experience in the mining industry. His career includes Senior Maintenance 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 Mining Equipment at Dale B Elphinstone Pty Ltd as Operation Manager and was also the Group Plant Manager at Thiess Contractors. Since joining Caterpillar in 1995, he has held the positions of General Manager, then Managing Director for Caterpillar Underground Mining in Burnie Tasmania, Product Manager for Large Tractors in Peoria, Illinois and is currently General Manager Asia Pacific in Caterpillar Global mining.



Graham EHM
BSc (Metallurgy), MAusIMM, MAICD

EXECUTIVE VICE PRESIDENT
GROUP PLANNING AND TECHNICAL
ANGLOGOLD ASHANTI
(APPOINTED 12 MAY 2011)

Graham Ehm is the Executive Vice President – Australasia for AngloGold Ashanti. He was appointed General Manager of Sunrise Dam Gold Mine in 2000, Regional Head Australia in 2006 and Executive Vice President Australasia in December 2007. He held the same position in Tanzania from 1 June 1 2009 to August 2010 before resuming his position as Executive Vice President Australasia. 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. For the past three decades, Graham has been working in mine operations and project management, covering the nickel, phosphate, copper, uranium and gold sectors.



Alex HATHORN
BSc (Mining Engineering)

RESOURCE INDUSTRY CONSULTANT
(APPOINTED 7 DECEMBER 2012)

Alex Hathorn has more than thirty years of mining industry experience in senior executive roles with Gold Fields, Kumba Resources, Anglo American, Peabody Energy and Hatch. He has been involved in mining projects and operations on a global basis and with a wide diversity of commodities – gold, platinum, iron ore and coal, amongst others. Alex has held a number of directorships; notably, he was on the Board of AMIRA for eight years, and is also a past director of Australian Coal Association Low Emissions Technologies (ACALET) and Australian Coal Research Ltd (ACARP). He is currently also a director of CBMI Ltd.



Kellie McKENZIE
BBus (Hons), CA

PARTNER – ERNST & YOUNG
(APPOINTED 26 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, AUTOMATION AND TECHNOLOGY, SANDVIK MINING GLOBAL BUSINESS, AND COUNTRY
MANAGER, SANDVIK AUSTRALIA
(APPOINTED 29 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.

He also holds the responsibility of Sandvik Country Manager, a role that considers all of Sandvik's business interests within Australia. He has over 30 years' experience in the mining industry in both operational roles (coal and iron ore), and with various suppliers and manufacturers. He is a member of the AICD.

ALTERNATE DIRECTORS



Andrew DOE
MEng (Mining), MAusIMM

VP TECHNICAL AND BUSINESS IMPROVEMENT, ANGLOGOLD ASHANTI AUSTRALIA LTD
(APPOINTED 7 NOVEMBER 2014)

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.

SENIOR EXECUTIVE TEAM



Professor 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 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. Jane 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 the Australian Festival of Chamber Music; and Energising Communities Limited a not-for-profit company. Jane has also served as independent chair of Fisher Adams Kelly, patent attorneys, as a director of City North Infrastructure Pty Ltd and as chair of the Queensland Institute of Medical Research Trust.



Carolyn Martin

MARKETING AND
COMMUNICATIONS MANAGER

Carolyn is an experienced Marketing and Communications Manager with over 15 years' experience leading campaigns across mining, infrastructure, agriculture, tourism, and scientific research sectors in Australia and overseas.

At CRCMining, it is Carolyn's role to keep stakeholders informed and engaged about the latest outcomes from research projects aimed at boosting mining productivity and sustainability.

Carolyn has a Bachelor of Business majoring in Journalism and Marketing, an IAP2 Certificate in Public Participation, and has completed the Foundations of Directorship certificate with the Australian Institute of Company Directors.



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 (2009-2015) and Chair of the School of Mechanical and Mining Engineering Teaching and Learning Committee (2015-on going)

In October 2013 Ross was elected a Fellow of the Australian Academy of Technological Sciences and Engineering (ATSE). In June 2015 Ross ended his sixteen year association with CRCMining to focus on his teaching and research activities with the University of Queensland.



Scott Adam

UNDERGROUND COAL MINING PROGRAM LEADER

Scott Adam is the 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.



Dihon Tadic

HARD ROCK AND SURFACE MINING PROGRAM LEADER

Dihon Tadic has been working with CRCMining 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.



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.

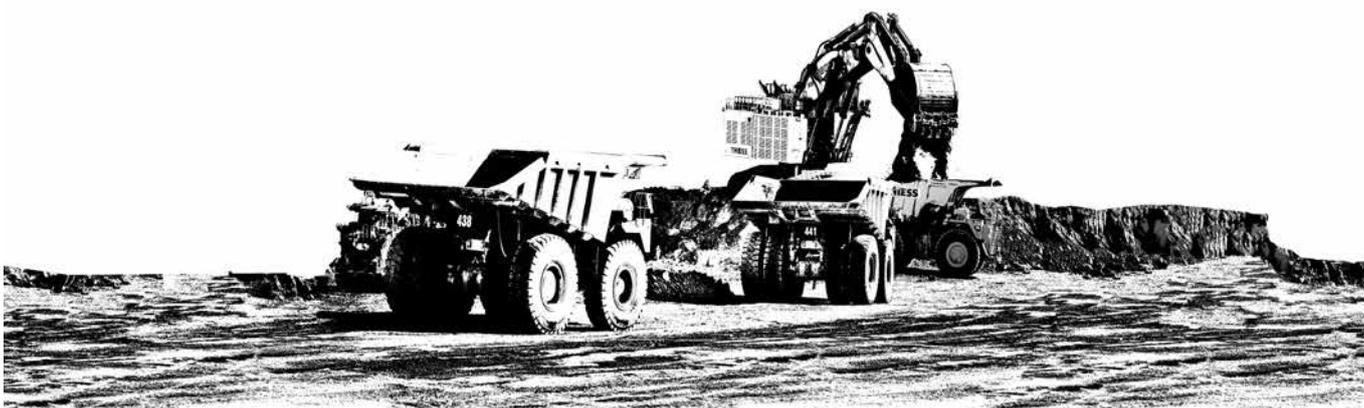


Professor Bob Betz

ENERGY AND POWER PROGRAM LEADER

Prof 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 main goal of CRCMining's technology transfer activities is to ensure industry impact (primarily through commercialisation) from new and existing intellectual property (IP) developed by the Centre.

CRCMining's industry directed research is aimed at utilising industry feedback and demand to focus research and commercialisation activities on to high value activities. This market "pull" is a key enabler of overcoming the early adoption challenges with new technologies.

The principles guiding commercialisation are:

- Reduced Time to Market: Ensure the IP generates industry impact (products and / or services) as quickly and reliably as possible, to the maximum benefit of our members and the mining industry; and
- Returns: Ensure that the IP generates commercial value and reputation to CRCMining 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:

- Utilise industry funding as a key test of determining real industry need;
- Utilise CRCMining's Technology Readiness Levels (TRL) process to focus research tasks on the range of activities to comprehensively de-risk and understand new innovation, and link research into product development;
- Develop commercialisation plans in conjunction with executing the research projects, with commercialisation plans being progressively more advanced as technology proceeds through TRL gates;
- Include consideration of creating spin-offs, licensing or assignment to Members, licensing to SMEs or other non-Members, or publishing, etc;

- Where possible involve potential partners early, in order to commence the tech transfer early, and to develop early joint commercial understanding;
- For spin-off companies:
 - Ensure adequate market opportunity, funding, management and innovation capability are all in place key criteria for any spin-off company;
 - Establish paths towards independent governance of spin-off companies;
 - Support and guide those companies towards generating a dividend stream, or to an appropriate exit, enabling CRCMining to realise value from its shareholdings.

For licensing, to support licensees where possible, either as knowledge-transfer or funded research projects, in order to reduce the time to market of 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.
- Top Ranked Universities that conduct research to solve industry problems.

The Centre ensures that research outputs deliver significant outcomes, and 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.'

2014-15 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, Russell Mineral Equipment, Barmenco, Surtron Technologies, Elexon Mining (Cave Tracking), Gas Field Services, Mineware, 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. During 2014-2015 the Centre secured over \$7 million of industry and participant funding, of which \$2.5 came from international projects.

COMMUNICATIONS

The Centre relies on its Communications Strategy to promote CRCMining's work in mining technology and equipment research and development. A detailed Marketing and Communications strategy and activities plan is formulated and reviewed yearly.

During the 2014-15 year, communications initiatives included:

- CRCMining Industry Forum
- CRCMining participation in member and partner events
- 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 Austmine 2015, Uearthed hackathons, IMARC 2014, Qld Gas Conference 2014 and ACARP events.

2014 CRCMINING INDUSTRY FORUM

The Centre held its annual Industry Forum on 20 November 2014 at Customs House in Brisbane and was attended by 80 mining industry professionals. The theme of the forum was Research and Innovation Delivering Productivity Gains, focussing on the importance of innovation in the sector. Industry leaders, and CRCMining research leaders presented on thought leading strategies, step-change technologies, new research and innovations.

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.

The Member Portal provides the following services to Members:

- A Committee Meeting Room for each Program committee that houses respective committee documentaiton in a secure, permission based manner;
- A research library of research papers, ACARP project reports, patents, annual reports, newsletters, PhDs and project summaries;
- A secure project share space for current project details to be referenced and in the future offer project collaboration between Members and project staff; and
- A platform to share presentations and images from key events such as the CRCMining Industry Forum.

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 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.

CRCMINING SUBSCRIBERS

CRCMining established an online subscription service to enable current members, staff and mining industry stakeholders to subscribe to CRCMining newsletters, media releases and events. The database continues to grow with national and international subscribers and enables CRCMining easier engagement with wider audiences.



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 in 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 eight 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 reduce the time to market for 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
 - Step-change and Next Generation technologies, equipment, methods and processes to increase productivity, safety and sustainability
- SELECTIVE MINING
 - Low-cost, highly productive and safe methods and technologies to selectively mine large deposits
- RAPID MINE DEVELOPMENT
 - High-speed, safer access to mine deposits for rapid profitability
- MINING IN CHALLENGING ENVIRONMENTS
 - 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





RESEARCH DELIVERY STRUCTURE

DURING THE 2014-15 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.

5 GRAND CHALLENGES

RESEARCH PROGRAMS

PARTNERS PEOPLE



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.

PROGRAM CAPABILITIES

The Automation Program has capabilities in the following project areas:

N641 SHOVEL LOAD ASSIST PROGRAM (SLAP)

This project is being conducted with Joy Global (previously known as P&H) and is financially supported the Australian Coal Association Research Program (ACARP). The project commenced in 2008 and over its duration has developed and demonstrated a suite of operator assist and automation technologies that improve the efficiency and safety of electric mining shovels.

Work in 2014/15 focused on four technologies:

- **TruckShield:** A safety-related system that provides an engineered layer of protection against high-energy collisions between shovels and trucks.
- **DozerShield** layer of protection against high-energy collisions between shovels and the clean-up dozer.
- **AutoSwing:** An assistive technology providing a semi-automation layer that allows the swing, dump and return phases of the shovel cycle to be performed autonomously.
- **AutoFill:** An assistive technology providing a near-full-automation layer that allows the dig, swing, dump and return phases of the shovel cycle to be performed autonomously.



This year saw the successful completion of trial of TruckShield, DozerShield and AutoSwing at Anglo American's Lake Lindsay mine and the development and proof-of-concept of AutoFill. In addition to the technical demonstration of the systems, the project has also applied a structured framework to help understand the value that can be derived from these technologies. The key outcomes of the project in 2014/2015 are:

- There are inherent risks associated with the loading of trucks by electric shovels. TruckShield can address these risks with no observable detrimental impact on cycle times.
- Currently, operations must rely on either procedural or alarm based solutions to manage the risk of dozers performing clean-up around shovels. This project has demonstrated, with the application of DozerShield, that a hard engineering control can be successfully applied.
- The autonomous loading of trucks is feasible and provides swing time reductions in the order of 10 to 15%.
- Fully autonomous truck loading, including digging, is technically feasible and shows promise for ensuring repeatability and compliance with processes and has the benefit of providing optimal truck tray distribution.
- The value proposition for TruckShield, DozerShield and AutoSwing can be presented in a clear and logical form despite the underlying complexities of the systems. DozerShield and AutoSwing present strong value propositions while TruckShield is an attractive solution along the path to automation.

The completion of the SLAP project represented a significant milestone for the automation program as the culmination of 8 years work that has resulted in two commercial products (P&H Payload and P&H TrackShield). Recent achievements should translate into several future products.

N692 – AUTOMATED BULK DOZER PUSH - REDUCING THE COST OF OVERBURDEN REMOVAL

Caterpillar SATS is a Semi-Autonomous Tractor System for D11T dozers that can perform bulk dozer. This new technology has been developed at a Wyoming coal mine where it has now moved over 10 million bcms. The SATS system is capable of executing push-to-an-edge bulk dozing and has been successfully used for dragline bench preparation. The rehandle resulting from the push-to-an-edge strategy is influenced by the geometry of the spoil design shell and the post-blast material profile. In certain applications, e.g. cast-doze-excavate (CDX), a pivot-push-with-back-stacking strategy is favored to minimize rehandle. SATS cannot currently execute such a strategy.

The objective of the project is to extend the capability of SATS so that the system can perform pivot-push with back-stacking. The research involves determining how to best choreograph the sequence of cuts and moves performed by an autonomous dozer for bulk moves by pivot push so that the volume of material moved is maximized within the economic limits of the dozer push operation.

This project commenced in February 2015. The work is being financially supported by ACARP and Caterpillar and field work is taking place at a Peabody site.

The objectives of the work are:

- Clarification of, and justification for, how to best execute automated pivot push back-stacking for bulk material movement by dozer in a CDX operation.
- Extension of the Caterpillar SATS system to perform automated pivot push.
- Performance evaluation of the autonomous system in head-to-head comparison with manual operation.

N693 ACTIVE PEG

- The Active Peg project has sought to find a viable localization solution for reef-boring machines in an underground mine based on ultra wideband ranging (UWB) technology. The end goal is to provide machine pose information to an automated control system as part of a fully autonomous reef-boring process system. This automated solution will improve efficiency and safety while expanding opportunities to mine deeper sections of the mine that are currently not viable using current techniques.
- Work completed this year expands on the results achieved previous testing in November 2014 at Anglo Gold Ashanti's TauTona mine. This earlier work shown that a localization system based around UWB technology can be used in an underground environment to estimate the pose of the baseplate of the reef-boring machines.

- Analysis and evaluation from earlier work brought to light a number of constraints necessary for the system to perform to specification in the underground environment. Specifically, it became clear that the effect of using different positioning of the tunnel and equipment transceivers needed to be studied further to ensure the Active Peg system meets the accuracy specifications. This analysis was completed and identified a viable sensor geometry given the constraints of tunnel geometry. A system was deployed and tested at TauTona mine and the results were very very promising, with the pose estimate output by the Active Peg system matching the manually surveyed pose within the acceptable bound of error as specified. The system also showed the capability to monitor machine pose (and movement) during drilling. The technology is currently being commercialized for Anglo Gold Ashanti by a South African SME.

N700 DRAGLINE EXCAVATION SEQUENCING

The task of excavation sequencing is to determine a sequence of tub positions and the material movement tasks at each position that maximize the lineal advance of the dragline and best utilizes the available spoil room. In practice, the decision to excavate material from a given position is driven by many factors: how much volume is reachable from the position and where that volume is located; how efficiently can the reachable material be excavated from the position; the average cycle time for moving the material to final spoil; the spoil room available from the position and where the available spoil room is located; and the impact that the assigned material movement task has on later excavation decisions.

The project was funded by ACARP completed in collaboration with the SME Mineware. It is founded in the context of a broader roadmap toward improving dragline operation through automation with the aims of:

1. Understanding the requirements of an operator assist for excavation sequencing from the perspective of dragline operators, supervisors, and engineers.
2. Characterizing the decision making process for excavation to understand the functional elements of the sequencing problem and how they interrelate, and to identify sub-problems that can be solved.
3. Developing software framework for providing the functional capabilities of excavation sequencing.
4. Apply identified strategies to address excavation sequencing for a steady state excavation scenario and make comparisons with actual operation.

This project laid the foundations for an operator assist product capable of providing excavation sequence guidance to operators. The key outcomes of the project are:

1. The creation of a shared vision aligned with industry needs on the benefits of the dragline excavation sequencing. The value associated with the common vision, and the collective understanding of dragline sequencing, is key to the progression of the work towards a commercially available technology that brings industry benefit.

2. Identification of an embodiment of the excavation sequencing concept as a real-time, adaptive excavation supervisor that resides on-board the dragline and provides guidance to operators on where to position, where to dig, and where to spoil. The operator assist concept matured with progress in the project with many sub-problems identified as value added components that would enhance tools available to operators, supervisors, and engineers.
3. Articulation of the problems that need to be solved to realise the operator assist vision and identification of the key features required of such a technology. Dragline excavation sequencing is a complex problem and combines a series of coupled decisions across planning and execution domains.

While excavation sequencing for simple scenarios has been achieved, to realise the potential value, the work needs to be extended and refined. The success of the project has underlined that dragline excavation sequencing is a complex problem with many input variables. It is a combinatorial problem requiring a sequence of coupled decisions over time to achieve a desired objective. Each decision impacts future possible decisions and finding ways to solve for these is technically challenging and not fully explored. The problem is also complicated by multiple competing objectives that are coupled to the decision points within an excavation sequence.



HARD ROCK AND SURFACE MINING

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:
 - Excavation design
 - Methods for assessment of rock masses
 - 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

SELECTED PROJECTS SUMMARY:

G614 TOP-OF-COAL DETECTION 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.

In late 2014, the project team completed a comprehensive re-evaluation of the system components and design of the original proof-of-concept system, and developed a new technical approach with significant cost, robustness and technical advantages. A provisional patent application was made for this new system. The new system will be more easily retrofitted to existing rigs and removes electronics from down the hole.

In April this year, tests were conducted on a field rig in a drilling supplier yard to assess the key component installation and basic functionality (mechanical and electrical) response to compressed air flow through the string. These tests were successful and supported progression to site drilling trials, which demonstrated validity of the detection concept in a mining environment. Additional development and testing is required to further develop the technology and produce a production prototype, which ACARP is continuing to support into the next phase of the project in 2016.



G647 QUANTIFYING DEVELOPMENT RISKS FOR A HIGH CAPACITY SURFACE MINING CONTINUOUS CUTTING SYSTEM IN WASTE

The objective of this project was to assess the feasibility of various current and emerging rock cutting systems and to identify the key risks around successfully developing and implementing a high capacity surface continuous cutting (HCSCC) technology for surface coal mine overburden excavation up to 100MPa UCS.



Geotechnical data from a representative subset of Australian coal overburden was compiled using site-specific geophysical data. OEM engagement was a primary focus for the project, to gather productivity and cost inputs towards assessment of the various current and emerging mechanical excavation technologies.

Next-generation technologies were explored via OEM engagement and by physical cutting tests applying the Joy Global Oscillating Disc Cutting (DynaCut) pre-prototype machine against massive sandstone (80MPa UCS).

A principal finding of this investigation was that, of all the current and emerging rock cutting technologies, the ODC-based DynaCut system appears to be the only cutting technology likely to be an economic method for continuous mechanical mining of the med-high strength overburden materials (>50 MPa UCS).

A high level of OEM engagement by Sandvik, Wirtgen and Joy Global was critical to the success of this project. ACARP has supported a subsequent project phase in 2016, aimed at quantifying the performance of DynaCut in a range of overburden materials, and investigating mine design considerations and opportunities for continuous high capacity cutting systems. CRCMining is currently working with industry to secure a host mine site for cutting tests in 2016.

G646 ALTERNATIVE AND SUSTAINABLE EXPLOSIVE FORMULATIONS

Various research has been conducted that focussed on minimising the risk of post-blast nitrogen oxide (NO_x) fumes by better understanding the behaviour of current explosive products. The main outcomes from these studies have been the development and implementation of guidelines or administrative controls to minimise the NO_x fume risk, and reduce potential exposure to this hazard. This research project aims to address the NO_x fume issue by providing a step-change solution that has the potential to completely eliminate the NO_x hazard.

This is an ACARP funded project investigating the development of a novel explosive formulation that substitutes the use of Ammonium Nitrate (AN) with hydrogen peroxide (H₂O₂) as the main oxidising agent. The initial phase of this project (12 months) is now complete, with the next 12-month phase to run from H2 2015 to H1 2016. ACARP is supportive of this next phase, based on the successes achieved during the past year.

The focus in year 1 was on demonstrating the potential of the novel explosive formulation. The influence of different sensitising methods on the velocity of detonation (VOD) of H₂O₂ fuel mixtures was measured in 100 mm diameter charges. Further detonation tests for a range of diameters were also conducted for both Glass Micro Balloons (GMB) and chemical gassing. These tests were complemented with the use of very high speed video analysis (90,000 fps), providing unique data and a broader understanding of the detonation behaviour of H₂O₂ -fuel mixtures.

Upon completion of the characterisation work of H₂O₂ mixtures, product testing focused on confined rock breakage trials in a Limestone quarry in Southeast Queensland. High speed video analysis and triaxial accelerometer data showed comparable breakage performance between the H₂O₂ product mixture and ANFO. Data was also obtained from in-hole detonation pressure sensors, temperature sensors, and near field triaxial accelerometers. A prototype mixing and delivery unit has also been developed, to illustrate the modular and scalable on-site mixing capability for this product.



Elimination of the hazard of post-blast NO_x fumes from blasting will reduce risks to mining personnel and has the potential to substantially reduce the operational costs associated with ensuring appropriate standards of safety around blasting processes. There are also benefits associated with the elimination of potential AN discharge into groundwater systems, and overall community safety associated with manufacturing and transportation processes.

This work is being led by Dr Italo Onederra, Senior Lecturer with the School of Mechanical and Mining Engineering at the University of Queensland, and Mr Miguel Araos PhD Research Scholar at the University of Queensland.

G639 RC DRILLING REEF DETECTION

This project developed proof-of-concept systems for detecting reef intersection while drilling, and a post-drilling deployment system for hole logging and surveying. These technologies would provide enhanced capability for miners of gold reefs to accurately map reef deposits to allow improved placement of development drives, stopes and production holes for emerging “reef boring” mining operations. Two site trials in 2014 at Sunrise Dam Gold Mine in Western Australia confirmed the functionality of a novel borehole crawler device, demonstrating deployment (upwards) into near-vertical boreholes to distances of 150m. The reef intersection detection system was tested successfully at TauTona mine in South Africa in November 2014.

The deployment system was also tested at TauTona mine, in both flat and steeply dipping holes. The system performed as intended; however, significant damage to the holes (delamination and collapse), due to the high-stress mining environment of

these deep South African deposits, prevented deployment to the full 300m target distance. The robot device was otherwise effective, and offers a technology that can be adapted for various applications for deployment of sensors in up-holes where ground conditions are suitable.

G819 MINING DEVELOPMENT AT GREAT DEPTH

Current excavation methodologies and support regimes are not suited to very deep, high stress environments, where risk of rock mass failure is becoming unmanageable. At the present time, very high stress mining conditions have led to the abandonment of operations that have reached significant depths, leading to losses of 100's of millions of dollars. However, over the next two decades or so, when the moderate depth resources are likely to be depleted, those conditions will be faced routinely. New excavation, monitoring and support strategies are required to enable extraction of deep orebodies in high stress environments.

This project aims to investigate a hypothesis of excavation damage (on-set and progression to violent failure) that will substantially change the way development mining is undertaken at great depths and in challenging stress conditions. A three year work plan has been constructed, including investigation of excavation shape, preconditioning effects, monitoring and visualisation techniques, and ground support installation strategies for deep and high-stress environments. Support and funding has been secured from companies including Codelco and MMG.

A collaboration between CRCMining and Curtin University's Western Australian School of Mines (WASM), this project is led by Professor Ernesto Villaescusa and builds on many years of his research in the areas of ground support regime design and testing, and the response of rock masses to mining excavations. This work is becoming increasingly relevant as the mining industry chases deeper orebodies in more challenging and risky mining environments.



G644 UNCRUSHABLES DETECTION SYSTEM

This is a collaborative project, primarily funded by Anglo American. The objective of the technology is to sense unwanted material in mined product during digging/loading, to prevent damage to downstream equipment - in particular primary crusher units.



The first two phases of this project were completed in 2014 and 2015. Phase 1, Development and testing of a concept prototype, demonstrated reliable detection of ferrous metals with a detector fitted inside a 1/10th scale shovel dipper. Phase 2, Development and demonstration of full scale prototype, up-scaled this system to demonstrate basic detection capability in a static configuration in a Front End Loader (FEL) machine.

The third Phase of the project commenced in late 2015, aiming to prepare and demonstrate a full-scale system in a mining environment. This requires further development and testing at CRCMining laboratories, and site testing at a sponsor's mining operation. The site tests are scheduled for H1 2016.



The original concept for this detection system was developed by Professor Paul Lever and Bart Pienaar, and illustrates an innovative approach for adapting and advancing existing technology to solve a common and challenging mining problem. CRCMining is drawing on expertise from the University of Newcastle to develop this technology, with Bart Pienaar working with Dr Terry Summers and his team in Newcastle on the refinement and commissioning of the electronics system for the upcoming site trial.



For more information on projects within the Hard Rock and Surface Mining Program contact CRCMining on 3365 5640 or email Dihon Tadic at d.tadic@crcmining.com.au.

ENERGY AND 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.

- The DC Duty Meter project looks primarily at degradation of the commutation related hardware on the machine.
- The AC Motor Duty Meter is concerned with insulation failure, rotor defects and air gap eccentricity (related to mechanical bearing failure).
- Models developed within the Duty Meter projects may be then used in designing a “perfect digging cycle” for autonomous mining, in which the internal motor stresses are minimised without increasing the digging time.
- 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
- David Gray: Battery projects

AWARDS

During 2014-15 the Energy and Power project team received the following awards:

- IEEE Industry Applications Society, The Renewable and Sustainable Energy Conversion Systems, 2014 Third Prize Paper Award for “Implementing PCC Voltage Estimation Utilising Cascaded PI Controllers in the dq Rotating Reference Frame for Microgrid Inverter Control” as presented at the 2013 Energy Conversion Congress and Exposition, Denver, USA.
- Best Paper Award, 3rd International Conference on Renewable Energy Research and Applications (ICRERA 2014), held in Milwaukee USA, Oct 2014, for the paper titled “Current Sensorless Control of a Cascaded H-bridge Photovoltaic System”.

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 REALIABILITY

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.

This facility was augmented in 2014-15 by the incorporation of a diesel generator with fully electronically programmable AVR and governor such that the generator can match the dynamics of the systems that it is connected to. It was further augmented by the acquisition of an electric vehicle.

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

This project's technical aspects were completed in the second quarter of 2015. The results obtained confirmed results from simulation studies that relatively high penetrations (> 40% of peak load) of solar generation can be integrated into mining precincts with very large dynamic loads, in per-unit terms, without loss of power quality or stability. A report showing the simulation results has been submitted in mid-2015. A final report is still pending.

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.

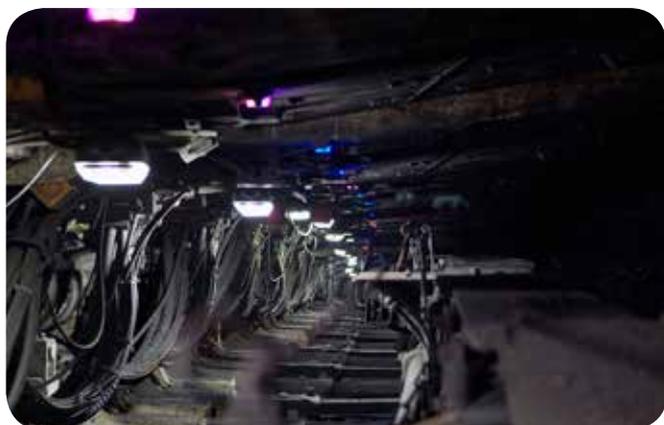
The potential benefits to the mining sector are enormous. Wireless charge technology will require no battery change-out, trailing cables or connector brushes. Machines will be able to operate with all the flexibility of diesel powered machines but without generating carcinogenic particulates, operating 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.

This project was completed in late 2014 with a report submitted to members.

E723 BATTERIES AND UNDERGROUND MINING: THE EVOLUTION OF BATTERY TECHNOLOGY

This project's aim was to provide a detailed study into the evolution of battery technology from the perspective of the underground mining sector; to consider the suitability of different battery chemistries available both today and projected to be available in the near future; to investigate the current status of mining legislation and expected future movements and to provide a detailed assessment of risk relative to battery chemistry and its prospective application/s.

A draft report has been submitted to the funding members Caterpillar and Sandvik. The final report is still pending.



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 Saïed Aminossadati – Distributed Fibre Optic Sensing – Gas Sensing, Conveyor Systems

Enver Bajram – Electronics Systems and Spark Testing

Edward Prochon – Geophysical Sensing, Distributed Fibre Optic Sensing, Electronics Systems

F129 SPARK TEST APPARATUS

The Electronic Spark Tester (EST) project, sponsored by ACARP, is a new concept for assessing 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.

A draft technical specification for the EST concept was presented to the IEC council in late 2014. This technical specification was presented for inclusion in the standard IEC 60079.11. This was well received with an indication the EST could be included into the standard during the next publication.

The second phase of the project was completed in early 2015, with the third phase scheduled for completion in October 2016. The results of this research have led to a better understanding of spark energy and spark physics required to ignite hydrogen and methane mixtures at low voltages. The research has also shown that the energy required to ignite methane at low voltages is significantly higher than was previously understood.

The third phase of the project will further the development of the research prototype EST apparatus to an integrated unit with improved software to a standard operable by testing authorities and 3rd party experts for further demonstrations of the EST concept.

F303 ADVANCED LOGGING SYSTEM

The aim of the Advanced Logging Tool project is to develop geological survey tools for the Underground In-Seam (UIS) drilling industry. Our aim is to also collaborate with other leaders in this field to provide data that can be leveraged for longwall horizon planning and control. With the development of the In Seam Wireless Drill String and the Advanced Logging Tool architecture, CRCMining is positioning itself to be able to deliver tools into a niche market. The industry regards the technologies that we are developing as game changers.

Two pre-commercial contracts were executed under standard commercial conditions for the purpose of evaluating the method. The results of these trials are subject to confidentiality conditions.

To promote and demonstrate the Technology Transfer process, CRCMining collaborated with two local SME's to deliver this work. In Phase 1 this important collaboration has demonstrated that with some minor engineering improvements, the current system is technically operable by local SME's. In Phase 2 the focus will be on demonstrating economic operation.

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 for sending data and control messages between the BHA and drill rig during an Underground In Seam (UIS) drilling operation.

The technology facilitates real-time wireless orientation and geological surveying whilst drilling, which will improve steering of the drill through the coal whilst also mapping the geology of the seam. This will provide an alternate to the existing wired drill pipe technologies and would enable standard drilling rods to be used, which then provides a path for a wider range of enhanced geological surveying technologies to become available, provides the necessary safety that the industry requires, and reduces 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's Tahmoor mine as well as several SME's involved in drilling technology.

Phase 1 of the project was successfully concluded in Q3 2014 with a field trial conducted at Glencore's Tahmoor mine site. The results demonstrated a strong and robust bi-directional communications signal between the drill string and the drill rig. In phase 2 we are designing and manufacturing a fully operable wireless survey tool that will be certified for intrinsic safety. The design is complete and manufacturing is also nearing completion. Certification is currently underway.

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.

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 was deployed at Arrow energy in 2014. This work successfully demonstrated the system on a Coal Seam Gas property, working under the Petroleum and Gas Safety Act for the first time.

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 of Dec 2015, a prototype drilling system has been developed and tested at the CRCMining Waterjet Drilling Laboratory. The drilling tool is slated for deployment in early 2016 to Wambo Underground Coal (Peabody) to assess its capabilities and performance in an underground environment. The purpose built deployment rig will allow drilling of 6-8m long vertical holes into the roof.

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 (400m), survey accuracy and steering control are adequate, and that the borehole quality improvement developed in the TRD project translate to the cross panel application.

As of Dec 2015 the deployment system had been commissioned and is ready for deployment together with the Waterjet Cable Bolt Drilling system to Wambo Underground Mine in early 2016.

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, and an additional director whose appointment will facilitate a strategic relationship or otherwise be beneficial to the interests of the company.

As at 30 June 2015, the Board comprised six non-executive directors (including the Chairman, but with one vacancy) 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 2015.

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

Director	Board of Directors		A&R Committee		Audit Committee	
	HELD	AT-TENDED	HELD	ATTENDED	HELD	ATTENDED
Dr L Hammond	5	5	2	2	2	2
Prof P Lever	5	5				
Pro D Mee	5	5	1	1		
Mr G Ehm	5	4	2	2		
Mr A Hathorn	5	5	2	2		
Ms K McKenzie	5	5			2	3
Mr R Melrose	5	4			2	1
Mr A Ransley	5	4			2	
Mr A Doe	1	1				

The Board met on 29 July 2014, 23 September 2014, 20 November 2014, 3 March 2015 and 1 June 2015.

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 2015, the Committee was chaired by Mr Rowan Melrose (following the resignation of the former Committee Chair, Ms Kellie McKenzie on 1 June 2015), with the other members being Dr Laurie Hammond 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. An assessment of the technical expertise of the Committee's members occurs on an annual basis. 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 2015 the Committee was chaired by Dr Laurie Hammond, with the other members being Mr Graham Ehm, Mr Alex Hathorn and Professor David Mee. All members of the A&R Committee are non-executive directors. The A&R Committee is structured so as to comply with the ASX 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
Andrew Doe	AngloGold Ashanti
Steve Hall	Curtin University
Roger Thompson	Curtin University
Brad Nielson	Joy Global
Thys Greyvensteyn	Anglo American
Donovan Waller	Anglo American
Steve Amor	Anglo American
Pasi Julkunen	Sandvik
David Mee	University of Queensland
Mike Onsager	Caterpillar

As at 30 June 2015, 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 and the Member portal.

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.

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.



Above: CRCMining Board 2014-15 (L to R) Kelly McKenzie, Professor Paul Lever, Laurie Hammond, Rowan Melrose, Jane Seawright, Alex Hathorn (absent Graham Ehm, Andrew Ransley, and David Mee).

INTELLECTUAL PROPERTY MANAGEMENT

CRCMining maintains an IP Register. Key pieces of IP currently held by the CRCMining are detailed in the schedule of patent families below:

PATENT FAMILY NAME	NO OF COUNTRIES		OTHER*
	ISSUED	PENDING	
UNIVERSAL DIG AND DUMP TECHNOLOGY			
Dragline bucket rigging and control apparatus	9	1	PCT
Dragline dump position control	9		PCT
Dragline bucket	4		PCT
TIGHT RADIUS DRILLING			
Fluid drilling system	10		PCT
Erectable arm assembly	9		PCT
Fluid drilling head	9		PCT
Drill-head steering	9		PCT
Fluid drilling head with sliding gauging ring		9	PCT
Fluid drilling head nozzle design		9	PCT
SHOVEL AUTOMATION			
Payload estimation system and method	4	2	PCT
Collision avoidance for electric mining shovels	5	1	PCT
A real time method for determining the spatial pose of electric mining shovels	5	2	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	3	3	PCT
OSCILLATING DISC CUTTER			
Rock Boring device	6	1	PCT
Rock cutting machine	12		PCT
Controlling bearings	14		PCT
Rock sampling apparatus	5		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	8	1	PCT
Measuring scalp potential	0	3	PCT
Measurement of bulk density of the payload in a dragline bucket	7	5	Prov.
Spark testing apparatus	2	1	PCT
TOTAL	141	53	

*PCT - Patent filed under Patent Cooperation Treaty
Prov - Provisional application made in Australia

SPIN OFF COMPANIES

Mineware Pty Ltd markets sophisticated electrical and software monitoring equipment (Pegasys for draglines, Argus for rope shovels and hydraulic shovels/excavators) for large mining equipment that provide information in real-time to optimise 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 / Excavator Monitor is an advanced monitoring system that addresses key issues of managing truck payloads, excavating in compliance with mine plans, operator performance, and machine positioning.

SmartCap Technologies Pty Ltd (formerly EdanSafe Pty Ltd) was 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.

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.

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

Acumine Pty Ltd was established to develop and market a world-leading system for avoiding collisions between vehicles on mine sites.

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

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.

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.

EDUCATION AND TRAINING

CRCMining trains highly skilled experts to drive the adoption of new technologies in the global mining industry. Supervised by Professor Paul Lever, 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 needed to successfully maintain automation technologies.

STUDENT	DEGREE	TOPIC	INSTITUTION	SUPERVISOR(S)
Mohammad Amanzadeh	MPhil	Optical Fibre for methane detection	UQ	Saiied Aminossadati Paul Lever
Ali Soofastaei	PhD	Australian Mining Industry Energy Consumption and Savings	UQ	Saiied Aminossadati
Virginia Bailey				

CRCMining actively contributes to undergraduate teaching programs at its partner universities. During the 2014-15 financial year, the following CRCMining staff had teaching responsibilities at their respective institutes:

University of Queensland

- Paul Lever, Ross McAree, Peter Knights, Kevin Austin, Italo Onederra and Saiied Aminossadati.

University of Newcastle

- Bob Betz, Terry Summers, Galina Mirzaeva/Curtin University of Technology (Western Australian School of Mines)
- Ernesto Villaescusa and Steve Hall

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 THE CRCMINING 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 the CRCMining Annual Conference, as well as postgraduate seminars conducted through University members.



FINANCIAL REPORT

The 2014-2015 financial year is CRCMining's first year as an industry-only funded research centre and a landmark year in the Centre's history. This, the first year of its transition has also coincided with a significant deterioration in the fortunes of the mining industry which saw a number of members deciding not to continue their membership. Despite losing \$2.4m in government funding and a reduction of \$1.1m in member's fees and an overall 30% decrease in operating income the Centre managed to limit its loss for the year to only \$175,000. This was achieved by reducing overheads and administration as well as some research staff. Despite the latter, the reduction in the direct research spend was limited to only \$391,000 or 6.7%.

Even though the downturn in commodity prices continues the Centre is still attracting new work and is seeing an increase in the number of proposals being requested as mining companies reach the point where further cost cutting options in on-going operations are limited leaving efficiency gains as the only other alternative which requires new technologies or better use of existing ones and which the Centre is ideally placed to provide.

We are also currently talking to a number of potential new mining members which would see an increase in research activity.

Whilst the coming year will be a difficult one we are satisfied that the current work load coupled with a strong balance sheet will sustain the Centre financially.

Participants' contributions represent the membership fees payable by both university and industry partners and are not tied to specific research projects but used firstly to run the Centre and secondly are applied to the research programs as directed by the Centre.

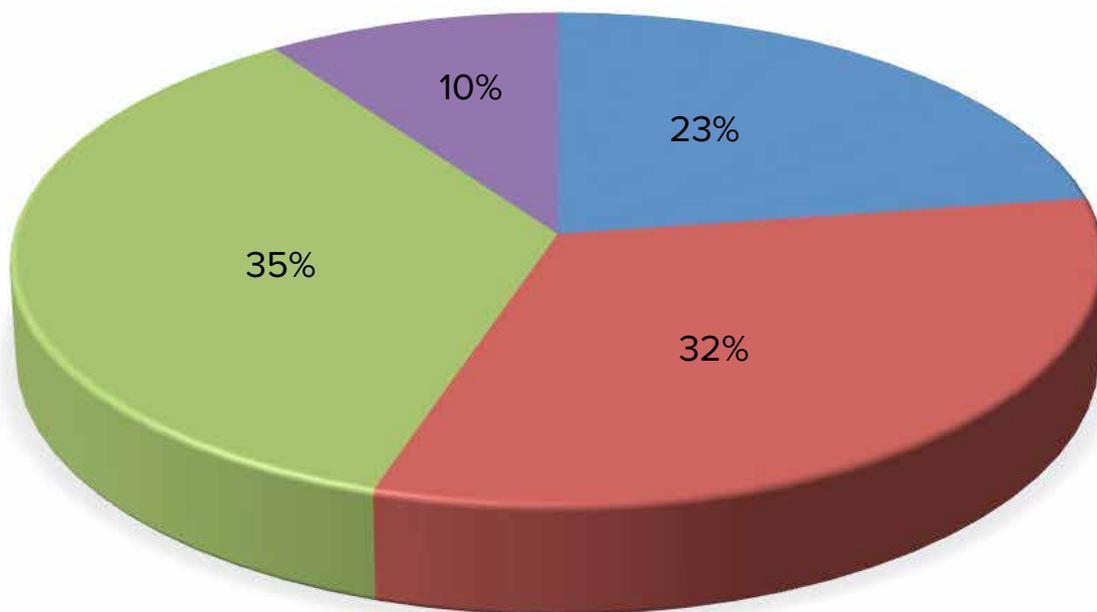
Other grants comprise funding received from state governments and industry groups directed to specific projects. Industry funded research revenue is money received from mining companies and OEMs which is also directed to specified projects.

Expenditure on research programs comprises 76% of all expenditure and represents both the direct and indirect (overhead) costs of conducting the Centre's research.

Technology transfer expenses include intellectual property protection.

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

A copy of the audited Annual Financial Statements of CMTE Development Limited, trading as CRCMining is available to Directors, staff and participants on the CRCMining website.



Industry funded

Other grants

Participants' contributions

Other revenue

APPENDIX A - PUBLICATIONS

JOURNAL ARTICLES

Aminossadati, S.M., Kargar, A., Ghasemi, B. (2014) Computational analysis of magnetohydrodynamic natural convection in a square cavity with a thin fin, *European Journal of Mechanics B-Fluids*, 46:154-163.

Araos, M and Onederra, I (2015) Development of a novel mining explosive formulation to eliminate nitrogen oxide fumes. *Mining Technology*, 1-8.

Bai, T.L, Chen, Z., Aminossadati, S.M., Pan, Z., Liu J. and Li, L. (2015) Characterization of coal fines generation: A micro-scale investigation, *Journal of Natural Gas Science and Engineering*, 27(2) 862-875.

Catalan, A and Onederra, I, 2015. Implementation of leading practice in geotechnical and blasting performance evaluations and the Centinela Sulphide Mine. *Mining Technology*, Accepted July 22nd 2015.

De Francia, M., Soofastaei, A., Aminossadati, S.M., Kizil, M.S. and Knights, P. (2015) Filling up the tank, *Australasian Mining Review*, 2(12), 56-57.

Farsani, R.Y., Ghasemi, B., Aminossadati, S.M. (2014) Magnetohydrodynamic mixed convection effects on the removal process of fluid particles from an open cavity in a horizontal channel, *Journal of Heat and Mass Transfer Research*, 67-74.

Kasaiepoor, A., Ghasemi, B., Aminossadati, S.M. (2015) Convection of Cu-water Nanofluid in a Vented T-shaped Cavity in the Presence of Magnetic Field, *International Journal of Thermal Sciences*, 94, 50-60.

Marks, N.D.; Summers, T.J.; Betz, R.E., "Reactive power requirements for cascaded H-Bridge photovoltaic systems," in *Industrial Electronics Society, IECON 2014 - 40th Annual Conference of the IEEE*, vol., no., pp.2219-2225, Oct. 29 2014-Nov. 1 2014.

Marks, N.D.; Summers, T.J.; Betz, R.E., "Control of a 19 level cascaded H-bridge multilevel converter photovoltaic system," in *Energy Conversion Congress and Exposition (ECCE), 2014 IEEE*, vol., no., pp.2265-2272, 14-18 Sept. 2014.

Marks, N.D.; Summers, T.J.; Betz, R.E., "Current sensor-less control of a Cascaded H-Bridge photovoltaic system," in *Renewable Energy Research and Application (ICRERA), 2014 International Conference on*, vol., no., pp.212-217, 19-22 Oct. 2014.

Onederra, I., Thurley, M. J. and Catalan, A. (2014) Measuring blast fragmentation at Esperanza mine using high-resolution 3D laser scanning. *Mining Technology*, 124 1: 34-46.

Onederra I, Catalan, A and Quidim J. 2015. Evaluating pre-split performance through direct measurements of near field acceleration, particle velocity and gas pressure. *Mining Technology*, Accepted 8th July 2015.

Parra, H, Onederra, I, Michaux, S, Kuhar, L, McFarlane, A and Chapman, (2015) A study of the impact of blast induced conditioning on leaching performance. *Minerals Engineering*, 74 1-12.

Soofastaei, A., Aminossadati, S.M., Kizil, M.S. and Knights, P. (2014) Payload variance plays a critical role in the fuel consumption of mining haul trucks, *Australian Resources and Investment*, 8(4): 64.

Townsend, C.D., Summers, T.J., Betz R.E. (2015), "Phase-Shifted Carrier Modulation Techniques for Cascaded H-Bridge Multilevel Converters", *IEEE Transactions on Industrial Electronics*, 62(11), pp 6684-6696.

Marks N.D., Summers T.J., Betz R.E., "Phase Shifted Maximum Power Point Tracking in a Cascaded H-Bridge Photovoltaic Power System", 17th European Conference on Power Electronics and Applications, EPE'15, ECCE-Europe, 2015.

Townsend, C.D.; Summers, T.J.; Betz, R.E., "Impact of Practical Issues on the Harmonic Performance of Phase-Shifted Modulation Strategies for a Cascaded H-Bridge StatCom," in *Industrial Electronics, IEEE Transactions on*, vol.61, no.6, pp.2655-2664, June 2014.

Yuan, X.N., Aminossadati, S.M., Schaffer, G.B., Qian, M. (2014) CFD modelling of the nitrogen gas flow pattern during sintering of an Al-7Zn-2.5Mg-1Cu alloy and its effect on distortion, *Powder Metallurgy*.

CONFERENCE PAPERS

Altamirano, Castro and Onederra (2014). Engineering approach for the design and analysis of drawbell blasting in block and panel caving. the 3rd International Symposium on Block and Panel caving, held in Chile, June 2014. Edited by The University of Chile.

Aminossadati, S.M., Amanzadeh, M., Kizil, M.S. and Liu, T. (2014) Development and Utilisation of Fibre Optic-Based Monitoring Systems for Underground Coal Mines, in *Proceedings of the 14th Coal Operators' Conference*, 369-380.

Aminossadati, S.M., Nehring, M., Hay, E., Seib, W., Kavanagh, L. and Kizil, M.S. (2015) First-Year Student Engineers Experience Authentic Practice with Industry Engagement, In: *Australasian Association for Engineering Education Conference 2015*, Geelong, 7-9 December 2015.

Aminossadati, S.M., Yang, B. and Kizil, M.S. (2015). A Real-time Conveyor Monitoring System. In: *Fiber-Optic and Photonic Sensors for Industrial and Safety Applications*. International Conference on Fiber-Optic and Photonic Sensors for Industrial and Safety Applications, Jinan, Shandong, China, (13-24), 20-23 January 2015.

Bai, T., Chen, Z, Aminossadati, S.M., Pan, Z and Liu, L. (2015) Prediction of Mobility and Settlement Position of Coal Fines During Dewatering. In: *China Shale Gas 2015: Program and guide*. China Shale Gas 2015, Wuhan, China, 6-8 September 2015.

Bai, T., Chen, Z., Aminossadati, S.M., Li, L. (2015) Characterization of Coal Fines Generation: Importance of Flow Condition, In: *7th International Conference on Mining Science and Technology (ICMST 2015)*, Xuzhou, China, April 26-29, 2015.

Cavanough G, Torrance A, Onederra I, Nipperess M and Olson A. (2015) Quality Control of Bulk Explosive Products to Minimize the Risk of Fumes. 41st Annual Conference on Explosives and Blasting Technique, Feb. 1 — 4, 2015. Sheraton New Orleans Hotel, New Orleans, Edited by the International Society of Explosives Engineers (ISEE). Pages, 2-11.

Danesh, N.N., Chen, Z., Aminossadati, S.M., Kizil, M.S., Pan, Z. and Connell, L.D. (2015) Creep: A Neglected Phenomenon in Coal Permeability Evolution and Coalbed Methane Production, In: *The SPE Asia Pacific Unconventional Resources Conference and Exhibition*, 9-11 November 2015.

Hay, H. and Aminossadati, S.M. (2015) Monetary Savings Opportunities of Electronic Blast Initiation Systems, In *Proceedings of the 15th Coal Operators' Conference*, University of Wollongong, Australia (321-329), 11-13 February 2015.

Kamyar, S.M. Aminossadati, C. Leonardi (2015) Thermal and Hydraulic Performance of a Heat Exchanger Operated with Ice Slurry as Refrigerant. In: *17th IAHR International Conference on Cooling Tower and Heat Exchanger*, Gold Coast, QLD Australia, 7-11 September 2015, 273-283.

- Liang, X; Knights, P; Jessett, A (2015). "Optimisation of Dragline Digging Sequences Using Genetic Algorithm". In Bandopadhyay (Ed). Proc 37th International Symposium on the Application of Computers and Operation Research in the Mineral Industry (APCOM 2015) Fairbanks, Alaska, Society for Mining, Metallurgy and Exploration,(SME), Englewood, Colorado, pp.995-1008, 2015.
- Marks N.D., Summers T.J., Betz R.E., "Current Sensorless Maximum Power Point Tracking in a Cascaded H-bridge Photovoltaic Power System", Energy Conversion Congress and Exposition (ECCE), 2015.
- Onederra, I and Araos, M, 2015. Detonation and Breakage Performance of a Hydrogen Peroxide-based Explosive Formulation. In Proceedings of 11th International Symposium on Rock Fragmentation by Blasting, pp565-574, 24-26 of August, Sydney Australia (The Australasian Institute of Mining and Metallurgy, Melbourne).
- Scott, A and Onederra, I, 2015. Characterising the blasting properties of iron ore, in Proceedings Iron Ore 2015, pp481-490, 13-15 July, Perth, Australia (The Australasian Institute of Mining and Metallurgy, Melbourne).
- Scott, A and Onederra, I, 2015. Characterising rock mass properties for fragmentation modelling. In Proceedings of 11th International Symposium on Rock Fragmentation by Blasting, pp149-160, 24-26 of August, Sydney Australia (The Australasian Institute of Mining and Metallurgy, Melbourne).
- Soofastaei, A, Aminossadati, S.M., Kizil, M.S. and Knights, P. (2015) Simulation of payload variance effects on truck bunching to minimise energy consumption and greenhouse gas emissions, In Proceedings of the 15th Coal Operators' Conference, University of Wollongong, Australia (338-347), 11-13 February 2015.
- Soofastaei, A., Aminossadati, S.M., Kizil, M.S. & Knights, P. "Payload variance plays a critical role in the fuel consumption of mining haul trucks", Australian Resources and Investment, Vol.8, No.4. p.64, 2014.
- Soofastaei, A., Aminossadati, S.M. and Kizil, M.S. (2014) Development of an artificial intelligence model to determine mining trucks energy consumption, Poster Presentation, Energy Future Conference, Sydney, Australia, Book of Abstracts, 178-179.
- Soofastaei, A, Aminossadati, S.M. and Knights, P. (2014) Truck Bunching In Deep Pit Mining Operations, Fleet and Haulage Optimisation in Mining, Brisbane, Australia, Oral Presentation.
- Stewart, C.M., Aminossadati, S.M. and Kizil, M.S. (2015) Underground fire rollback simulation in large scale ventilation models. In: The 15th North American Mine Ventilation Symposium 2015. The 15th North American Mine Ventilation Symposium 2015, Blacksburg, Virginia, USA, 20-25 June 2015.
- Stewart, C.M., Aminossadati, S.M. and Kizil, M.S. (2015). Use of Live Sensor Data in Transient Simulations of Mine Ventilation Models. In: Fiber-Optic and Photonic Sensors for Industrial and Safety Applications. International Conference on Fiber-Optic and Photonic Sensors for Industrial and Safety Applications, Jinan, Shandong, China, (3-12), 20-23 January 2015.
- Yang, B., Liddell, K., Aminossadati, S.M. and Kizil, M.S. (2015). Fibre Optic Based Distributed Temperature Sensing System Monitoring of Underground Coal Mine Inertisation in Australia. In: Fiber-Optic and Photonic Sensors for Industrial and Safety Applications. International Conference on Fiber-Optic and Photonic Sensors for Industrial and Safety Applications, Jinan, Shandong, China, (25-36), 20-23 January 2015.

Contact Us

CRCMining Head Office

Building 101
2436 Moggill Rd
Pinjarra Hills Qld 4069 Australia

PO Box 5234
Kenmore East Qld 4069 Australia

T: +61 7 3365 5640

F: +61 7 3365 5636

E: info@crcmining.com.au

CRCMINING.COM.AU