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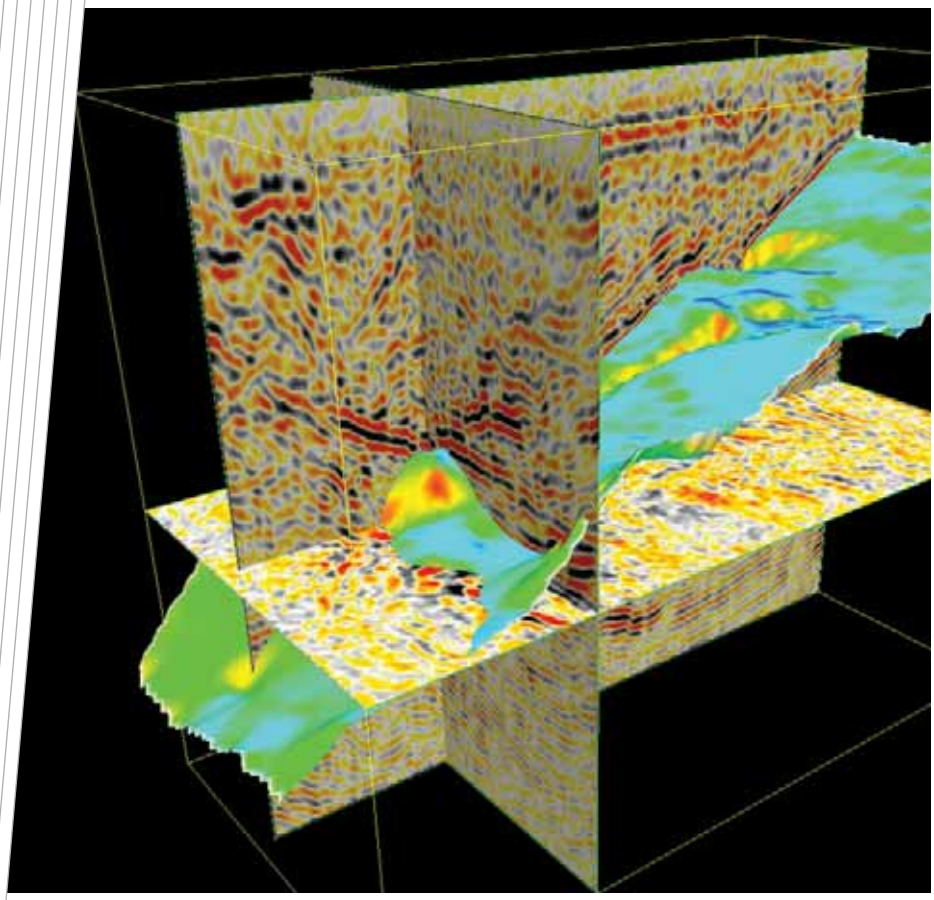

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Annual Report 2006-07

Queensland Centre for Advanced Technologies

Government occupants

CSIRO

- Energy Technology
- Exploration & Mining
- ICT Centre
- Materials Science and Engineering
- Minerals
- Minerals Down Under National Research Flagship
- Energy Transformed National Research Flagship

Defence Science Technology Organisation

Centre for Low Emission Technology

Cooperative Research Centre for Coal in Sustainable Development

Commercial occupants

Alcan Queensland Research and Development Centre

Applied Mining Technologies Pty Ltd

Carbon Energy Pty Ltd

ComEnergy Pty Ltd

CET Group

GeoTek Solutions

Instinct Television

LAADtech

Mission

The Queensland Centre for Advanced Technologies is a world class research and development precinct recognised for the excellence of its contribution to the mining, energy and manufacturing industries. Our mission is to generate products and processes of high value to Australia's mineral, energy resources, and manufacturing industries with particular focus on those resources and industries located in Queensland.

Goal

Our goal is to increase the international competitiveness and efficiency of Queensland's and Australia's resource based and related industries.

History

The Queensland Centre for Advanced Technologies is a collaboration between the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the State Government of Queensland. The establishment of the Centre flows from an agreement between the Australian and Queensland Governments in 1990 to expand and diversify the research and development activities undertaken by CSIRO in Queensland. The Centre commenced operation in 1992 and was officially opened in 1993. Following the construction of new facilities, Stage Two was opened in 2000. The precinct continues to grow and planning for Stage Three expansion is already under way.

QCAT Annual Report 2006–07

Foreword

A strong and vibrant national innovation system is critical for Australia's long-term social and economic prosperity. The Australian Government is committed to building our research strengths and addressing areas of opportunity or need. To this end the Commonwealth has established a series of broad based, multidisciplinary National Research Priorities: An Environmentally Sustainable Australia; Promoting and Maintaining Good Health; Frontier Technologies for Building and Transforming Australian Industries; and Safeguarding Australia.

The Queensland Centre for Advanced Technologies (QCAT) is a collaboration between the Federal Government, through the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and the Queensland State Government. The QCAT precinct is an excellent example of an environment that allows multidisciplinary research organisations and industry to work collaboratively in addressing Australian research priorities.

In 2006-07 the minerals sector contributed $91.3 billion in export earnings and made up eight percent of the Australian GDP. In achieving these results, we face competition from other countries and must continue to maintain and strengthen our competitive advantage internationally. Research and development across the QCAT precinct is transforming the resources industry and addressing the national priority to create a sustainable environment. Clean coal technologies that reduce greenhouse gas emissions associated with mining, processing and utilising coal are being developed, along with systems that improve mining safety and productivity, ensuring continued export success and earnings for the nation over the coming decades.

Researchers across the QCAT precinct have embraced emerging technologies in the areas of Information Communication Technology (ICT), sensors, and new materials. The official opening of the Defence Science and Technology Organisation Brisbane at QCAT is evidence of the expertise drawn to the precinct by the opportunities presented for collaborative research in these areas.

Importantly, the QCAT precinct has a strong record of achievement in technology transfer; delivering innovative technology and new systems that are providing economic, social and environmental benefits to Australians.

I congratulate all of the research groups across the QCAT precinct for their hard work and wish them success in their future endeavours.

The Hon Julie Bishop MP

Minister for Education, Science and Training

Executive Manager's Report

This is my first report as Executive Manager of the Queensland Centre for Advanced Technologies (QCAT) and it is my pleasure to present the 2006-07 QCAT Annual Report as a record of the achievements made across the QCAT precinct this year.

The 2006-07 year has seen recognition of the increasingly urgent need to lower greenhouse gas emissions on a global scale. Clean coal technology is a key strategic approach to meeting those emissions targets. QCAT is CSIRO's major centre for clean coal technology R&D and is also home to the Centre for Low Emission Technology and the Cooperative Research Centre for Coal in Sustainable Development. QCAT-based collaborative research into clean coal technologies has been supported by the State and Federal Governments, the coal industry and international research partners.

This support has seen the establishment of a number of new programs through the Australian Greenhouse Office that look at methods for mitigation and utilisation of methane released in coal mining. These projects are being run in partnership with major Chinese coal mining companies under the Bilateral Climate Change Partnerships Programme, which aims to help partner countries implement practical solutions to reducing greenhouse gas emissions.

At the commercial level I am pleased to advise of the spin-off of Carbon Energy Pty Ltd (CEPL), based at QCAT's Technology Transfer Centre. CEPL is a joint venture between CSIRO and Metex Resources Ltd to commercialise CSIRO's know-how in underground coal gasification (UCG). The UCG process transfers the energy in coal to syngas which can be used directly as a low emissions power source.

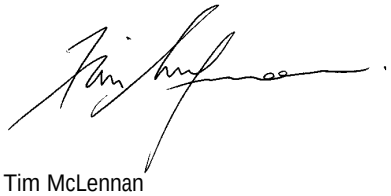
The 2006-07 year has also seen the emergence of an advanced aeronautical engineering R&D cluster at the QCAT precinct. In April 2006 the QCAT community officially welcomed the Defence Science and Technology Organisation (DSTO) Brisbane to the QCAT Technology Transfer Centre. The evolution of this cluster, comprising DSTO Brisbane's Applied Hypersonics Branch and CSIRO Autonomous Systems Laboratory's Unmanned Aerial Vehicles group, recognises Queensland's growth as an Asia Pacific hub for the aviation and aerospace industries.

The QCAT precinct received international recognition this year when we collaborated with the Queensland Government Department of the Premier to host a site visit by the Vice Premier of China, Mr Zeng Peiyan. The Vice Premier and his delegation toured QCAT's mining, robotics and clean coal technology research areas. The Vice Premier later stated through an interpreter, "I am very impressed with the level of technologies demonstrated. They are certainly relevant to China and I feel there is a lot of opportunity for us to work together in the future."

Innovation and Excellence: the QCAT research report 2006 was well received. The industry day has now become an annual event that continues to provide broad networking opportunities for government and industry.

The QCAT precinct trades in innovation and partnership and I wish to acknowledge the important role the small to medium enterprises based at the QCAT precinct and our industry partners play in taking our technology innovations out into the broader industry. Throughout the year CSIRO and our commercial tenants at QCAT have partnered with National Research Flagships, cooperative research centres, universities and industry including: the Minerals Down Under Flagship, the Energy Transformed Flagship, the Light Metals Flagship, the Cooperative Research Centre for Cast Metals Manufacturing, CRC Mining, the Parker CRC for Integrated Hydrometallurgy Solutions, The University of Queensland and the Queensland University of Technology, Boeing Australia, AMIRA and the Australian Coal Association Research Program (ACARP).

In 2007-08 year I look forward to seeing even greater recognition of our innovative science as it makes a real difference to our industry and community.



Tim McLennan

Executive Manager, QCAT

Mining

Australia's minerals export industry was worth $91.3 billion in the 2006-07 financial year, making up over two thirds of Australia's total commodity trade. Australia is the world's largest exporter of black coal, alumina, iron ore, lead and zinc and also supports a mining technology services industry of more than $2 billion. Maintaining this edge is vital in the increasingly competitive global minerals market.

Mining has evolved into an extremely sophisticated, 21st century industry and Australia is a global leader in developing new technologies. The smart mining cluster at the QCAT precinct incorporates CSIRO and a number of small to medium enterprises supporting the mining services sector. Collaborative R&D at the precinct covers a broad range of mining activities from coal to hard rock and sand, underground and open cut systems. Research aims to improve safety, increase productivity and reduce environmental impact by providing applied technology solutions to major issues confronting Australia's mining industry.

Mining geoscience

Borehole logging

CSIRO's QCAT-based research on borehole and offline logging technologies has applications in all commodity areas – coal, iron, copper and other base metals. Demand is growing for improved nuclear techniques in areas directly related to exploration and mining as well as areas with an environmental focus. The nuclear group is expanding its client base and the number of collaborating organisations to meet industry demand.

There is considerable interest in the application of Prompt Gamma and Delayed Gamma techniques in the coal and base metal industries for the measurement of trace elements in a borehole. CSIRO's long-term goal is to develop higher resolution detectors that use non-isotopic sources for the measurement of trace elements such as phosphorous, potassium, and arsenic. The first phase of these projects, a feasibility and industry needs analysis, was funded by the Minerals Down Under National Research Flagship for the metals applications and by the Australian Coal Association Research Program (ACARP) for the coal application.

Coal density plays an important role in projecting and reconciling coal tonnage and quality variation. The best estimation of coal density is from the direct measurement of core, but cored holes are relatively sparse in comparison to chip holes due to cost of drilling and subsequent laboratory analysis. All holes are geophysically logged, and if the geophysical data are accurately calibrated against core then they can be used to improve the sampling of spatial variability across a deposit. An ACARP project on improving density and grade estimation from borehole geophysical logs was completed this year.

A very successful collaboration with the Australian Nuclear Science and Technology Organisation (ANSTO) is well under way. The first joint project is progressing well in assessing the use of the Prompt Gamma Neutron Activation Analysis (PGNAA) technique for the measurement of hydrological parameters in a borehole.

The group is also collaborating with colleagues in South Africa on Uranium grade determination as well as the application of the PGNAA technique for a new and novel out of borehole application.

Coal Characterisation

CSIRO researchers from Exploration and Mining and Energy Technology are working with the coal industry to improve the efficiency of fine coal recovery and the performance of coal during coke making.

Supported by ACARP and the coal producers themselves the group is using advanced optical microscopy imaging to obtain quantitative information on the organic constituents in individual coal particles. This information is being used to select flotation reagents that either enhance or suppress the floatability of specific grain types and hence improve product recovery or reduce product ash.

Optical microscopy characterisation is being used to develop milling strategies that optimise the quality of coke made from different coals. This project is being done in collaboration with BHP Innovation in Newcastle. As well as having industry support via ACARP, this work area has significant direct support from BHP Billiton, Anglo Coal and BMA.

3D imaging and data analysis

The development of CSIRO Exploration and Mining's three dimensional (3D) imaging capability is supported by extensive work on the modelling and analysis of 3D structure of a rock mass that is now being used in the Large Open Pit project. In addition the 3D imaging technology is now being applied to automation projects

CSIRO's 3D imaging and data analysis team has implemented a technique to network individual 3D images from the Sirovision® system into one composite 3D image. Sirovision® is a high precision 3D imaging technology that supports fast, accurate geotechnical and geological mapping of rock and terrain surfaces in 3D. It has significant implications for mine safety, as detailed spatial and orientation information can be collected without staff positioning themselves in high-risk situations. Networking Sirovision's 3D Images has four major benefits:

- it improves efficiency for field work by substantially reducing the number of surveyed ground control points;
- speeds up image processing;
- allows seamless mapping across a composite 3D image; and
- enhances visualisation and interpretation of the mine area.

The 3D imaging group is building a new capability for improved mapping efficiency. The mosaic achieved an accuracy of the order of 2 to 3 centimetres from a flying height of 1.5 kilometres. This accuracy was checked against a set of supplied ground control points. The 3D images that were built had a ground resolution per pixel of less than 20 centimetres and the spacing of the spatial data points on the ground was approximately one

metre. The alignment and positioning of these complex networks of overlapping images has been tested using a set of 56 aerial images. Each image was 80 mega pixels. The composite 3D image that was created covered approximately 6 square kilometres, had approximately 5 million spatial data points and 50 million visual pixels.

The routines were tested using an aerial photography application and will be adapted and implemented in the current Sirovision Open Pit and Underground applications. On the commercialisation front, Gemcom Software International Inc and Datamine Software Limited continue as non-exclusive resellers of the Sirovision® system. To date over 120 commercial licences and over 20 educational licenses have been sold globally.

Microseismics

A real-time microseismic system is currently being developed for underground coal mines. It will allow the location of rock fractures and predict impending hazards such as roof falls and rock bursts. The acquisition hardware is low in power consumption, allowing it to be powered by solar cells. Cables – which are time-consuming to lay, and prone to damage – have been replaced by wireless links and new algorithms allow seismic events to be processed and located automatically, to be displayed in real-time in the mine office.

CSIRO researchers have completed a project examining the possibility of using a coal longwall shearer as an energy source for imaging the rock mass ahead of mining. Geophones deployed in a gate road detected vibrations created by the shearer, and cross-correlation techniques were then used to determine relative travel times. This gave an image of the rock velocity, which can be related to stress conditions and other potential mining hazards ahead of the face.

Accurate drill-bit location with respect to the coal seam is especially useful for coal-bed methane applications. CSIRO's researchers have begun a new project using seismic instruments to locate the position of a drill bit, by analysing the vibrations caused by the drilling.

Research is also being done in passive seismics: the use of noise for imaging the earth. Sources of energy include man-made sources such as mining machinery or road traffic, as well as mining-induced microseismic fractures, or earthquakes. Researchers are looking at using passive seismics to image geological structure, as well as geotechnical properties like stress and fracture state.

Coal mining

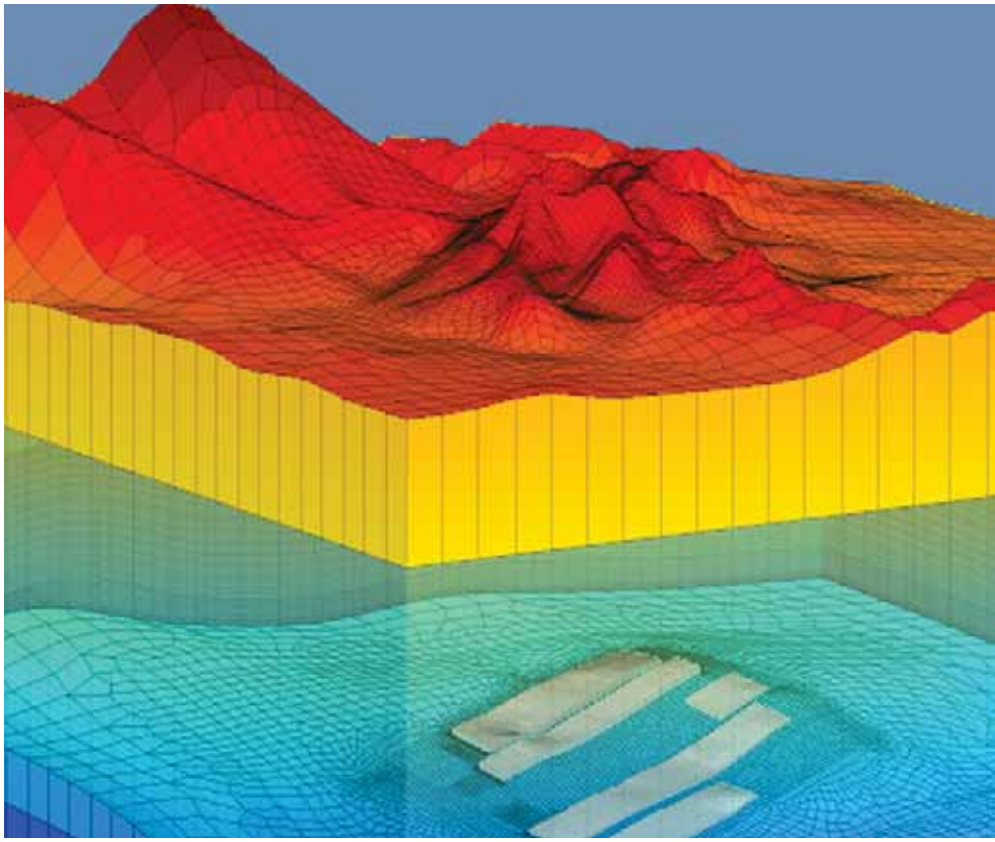
Longwall Top Coal Caving

Longwall Top Coal Caving (LTCC) was successfully developed by the Chinese coal industry to mine coal seams 4.5 –12 m thick. With support from the Australian Coal Association Research Program (ACARP) CSIRO recently completed a research project into the key elements for the implementation of LTCC in Australia. Longwall extraction heights in Australia are currently limited to 4.8 meters. By using LTCC miners are capable of recovering more than 80 per cent of a thick seam. Adapting LTCC to Australian conditions has opened the way for the responsible exploitation of Australia's thick coal seam reserves, potentially doubling the recoverable amount of coal. LTCC also offers safety benefits through lower cutting heights and a reduced risk of spontaneous combustion by reducing the amount of coal left in waste areas (goaves).

CSIRO is now working with several major mining companies to assess the potential of LTCC implementation at three mine sites in Australia. These assessments use the engineering and modelling tools developed in the ACARP project to enable the accurate characterisation and assessment of caving conditions in conjunction with the impacts of ventilation, gas, dust and spontaneous combustion on LTCC operations.

Inertisation

The frequency of fire incidents in longwall panels has increased significantly in recent years, leading to production losses and safety risks for a number of coal mines in Australia and around the world. To address this major industry issue CSIRO, in conjunction with ACARP and the Australian coal industry, has developed optimum proactive inertisation strategies to reduce the risk of heatings/fires in underground longwall mines.



An ACARP-funded study is now investigating new inertisation techniques that can be applied cost effectively to avoid spontaneous combustion during active mining. The new techniques can also be used in conjunction with existing inertisation methods, increasing their effectiveness during routine longwall mining and in the instance of a prolonged mining stoppage.

COSFLOW

Reliable prediction and management of mining-induced water inflows and aquifer interference is a major emerging challenge confronting the Australian coal mining industry. The absence of robust and reliable analysis tools may significantly affect the industry's ability to gain mining approval and licenses, where significant aquifers, surface water or flooded workings are involved.

CSIRO recently completed an ACARP-funded research project aimed at advancing the understanding of fundamental mechanics of strata and groundwater interaction processes, to facilitate prediction of water inflows into

longwalls and mining-induced aquifers interference.

Comprehensive field work was undertaken at Springvale colliery to understand the in situ hydrogeological environment and determine the extent and magnitude of induced hydrogeological changes in the surrounding strata during longwall mining. COSFLOW simulations were then used for the back analyses of the field monitoring data, development of a hydrogeological response model, and assessment of the effect of longwall panel geometry on aquifer interference and mine water inflow. COSFLOW is an integrated simulation software package developed by CSIRO, in conjunction with JCOAL and NEDO in Japan, that couples fluid (gas and water) flow through a porous medium with rock deformation and stress. It is the only product of its kind in the world to simulate ground deformation and water/gas flow.

Transparent flameproof enclosure cover

In underground coal mines opaque flame proof covers are used on all electrical equipment with the potential to spark and cause explosions in the gassy mine environment. Because of the 'see through' function of a transparent flameproof cover, there is the potential to provide improved equipment diagnosis and preventative maintenance capabilities that will ultimately lead to improved mining machine availability.

Prototype flameproof covers with the dimensions 860 mm x 690 mm were manufactured in the 2005-06 year. They have since been pressure tested and a finite element analysis of the steel frame led to the development of an improved design for this section of the cover. CSIRO has applied for Australian patent protection for the new technology.

Practical design guidelines for the manufacture of a large transparent flameproof cover have been documented. These guidelines will prove an invaluable tool for Australian flameproof manufacturers who wish to adopt this new technology.

COLLABORATION

Asia-Pacific Partnership on Clean Development and Climate

The Asia-Pacific Partnership on Clean Development and Climate was established in January 2006. The founding partners Australia, China, India, Japan, Republic of Korea, and the United States have agreed to work together and with private sector partners to meet goals for energy security, national air pollution reduction, and climate change in ways that promote sustainable economic growth and poverty reduction through practical, pro-growth, technology-driven efforts.

Researchers from QCAT are involved in two projects funded through the Partnership.

Integrated coal and methane extraction

Coal mining and methane drainage for mining safety involve two processes. To increase coal production, improve coal mining safety, and reduce fugitive mine methane emissions, it is strategically important to integrate the two processes. This project seeks to improve mine safety and increase coal mine methane and coal bed methane production and utilisation in partner countries, primarily in Australia and China, by demonstrating and promoting the use of an integrated coal production and methane extraction approach, reliable planning and optimisation of the joint production processes, and effective operational control and risk management technologies. The project will apply and demonstrate an advanced approach and technologies to support and promote integrated coal production and methane extraction in partner countries. Australia, China, and the United States are the participating partners in this project.

Thick coal seam extraction

The major outcome of this project is optimisation of extraction methods and/or designs to substantially improve recovery rates and safety of mining operations in Indian thick seam environments. It will focus on thick seam environments in India and Australia. There is an urgent need for comprehensive investigation of various options for thick seam mining and development of optimum extraction technologies and designs for improving coal recovery in thick seam environments in these two partner countries. Australia and India are the participating partners in this project.

Metalliferous mining

SMART*CUT – cutting tools for hard rock

SMART*CUT technology provides effective cutting tools for mining and civil industries and helps to improve productivity and reduce operating costs. SMART*CUT uses a CSIRO worldwide patented bonding technology to join thermally stable diamond composite cutting elements to the tool body. The technology can be applied to mechanical excavation, rock cutting, drilling and sawing.

SMART*CUT provides an economical and effective solution for cutting hard rocks that previously could not be cut by conventional tools. It also provides significantly reduced tool wear rates and increased tool life, compared with conventional tools. The ability to economically cut hard rock will now enable new mining methods.

In January 2007 CSIRO Exploration & Mining and Fortescue Metals Group signed a contract and started a joint project to conduct field trials with SMART*CUT picks for surface mining of iron ore. Surface mining techniques could previously be used only for soft to medium strength rock like coal and limestone. Using surface mining with SMART*CUT drilling technology, rather than traditional drilling and blasting, will deliver benefits to the iron ore industry previously only seen in soft and medium rock cutting. These benefits include:

- improved continuity of the mining cycle through reductions to drill and blasting interruptions;
- reduced output size of the ore leading to a reduction or elimination of the need for primary crushing;
- improvements in lump/fines ratios;
- flatter pit floors which reduce the burden on tyres and operators;
- reduced particle size of the ore leads to a reduction in the requirements for heavy armouring in the haulage fleet; and
- waste seams can be selectively extracted leading to improvements in grade.

Sand mining systems

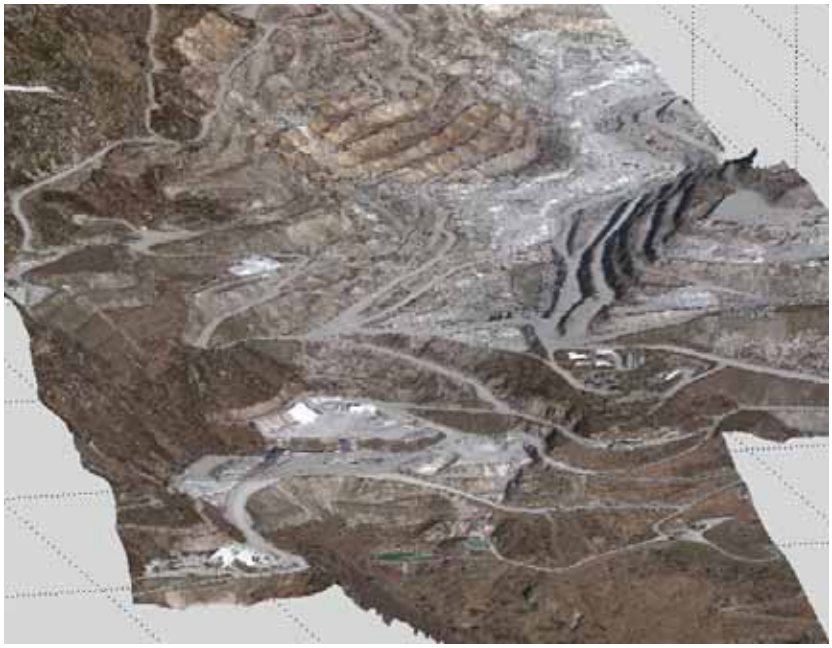
QCAT researchers have worked for a number of years to improve the operation of mineral sand mining. Traditionally, surface mining methods are used to recover these minerals that are used in the manufacture of pigments, ceramics and abrasives. Such deposits are typically located near ocean beaches. Australia has considerable resources of mineral sands that lie buried at inland locations in the Murray Darling basin through New South Wales and Victoria and the Eucla Basin of South Australia.

QCAT researchers have developed mining concepts to mine these deposits using underground mining methods. This will minimise disruption of alternative land uses and environmental impact.

Large Open Pit Mine Rock Slope Stability Project

CSIRO is internationally recognised for its expertise in the field of slope stability and open pit mining geomechanics. In 2004 the group initiated a major research project involving the stability of rock slopes in large open pit mines. The project, now in its third year, aims to address critical gaps in the knowledge and understanding of the relationship between the strength and deformability of rock masses and the likely mechanisms of failure in large open pit mines.

An authoritative new generation pit slope design guidelines text will be published by the group and is currently undergoing revision. The text links innovative geomechanics research with best practice in open pit data



collection and management, slope design, mining, slope management and monitoring, and risk management.

Research is also being undertaken to provide new knowledge and design criteria that describe the critical gaps in our current understanding of rock mass failure in large open pit mine slopes. This includes research directed at enabling the effective use of 3D modelling, rock mass strength simulation and uncertainty analysis in pit slope design.

The project is sponsored by twelve mining companies representing the majority of the world's production of diamonds and base metals. These companies are:

- Anglo American plc, London, England
- Barrick Gold Corporation, Toronto, Canada
- BHP Billiton Innovation Pty Limited, Melbourne, Australia
- Corporacion Naciónal Del Cobre De Chile ('CODELCO'), Santiago, Chile
- Compania Minera Dona Ines de Collahuasi SCM, Iquique, Chile
- DeBeers Group Services, Johannesburg, South Africa
- Newcrest Mining Limited, Melbourne, Australia
- Newmont Australia Limited, Perth, Australia
- Xstrata Queensland Limited, Brisbane, Australia
- Debswana Diamond Co., Gaborone, Botswana
- The RioTinto Group, Brisbane, Australia
- Companhia Vale do Rio Doce ('CVRD'), Rio de Janeiro, Brazil

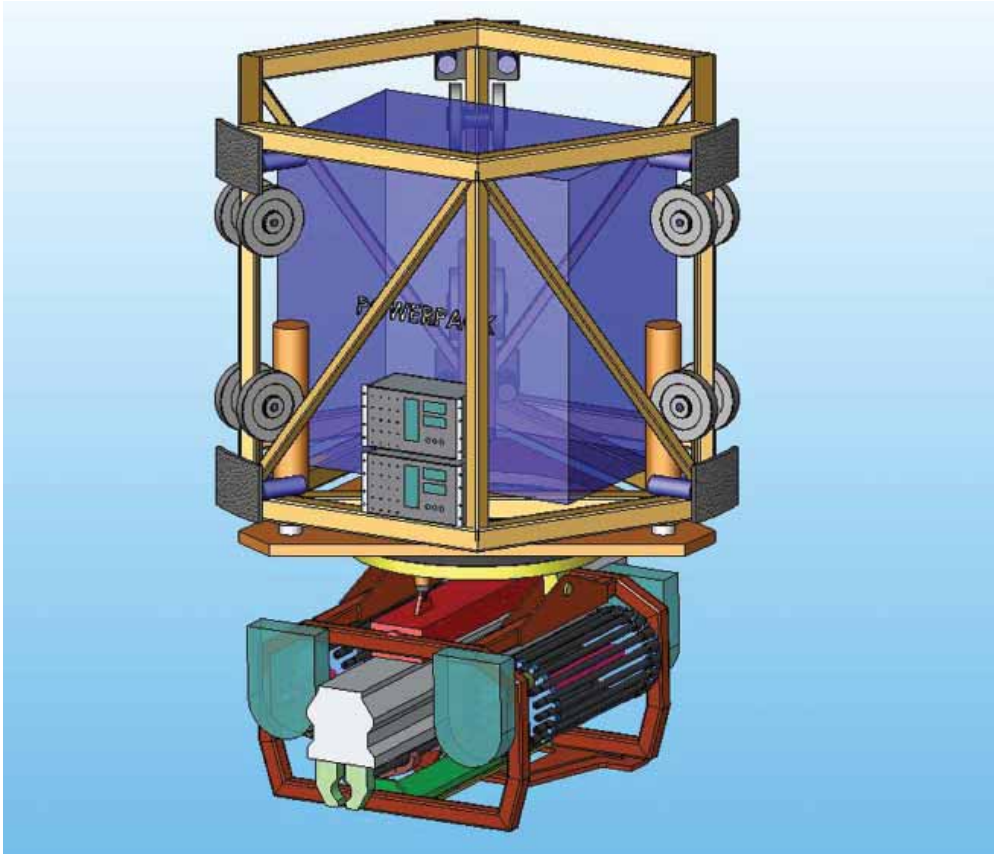
ROES™, a new non-entry mining method

Significant improvements to mining safety and efficiency can be achieved by using automation to remove people from hazardous areas. For hard rock mining, a non-entry, remote controlled method called ROES™ is being developed by CSIRO and a number of collaborative partners. ROES™ uses a new generation of remote controlled equipment to drill, load explosives and initiate blasts.

In traditional mining, underground roadways provide access to the ore body at a number of levels. However, with ROES™, one vertical shaft runs down through the ore body and an underground roadway provides access only to the base of the mining area.

Automated equipment is lowered down the shaft to drill, load explosives and blast. The blasted ore is collected from the base. Because access is required only at the top and base of the mining area, mine development costs are dramatically reduced.

CSIRO and Orica are working together on automated explosive loading and ROES™. A number of mining companies are currently assessing the advantages of ROES™ at selected sites. This follows earlier work by CSIRO and Curtin University, through the Western Australian School of Mines. Valuable strategic funding has also been provided by the Western Australian Government through the Australian Resources Research Centre.



During the year a project proposal to develop ROES™ through to completion of mining trials was placed with AMIRA to establish sponsorship among mining companies. A mining study was also undertaken for Xstrata to test the potential benefits of using ROES™ for their Mount Isa copper mine. The study was positive and provided a mine design and first-order costing and production rate.

Deep sea mining – stakeholder perspectives

The Wealth from Oceans National Research Flagship is interested in understanding the risks to a deep sea floor mining industry. QCAT's newly established social research group has developed a potential template for progressing the deep sea floor mining industry. After an initial scoping study three stakeholder workshops were conducted with representatives from government, industry, and community groups including environmental non-government organisations. Follow up activity will be undertaken in the 2007-08 financial year to test and verify this template with the stakeholder groups.

In addition to the stakeholder workshops, desktop reviews were carried out with the aim of contextualising both the Australian and international legal and regulatory framework for this emerging Australian industry. The results of the work are currently being drawn together and there is likely to be ongoing engagement and dialogue around the topic.

As a result of this work, CSIRO's researchers were invited to attend and observe a combined stakeholder workshop in Papua New Guinea to address concerns about a new deep sea-floor mining venture in those waters.

Mining ICT & Automation

CSIRO Exploration and Mining and the CSIRO ICT Centre collaborate on a number of projects. During 2006–07 the Autonomous Systems Laboratory of the ICT Centre has delivered field-proven robotics systems that provide the building blocks for future automation of mining equipment in surface and metalliferous underground operations. The Mining ICT and Automation group's ongoing emphasis on applied research and development has continued to produce novel and robust industrial solutions as well as stimulate new science ideas.

Truck and shovel automation

Most surface mines use large electric shovels or hydraulic excavators to dig material directly from a mine face or to load rock that has been blasted. CSIRO has been able to automate the essential processes involved to improve productivity and reduce equipment damage. Three key operations have been addressed: digging, swing and dump into a truck; mapping of the face/rock, bucket and local terrain using scanning lasers; and tracking/ the movement and parking of the truck with respect to the excavator/ shovel.

The technology has been demonstrated on a 1:7 scale shovel through a research project sponsored by ACARP. The automated truck loading component of the work is currently being developed on full size equipment in a project with Ezymine (a CRC Mining - P&H joint venture) with ACARP support.

Long distance remote control and automation

Mining companies and NASA are looking at the control of mining equipment over vast distances where the delay in communication makes remote control very difficult. Sponsored by NASA, researchers at QCAT have overcome many of these difficulties and demonstrated the remote control of a locally based 1/7 scale electric dragline and an automated hot metal carrier from the USA. These capabilities are now being applied to mining operations in Australia where there is a desire to remotely control equipment based at remote mines sites. This work is now being sponsored by mining companies.

Wireless Localisation and Protocols

The long-term goal of this project is to develop technologies and standards for an integrated mine communication system that includes localisation, data and voice communications using wired and wireless communications as appropriate. A novel radio location system is being developed, and algorithms will be developed for fusion with other localisation modalities (particularly inertial). The system will initially rely on an infrastructure of base stations, and will evolve to be a full distributed cooperative localisation system using robust ad hoc communications.

Landmark Longwall Automation

A significant component of coal mining research continues to address longwall automation. CSIRO's ACARP-funded Landmark Longwall Automation project successfully demonstrated new face alignment, horizon control, communications, geotechnical monitoring and information systems. A two year extension began in April 2005 the final project report will be submitted late 2007.

Major activities in the extension project have been:

- The implementation of automatic face alignment systems on a production basis at Beltana and Broadmeadow mines and system installation at Grasstree mine.
- Further development of automatic horizon control, employing inertial navigation system-based shearer position measurement, ranging from factory trials to underground production operation with two shearer manufacturers.
- The development of a longwall automation system to provide 3D visualisation of the longwall, including face equipment, geology, geophysics and other infrastructure.
- Further development and refinement of scanning laser-based sensors for accurate measurement of longwall position.
- The development of an across-face camera array for coal interface detection and face observation.
- Development of commercial-grade hardware to meet the requirements of the longwall equipment manufacturers and mine operators.

At the conclusion of this project, face alignment and horizon control systems will be mature technologies and new sensing, monitoring and information systems will be developed and demonstrated at the pre-commercialisation stage.

A parallel project has focused on commercialisation of the initial face alignment and horizon control outcomes of the longwall automation research. The selected route to market is via the major longwall equipment suppliers. Licensing and royalty terms with these commercialisation partners have been negotiated and procedures for the handover and ongoing support of project intellectual property have been developed. Commercialisation arrangements are in the final stages of negotiation.

Mine communications information system for real-time risk management

The project seeks to introduce step-change capabilities in the areas of real-time safety and operational management through information capture, integration and rules-based analysis. The intrinsically safe communications hardware will allow the world's underground coal mining industry to fully utilise the ethernet-based communications systems enjoyed for so long by surface and non-hazardous area industries.

The system will monitor several proprietary safety and productivity data capture systems (including proprietary supervisory control and data acquisition systems) over a fibre optic network, convert them into a common language, analyse the data as a whole and integrate

the results. Data sources captured will include:

- ventilation monitoring and gas detectors
- coal seam gas drainage holes
- fires and spontaneous combustion
- roof-fall monitoring
- man and equipment locations
- operational and productivity data
- environmental monitoring.

Once integrated into a central database, the Nexsys Real-time Risk Management System will use a series of pre-set program rules to determine the real-time risk profiles present at the mine. Such analysis will allow for pre-emptive corrective and preventative action. All data and risk analysis information together with the location of the workers will be displayed on a real-time, 3D graphic user interface that represents the layout of the mine (or workshop) and can be viewed from any computer connected to the local area network.

The project will deliver:

- IS certified (IEC Standards Ex Ia) auto-sensing fast ethernet switch
- IS certified (IEC Standard Ex Ia) serial to ethernet protocol converter
- database connectors and integration software
- commercial release version of the NEXSYS™ real-time risk management system
- manufacture version of e-Reporting tablet and software system.

These combinations of ethernet-based hardware devices and real-time analysis software systems are currently installed in two Australian coal mines (in Qld and NSW) and are undergoing extensive field-trialling and validation. A third field trial installation was conducted at a Japanese coal mine in November 2006, with future plans for installations in China and India.

In the 2006-07 year commercial agreements were made with an Australia manufacturer for the technology transfer of the hardware devices, and negotiations are continuing for the commercialisation of the integrated software system

Laser Scanning Technologies

Laser scanners are a relatively mature technology, but the full scope of their capabilities and potential applications have yet to be fully realised.

The group is continuing work on a real-time localisation system for measuring the position of a longwall shearer in the underground coal mining environment, a key component in longwall automation.

A collaborative project with Anglo Coal to measure coal surge bin levels was completed, with the system installed and working at Grasstree Colliery.

In 2006-07 research has continued on a new system for automatically measuring the 'carry back' of coal in Queensland Rail rolling stock. The system is leading to significant improvements in transport efficiency and the group is targeting a pre-commercial prototype for installation at the Gladstone Coal Terminal. A related application is being investigated that will allow Queensland Rail to optimise coal loading and distribution.

Sub-surface Imaging using Ground Penetrating Radar

Ground penetrating radar is an electromagnetic sensing technology that can be used to produce a pseudo image of the sub-surface. Ground penetrating radar has traditionally been used by expert operators in a survey-type capacity. A high level of expertise is required because of the very complex nature of signals produced by the radar. This signal complexity has long been a barrier preventing broader application of the technology.

The signal processing expertise in the CSIRO Mining ICT and Automation group is being employed to overcome this fundamental barrier. This is primarily being realised through the development of new intelligent radar processing methods.

Collision avoidance

Research into collision avoidance technologies for mine haul trucks may lead to significant benefits in safety at mine sites. At QCAT research into this area has progressed over a number of years and technology is now licensed to Advanced Mining Technologies. In 2006, successful vehicle trials of a radar-based system mounted on a Land Cruiser were held on site at QCAT. In October 2006 successful vehicle trials were carried out at BMA Goonyella open cut mine site with the system mounted on a Caterpillar 793 haul truck. The prototype Doppler radar proximity detection performed very well and is now going into pre-production by Control Technologies International Pty Ltd, CSIRO's commercial partners in the ACARP-funded project.

QCAT Commercial Tenants

Applied Mining Technologies

Applied Mining Technologies plays a key role in the successful transfer of mining guidance technologies from research to a commercial, industry-accepted solution for highwall mining applications.

Machine guidance is considered essential for safe and productive highwall mining, and equipment manufacturers have incorporated AMT technology into new and existing production systems. This has resulted in significant improvements in production rates and resource recovery and has provided the enabling technology for ongoing advances in automation.

In collaboration with major equipment manufacturers and suppliers, AMT has developed a complete and integrated highwall monitoring and control package incorporating inertial and horizon control technologies.

CET Group

Cutting Edge Technology Pty Ltd (CET) was established at QCAT in 1995 as a mining consultancy that specialises in the research and development of mining systems, integrating geomechanical and mining equipment engineering.

CET aims to promote auger mining technology and to identify and develop opportunities in the Australian surface and underground mining industries through Coal Augering Services Pty Ltd (CAS). In the 2006-07 year CET's primary focus has been the development of CET Resources Pty Ltd (CETR).

CET, CAS and CETR have common ownership but trade as independent companies from their head office at the QCAT precinct.

Coal Augering Services Pty. Ltd

To maximize the commercial return from its mining technology CET expanded into contract mining in 2003 as CAS. Auger mining is employed to increase reserves by accessing coal lying beyond the economic reach of conventional surface mining operations.

Since its formation CAS has undertaken a range of contract mining projects for Anglo Coal, Centennial Coal, Foxleigh Mining, CVRD and Peabody, in Queensland and New South Wales.

CET Resources Pty Ltd

CETR was formed to participate in mine ownership building on our mining technology and contract mining background. The aim is to develop CETR as a niche resource-based company, leveraging off in-house mining technology and expertise to realize the full potential of both Brownfield and Greenfield opportunities.

In November 2006 CETR purchased a controlling interest in Coalpac Pty Ltd. This marked CETR's entry into coal mine ownership. The company's aim is to generate a balanced portfolio of operations which encompass long-term local power station supply, domestic thermal supply and export thermal coal supply. CETR is focused on acquiring additional projects and is looking towards future growth.

GeoTek Solutions

GeoTek Solutions is a geotechnical consultancy specialising in slope stability for open cut mines. Since formation in 1999, the company has operated from the QCAT Technology Transfer Centre.

Reflecting the continuing importance of coal to Queensland's economy, GeoTek Solutions has operated mostly in the Bowen Basin during the past year. To help with an increased workload, the company has employed geology students from UQ. This has provided them with an opportunity to do hands-on engineering geology work for the mining industry while studying.

At the beginning of 2007, in collaboration with CSIRO, GeoTek Solutions mapped the whole of the Ok Tedi open cut mine in PNG for geological structures, using the CSIRO-developed Sirojoint technology. The Ok Tedi mine is one of the world's large open pits and this was the first time that Sirojoint had been used to map such a large mine.

Projects have also been carried out with occupants of the QCAT Technology Transfer Centre. These include underground coal gasification projects with Carbon Energy in Australia and India, and open cut mining projects with CAS.

Processing

Australia is the world's largest exporter of alumina, iron ore and black coal. The Australian resources industry is experiencing strong growth and is under pressure to optimise existing operations and reduce costs. Innovative and cost effective processing of our mineral wealth is essential to maintaining the competitive position of the Australian resources industry. Researchers from the Alcan Queensland Research and Development Centre and CSIRO form QCAT's minerals processing cluster and are assisting the industry in Australia and overseas.

Iron ore processing

CSIRO provides unique expertise, including detailed mineralogical, beneficiation and agglomeration evaluations of new and existing ore types and deposits, and predicting and optimising the processing performance of sinter, pellets and lump in blast furnaces and other downstream processes.

Predicting processing performance

CSIRO continues to investigate the processing characteristics of new and existing ore deposits as well as new ore blends derived from these ore deposits. An improved ability to predict processing performance will ultimately allow industry to speed assessment of the likely viability of new ore deposits by minimising expensive laboratory and pilot-scale research on ores that do not show promise. It will also allow more rapid assessment of processing options.

CSIRO's work on the automation of ore characterisation has continued with a focus on the prediction of downstream processing performance by linking ore mineralogy and petrology to metallurgical performance, e.g. sintering properties. Technologies developed by CSIRO for predicting processing performance include optical microscopy, computer-based image analysis for in-house use and mineralogy-based models of a range of unit operations, such as hydrocycloning, magnetic separation and reverse flotation. In addition, a stand-alone image analysis software package, based on CSIRO's in-house software, is being developed for client use.

More effective beneficiation strategies

Alternative iron ore sources of lower grade ore containing impurities, such as Marra Mamba, high-phosphorus Brockman and Channel Iron Deposits, are being exploited to meet market demand from China. The need to develop more effective beneficiation strategies has triggered the establishment of an impurity removal project. The project runs under CSIRO's Minerals Down Under National Research Flagship which underpins the future of Australia's iron ore industry. A range of new approaches are currently under investigation, including:

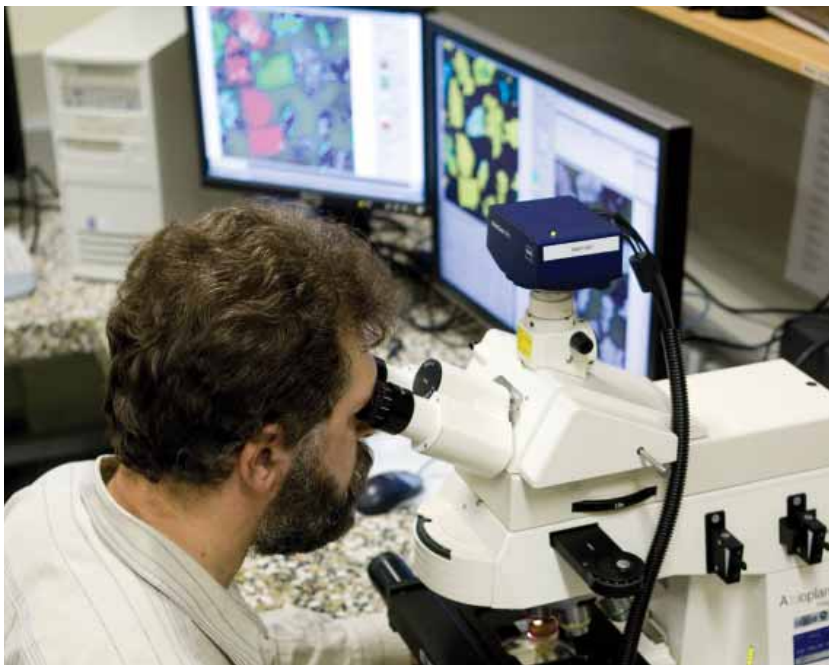
- dry tabling
- utilisation of a unique jig-wet high intensity magnetic separator and
- microbe induced flotation of alumina.

The current iron ore boom and shortfall in supply of traditional hematite/goethite ores has created a strong interest in Australia's substantial magnetite ore resources. Characterisation and beneficiation research on magnetite resources is continuing, with a number of Queensland ores included in the study.

The successful commissioning of new laboratory and pilot-scale magnetic separation equipment has led to a better understanding of the mineralogy and beneficiation potential of magnetite resources, including magnetite tailings. This new knowledge includes ways to target the removal of some of the minor elements that cause problems in subsequent pelletising and iron making operations.

Iron ore sintering and blast furnace burden characterisation

The sintering research conducted at QCAT continues to be pivotal to proving up new Australian iron ore resources for export. At the fundamental level, laboratory scale research is being conducted to understand and minimise the effect of increasing alumina and



goethite in Australian ores on sinter quality and to better understand the fundamental characteristics of high-phosphorus Brockman ores.

The granulation characteristics of iron ores have also been investigated, with a particular focus on the interaction of size distribution and ore mineralogy. This is crucial, because as Australian iron ores become more diverse, we require a greater understanding of granulation properties and in turn their impact on sintering.

To enhance CSIRO's capabilities in evaluating the sintering behaviour of new and existing Australian iron ore deposits, the CSIRO state-of-the-art pilot-scale sinter rig (~80–100 kg samples) has been used routinely to investigate sintering performance at sinter bed depths of up to 860 mm consistent with industry practice. In addition, the CSIRO small-scale sinter rig (~5 kg samples) has been enhanced to enable automatic data logging and reduce heat losses to the wall of the sinter pot, to improve the quality of sintering data.

In the blast furnace burden characterisation area, the CSIRO softening and melting furnace has recently been successfully commissioned after an extensive upgrade to allow improved data logging and better atmosphere control. Instrumentation has also been added to enable measurement of waste gas concentrations, such as CO, CO_2, O_2 and H_2.

Iron ore pelletising

The CSIRO pilot-scale iron ore pelletising facility has been used over the past year for optimising balling, drying and induration of iron ore pellets, particularly for magnetite ores. Significant international interest has continued in the new laboratory-scale infra-red image furnace at QCAT that is being used for determining reactions during the firing of iron ore pellets.

The Siro–Indur computer-based simulator developed by CSIRO is being used for optimisation of straight-grate and grate-kiln pellet induration. It has already been applied in Australia and North America, and there are potential applications in Brazil and China.

Non-ferrous minerals processing

Plant optimisation

Research for the non-ferrous mining industry on SAG mill optimisation and both fine (<38 micron) and ultrafine (<10 micron) grinding is continuing. The three year extension of the AMIRA SAG mill project (P667A) to monitor mill performance via surface vibrations was completed and an extension project is expected to begin soon. A ruggedised industrial monitor with an inertial power supply for continuous operation has been developed and demonstrated at the Northparkes mine. An additional installation for one of the project sponsors is well advanced, with another to follow soon after. Expressions of interest have also been received by other sponsoring companies. The monitor can track the toe and shoulder positions of the charge inside the mill as well as other operating parameters such as mill load and charge size.

In the fine grinding area, a wide range of laboratory and pilot-scale stirred milling equipment from various manufacturers has been assembled at QCAT, including a tower mill, a Metso detritor and an IsaMill. This provides a unique capability for conducting side-by-side comparisons of the relative performance of these fine grinding machines, including mill wear properties and the performance of various fine grinding media.

COLLABORATION

The Centre for Sustainable Resource Processing

CSIRO will contribute to the research activities of the Centre for Sustainable Resource Processing, in collaboration with research staff and students from the Julius Kruttschnitt Mineral Research Centre. The main focus of the research is to investigate the energy performance of high pressure grinding rolls (HPGR). The overall objective is to quantify energy efficiency for a three HPGR flowsheet in comparison with a conventional milling circuit. As well, CSIRO has been quantifying the benefits of using more energy-efficient comminution equipment, such as tower mills and horizontal stirred mills, in different applications.

Standards development

Our researchers continue to play a leading role in the development of International Standards Organisation (ISO) and Australian Standards for international trade in iron ore, base metals and coal. Current efforts are aimed at improving methods for the sampling of iron ores, coal and copper, lead, zinc and nickel concentrates, while new methods are under development for sampling slurries and smelter products and residues. Improved ISO methods for physical testing of blast furnace and direct reduction feedstocks for iron and steel making are also under development.

Coal processing

QCAT-based CSIRO researchers are working with the coal industry to improve the quality and competitiveness of Australian coal on international markets.

Supported by ACARP and the coal producers themselves, the group is developing components for the conceptual intelligent plant system. New hardware and software developments will allow a processing plant to know its current operational performance in real time, and how it compares with optimal standards. This will improve efficiencies and long-term operating costs in coal production plants.

Our researchers are also attempting to identify factors controlling the efficiency of fluid recovery, partition curves and magnetite recovery. In addition, we are exploring the potential of electrical impedance spectroscopy as a new tool for monitoring unit operations in coal preparation plants, and new capabilities for optimising plant performance. A number of proof-of-concept projects were completed successfully with dense medium cyclones and coal flotation systems at the pilot scale. Industry funding has been obtained to continue the work with focused plant trials. Ludowici Mineral Processing Equipment Pty Ltd has signed a contract to commercialise three recently developed instruments which will enter the marketplace in the next year.

QCAT Commercial Tenants

Alcan Queensland Research and Development Centre

As part of a long-term commitment to bauxite mining and alumina production in Australia, Alcan relocated a significant part of its bauxite and alumina research and development efforts to Australia in 2002.

The Alcan Queensland R&D Centre (QRDC) was established at the QCAT campus in 2005. Alcan QRDC has since been steadily developing capability and extending its R&D program. Alcan QRDC has been recertified for ISO 14001 and 18001 after continuing reviews and fine-tuning of environmental health and safety policies and procedures.

The new laboratory has developed world class R&D capability in alumina refining from bauxite (Bayer process). It has put Brisbane and the QCAT campus on the world stage in the alumina industry. In February 2006, QRDC's Manager (Mr Steven Healy) was appointed to the role of Global R&D Director for Alcan's Bauxite and Alumina business group, further promoting QRDC and QCAT as a premier facility for Alcan and the Australian alumina industry. In July 2007, Dr Lyndon Armstrong was appointed QRDC Manager.

QRDC supports Alcan's Australian assets, including the Gove bauxite mine and alumina refinery in the Northern Territory (100 per cent ownership), Queensland Alumina Limited, Gladstone, Queensland (41.4 per cent ownership), and the Tomago Aluminium smelter in NSW (51.55 per cent ownership).

Much of the effort at QRDC in the last year has supported the 1.8 million tonne, $2.4 billion Gove Expansion in the Northern Territory. Technical assistance to other Alcan operations, to technology sales customers, and strategic research and development projects provide the balance of value-added activities.

Alcan continued in the last year to expand its collaborations with Australian research organisations. Alcan's commitment to the seven year Parker Centre III CRC has been formalised. Alcan supports a number of collaborative research initiatives involving CSIRO or CRCs with CSIRO participation, including several AMIRA projects. Other projects are being developed or initiated in the coming year.

Alcan Inc. is a leading global materials company with world-class technology and operations in bauxite mining, alumina processing, primary metal smelting, power generation, aluminium fabrication, engineered solutions as well as flexible and speciality packaging. Alcan is represented by 68,000 employees, including its joint ventures, in 61 countries and regions, and in 2006 posted revenues of US$ 23.6 billion. The company has featured on the Dow Jones Sustainability World Index continuously since 2003.

Advanced Materials Engineering

Advanced Materials Engineering is an emerging R&D cluster at the QCAT precinct that includes researchers from the CSIRO Divisions of Exploration and Mining, and Materials Science and Engineering. Research within the cluster focuses on light metals and fibre composites, growing sectors in Queensland's developing manufacturing industry.

Manufacturing with Light Metals

Light metals are a vital component of the Australian economy. Australia is the world's leading producer of bauxite and alumina. Plans to expand Queensland's alumina production, aluminium smelting and magnesium alloy technologies, combined with increased demand for products, especially in the automotive industry, are driving the growth of Queensland's light metals industry.

Light metals fatigue

Recent research at QCAT on the fatigue properties of castings has focussed mainly on parts manufactured by the high-pressure diecasting process. This process accounts for the majority of light alloy parts manufactured, especially for automotive applications. However, it is usually perceived to produce parts with lower reliability than other casting processes and so has limited use in safety-critical components.

A novel heat-treatment process for diecastings is being developed in the CSIRO Light Metals National Research Flagship. Work at QCAT and CSIRO's Clayton campus has shown it can deliver improvements in strength, ductility and fatigue life. Experiments are now focussing on developing new alloy specifications that make maximum gains from the new process. A separate project has begun into optimising heat treatments of aluminium alloys to promote self-healing during fatigue crack growth.

Magnesium alloy development

Magnesium (Mg), alloyed with a few percent of rare-earth (lanthanide) elements, has proven to give light castings with excellent properties at the typical temperatures found in car engines. Previous work at QCAT on Mg-rare-earth alloys has achieved substantial process cost reductions, but in 2006 a new alloy formulation was developed that brought increased castability and improved strength with no cost penalty.

Rapid oxidation of molten magnesium alloys has always been a significant barrier to its use as a casting alloy, and additives that substantially improve oxidation resistance of certain alloys have been identified.

Steel coating improvements

Aluminium-zinc alloys have been used for many years to coat steel sheeting material for increased corrosion resistance. Researchers at QCAT and the University of Queensland are collaborating with BlueScope Steel to produce an improved coating alloy. One promising alloy has been identified and is undergoing further trials at BlueScope's research laboratory.

Fibre composites

Modern fibre composite materials are made by embedding high strength fibres in plastic. Researchers from CSIRO use the properties of fibre composites to improve existing designs and create new products that would be impossible using other materials.

New lightweight corrosion-resistant fibreglass piping system

Mining and industrial supplier AC Whalan will work with CSIRO to research and develop a lightweight, reusable duct system which is expected to replace corrodible steel piping in many coal mines.

The system will initially be used for two mining applications: coal seam gas drainage and the supply of water from the surface to underground equipment. While conventional steel piping has to be removed, the fibreglass composite material can be cut up by the shearer and removed at the wash plant, not affecting the purity of the coal. It will also be made fire retardant and anti-static.

The project was recently awarded a $A335,000 grant under the Queensland Government's Research-Industry Partnerships Program.

Researchers have completed the first stage of four in this project and are starting design and testing of concepts. The fibre composite had already been tested in corrosive environments and proved effective.

Fire suppression duct

Queensland underground coal mines need to be compatible with a GAG Unit – a jet engine with an afterburner and water injection that pumps oxygen-depleted gas at about 85ºC into mines to extinguish fires and reduce the risk of explosions.

One Queensland mine client ducts GAG Unit gas into its mine via a 900 mm diameter steel-lined hole, bored 80 m from the surface through soil and rock to the mine. When the mine moves to the next coal panel, a new hole is bored and lined. The steel linings are not reusable, and the cost of boring holes is very high.

For a better solution, we are designing a lightweight reusable duct where the bulk capital cost is incurred just once and the duct is moved from panel to panel as the mine develops. Small changes in length or direction may have to be made, but this cost should be much less than building a new duct and very much less than boring another steel-lined hole.

To minimise the work in shifting the duct, and to span uneven or steep ground, widely spaced supports are needed. To achieve this, most of the glass fibres are aligned lengthwise, providing great strength and stiffness for the large bending loads between supports. The material is E-glass fibres in vinylester resin, a combination giving the best mechanical properties under the hot and wet conditions at the least cost.

If the same product was made from steel, it would be about 30% heavier, have larger thermal expansion stresses and would require significant corrosion protection.

Lightweight aerospace components

The HyCAUSE scramjet was launched from Woomera on the 15th June 2007. Protecting it during launch at speeds of over 10,000 km/h was a lightweight fibre composite nosecone built by CSIRO and the University of Queensland Centre for Hypersonics. The scramjet builders previously used inexpensive metal nosecones, but for HyCAUSE staying within a weight limit was critical: if the rocket was too heavy it would not reach sufficient speed.

A carbon fibre composite nosecone weighs about half as much as a metal nosecone, saving 20 kg. A phenolic plastic was used for strength at high temperatures, where a process called ablation decomposes the outer layer, protecting the cooler material underneath. During launch, the 22 kg nosecone survived aerodynamic loads of 1.5 tonnes force pushing the nosecone back into the scramjet and up to 1 tonne force acting sideways.

Borehole sensor housing

A CSIRO group at QCAT is developing instruments to determine the surrounding material from water-filled boreholes at great depths. The instruments use radiation sources and detectors and so need an instrument housing that does not interfere with measurements, yet is strong and stable enough to resist the crushing external pressure at more than 1 km underground. Previously, the group used aluminium tube housings that were machined, anodised, coated with enriched boron (to prevent interference from the aluminium), and then wrapped with a protective fibre composite material layer. These housings were very expensive and susceptible to buckling (like crushing an aluminium can) at great depth.

We designed carbon-epoxy composite tubes, a material that does not interfere with the measurements and therefore requiring no boron, no machining and no coatings. The fibres were oriented for maximum buckling resistance: the inner and outer layers are wrapped in hoops around the tube to prevent buckling, while the middle layer is wrapped in a helix to give the tube strength in its lengthwise direction. This design created cheaper, lighter and stronger instrument housing.

Clean Coal Technology

The coal industry is rising to the challenge of reducing greenhouse gas emissions while still meeting the growing energy and resource demands of our society. Clean coal technologies aim to reduce emissions and improve efficiencies right through the coal cycle. Clean coal R&D at QCAT addresses issues across the coal lifecycle, from mining and preparation to utilisation as a low emission energy source. The researchers and commercial tenants forming QCAT's clean coal technology cluster are supported by the state and federal government, universities, industry and international partners.

Coal mine methane capture and utilisation

Bilateral Climate Change Partnerships Programme

The Bilateral Climate Change Partnerships Programme aims to develop and implement a range of projects that deliver mutual practical benefit for Australia and partner countries and help build the capacity of developing countries to take action on climate change.

The following three research projects are being undertaken with Chinese partners to investigate coal mine methane capture and utilisation. The projects have received funding through the programme from the Australian Greenhouse Office

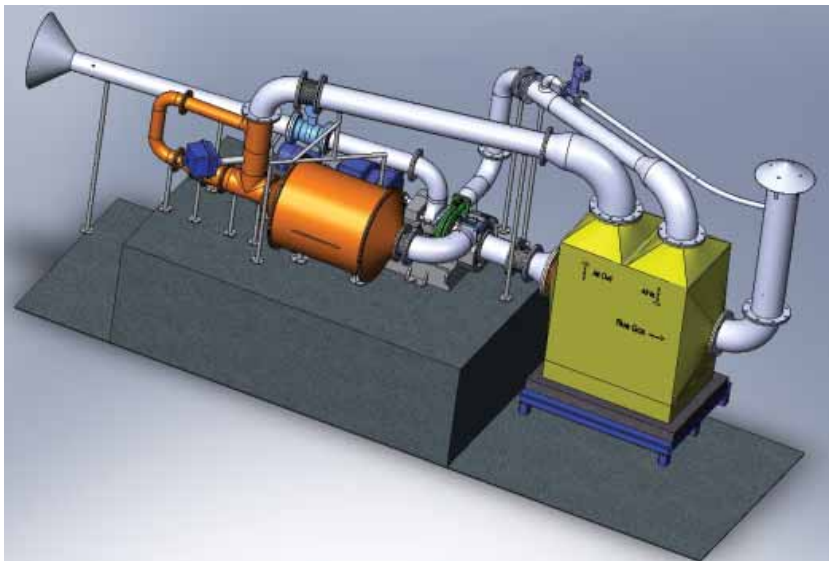
VAMCAT – generating power from low percentage mine methane

Conventional gas utilisation technologies will not work on ventilation air methane at concentrations of less than 1%, or on drainage gas with methane concentrations lower than 25%. Ventilation Air Methane Catalytic Turbine (VAMCAT) technology provides greenhouse gas reductions and generates clean power through the heat released by methane oxidation of mine ventilation air methane and poor drainage gas and can be powered with about 1% methane in air.

As part of the Bilateral Climate Change Partnerships Programme between Australia and China, CSIRO will develop and commission a ~30kWe VAMCAT prototype demonstration unit at a Huainan Coal Mining Group mine site. This project has received funding from the Australian Greenhouse Office. Our Chinese partners for this project are: Shanghai Jiaotong University and Huainan Coal Mining (Group) Co. Ltd. During 2006-07 the design of the 30kWe prototype demonstration unit was finished and it is now being manufactured.

Coal mine methane resources and potential project development

CSIRO is working with the China Coal Information Institute to investigate potential coal mine methane resources and emissions developing in the next five years across key coal mining areas in China, and to study the potential for coal mine methane/VAM capture and utilisation in these areas. The two parties are conducting a case study aimed at predicting future coal mine methane emissions and production; this is necessary for the development and planning of methane mitigation and utilisation plants at mine sites. The project will contribute to the development of a policy framework for CMM development projects in China. Our Chinese project partners for this project are: China Coal Information Institute, and five key coal mining groups in China. During 2006-07, the participating coal mine groups were



being selected. Mine site surveys have begun and are due for completion in November 2007.

Coal mine methane capture maximisation

CSIRO is working with Huainan Coal Mining (Group) Co. Ltd to design and optimise drainage gas systems based on CSIRO's advanced gas capture techniques and strategies. The design will be implemented at a mine in Huainan to demonstrate improved coal mine methane capture. The demonstration mine site has been determined, and design and optimisation of the positioning and sealing of gas drainage boreholes are under way.

CSIRO is also working with the China Coal Information Institute to identify gaps and opportunities for improved mine methane capture and utilisation. Site-specific implementation strategies for advanced mine methane capture technologies are being investigated at five Chinese mine sites. The techniques and strategies developed through this collaboration can be applied at a large number of gassy underground coal mines in China to maximise captured drainage gas that can then be utilised directly with conventional gas utilisation technologies.

Low emission technologies

Demand for electricity in Australia is growing strongly and the demand for Australian coal in world markets is at unprecedented high levels. The demonstration of clean coal technologies internationally is increasing, and as these new technologies are adopted, the export market for Australian coals will change. Furthermore, generation of electricity in Australia will be required to increase efficiencies and decrease emissions of pollutants, at a large scale and at an acceptable cost.

Research undertaken at QCAT is increasing the scientific understanding of the gasification process, supports the Australian export coal industry adapt to a changing marketplace, and helping the Australian electricity industry reduce the risks of selecting and implementing advanced power generation technologies. Our research also contributes to the expertise required to evaluate fuel and energy strategies for sustainable energy conversion technologies in this country.

Coal gasification

As part of its participation in the Cooperative Research Centre for Coal in Sustainable Development (CCSD), CSIRO operates an advanced gasification research facility at QCAT. The facility investigates the coal gasification process at a scientific level, identifying key performance criteria and providing a basis for the development of gasification models. This allows evaluation of the performance of Australian coals under high temperature, high pressure gasification conditions, as well as the design and optimisation of specific gasification technologies.

By 'deconstructing' the gasification process, and understanding the scientific principles underlying the important stages in gasification, CSIRO's gasification research is providing the detailed technical information required to support the adoption of clean coal technologies in Australia. Furthermore, by 'reconstructing' the process, in part using our high pressure entrained flow reactor, impacts of coal properties and other variables can be assessed.

Syngas Processing and Gas Separation Technologies

CSIRO is the major research contributor to the Centre for Low Emission Technology (cLET). cLET's research focus is the important gas cleaning, processing and separation technologies that will be necessary enabling technologies for the development of commercially feasible, coal gasification based power systems that incorporate large scale CO_2 capture and hydrogen production.

This program is using state-of-the-art facilities and capabilities for the development and assessment of hot gas cleaning materials, as well as novel catalytic gas processing and membrane separation systems. For example, CSIRO's high-temperature amorphous alloy membranes, fabricated from low-cost components, have the potential to produce pure hydrogen at a fraction of the cost of traditional palladium membranes. Materials and techniques such as these will be at the heart of the future development of large scale, low cost, coal-based hydrogen energy systems.

This world-class facility and research program is an important part of a broader national effort to address long-term efficiency and emissions goals for the coal, power and energy industries.

Social attitudes to energy technologies

QCAT has been developing a growing capability in social research. The main aim of the research is to broker knowledge between science research and a range of key stakeholder groups.

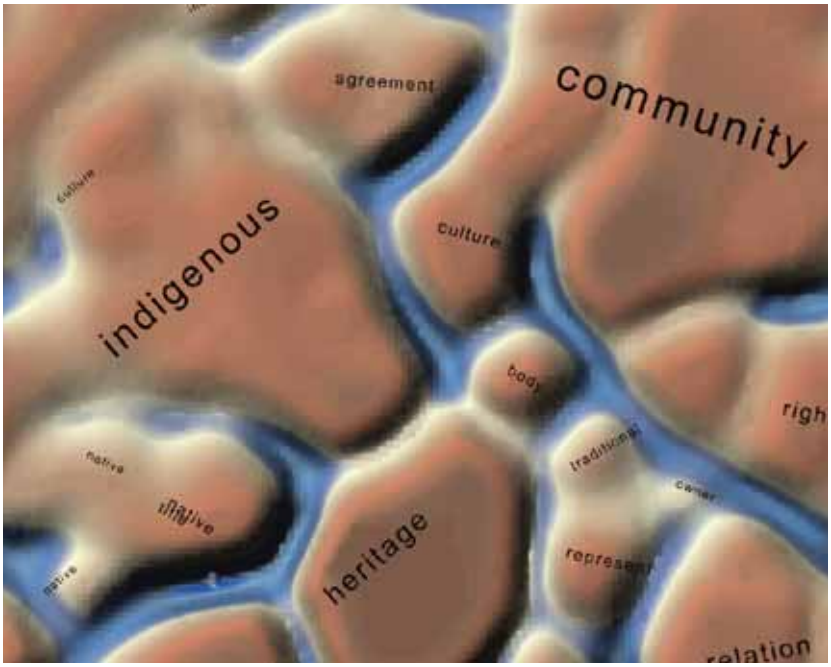
International Carbon Dioxide Capture and Storage Social Research Network

QCAT's social research team is now part of the Carbon Capture and Storage Social Research Network (C2S2RN). The network comprise individuals and research institutions from UK, Canada, Sweden, Japan, the Netherlands and the USA. In early 2007 researchers from QCAT and other C2S2RN members around the world conducted an internet-based survey. The results allowed greater understanding of cultural similarities and differences in understanding climate change, energy technologies and potential greenhouse gas mitigation strategies.

Societal Uptake of Alternative Energy Futures

In 2006 the social research team at QCAT ran the Societal Uptake of Alternative Energy Futures project to provide a lay person's perspective on the scenarios developed in the Energy Futures Forum. The Energy Transformed Flagship's Energy Futures Forum brought together industry and community groups and used modelling to develop future energy scenarios for Australia. These scenarios helped identify potential energy industry and technology pathways and highlighted prospective impacts to society, the environment and the economy.

Key achievements of the project included the synthesis of three citizens' panels on energy technologies. The research fed directly into the Energy Transformed Flagship's report entitled *The Heat is on: the future of energy in Australia*. The research team also conducted a review of the Energy Futures Forum process which provided valuable insights to the Flagship for its forthcoming Alternative Transport Future Fuels Forum.



The Intelligent Grid Project

The Intelligent Grid Project aims to establish the value proposition in terms of social, environmental and economic benefits for distributed energy in Australia. A distributed energy system uses many small generators to produce electricity close to where it is used; cutting down on energy lost through transmission. The social research component has concentrated on first understanding individual and organisational values which may influence the acceptance of distributed energy through large scale surveys across South Australia, Victoria, New South Wales and Queensland. This three year multi-disciplinary research project is part of the Energy Transformed Flagship and draws on capability from a range of divisions across CSIRO

At a grassroots level the social research team has joined forces with CSIRO's Sustainable Communities Initiative to partner with the Mount Alexander Sustainability Group, which is exploring potential distributed energy solutions for five large industry players in the Mount Alexander Shire. The research team is particularly interested in documenting the outcomes at Mount Alexander Shire, including what motivated the organisations to implement the solution and any challenges that arise as a result of the implementation process.

QCAT Commercial Tenants

Cooperative Research Centre for Coal in Sustainable Development

The CCSD is headquartered at QCAT and brings together the majority of Australia's coal research skill base as well as experts in sustainability who are recognised internationally as being at the forefront of coal research. Government and industry have committed $63 million over the seven-year period 2001-08 to identify and investigate opportunities for coal chain efficiencies and reducing carbon intensity in energy systems by providing a better understanding of Australian coal performance in combustion, gasification and emerging sustainable coal utilisation technologies. Other research areas include environmental and social assessment, iron making, and by-product and waste utilisation.

CCSD's 19 participants from industry, government departments, CSIRO and universities provide strong support through their participation in all aspects of the Centre's research and development agenda. The CCSD Education Program supports several PhD students in the research programs as well as industry education through seminars and workshops.

2006-07 is CCSD's penultimate year of operation before closure in June 08. Fittingly, in this year the CCSD's focus on power generation from low emissions coal utilisation technology has moved into an application phase.

Oxy-fuel Demonstration Project

Following on from a feasibility study in CCSD, the Oxy-fuel Demonstration Project at Callide A Power Station was submitted to the Australian Low Emission Technology Demonstration Fund by an Australian-Japanese consortium led by CS Energy. The submission was successful and an independent joint venture has been assembled to execute the project worth around $180 million dollars.

The impact of carbon pricing

The Centre's work on power generation portfolio planning has particular resonance with Australia's regulatory intention to introduce an emission

trading scheme. Work on the impact of carbon pricing showed that with current carbon prices the logical short-term choice for investors will continue to be supercritical coal-fired or natural gas combined cycle plants – but these would not do much to cut greenhouse emissions. With the required technology development and learning, a moderate to high carbon price signal would make options such as supercritical coal-fired plants with post-combustion capture of CO_2 viable around 2014. If high prices prevailed then Intergration Gasification Combined Cycle (IGCC) or oxy-fuel plants could become viable around 2020 – and these could make major inroads into national greenhouse emissions. The most recent study by CCSD also takes into account the prospects for nuclear energy in the nation's power generation portfolio. More importantly it identifies that the strategy chosen for phasing in emissions trading will have a substantial effect through the market signals it generates. These signals have implications for technology selection decisions that are long lived in the power generation sector.

Mine backfill applications

In a targeted and specific application of the CCSD's hydro-geochemical modelling capability, some of the CCSD's industry participants have co-funded a new study to develop assessment methods and protocols that better manage risks in mine backfill applications for flyash deposition. After completing its first phase of study, industry partners elected to continue the work through additional funding to CCSD. The work is scheduled for completion in December 2007.

Improving mill performance through de-sanding

CCSD, through its West Australian participants, has developed solutions to mitigate mill wear caused by heavy minerals, such as free quartz and pyrite contained in coal. The approach involves extraction of partially milled coal particles from the mill that are enriched with heavy minerals, followed by separation of the minerals for disposal and the return of the recovered coal back into the mill system. The engineering solution has been tested at commercial scale and has proven successful. The Centre has commenced assessment of the commercial potential for assignment of the intellectual property.

Gasification study tour

During the year CCSD submitted an application to the Australian Greenhouse Office to conduct a gasification study tour for industry participants considering the deployment of low emissions coal gasification technologies. The application was successful and the study tour will be conducted in October 2007.

Publications

Thirty-three reports were published for limited circulation to participants during the year. These included seven technical notes and two discussion papers and are available from www.ccsd.biz.

COLLABORATION

CCSD coal gasification pilot test program

CCSD and its research participant CSIRO are preparing to apply QCAT-based research into the gasification process at full scale. During the 2006-07 year CCSD assembled funding of over $1 million to test four Australian thermal coals at the Siemens gasification facility in Freiberg, Germany in September 2007. These trials will provide vital information to determine the most important coal performance factors for developing test procedures and coal selection criteria, and to help optimise operating strategies for the use of gasification technologies with Australian coals. These tests will validate 10 year's of CCSD's research as well as laboratory data generated at QCAT, against pilot-scale test data.

Centre for Low Emission Technology

The Centre for Low Emission Technology (cLET) continues its R&D into ways of using Australia's coal resources to produce near-zero carbon emission electricity and hydrogen, to allow a smoother transition between the current energy infrastructure and a low carbon emission energy infrastructure of the future.

Headquartered at QCAT, cLET (see www.clet.net) is an unincorporated joint venture of the Queensland Government through the Department of State Development, CSIRO's Energy Technology and Energy Transformed Flagship, Stanwell Corporation, Tarong Energy, ACARP and the University of Queensland. These partners have combined their resources to develop the technologies needed to enable the production of low emission electricity and hydrogen from coal, and have focussed on coal gasification and advanced gas processing as having considerable development potential.

National low emissions gasification test facility

The project is developing a proposal to build a 5 MWt pilot scale gasifier in Australia, the aim being to provide a facility for comprehensive testing of coal performance, assisting in gasifier and gas cleaning technology selection, supporting a gasifier demonstration plant and testing the scale-up of gas processing concepts (such as those under development by cLET). The facility would also have the potential to test biomass blending with the coal feed, and utilisation options such as fuel cells, hydrogen combustion and storage and coal-to-liquids technology.

Syngas generator

This project will address the design, construction and operation of a pilot syngas generator unit. The unit will process black coal for the primary purpose of providing contaminant laden streams for the testing and development of technology modules for gas cleaning, gas separation and gas processing being developed by cLET.

Dry gas cleaning

Dry gas cleaning research looks at methods for filtering gas to protect downstream process units, with less water consumption and loss of power.

Water gas shift catalysts

cLET researchers are testing the performance of water gas shift reaction catalysts on coal-derived syngas. Currently available water gas shift catalysts operating at temperatures below 300°C were developed for use with natural gas. Their performance remains largely unproven or is less than optimum with coal derived syngas streams that contain higher CO, CO_2 and H_2S concentrations in the feed and product streams.

High temperature catalytic membrane reactor

cLET researchers are investigating a high temperature catalytic membrane reactor with the aim of developing a separator module that combines the shift reaction and hydrogen separation in one integrated unit. This will simplify both syngas processing and hydrogen production and recovery relative to current operating practice.

COLLABORATION

Understanding and integrating stakeholder perspectives to low emission technologies

This year saw the culmination of the Centre for Low Emission Technology's (cLET) social and economic integration research. The work aimed to understand stakeholder perspectives to low emission technologies, in particular clean coal, in Queensland and New South Wales.

Research was conducted by CSIRO's social research team, based at QCAT. The team established a baseline understanding of opinions about a range of low emission technologies, using quantitative analysis. A series of workshops were held in metropolitan and regional areas to engage a range of community leaders and the general public in discussion about climate change options for mitigation.

A major finding was that individuals had a strong preference for solar technologies. Research also showed participants became more positive about carbon capture and storage as a result of the information and discussion process. The results of the work conducted in Queensland have been reported and released through workshops, and provided a basis for ongoing activities at state, national and international level. The results have attracted international attention and were presented at the Eighth International Conference on Green House Gas Technologies in Trondheim in Norway, 2006.

Molecular sieve silica membrane systems

A lower cost ceramic separator is being developed to separate hydrogen from shifted syngas. This will provide new opportunities for H_2 separation that replaces the use of physical solvents for CO_2 capture from a syngas stream.

Metal membranes for hydrogen separation

This project addresses hydrogen separation from syngas streams at high temperature (up to 880°C) through the development of thin film metal membranes that are not palladium based. Palladium is currently an expensive and scarce rare metal resource.

The QCAT-based social research team is also synthesising the quantitative data arising from the cLET research using CSIRO Self Organising Maps, a data mining system. This research aims to profile sub-groups of public opinion to energy technologies. Four major groups appear to exist: those who are indifferent to climate change and energy technologies; those who exhibit a preference for renewable energy technologies, those demonstrating a stronger preference for nuclear; and finally a group that shows a preference for carbon dioxide capture and storage. While this work is still at an exploratory stage it is hoped to integrate the research with other work from the Carbon Capture and Storage Social Research Network (C2S2RN).

Carbon Energy Pty Ltd (CEPL)

Carbon Energy Pty Ltd (CEPL) was formed as a joint venture between the CSIRO and Metex Resources Pty Ltd in 2006. CEPL owns unique intellectual property in UCG and a range of associated technologies and has the full backing of CSIRO's capability in underground coal gasification (UCG).

CEPL's business is to deliver a new generation of large scale energy projects based on cleaner and greener use of coal. The key to this is coal gasification which transfers the energy from coal into syngas (hydrogen and carbon monoxide). This can be used directly as a low emission fuel gas for power generation, and as feedstock for catalytic syntheses of liquid fuels, chemicals and fertilisers. It can be further transformed with steam into hydrogen, and carbon dioxide which can be removed, effectively decarbonising the energy to zero emission hydrogen with potential uses in fuel cells, turbines and as a transport fuel.

CEPL's advantage lies in its proprietary underground coal gasification technology which can produce syngas from coal in large scale commercial volumes, at much lower cost than surface coal gasification methods. This increases the profitability of projects by reducing source fuel costs and upfront capital requirements. Other important advantages are that UCG can use deep, high ash, conventionally unmineable coal, and hence has an enormous resource base to draw on. It also avoids the expense and environmental impact of coal mining, handling, and surface gasification plant. This results in a low cost, low impact, low emission route to clean coal utilisation for power and liquids.

CEPL has over 2000 square kilometres of exploration permit covering billions of tonnes of potential coal deposits. The target resource in the Surat Basin of South Eastern Queensland is likely to contain between 50 and 500 million tonnes of high ash coal suitable for UCG production. Exploration in 2007 has found many sites with thick coal, and to date one of these has been in-fill drilled to show a Joint Ore Reservoirs Committe-inferred coal resource of 45 Mt with ongoing drilling yet to establish the full extent of the deposit. A mineral development licence application has been lodged over this deposit, and CEPL intends to commence gas production from the site in August 2008. CEPL is targeting a resource that will support a commercial scale UCG plant (10,000+ bbl/day and 100MW+ power).

CEPL aims to develop power and synthetic diesel production plants on CEPL's coal deposits, and build the partnerships required to implement and fund such projects. It has commenced a staged development plan for the first of these on the Surat Basin leases. CEPL has signed a MOU with Singareni Collieries Company Limited, India's second largest coal producer, to collaborate in development of UCG projects on the company's coal leases in Andhra Pradesh State.

Information and Communication Technology

Information and Communication Technology is a core enabling technology that flows through many areas of new development in diverse range of industries. The CSIRO ICT Centre at QCAT is investigating new technology applications in wireless sensor networks, and autonomous vehicles for land, sea and air.

Automation

The CSIRO ICT Centre's Autonomous Systems Laboratory at QCAT has been researching automated ground vehicles since 1999 when it demonstrated an automated Load Haul Dump (LHD) vehicle at North Parkes mine, NSW.

Autonomous Hot Metal Carrier

Hot Metal Carriers (HMCs) are large forklift vehicles used to transport molten aluminium in large metal bucket-like containers called crucibles, from a smelter's potting line to the casting house. They operate 24 hours a day, seven days a week. The main objective of the HMC project is to develop technologies that will allow a fully autonomous vehicle to conduct continuous, safe, dependable operations around a worksite containing humans and vehicles.

The team has developed algorithms for localisation, navigation and crucible manipulation, and has now operated the vehicle autonomously for over 300 hours. The past year (2006-07) has seen the development of fault detection and recovery schemes to improve the reliability of the system. An obstacle detection system was also developed that is capable of detecting obstacles in the path of the HMC and stopping the vehicle to avoid a collision.

The project expanded into Tasmania in 2006-07 when key equipment was tested on a production HMC at Rio Tinto Aluminium's Bell Bay smelter. Future work in this project includes the development of a system to detect people in the vicinity of the vehicle.

The Autonomous Hot Metal Carrier project is part of CSIRO's Light Metals Flagship program.

Wireless sensor and actuator networks

Wireless sensor & actuator networks provide the means to observe, understand and control the natural environment to a level that has never previously been possible. They comprise networks of nodes, where each node can co-operate with its neighbours to sense and share information wirelessly. Tiny microprocessors built into each device enable decisions to be made inside the network, allowing autonomous actuation to take place where needed.

Autonomous spatial management of animals

Cattle control via sensor and actuator networks has been a key part of the ICT Centre research program, with initial work focussing on autonomous bull separation to prevent injuries during the breeding season. Our latest work has been undertaken in collaboration with CSIRO Livestock Industries as part of the Food Futures National Research Flagship program. The goal of this work is to develop a methodology for combining scientific knowledge about animal behaviour with computer science techniques, to enable autonomous spatial control of cattle with virtual fence lines.

An autonomous trial was successfully completed in April 2007 where a herd of cattle was kept behind a virtual fence line for 13 hours. Future research in this area is now funded by the Department of Environment and Water Resources, with the application focus shifting to protection of environmentally sensitive areas such as river banks or riparian zones. This next phase of work will address issues in scalability as well as exploit information about the state of the herd, rather than making all decisions at an individual animal level.

Saltwater intrusion monitoring

Saltwater intrusion into coastal aquifers due to poor management has been an ongoing concern for water managers globally. The principle decisions to be made in relation to exploiting these coastal groundwater resources are: where to place the extraction bores, and how much water can be extracted sustainably. Steadily rising salinity levels have been noticed in a number of production bores near the coast in the Lower Burdekin in North Queensland. Current concern is that the groundwater resource in these areas may be degrading, however the extent and the cause of the problem is not well understood. Similarly, the management options available and the efficacy of particular options are not well understood.

As part of the Water Resources Observation Network initiative in CSIRO, the ICT Centre has developed and deployed a network to monitor the state of bores in the Burdekin region. The project team designed the hardware and software required to deploy a sensor network in this region. Each node in the network measures the volume and rate of water being pumped, the ground-water depth, and the electrical conductivity (correlated with salinity) of the water being pumped. The network was deployed in March 2007 and has been providing data regularly since mid-April. The network consists of five sensing nodes, two relay nodes and a base-station node. The data is stored in a database and is available from a web-server.

The network has demonstrated the feasibility of using sensor networks in these types of applications and can be used as a test bed for further work in the use of sensor networks for water management. It also provides a valuable resource for hydro-geologists interested in validating their theories and models of the aquifer structure.

Underwater robotics and monitoring

Autonomous underwater vehicles (AUVs) and sensor networks will greatly improve offshore operations in areas including environmental monitoring and industry sectors such as oil and gas. Since 2004, the CSIRO ICT Centre team based at QCAT has been developing and demonstrating technologies to create significant impact in these areas.

During 2006-07, two projects were undertaken as part of the CSIRO Wealth from Oceans Flagship program. The first focused on the development of the next generation Starbug AUV for application in the environmental monitoring and habitat mapping in areas of Tasmania's Derwent River and the Clarence River in NSW. The second project focused on developing sub-sea technologies to allow new methods of remote monitoring and inspection in deep, offshore oil and gas fields. The key technologies developed included algorithms for sensor network based localisation, improved vision-based obstacle avoidance, development of a fully adhoc acoustic network system, and a new concept for remote wireless sub-sea pipeline monitoring.

Over the last year, the project was successful on a number of fronts. The Starbug AUV won the Innovation Award at the Queensland Division of Institute of Engineers Engineering Excellence Awards, in addition to a national Australian Engineering Excellence Award. A provisional patent was lodged on the pipeline monitoring system, and a first demonstration of a ten node acoustic ad hoc communication system was conducted in Brisbane's Moreton Bay.

Future work in this project will include the development of new vision-based inspection technologies, robust localisation and robot sensor network interaction strategies. These technologies will be deployed and trialled in Brisbane, Tasmania and Perth.

Aviation and Aerospace

Queensland is fast becoming a leading aviation and aerospace hub in the Asia Pacific region. In April 2006, QCAT welcomed the Defence Science and Technology Organisation (DSTO) Brisbane. Its Applied Hypersonics Branch and CSIRO Autonomous Systems Laboratory's Unmanned Aerial Vehicles group support R&D in this area.

Unmanned aerial vehicles

The ICT Centre's Autonomous Systems Lab is pioneering research on vision-based flying robots. These will be used by experts without piloting skills for inspecting infrastructure such as bridges, cooling towers, powerlines and pipelines.

In past years the group demonstrated an autonomous helicopter capable of estimating its speed and height above the ground using a robotic vision system. This allows the vehicle to observe the world and then use that information to control itself.

In May 2003, the project team demonstrated stereo vision-based hovering for over five minutes on a small helicopter. Since 2006, the group has been developing an autonomous flight capability for a larger (15 kg payload) turbine-powered helicopter.

In 2006-07, work started on adapting a commercial mini-helicopter. The team also assembled a pod for the Air Vehicle Simulator (AVS), and a touch screen-based ground station for the helicopter. The AVS pod carried the embedded computers and sensors that will be flown on the mini-helicopter. The AVS was used to test two key capabilities: obstacle detection and object tracking.

QCAT Commercial Tenants

Defence Science Technology Organisation

Hypersonics

Flights at hypersonic speeds potentially offer significant advantages in performance for defence and civilian aerospace applications. Civilian applications include low-cost satellite launch and high-speed aircraft. DSTO activities in hypersonics cover:

- applied research into air-breathing hypersonic propulsion and hypersonic aerodynamics
- interaction and collaboration with Australian universities and industry involved with hypersonics research and development
- maintaining international linkages of relevance to DSTO's hypersonics program
- developing flight hardware and conducting ground and flight testing; and
- providing an avenue for advanced research in related areas such as materials, guidance and control, structures and sensors.

In November 2006, DSTO and the United States Air Force signed an eight-year, $70 million agreement to advance research into high-speed (hypersonic) flight. The Hypersonics International Flight Research Experimentation (HIFiRE) Agreement will see up to 10 hypersonic flight experiments conducted over 5 years. DSTO will collaborate with the University of Queensland and Boeing Australia in developing some of the flight configurations. This collaboration is supported by the Queensland Government.

On June 15, DSTO conducted the Hypersonic Collaborative Australian/United States Experiment (HyCAUSE) trial at Woomera. The successful trial completed one of the world's fastest air-breathing engine experiments aimed at demonstrating ignition of a supersonic combustion ramjet (scramjet) engine at speeds close to Mach 10 during re-entry after climbing to an altitude of more than 450 km.

Recent recovery of debris of the scramjet engine marks a significant landmark for DSTO. The find is important in analysing the outcome of the flight experiment and will add to the already huge amounts of data collected during the experiment. Seismic sensors were deployed to help identify the location of the impact. Data gathered was analysed by the DSTO Brisbane staff with assistance from industry and state government bodies. The seismic data, when combined with the telemetry and radars that were tracking the experiment, greatly reduced the search area, enabling an aerial reconnaissance team to make visual confirmation and locate the impact area on the first fly-past.

The benefit of the research and recovery expeditions is a broadening of DSTO's understanding of the fundamental physics in the field of hypersonics and the engineering involved, which is on the very fringe of our understanding. The information gathered will be used to build more robust and reliable hypersonic flight vehicles in DSTO's follow-on program, the HIFiRE Project. The next launch is planned for around May 2008 from Woomera.

Minerals Down Under – New National Research Flagship

Ongoing research and innovation underpin Australia's endeavour to remain competitive in the global minerals market. This was recognised in May 2007 with the announcement of new funding from the Australian Government to establish a new National Research Flagship, Minerals Down Under. The Flagship will receive $A34.6 million from the Australian Government over four years, and will enable CSIRO to work with Geoscience Australia and industry to achieve its goals.

The role of the Minerals Down Under Flagship is to create knowledge and transformational technologies for the mineral sector and to ensure there are appropriate pathways for the transfer of that knowledge and technologies to industry to improve Australia's global competitive position.

Minerals Down Under has the goal of adding one trillion dollars to Australia's mineral resources by developing ways of finding new ore and extracting currently uneconomic resources in a sustainable manner. The Flagship also aims to more than double the size of the associated services and technology sector to A$10 billion per year by 2015.

This bold goal will be achieved by CSIRO collaborating with partners in Government, industry and academia. The scientific expertise from at least six CSIRO divisions will be harnessed for Minerals Down Under. QCAT is a key research node for the Flagship. Other research nodes are located at Waterford and the Australian Resources Research Centre in Western Australia, North Ryde in New South Wales and Clayton in Victoria.

Many of the deposits that underpin Australia's success in the mineral industry are now rapidly dwindling or experiencing declining grades. New discoveries are in decline. Research will focus on discovery through the development of advanced exploration systems, drilling and development of future mining systems, processing technologies for resources, and development of solutions for sustainable processing.

CSIRO's National Research Flagships were launched in 2003 to address major national challenges in areas such as energy, water and health and also opportunities for industry development and job creation. An independent review of the Flagships Program, conducted in 2006 and chaired by former Government Chief Scientist, Dr Robin Batterham, highlighted the fact that the Flagships are delivering powerful scientific solutions to national problems, successfully driving large-scale activity addressing Australia's National Research Priorities in a collaborative, cooperative, and intensively managed manner.

The Technology Transfer Centre

QCAT acts as a focus for interaction between researchers and industry, and has a strong commitment to furthering technology transfer in the resources industries. The co-location and support of commercial enterprises and other research and development organisations at QCAT's Technology Transfer Centre provides an environment where the exchange of insight, information and technology can thrive.

Tenants at the Technology Transfer Centre change as new research partners set up offices and as commercial enterprises are established, develop, expand and move on to the next phase of their commercial development.

Commercial tenants in the 2006-07 year included:

- Applied Mining Technologies Pty Ltd
- Centre for Low Emission Technologies
- CET Group
- Cooperative Research Centre for Coal in Sustainable Development
- GeoTek Solutions

New tenants in the 2006-07 year:

- Carbon Energy Pty Ltd
- Defence Science and Technology Organisation

Outgoing tenants in the 2006-07 year:

- ComEnergy Pty Ltd

ComEnergy was formed by CSIRO and Liquatech Turbine Company in 2003 to commercialise the hybrid coal gas turbine technology developed by CSIRO. The technology allows waste coal and methane to be burnt efficiently to produce electricity. In June 2006, 58% of Liquatech Pty Ltd was acquired by EESTech Inc. At the close of the 2006-07 financial year CSIRO sold its 50% stake in ComEnergy to EESTech Inc, a US listed company.

- Instinct Television

Instinct Television is an independent television production company creating quality documentaries for the Australian and international television market. The company is currently exploring video delivery methods for a large screen display system currently in development.

- LAADtech

LAADtech started operation at the Technology Transfer Centre in November 2005, and is currently in the R&D stage, investigating new large-area screen display systems. It also works in conjunction with Instinct Television in developing video content delivery systems.

QCAT Events

DSTO Brisbane opening

The DSTO Brisbane facility was officially opened by Mr Peter Lindsay, Parliamentary Secretary to the Minister for Defence, in April 2007. The facility at QCAT will act as both the DSTO headquarters in Queensland, a focal point for interaction with the state's industry, and also as the Organisation's primary research facility for hypersonics, the study of velocities greater than five times the speed of sound.

Australia's Chief Defence Scientist, Dr Roger Lough, told guests at the opening ceremony that DSTO's move into Brisbane reflected the Organisation's commitment to pursue new and emerging technologies in partnership with Queensland industry and universities.

DSTO Brisbane will be home to Australia's leading effort in hypersonics research. DSTO is participating in an eight-year, $70 million agreement to advance research into high-speed (hypersonic) flight with the United States Air Force and will continue to collaborate with the University of Queensland and Boeing Australia. This collaboration is supported by the Queensland Government.

The official opening was followed by a seminar attended by representatives from Queensland companies, universities and state government agencies to examine opportunities for collaboration with DSTO.

QCAT hosts Vice Premier of China

On Saturday 24 March 2007, QCAT hosted a visit by Vice Premier Zeng Peiyan of the Peoples Republic of China. The Vice Premier and his party were shown recent advances in automated mining technology, mining safety, clean coal technologies, rock cutting, minerals processing and robotics.

CSIRO has a 30-year history of research and industry collaboration with China and is currently working with Chinese companies and research institutions at a number of levels. Some of these relationships, especially in the mining and minerals processing sectors, were highlighted during the Vice Premier's tour of QCAT. Following the visit, the Vice Premier thanked CSIRO for its hospitality and stated through an interpreter "I am very impressed with the level of technologies demonstrated. They are certainly relevant to China and I feel there is a lot of opportunity for us to work together in the future".

QCAT staff collaborated with the Queensland state government's Department of the Premier to host the visit. Vice Premier Zeng was welcomed to QCAT by CSIRO's Dr Rod Hill, representing CEO Dr Geoff Garrett, and by Tim McLennan, Executive Manager of QCAT. Scientific presentations and the tour of the site were by CSIRO staff with fluency in Mandarin.

Queensland Government delegations

QCAT has renewed its focus on establishing and maintaining its links with our key stakeholders from across Queensland Government. In 2006-07 the QCAT community was pleased to host site visits and briefings for a number of key ministers and members of the Queensland Government.

The Hon Geoff Wilson MP, Minister for the Department of Mines and Energy

In March 2007 Geoff Wilson, Minister for Mines and Energy and senior members of the Department of Mines and Energy, including Mr Dan Hunt, Director-General of the Department of Mines and Energy, were briefed on activities at QCAT. Their tour of the precinct showcased CSIRO's research activities in coal and metaliferous mining, coal preparation and utilisation, mineral processing. Light metals manufacturing technology, and

information communication technologies including machine automation. The Minister and his group were also briefed on the range of research undertaken by the groups making up QCAT's clean coal technology cluster: CSIRO, the Cooperative Research Centre for Coal in Sustainable Development and the Centre for Low Emission Technology.

The Hon John Mickel MP, Minister for State Development Employment and Industrial Relations

Minister Mickel toured the QCAT precinct in April 2006 accompanied by Carolyn Male, Member for Glasshouse; Gary Fenlon, Member for Greenslopes; Phil Gray, Member for Gaven; and Annastacia Palaszczuk, Member for Inala.

The group was briefed on a range of new technologies promising benefits for Queensland industry, including developments in clean coal technologies, mining technologies, robotics, minerals processing and light metals manufacturing. They met research leaders from CSIRO, Alcan QRDC, DSTO, CCSD and CLET. Minister Mickel praised the QCAT team for its R&D into boosting Queensland's mining, energy and manufacturing industries saying, "QCAT is integral to the future growth of the mining sector."

Minister Mickel used the opportunity to publicly launch the results of one of the most detailed research projects undertaken into public perceptions of new power generation technologies and how they contribute to global warming. Conducted by CSIRO for cLET, the report *Understanding and Incorporating Stakeholder Perspectives to Low Emission Technologies*, received strong coverage in the Australian media and has attracted international attention after being presented at the Eighth International Conference on Green House Gas Technologies in Trondheim in Norway, 2006.

Dr Peter Andrews, Queensland Chief Scientist

In May 2007 Queensland Chief Scientist, Dr Peter Andrews, visited the QCAT precinct. He was briefed on a broad range of CSIRO's activities at the precinct and also met representatives from the Alcan QRDC and DSTO Brisbane. Dr Andrews visit led to an invitation for QCAT Executive Manager Tim McLennan to present on the technology innovation process at Queensland Government's Science in Parliament.

Hon Judy Spence MP, Minister for Police and Corrective Services

In May 2007 the Judy Spence, Minister for Police and Corrective Services and Stephen Biggs, Director of International Operations, Department of the Premier and Trade, visited the QCAT precinct to be briefed on clean coal technology R&D at the precinct.

Innovation and Excellence

Innovation and Excellence is an annual event that provides representatives from the resources industry, government and other research bodies with an opportunity to build networks and to preview the ground breaking R&D conducted at the QCAT precinct.

The highly successful event in 2006 showcased 13 current research projects from QCAT in areas including: clean coal technologies, mine communication, mining automation and minerals processing. Each project promising major benefits to the Queensland and Australian economies, as well as our resources industries.

QCAT Steering Committee

The QCAT Consultative Steering Committee exists to consult with and provide advice to CSIRO on research directions and other issues relating to the development of the QCAT precinct. The Consultative Steering Committee maintains and independent chair and its members are drawn from Queensland Government, Universities, Industry and CSIRO.

Members of the QCAT Consultative Steering Committee in 2006-07 were:

The Hon Mike Ahern AO (Chairman)
Special Representative for Queensland (Africa, Middle East and India), Queensland Government Department of Premier and Cabinet

Mr Bob Potter
General Manager Industry Development, Queensland Government Department of Mines and Energy

Associate Professor John Mott
Strategic Coordinator, Offices of Senior Deputy Vice-Chancellor and Deputy Vice-Chancellor (Research), the University of Queensland

Mr Brian Anker
Director, Technology and Service Industries Branch, Department of State Development

Replaced by
Mr Ray Kelly
Executive Director, Innovation & Emerging Industries, Queensland Government Department of State Development

Mr Michael Roche
CEO Queensland Resources Council
Joined the Committee in 2007

Dr Michael Barber
Group Executive, CSIRO Information, Manufacturing and Minerals Group

Replaced by
Dr Rod Hill
Group Executive, CSIRO Information, Manufacturing and Minerals Group

Dr Cliff Mallett
Acting Chief, CSIRO Exploration & Mining and QCAT Executive Manager

Replaced by
Mr Tim McLennan
QCAT Executive Manager and Director - Business Development & Commercialisation Minerals Down Under - National Research Flagship

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