CSIRO

QCAT Annual Report 2004-05

Queensland Centre for Advanced Technologies

Government occupants

CSIRO
Energy Technology
Exploration and Mining
ICT Centre
Manufacturing and Infrastructure Technology
Minerals

Joint Venture
Centre for Low Emission Technology

Cooperative Research Centres
CRC for Cast Metals Manufacturing (CAST)
CRC for Coal in Sustainable Development

Commercial occupants

Advanced Mining Technologies Pty Ltd
Alcan Queensland R&D Centre
Applied Mining Technologies Pty Ltd
Australian Centre for Mining Environmental Research Limited (ACMER)
Cheron Group
Coal Recovery Australia
ComEnergy
Cutting Edge Technology Pty Ltd
GeoTek Solutions
Instinct Television
Jenkins-Kwan Technology Pty Ltd

Mission

The Queensland Centre for Advanced Technologies will be 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

The Queensland Centre for Advanced Technologies is a world class facility for research and development for the mining, energy and manufacturing industries.

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. Planning for Stage Three expansion is already under way.

QCAT Annual Report 2004-05

Foreword

The resources industry is vital to Australia's continuing prosperity. It contributes around eight per cent to GDP and boasts exports of around $55 billion. However, Australia's position as a major resource and resource-based technology and software supplier to the world is not guaranteed. Quality research is essential to continually sharpen our international competitive edge.

The Queensland Centre for Advanced Technologies (QCAT) has emerged as a centre of critical mass and a premier research node for mining related research.

QCAT was set up as a joint venture between the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Queensland State Government. It delivers world-class research and technology to the Australian exploration, mining, minerals processing and manufacturing industries.

The relatively small size of Australia's science and innovation system demands that scientists collaborate and engage with others wherever possible. QCAT is an outstanding example of collaboration between CSIRO, the Queensland State Government, CRCs and universities.

Importantly, QCAT is not just about gaining new knowledge; it's also about knowledge transfer. This transfer of knowledge has resulted in a significant flow of innovative, leading edge technologies and high value products and processes to industry.

The Australian Government strongly supports greater commercialisation of publicly-funded research, and is delighted with the performance of its investment in QCAT.

I commend QCAT for its science and its strong performance enhancing Australia's international competitiveness in the vitally important resources sector.

The Hon Dr Brendan Nelson

Minister for Education, Science and Training

Executive Manager's report

It has been an exciting year.

Research based at QCAT continues to deliver projects that promise outstanding benefits to the industry. A new real-time risk management system has been successfully installed and field-trialled in both Australian and Japanese underground coal mines.

We have determined significant potential savings for Olympic Dam through the use of a new mining method called ROES™. This project is a good example of effective collaboration between CSIRO and industry partners.

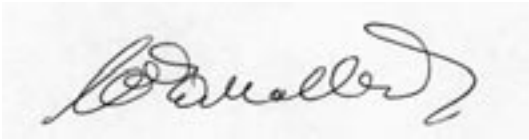
In addition, a new ruggedised continuously powered sensor system for monitoring SAG Mill surface vibrations has been developed. And in a major recognition of the quality of our research, the Longwall Automation team received the prestigious biennial 2004 Australian Coal Association Research Program award for research excellence in the underground category.

Important markers for growth are now firmly on the horizon.

CSIRO has identified the potential for a new cross-divisional, multi-disciplinary project called Minerals Down Under (MDU). It will operate across the whole mineral value chain from exploration to mining and processing with a key focus on sustainability. MDU will involve nine CSIRO Divisions collaborating with other key players such as Geoscience Australia, the Geological Surveys, universities and research centres. QCAT will be heavily involved with this project.

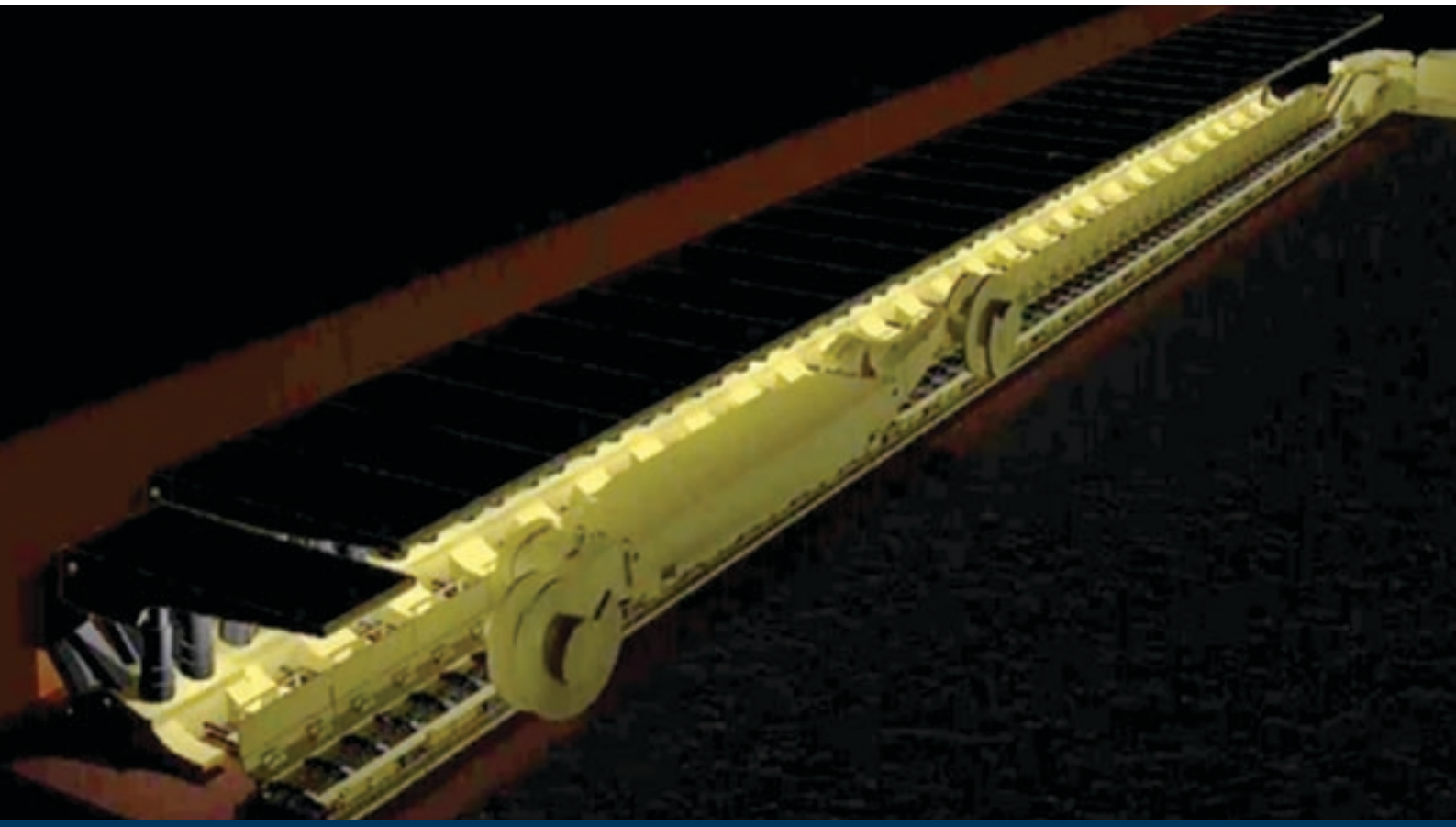
Planning for QCAT Stage 3 expansion continues. A larger QCAT will dramatically improve Queensland's ability to benefit from its massive resource base. Construction of a two-million dollar home for Alcan's Pacific area alumina research within the QCAT precinct is the first sign of this expansion.

Our history of research excellence combined with the promise of further growth and increasing collaboration and partnerships with industry all add up to an exciting 2004-05 and a vibrant future for QCAT.



Dr Cliff Mallett
Executive Manager
Queensland Centre for Advanced Technologies

Outcomes: Geoscience



Efficient mining activities rely on a comprehensive understanding of geology. This means that the geosciences are crucial to the sustainability and future growth of the mining industry.

Ongoing improvements in safety, reliability and cost effectiveness will rely on improved technologies and systems for understanding the geological inputs to the mining and beneficiation process.

Mining Geoscience

The fundamental objective of mining geoscience is to provide solutions that reduce uncertainty associated with the knowledge of the minescale geological environment. Our primary focus is in two areas - Ground Conditions and Coal/Ore Quality.

3D imaging and data analysis

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.

During this year further development of the system has centred around extensions to open pit applications, development of an underground system, structural modelling and slope stability analysis and enhancements to the data computation algorithms.

On the commercialisation front, Surpac Minex has been appointed as a non-exclusive retailer and over 60 licences have been sold domestically and internationally.

Microseismic monitoring

Substantial progress has been made in our aim of developing a new real-time microseismic monitoring and hazard assessment system for the Australian coal industry. Research this year has focused on the development of algorithms for the automatic classification of microseismic waveforms and accurate location of microseismic events.

At Lihir Gold Mine in PNG, a second microseismic monitoring experiment was completed as part of the mine's strategy to manage geothermal hazards. This trial required the development of special geophone arrays able to survive temperatures up to 180°C. High quality data was recorded over a six month period and results are being analysed.

Structural assessment

The Rangal Structure Supermodel Project was completed this year, with the building of a3D visualisation model of the Rangal Coal Measures in Queensland, using information from seam correlations and structure mapping and characterisation. The project was funded by the Australian Coal Association Research Program (ACARP).

Research has continued in collaboration with staff from the University of Sydney to improve 2D and 3D seismic data analysis techniques. Results this year have included development of seismic depth conversion based on borehole ties, implementation of 3D fault mapping, impedance inversion algorithms and the ability to accommodate different seismic data processing algorithms.

Petrographic characterisation

Optical microscopy is used to provide size and compositional information on individual grains of coal and rock present in samples of fine coal. It enables the density and chemistry (maceral proportions) of each grain to be determined. This year we have continued to extend the application of this technology to optimise coal flotation and improve the understanding of the utilisation performance of different coals. We have completed three audits of flotation plants for industry.

In 2004 we completed an ACARP-funded project that established that coal wagon loading methods do impact the speed and efficiency of coal unloading at the port. This work will be extended to develop a coal handleability index through a new collaborative ACARP project with CSIRO Energy Technology.

Borehole logging

An ACARP funded project to assess the use of nuclear borehole logging techniques for measurement of in-situ rock mass properties to assist in the prediction of salinity and acid mine drainage was completed and delivered very encouraging results.

A re-engineering project to upgrade the SIROLOG borehole logging technology has progressed and aims to deliver improved accuracy, speed and depth capabilities.

A project was completed to assess new techniques for estimating rock strength from standard geophysical logging data collected by the coal industry. Self Organising Maps and Radial Basis Functions were assessed and suggest there is good potential to improve on existing methods used to estimate unconfined compressive strength from sonic logging data.

Data mining applications

CSIRO has developed a data-mining tool, CSIRO Self Organising Maps (CSOM), which is based on an innovative data analysis procedure. CSOM is aimed at providing geoscientists with access to new methods for determining the intricate relationships, within and between spatially-located, complex data sets.

This year the technique has been further refined and applied to the assessment of a wide range of case studies, including geophysical inversion data (gravity and magnetics), drill-hole geophysics, heavy mineral/diamond geochemistry, mine design with respect to rockburst events and business intelligence/performance management applications.

Outcomes: Mining

CSIRO works to provide applied technology solutions to major issues confronting the coal and metalliferous mining industries.

Mining is Queensland's largest export industry. In 2003-04 alone, mining exports totalled $10.9 billion, or roughly half of total Queensland exports. In the same period, the Queensland Government collected $611 million in royalties from mining. The sector is currently responsible for more than 19,000 direct and 65,000 indirect Queensland jobs. Mining has evolved into an extremely sophisticated, 21st century industry and Australia is a global leader in developing new technologies.

Australia also supports a mining technology services industry of more than $3 billion. Computer and communication technology is used throughout for mathematical modelling, mine design and optimisation of all process stages.

Laser Volume Measurement

Laser scanners are a mature technology, but their scope of application is only beginning to be realised, particularly in the mining industry. Trayscan is an example of a successful application: a novel haul-truck volume measurement system that has been developed using scanning laser technology. The main features of the system are the ability to measure the in-situ volume of the haul-truck load, to perform the measurement while the truck is moving, to calculate the volume automatically, and (when combined with a weight measurement) to provide a bulk density measurement. This density figure is of critical importance to truck manufacturers and mine operators as they seek to obtain the best possible fit between a truck tray (which is designed to carry a given load volume) and a truck body (which is designed to carry a given load weight). The Trayscan system consists of the laser scanning units (the basic measurement instrument), a rugged data acquisition PC running the Trayscan software, and a Windows-based user application for data analysis and display. The Trayscan project (Commercial Software for Truck Scanning Technology) has developed the CSIRO Trayscan technology into a commercial product for a commercial partner, Transcale Pty Ltd. The technology remains the property of CSIRO and is licensed to Transcale on a per-unit royalty basis.

Several other laser scanning projects are currently under investigation, including: scanning coal train wagons to identify carry-back, volume measurement of coal bins, and scanning of wood piles for the logging industry.

Radio Subsurface Sensing

One of the fundamental drivers for change in the mining industry is improved knowledge of the unmined resource, not only during the exploration phase but also within the mining process itself. The ability to accurately and reliably characterise the quality of this resource (to 'see through walls') has been an unfulfilled promise for years.

Sensing capability: Instruments that can provide geological information in the vicinity of mining. If we can see through the rock and earth to the ore-body or coal seam, we could guide the mining process with the same confidence and efficiency that we have when automating a surface vehicles. Using new and emerging technological breakthroughs, particularly in such areas as ground penetrating radar, Ultra Wideband radar systems, acoustics, and image analysis we are attempting to extract an increasing quantity of information from the blank face of a rock wall.

Processing technologies: Smart algorithms to reliably interpret sensor data in real-time for determining where the product is located. Of course, just providing data about the hidden world under the surface is not enough. We need to somehow interpret all this data to not only see through the wall, but also know what we are seeing behind. Application specific developments in the field of signal processing are required to isolate the knowledge we seek from the vast flow of noise that is generated by even the most specialised instrumentation. An intimate knowledge of the signal characteristics associated with our target environment is one step to solving this problem, a concerted approach using different sensors in a supplementary fashion is another, while ongoing improvements in the computational application of innovative signal processing provides the final piece. Such techniques will allow us to build up a dynamic picture of the target zone that will increasingly come into focus as the mining process itself begins to provide feedback about the distribution of the product being mined.

SLIC: Radar Imaging Technology (Simultaneous Localisation, Identification and Communication)

We are investigating integrated systems that combine the traditional localisation capability of radar and laser scanning systems with the communications capabilities of Wi-Fi networks. The goal is a new level of sensor-machine integration: communication and control systems that will use the information provided by subsurface and other sensors to intelligently guide the mining process. The data supplied by these various sensors will allow guidance on the basis of interpreting probabilities, not simple binary logic, like the traditional control systems of the past. SLIC algorithms will control the movement of mining machinery safely and efficiently while still learning about the destination: a truly self-guiding process.

Because some of the hazards associated with mining are so great (rock falls, tunnels collapsing, explosives placement, hidden water volumes, etc.), it is necessary that the human operator be removed from the immediate vicinity of mining. These dangers, plus the complexity of the information to be interpreted, demand an automated solution. But the mining process is more than a single machine working alone: in order to truly take advantage of the new information available at the cutting edge of the mine, the entire process must be able to anticipate the control decisions that are made. This requires a globally coordinated approach to the automation of multiple individual systems, an approach that will depend on developments in networking technology, broadband

wireless systems, distributed control elements, and enhanced rule-based engines.

The Australian GNSS Joint Undertaking

The best known global navigation satellite system (GNSS) is GPS, which was developed by the USA's Department of Defense. A second generation GNSS, namely Galileo, is being developed by the European Space Agency and is scheduled to commence operation in 2008. The Galileo satellites will provide increased accuracy, increased availability, guaranteed integrity and a safety-of-life service.

Galileo heralds the advent of a technological revolution comparable to that generated by mobile phones. It will lead to the development of a new generation of universal services in sectors such as transport, telecommunications, agriculture and fisheries. To date, only the American GPS system and the Russian GLONASS system have made this extremely profitable technology available. However, both those systems are funded and controlled by the military authorities. The Galileo program, on the other hand, will be managed and controlled by civilians. It offers a guarantee of quality and continuity which is essential for many sensitive applications. Because of the compatibility of GALILEO with present systems, navigation and positioning services will increase in reliability and availability throughout the world.

CSIRO, the Queensland University of Technology and the Queensland State Government Departments of Natural Resources and Mines, and State Development and Innovation, have embarked on a collaboration known as the Australian GNSS Joint Undertaking (AGJU) to exploit emerging Galileo technology. The AGJU researchers will undertake projects to develop GNSS technologies that improve the productivity and safety at surface mine sites and allied transport industries.

Draglines Dig to Plan

CSIRO ICT Centre's Autonomous Systems Laboratory has developed a laser-based system that enables draglines to generate precise Digital Terrain Maps (DTMs) of their operating surrounds with a single 360 degree rotation of the dragline. The DTM information allows the dragline operators to get a visual presentation of how they are performing in relation to the excavation plan and the mine planners can see how the actual excavation plan is performing in relation to the theoretical model. With this information both parties can maintain optimal performance and closely track the planned movement of overburden, the so-called dig to plan.

The system is to shortly commence a one month production trial at AngloCoal's Callide Mine. This work has been supported by industry through ACARP.

Rope Shovel Automation Phase II

This project aims to progress the industry established shovel, excavator and wheel-loader automation roadmap of the ACARP Open Cut Automation Scoping Study by demonstrating complete automated digging and truck loading using a scale-model rope shovel.

The project uses a 1/7 scale model rope shovel with a custom built representative 1/7 haul truck tray to allow autonomous loading.

During the complete automated cycle, the dipper will engage and disengage the bank when full, then swing, spotting the model haul truck tray, emptying the dipper, then return for the next dipper load. This process is repeated until the tray is completely full of dirt. This has required the development of a reliable laser-based online truck position measurement system and generation of digital terrain maps. Current work is focusing on the development and evaluation of algorithms to optimise the placement of soil within the truck tray to ensure best loading, as well to identify the optimal location of the dig point. This project will be completed early in 2006.

Coal mining

Queensland is the largest seaborne coal exporting province in the world. From total production of 160.06 million tonnes of saleable coal in 2003-04, Queensland exported a record 134.98 million tonnes valued at approximately $7.2 billion. This represented an increase of 4.5 per cent over the previous financial year. Queensland has coal reserves of more than 30 billion tonnes, enough for several hundred years. This wonderful resource can provide energy in many forms for centuries, if the industry can adapt to the changing needs and demands of a changing society.

Longwall Automation

A three-year, $4.31 million ACARP-funded project leading towards the full automation of a longwall shearer was completed in December 2004. The project team received the prestigious 2004 ACARP Award for Research Excellence in the Underground category for their work. A robust, military-grade inertial guidance system is at the heart of the new system that automated a number of the processes involved in operating a longwall. Previously, miners had to stop operations twice a day to realign the shearer using string lines. Automating this activity cuts downtime and

improves productivity by thousands of tonnes a day.

The major contributions of the project have been:

- new sensor development for closed loop control of face equipment
- integrated operation of face components through open communication systems
- new data flow and management methods and technologies
- identification of skills and qualities of people required for longwall operations
- development of new on-line condition monitoring and fault detection technologies.

Successful technical results of the automation components of this project include:

- automatic face alignment achieved using an inertial navigation-based sensor on the shearer to accurately measure face geometry and feedback signals used to move roof supports
- on-line measurement of operational creep with creep information incorporated into face alignment corrections
- inertial Navigation System-based horizon control bench tested
- broadband communications system to shearer using wireless ethernet operational on a commercial product basis
- new results obtained in location of coal-face features for use in thermal infrared-based horizon control
- landmark Information System developed to integrate information from multiple systems and sensors and to provide high quality visualisation and control interfaces.

Real-time Risk Management

CSIRO, together with JCOAL as a key collaborator and co-investor, has developed a system that can integrate data from various sources within an underground coal mine and present it in the mine control room in a clear, easily understood format. The work followed a survey of eight underground control rooms in Central Queensland in which the following problems were identified:

- a high workload and general sense of chaos in control rooms
- a wide variety of third party communication systems in use
- false and misleading alarms
- difficulty and time taken to locate and contact individuals
- a lack of reliable, modern, high throughput communications equipment suitable for use in an explosive environment and under difficult physical conditions
- a cumbersome statutory reporting system.

The system includes the Nexsys software package, which takes a three-dimensional view of the mine from a CAD file (regularly updated by mine surveyors) and regularly incorporates sensor data. This allows operators to easily see conditions in the mine, such as the location of miners, vehicles and equipment, environmental and gas conditions, and strata movements. In fact, virtually anything that can be detected with a sensor. The operator can easily focus on any point of interest and find more detailed information about any of this data. The system also includes a range of Intrinsically Safe electronic equipment, using TCP/IP over optical fibre as the communications backbone, including:

- a fast ethernet switch
- a Modbus Serial to Ethernet Protocol Converter
- an RF to Ethernet Bridge to obtain wireless data (from personal and equipment location tags, chock and strata monitors) and pass it on to the optical fibre backbone).

An electronic reporting system is also included. This system is capable of:

- immediately delivering reports to the control room (or anywhere else they might be required) as computer images
- organising the reports so they can be queried in a useful way
- integrating the data with the main software application.

CSIRO has installed the Nexsys system at Anglo Coal's Grasstree Mine in the Bowen Basin in Central Queensland. Together with key collaborator and co-funder, ACARP, it has also been installed at XStrata's Beltana Mine in the Hunter Valley of New South Wales. In addition, the system was trialled earlier this year in the Kushiro Coal Mine on Hokkaido, Japan. A version that can be run on hand-held (PDA) equipment is currently under development, and a new version of the main product is due for release by the end of the year. The ethernet-based electronic communication equipment has been developed and is currently undergoing IEC Exia (Intrinsically Safe) certification. Negotiations are currently under way for commercial manufacture. The electronic reporting system has also been developed and installed at Grasstree and Beltana Mines to gauge operator acceptance of this radically new method of recording and communicating traditional statutory and operational reports.

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 of prevention of fires and explosions in coal mining, CSIRO in conjunction with ACARP is developing optimum proactive inertisation strategies to reduce the risk of heatings/fires in underground longwall mines. Field studies carried out at two mine sites demonstrated that the proactive inertisation strategies developed during the research were highly successful in achieving effective inertisation and reducing the risk of heatings/fires in longwall goafs. Research in these areas is critical for survival of a number of highly capital intensive coal mines. Such research delivers potential benefits in the order of several hundred million dollars to the Australian economy through its major export earner, coal.

COSFLOW

Advanced COSFLOW software was recently developed to simulate mining induced complex interactive processes between rock, water and gas. This was a result of a collaborative project entitled "Predevelopment Studies for Mine Methane Management and Utilisation", between NEDO/JCOAL of Japan and CSIRO. Over the last few years, COSFLOW has been successfully applied to mine planning and environmental management at eight mine sites in Australia and China.

The recent development of COSFLOW software was a major breakthrough for the prediction of mining conditions, especially in the complex conditions associated with longwall caving, deep mining, and mining over and under or near rivers and stored water (natural aquifers or flooded abandoned mines). This software has major advantages over other commercial and research codes. It provides a completely new and effective approach for predicting and assessing the complex interaction between strata fracture/movement, water and gas flows during coal mining.

Longwall Top Coal Caving

CSIRO in conjunction with Yankuang Mining Group (China) and the University of New South Wales has assessed the application of longwall top coal caving (LTCC) to Australian conditions. More recently CSIRO funded by ACARP has been researching key elements for the implementation of the LTCC in Australia. This has resulted in the development initially of new tools to enable the accurate characterisation and assessment of caving conditions and the completion of the project will see ventilation, gas, dust and spontaneous combustion issues also addressed. With the commissioning of the first LTCC face in Australia to occur in June 2006 in the Hunter Valley of New South Wales, CSIRO has been working with the mine owners, Yancoal Australia, on various aspects of the mine's development

Transparent Flameproof Cover

A flameproof enclosure fitted with a transparent cover will improve the efficiency of electrical fault finding and diagnostic practices within the coal mining industry. The greatest advantage is that the operation of all enclosed electrical and electro-mechanical equipment, and instrumentation can be visually observed while power is applied to the enclosure. This is not possible with non-transparent cover material.

A direct result will be faster and more accurate fault identification and improved preventative maintenance practices. This will result in increased machine availability, and a decrease in maintenance cost, which in turn will lead to a significant increase in productivity.

Metalliferous mining

Queensland has a wealth of mineral bodies yielding 30 mineral commodities. Total metalliferous mineral production in Queensland in 2003-04 was valued at $4.8 billion, up from $3.5 billion in 2002-03. Metalliferous mining research at QCAT includes work in rock cutting, geomechanics, automation and new mining techniques.

*SMART*CUT*

The objective of the SMART*CUT technology is to commercialise the use of diamond and ceramic composite cutting elements in tools suitable for:
a. mechanical excavation
b. rock cutting
c. drilling
d. sawing.

This new generation of cutting tools has applications in the installation of mining and road profiling machinery, drill bits with longer life than currently available, and saw blades and diamond wires that offer increased productivity, efficiency and economics over current tooling systems.

CSIRO in collaboration with Placer Dome is developing picks for use in its mechanical excavation program. Initial laboratory trials to demonstrate the cutting performance of 8 and 12 mm diamond composite cutting elements on a 360 mm diameter cutting drum on a range of rock types have commenced. These trials will establish the operating envelope of the picks and measure the wear rate as a function of rock type, speed and feed rate.

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 in collaboration

with partners. ROES™ uses a new generation of remote controlled equipment to drill, load explosives and initiate blasts.

In traditional mining methods, 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 to the only 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.

Current estimates are that ROES™ will reduce mine operating costs by between 10 and 20 per cent. This will result in savings of up to $200 million a year in 18 target mines alone. It also means that at least $100 billion of currently sub-economic ore may become economic, creating large new reserves for Australia. In addition, the method is applicable to underground quarrying near cities.

CSIRO, Orica and BHP Billiton (formerly WMC Resources) and Stem Partnerships are currently working together on the feasibility of trialling ROES™ at Olympic Dam. This follows earlier work between 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.

Large Open Pit Mine Rock Slope Stability Project

CSIRO Exploration and Mining, through its expertise in slope stability and open pit mining geomechanics, has initiated a major research project involving the stability of rock slopes in large open pit mines. The purpose of the research is to address critical gaps in our 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.

There is a pressing need for such innovative mining geomechanics research. Historically, the largest open pit mines have been up to 500 metres deep. In the last ten years, some have reached 800 metres deep, and ten 10 years.

The inadequacy of current slope design in this inverted 'high rise' environment has been exposed by a number of spectacular slope failures. These failures has resulted in multiple fatalities and production losses and attracted extremely unfavourable world-wide publicity.

This project has three objectives:

1. Publication of an authoritative new generation Pit Slope Design Manual that links innovative mining geomechanics research with best practice in open pit slope design.
2. Research that provides vital 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 remote data acquisition methods, automated data analysis and interpretation methods, 3D modelling, simulation and design analyses, and uncertainty analysis.
3. Development of enhanced risk management criteria focussed on the relationship between risk reduction and the uncertainties of slope design and their impact on mine performance.

The research plan has been agreed and is being sponsored by a group of ten mining companies representing the majority of the world's production of diamonds and base metals. These companies are:

- Anglo American pl, 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.

Sand Mining Systems

Over several years CSIRO has collaborated with CRL to improve the dredging operation of North Stradbroke Island in Moreton Bay.

The objective of the project is to install instruments and monitoring computers on a CRL Dredge, North Stradbroke Island and use the results to design a system for remote control of dredges from the concentrators.

The project will deliver:

- electronic instrumentation and a monitoring system with touch-screen operator interface to assist the operator control the dredge
- design, project plan and budget, risk analysis for conversion of dredges to remote control.

Outcomes: Processing

Innovative and cost effective processing of Australia's mineral wealth is essential to the industry. Researchers at QCAT are conducting research and development to assist the industry in Australia and overseas.

Iron ore and non-ferrous mineral processing

With continued strong market growth, the iron ore industry is demanding more from its existing resources and equipment and is developing new resources to expand production. In response to these drivers, CSIRO Minerals at QCAT is continuing to work closely with the industry to meet its needs using CSIRO's unique range of expertise that extends from detailed mineralogical, beneficiation and agglomeration evaluations to predicting and optimising the processing performance of sinter, pellets and lump in the blast furnace. The non-ferrous mining industry is under similar pressure to optimise existing operations and reduce costs, particularly in the energy intensive grinding area, so QCAT research staff are also involved in optimising the performance of SAG mills as well as stirred mills.

Predicting processing performance

Research is continuing on the accurate prediction of downstream processing performance for resource evaluation and development. This involves linking ore mineralogy and petrology to metallurgical performance using optical microscopy/computer-based image analysis and mineralogy-based models of unit processes such as hydrocycloning and magnetic separation, which will enable more rapid assessment of processing options and the likely viability of new ore deposits. This approach is expected to minimise expensive laboratory and pilot-scale research on ores that are not promising.

More effective beneficiation strategies

While QCAT research staff continue to be involved in the search for premium grade iron ores and the subsequent evaluation of prospects, more effective beneficiation strategies are also being developed as alternative iron ore sources of lower grade or containing impurities, such as Marra Mamba, high-phosphorus Brockman and Channel Iron Deposits, are being exploited. However, there is still a shortfall in supply of traditional hematite/goethite ores to overseas markets, particularly to Chinese steel mills, which has kindled a keen interest in Australia's substantial magnetite ore resources, including a significant resource in Queensland. Research has continued on beneficiation of magnetite resources, including magnetite tailings, which involves mineralogical investigations coupled with the commissioning of new laboratory- and pilot-scale magnetic separation equipment. The challenge for the beneficiation of fine tailings is removal of some of the minor elements that cause problems in subsequent pelletising and ironmaking operations.

Agglomeration research

The agglomeration research being conducted at QCAT on sintering and pelletising of iron ore fines continues to be pivotal in proving up new resources for export and local consumption. Together with industry, new ores and ore blends for sintering are being optimised by conducting detailed mineralogical characterisation investigations to better understand the process fundamentals, together with trials at scales ranging from laboratory to pilot scale. A key facility in this context is CSIRO's state-of-the-art pilot-scale sinter rig, which is world class with automated computer-based data logging and emission monitoring capabilities, including CO, CO_2, NOx, SOx and particulates. The rig is currently being modified to enable deep bed sintering (>0.5 m bed depth), which is being introduced into sinter plants around the world to increase productivity. A small-scale sintering facility has also been commissioned over the last year that allows sintering performance to be assessed on samples of only 5-10 kg, compared with 80 kg for the pilot-scale facility. This enables initial assessments of sintering characteristics to be made on drill hole samples well in advance of bulk samples becoming available, allowing early termination of development if the sintering characteristics are unacceptable. Due to increasing environmental pressures on sinter plants to reduce emissions, research is also in progress on understanding the mechanisms of formation of CO_2, NOx and SOx and how to reduce these emissions at the outset, e.g. by replacing coke with alternative biomass fuels.

Iron ore pelletising

The recently commissioned pilot-scale iron ore pelletising facility has also been in active use over the last year for optimising balling, drying and induration of iron ore pellets, particularly for magnetite feed ores. At present, it is best configured for simulation of straight-grate pellet induration, so it is about to be upgraded to incorporate a rotary kiln for simulating grate-kiln induration, the preliminary design of which is complete. Grate-kiln induration is gaining favour around the world for iron ore pelletisation. A computer-based simulator called Siro-Indur has also been developed for optimisation of straight-grate and grate-kiln pellet induration. It has been applied both in Australia and overseas, and there are potential applications in Brazil and China.

Plant optimisation

Research for the non-ferrous mining industry on fine grinding (<38 micron) using stirred mills and SAG mill optimisation is continuing. A wide range of laboratory and pilot-scale fine grinding 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 the performance of various fine grinding media. The three-year extension of the AMIRA SAG mill project (P667A) to monitor mill performance via surface vibrations is well under way. It has been demonstrated that the toe and shoulder positions of the charge inside the mill, as well as other operating parameters such as mill load, can be monitored using this technology. A ruggedised industrial monitor with an inertial power supply for continuous operation has been developed and trialled on a full-scale SAG mill in Australia, with other installations expected to follow in the near future. This technique has also been applied to stirred mills with interesting initial results.

The Centre for Sustainable Resource Processing

A new area of involvement for CSIRO Minerals at QCAT is the Centre for Sustainable Resource Processing. In collaboration with research staff and students from the Julius Kruttschnitt Mineral Research Centre, QCAT staff are contributing to a foundation project on 'Eco-efficient Liberation and Comminution'. The objective of the project is to develop ways in which total comminution energy at selected industry sites can be reduced by 20 per cent or more. CSIRO's role is to assess the benefits of using more energy and efficient comminution equipment, such as stirred mills, instead of more conventional grinding mills, in a range of different applications.

Standards development

Our researchers continue to play a leading role in the development of both ISO and Australian Standards for international trade in iron ore, base metals and coal. Current efforts are aimed at improving the sampling of iron ores, coal and copper, lead, zinc and nickel ores and concentrates, as well as the analysis and physical testing of blast furnace and direct reduction feedstocks for iron and steel making. Recent work includes the development of draft standards for sampling coal, base metal and iron ore slurries for which there are no existing ISO or Australian standards.

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 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 focussed plant trials.

Outcomes: Manufacturing

Light metals are a vital component of the Australian economy. Australia is the world's largest producer and second largest exporter of bauxite, the world's largest producer and exporter of alumina and the world's fifth largest producer of aluminium. The total value of all aluminium sector exports was over $7.8 billion in 2003.

The vast majority of Australia's national product is generated, facilitated or channelled through our cities….It is here where the global competitiveness of the Australian economy will be secured. Intelligently developed cities with intelligently designed infrastructure not only benefit the country they directly benefit all business sectors……intelligent infrastructure investment stands out most prominently as guiding the pathways of cities in the global economic superstructure (from Crawford 1996).

Light metals engineering

Magnesium Alloy Development

QCAT played a supporting role in the development of a magnesium engine block alloy within the CAST CRC. The alloy has been used in an engine used in a Volkswagen Lupo that recently passed its 65,000 km tests. The 1.2 litre AM-SC1 magnesium engine is 70% lighter than the cast iron engine it replaces. This weight saving could result in greenhouse gas savings of up to 2.5 tonnes of carbon dioxide over the life of the vehicle. The work conducted at QCAT was to confirm the fatigue performance of the engine block alloy, particularly at operating engine temperatures.

BMW has started to introduce hybrid magnesium-aluminium engines in many of its models. The USCAR program in the USA is currently producing magnesium engine blocks from AM-SC1 for evaluation for use in vehicles in North America.

Magnesium Melt Protection

Researchers at QCAT developed a new system for stopping molten magnesium from burning. This is a major issue in magnesium processing as the current method uses sulphur hexafluoride, the world's most potent greenhouse gas. The new system replaces sulphur hexafluoride with a refrigerant gas that is commonly used in car air conditioning systems. Recent collaborative studies in conjunction with the US EPA in America, showed that the development can result in 98 per cent savings in greenhouse gas emissions compared to a conventional system.

Industrial trials of the new system are complete and conversions are taking place in three continents. At one US die caster, switching eight die casting machines to the new gas system saved the company US$10 per tonne of magnesium they processed and saved greenhouse gas emissions of over 170,000 tonnes of CO2-equivalent, the equivalent of taking 40,000 cars off the road. If adopted worldwide, total emission savings would be the equivalent of taking over 1 million cars from the road or planting 17 million trees.

Light Metals Fatigue

Ongoing research at QCAT on the fatigue properties of castings has continued for a number of magnesium and aluminium casting applications. In addition to studying the magnesium engine-block alloy referred to above, we are also investigating the influence of casting process and surface finish for suppliers of automotive parts. The aim is partly to improve fatigue life, but more importantly to reduce the scatter in component life, allowing a combination of lighter weight with higher reliability, especially of safety-critical components.

DC-casting productivity

The Boyne Smelter at Gladstone uses the VDC casting process to produce billet of aluminium alloy for subsequent extrusion, of which the most common example would be for window frames. Billet productivity and quality is limited by centreline hot-tearing. QCAT researchers, in collaboration with the University of Queensland, Monash University and Comalco have been studying the interrelation between minor chemical elements, solidification microstructure and hot-tearing incidence. Trends identified in the studies have been confirmed by studying production data from the smelter, and have suggested a direction for productivity improvements.

Environment, Water and Energy of Cities

The Brisbane Future Cities and Asset Performance and Sustainability teams focus on life-cycle assessment of the energy, water, and environmental impact of buildings and cities. Our partners include the CRC for Construction Innovation (CRC-CI based at QUT), Forest and Wood Products Research and Development Corporation, and the American Water Works Association Research Foundation.

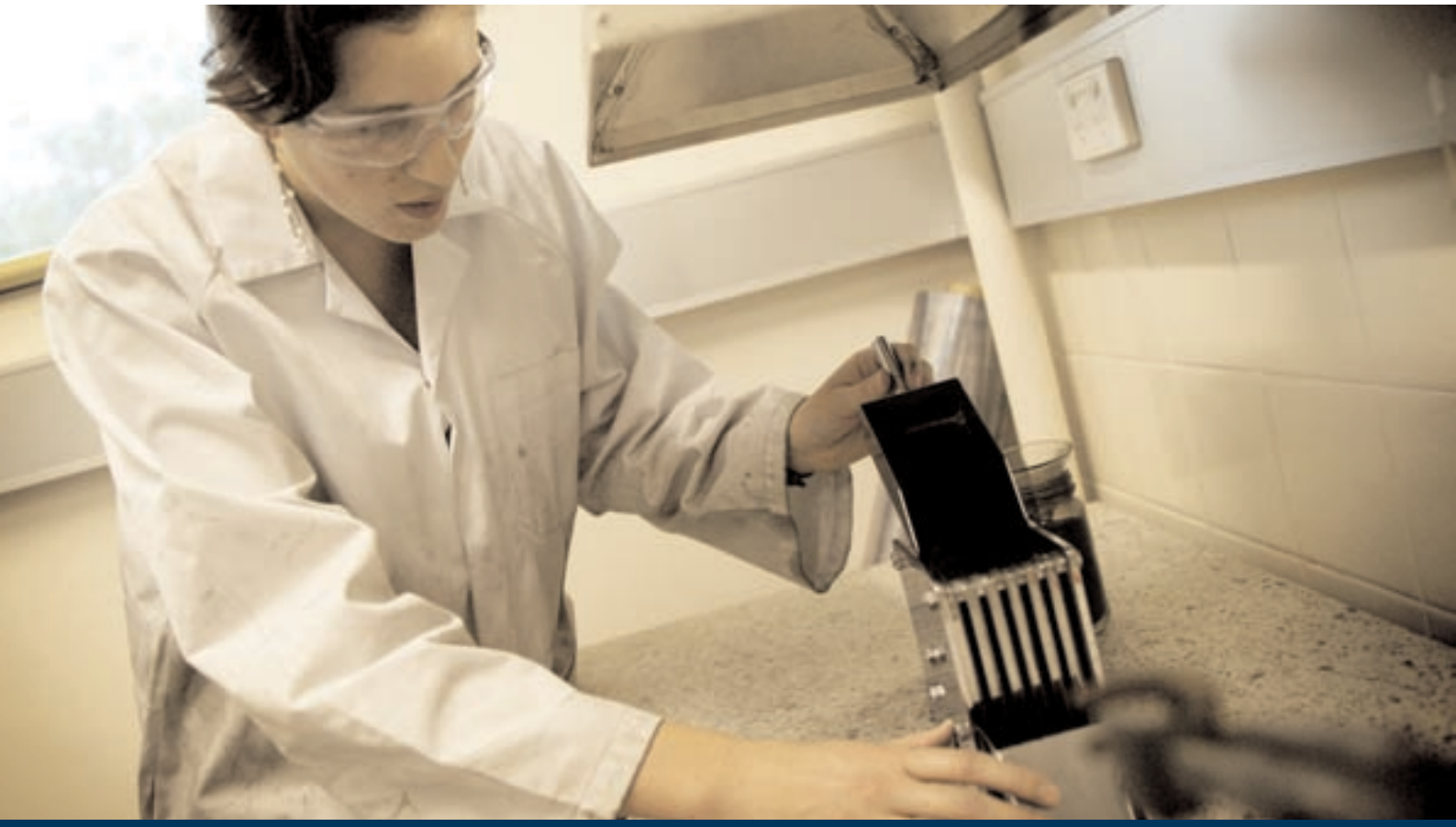
CRC-CI research includes the Life Cycle Analysis (LCADesign - Virtual Prototypes project) for commercial buildings, which helps designers understand the full impacts of alternative building designs. The sustainable subdivisions (energy efficiency) project has recently been expanded to investigate ventilation issues in South East Queensland.

Future Cities is also preparing a guidebook to triple bottom line reporting and sustainability assessment for American drinking water utilities.

New flagship and theme-strategic projects (e.g. system analysis of urban water) are also under way. Work is also emerging with the Qld Department of Housing, CRC for Desert Knowledge, the CRC for Water Quality and Treatment, and local government.

A new research agreement has recently been established with Queensland Housing to further develop consulting services and co-investment research.

Outcomes: Energy



Research into coal utilisation at QCAT includes assessing the gasification performance of coal. The ultimate goal is to improve power generation efficiencies, reduce emissions and provide research support for the development and implementation of advanced low emissions power generation technologies in Australia.

Coal utilisation

Demand for electricity in Australia is predicted to double by 2020. Similarly, demand for Australian coal in world markets is also at unprecedented high levels. It is therefore very important to improve the performance of Australian power generation technologies and to support the efficient and clean use of Australian coal in international energy markets. Major scientific projects and facilities at QCAT have been designed to address the environmental and commercial imperatives facing the coal and energy industries. Research encompasses the key stages of coal preparation and utilisation, coal gasification and the development of new 'low emissions' power generation systems.

CSIRO in collaboration with the Cooperative Research Centre for Coal in Sustainable Development, operates an advanced coal gasification facility at QCAT. The facility is used to evaluate the performance of Australian coals under the high temperature, high pressure gasification conditions that are central to the leading advanced power generation processes. This research provides practical information to assess and optimise coal use in 'clean energy technologies' that will form the basis of future coal-based power generation systems capable of operating with low, and ultimately zero, atmospheric emissions. These technologies are capable of underpinning the development of large scale hydrogen based energy systems that are likely to be required to meet future greenhouse emissions targets with practical and affordable energy technologies. It provides the detailed technical information required to introduce and support coal use in new domestic and international markets based on high efficiency coal utilisation technologies. This research will provide important technical support to assist the domestic power industries assess and implement these technologies in Australia.

In this field, QCAT is a recognised centre of excellence, with the necessary facilities and expertise for the evaluation of coals and technology performance. This work is helping the Australian electricity industry reduce the risks of selecting and implementing advanced power generation technologies and will make an important contribution to the expertise required to evaluate fuel and energy strategies for sustainable energy conversion technologies in this country.

CSIRO is also the major research contributor to the Centre for Low Emissions Technology (cLET). This Centre is a $26M joint venture between CSIRO ($9m), the Queensland Government ($9m), Stanwell Corporation ($2m), Tarong Energy ($2m), ACARP ($2m) and the University of Queensland ($2m). cLET focuses on key aspects of coal gasification and important gas cleaning, processing and separation technologies that will be necessary for development of commercially feasible, large scale CO_2 capture, and hydrogen production systems for power production. These are key technologies at the heart of future low-emissions power generation systems.

This world-class facility and research program is an important part of a broader national effort to increase the competitive advantage of Australia's mining, energy and manufacturing industries.

Outcomes: Sustainability

The Australian minerals industry is crucial to the country's economic and social wellbeing. Without a viable minerals industry we cannot maintain the social, economic and environmental processes that underpin sustainable development.

The industry's long-term future rests not only on how it responds to economic challenges, but also how it responds to the challenges of sustainable development. Research at QCAT provides the industry with strategies and technologies for developing sound sustainability practices.

Mining and Sustainable Development

Mining and Sustainable Development focuses on issues which assist mineral and energy companies to protect their licence-to-operate in exploration and mining. These areas are safety and health, environmental management and social integration.

QCAT scientists and engineers have been working on the following projects:

Collision avoidance

We have conducted research into collision avoidance at mine sites, with the most recently research system currently being installed on a demonstration vehicle.

Greenhouse gas mitigation

Work on the mitigation of greenhouse gases in mining continues, with a number of research prototypes being developed to generate power from mine ventilation air. The aim is to achieve significantly improved greenhouse efficiencies at mine sites by finding ways of using the low and variable levels of waste methane at the site.

Solar energy

A system of using solar heat to power a Stirling engine has been developed, in conjunction with a Queensland engineering firm. This research also seeks to improve the greenhouse efficiencies by providing an alternative power source for remote mine sites. The heat storage device being developed for this application to allow stable operation despite sunlight fluctuation is significant to other renewable energy and waste heat usage applications.

Microtunneller

A new type of drilling system is under development to provide a step-change in drilling cost reductions and flexibility for applications in coal and mineral mining. CSIRO is currently testing a prototype of the 'Microtunneller', in coal, sandstone and granite.

Underground Coal Gasification (UCG)

We have evaluated opportunities for CSIRO to partner with industry and governments in UCG development and demonstrations. Our research indicates that in carefully selected geological conditions, simple small scale underground gasification can be successfully operated, controlled, cleaned up and shut down in an acceptable manner.

Uptake/acceptance of technology

Considerable effort is being put into growing research looking at the effects the uptake and/or acceptance of technology and the institutions that constrain science. QCAT is leading an initiative on Minerals and Energy in Society within CSIRO that hopes to provide a practical route to achieving sustainability that does not undermine commercial advantages in the minerals industry. Research to date in this area has involved public consultation in Queensland, NSW and WA on the acceptability of different energy technologies and supply scenarios, with plans to expand to a systematic national study.

Outcomes: Information & Communication Technology

Information and Communication Technology (ICT) is a core enabling technology that flows through all areas of new developments in mining. Australia has an enviable record in mining ICT. Approximately 60 per cent of all mining software used throughout the world is developed in Australia.

Robust Outdoor Vision-based Experimental Robots (ROVER)

Another Autonomous Ground Vehicle (AGV) project is being run in parallel with the autonomous HMC project. ROVER is developing generic ground vehicle navigation technology, using vision as the primary sensor. The main ROVER test platform is a small red tractor which has been converted to a fully computer controllable mobile robot. The tractor can be fitted with a multitude of navigation sensors and is often seen driving around QCAT (sometimes without a driver on-board). The ROVER project is demonstrating how vision can be used to localise a vehicle (know where it is), detect potential obstacles, and also identify free-space (such as road way) to drive along.

The CSIRO ICT Centre's Autonomous Systems Laboratory is running another Autonomous Ground Vehicle (AGV) project in parallel with the autonomous HMC project. It is called ROVER (Robust Outdoor Vision-based Experimental Robots). The ROVER project is developing generic ground vehicle navigation technology, using vision as the primary sensor. The main ROVER test platform is a small red tractor which has been converted to a fully computer controllable mobile robot. The tractor can be outfitted with a multitude of navigation sensors and is often seen driving around QCAT (some times without a driver on-board). The ROVER project is demonstrating how vision can be used to localise a vehicle (know where it is), detect potential obstacles, and also identify free-space (such as road way) to drive along.

Autonomous Hot Metal Carrier

Hot metal carriers (HMCs) are large forklift vehicles used to move hot metal from the pot lines to the casting machines in the metal products area and hence are a critical link in the metal production chain. The industry is interested in automation for similar reasons to the underground mining industry: safety, consistency of operation and the minimisation of hand-over time. Currently there are no automated HMCs in production anywhere in the world. This project aims to demonstrate that it is possible for an HMC to operate autonomously around an industrial site such as QCAT, which is similar in layout to a typical smelter operation.

The project is funded by the CSIRO Light Metals Flagship. The project team previously developed the autonomous load haul dump (LHD) vehicle navigation technology for underground metalliferous mining at QCAT (1999-2001).

In January 2005, Comalco donated an ex-production HMC (from its Bell Bay smelting operation) to the project. The HMC was retrofitted with automation components to allow it to be driven by an on-board computer as well as the traditional human driver. The second half of 2005 will see the HMC driving autonomously around QCAT.

Autonomous Underwater Vehicles for Environmental Monitoring

This project is focused on the development and application of advanced computer vision techniques for the autonomous navigation and control of a unique underwater vehicle. This vehicle, called Starbug, has been field tested throughout the year at remote locations such as Heron Island and Moreton Bay with impressive demonstrations of autonomous terrain following and survey tasks in highly unstructured reef environments using vision as the primary sensor. This technology is being evaluated by CMAR for use in augmenting its current research activities on the Great Barrier Reef.

Wireless Sensor and Actuator Networks

Sensor networks capitalise on Moore's Law which facilitates low-cost embedded sensory and computational elements with ad hoc wireless capability. Their deployment is revolutionising the availability and density of sensory data, however challenges exist in building robust and adaptive systems that utilise this data.

Recent advances have shown the possibilities for low-cost wireless sensors, with developments such as the Berkeley Mote along the path to the ultimate goal of smart dust. Based on this technology we wish to create versatile ICT systems which comprise networked robots and sensors: thousands of small low-cost sensors embedded in the environment, mobile sensors, robots, and humans, all interacting to cooperatively achieve tasks. This is in stark contrast to today's approaches where data is collected and analysed centrally, and robots are complex monolithic engineered, stand-alone work-alone machines. A paradigm shift will occur where human users or robots interact with ubiquitous sensors, static or mobile, embedded in the environment - to deploy them, to harvest data from them, and to task them.

Our project is focused on the following technological issues which we believe prevented widespread use of wireless sensor networks (WSN):

- Programmability, software development, distribution and debugging. Should we be programming devices or the network?
- Infield management and maintenance
- Managing the data; centralised or distributed,
- Heterogeneous networks.

Our approach is unashamedly driven by applications. We believe that only by tackling real and difficult applications with audacious goals will we discover the important, rather than the imagined, science problems. We are currently working in three domains.

1. Farming 2020 is a collaborative project with CSIRO Livestock Industries, formulated by asking the futuristic question: “What kind of remote environmental IT system would we like to have in Australia?”

The answer is envisaged as a new approach comprising pervasive, self-configuring network of cheap, simple agents learning about their environment and seeking to control it for beneficial purposes.

2. Oceanic sensor networks with robotic interaction is a collaborative project with researchers at MIT and is exploring techniques in which underwater sensor networks and underwater robots operate synergistically to accomplish complex tasks.

3. The QCAT Fleck-Net currently consists of a small number of WSN devices. However, ultimately this sensor network will be expanded to more than 50 nodes, with nodes located in buildings, among trees, in creeks, on open grassy fields, indoors and even on people and machines. The intention of the QCAT Fleck-Net is to provide a real-world medium scale ad hoc wireless sensor network test bed which exhibits many of the challenges that need to be addressed to make sensor networks work. The QCAT Fleck-Net has been running since 8 March, 2005 and has collected nearly 800,000 packets, each containing multiple sensor readings.

The Centre for Low Emission Technology

Progressing the development of enabling technologies for the production of low emission electricity and hydrogen from coal

The Centre for Low Emission Technology (cLET) is a $26 million partnership between world class research and development providers that will make it possible for Australia to continue using its abundant coal resources for the production of zero carbon electricity and/or hydrogen. This partnership includes the Queensland Government through the Department of State Development and Innovation, CSIRO through CSIRO Energy Technology and its Energy Transformed Flagship Program, Australian Coal Research Limited, Stanwell Corporation Limited, Tarong Energy Corporation Limited and the University of Queensland.

The primary focus of the Centre is on research and development of next generation low emission technologies with an emphasis on improved gas cleaning, gas separation and gas conditioning technologies for the development of Pulverised Coal and Integrated Gasification Combined Cycle based, advanced power and/or hydrogen and synfuels production technologies.

The approach being taken by cLET is to contribute to a coordinated research and development effort with its partners and other Australian stakeholders such as Coal 21, the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC) and the Cooperative Research Centre for Coal in Sustainable Development (CCSD). cLET recognises that there are other organisations conducting R&D in related areas and is committed to actively liaising with these and other relevant groups in Australia and overseas to ensure the best possible use of resources, and in ensuring that the work conducted by cLET compliments and builds on that being undertaken elsewhere.

Five main program areas of work associated with the development of the core technologies identified above will be pursued in the work undertaken by the centre. These include gasification and core facility development, gas cleaning, gas processing (or conditioning), gas separation and social and economic integration. Projects being undertaken by the Centre include the following:

Gasification/Core Facility: GCF001 - Gasification performance of Australian coals - Pilot gasifier trials; GCF002 - Scoping the development of a national low emissions gasification research facility; GCF003 - Syngas Generator for the cLET research program.

Gas Cleaning: GC001 - Identify novel protectors for candle filters and identify sorbents to co-remove gaseous contaminants.

Gas Processing: GP001 - Catalysts for water gas shift reaction with coal-derived syn gases in fixed-bed and catalytic membrane reactors; GP002 - Water gas shift reactions in high temperature membrane reactors.

Gas Separation: GS001: Proof-of-concept engineering systems for membranes and catalytic membrane reactors (CMR) in coal gasification; GS002 - Thin film metal membranes for hydrogen separation.

Social and Economic Integration: SEI001 - Assessing and integrating stakeholder perspectives.

Dr. Kelly Thambimuthu was appointed as the CEO of cLET in October 2004. His former role was as a Science and Technology Director at the CANMET Energy Technology Centre in Ottawa, Canada. His ongoing commitment to other external activities includes roles as: Chairman since 1995 of the International Energy Agency Greenhouse Gas R&D Programme, the leading group within the International Energy Agency/Organisation of Economic Cooperation and Development (IEA/OECD) evaluating options to achieve deep reductions in greenhouse gas emissions from fossil energy use; and as an editorial panel member and coordinating lead author since 2002 of the UN Intergovernmental Panel on Climate Change (IPCC) committee formed to write a special report on CO_2 capture and storage as a climate change mitigation option.

Alcan's Queensland Research & Development Centre

The recent opening of the Queensland Research and Development Centre (QRDC) at Queensland Centre for Advanced Technologies (QCAT), further cements Alcan's leading position in alumina technology research.

QRDC is located in a new purpose-built $2.4 million laboratory at QCAT, which was constructed with financial support from CSIRO and the Queensland Government, and leased back to Alcan, for the term of 15 years.

The centre is developing new technologies and enhancing existing alumina production processes.

Combined with Alcan's existing research and development centre in Quebec Canada, QRDC's establishment strengthens the company's position to provide innovative technology for the future of its Bauxite and Alumina Group.

Alcan's investment in R&D at QRDC is expected to exceed $50 million over the period of the lease.

The location

In 2002, Alcan decided to relocate a significant part of its bauxite and alumina R&D to Australia, as part of a long-term commitment to maximising value in the country's minerals and resources industry.

Brisbane was selected as the location for QRDC due to its proximity to the 100 per cent Alcan-owned bauxite mining and alumina refining operations in Gove in the Northern Territory, which is undergoing an AU$2 billion expansion, and the 41.4 per cent owned Queensland Alumina Limited.

Furthermore, it is only five hours flying time from Perth, where an Australian (and global) concentration of alumina production and industry research infrastructure exists.

Other important factors were Brisbane's intellectual, civil and social infrastructure, and its access to international and interstate travel, as well as the establishment and rapid growth of Alcan Engineering Pty Limited, a wholly-owned Alcan subsidiary which is working towards becoming the alumina industry's preferred engineering provider.

Collaboration

QRDC's location at QCAT gives Alcan an opportunity to work in collaboration with premier Australian research organisations such as CSIRO.

Collaboration is one of QRDC's mandates and it recognises the many benefits in partnering with CSIRO due to its depth of expertise and scope of work.

QRDC also collaborates with external research institutions and alumina refineries across the globe.

QRDC's research

QRDC is Alcan's global centre for R&D in the areas of Bayer precipitation, impurity removal and management, corrosion, process modelling and lime chemistry.

While increasing productivity and lowering costs, QRDC will deliver sustainable technology improvements that benefit employees, the environment and local communities.

The technology improvements will make for a safer and cleaner process, produce more alumina from fewer raw materials and energy, and lower waste and emissions.

Major projects

World class technology is being developed at QRDC to enhance the Bayer process. Some objectives include:

- Improving precipitation yield by 30 per cent above best practice
- Developing knowledge and analytical tools for better control of precipitation processes and product quality
- Lowering costs for removal of impurities from Bayer liquor
- Increasing effective use of lime in the Bayer process
- Developing innovative impurity removal and management processes
- Developing computer process models which allow improved simulation of the Bayer process
- Further developing Alcan's Hyprod© Precipitation model that is supported at QRDC
- Reducing corrosion in alumina refineries through better materials selection and operating practices.

Facility opening

QRDC was officially opened on Tuesday 26 July 2005 by the Honourable Ian Macfarlane MP, Federal Minister for Industry, Tourism and Resources and Mr Michael Choi MP, Member for Capalaba, who was representing the Honourable Tony McGrady MP, Queensland Minister for State Development and Innovation. Alcan was represented at the opening by Richard Yank, President of Alcan Bauxite and Alumina's Pacific Operations.

Around 70 guests attended the event, including representatives from CSIRO, Alcan and industry groups and other federal and state government departments.

Employees

At full strength, QRDC will employ 16 people dedicated to R&D for Alcan's present and future alumina production facilities.

QRDC's employees will leverage the many opportunities for collaborative research in Australia. Other specialists will be employed indirectly through projects with organisations such as CSIRO, Cooperative Research Centres, universities and private research organisations.

About Alcan

Alcan is a multinational, market-driven company and a global leader in aluminium and packaging, as well as aluminium recycling. With world-class operations in bauxite mining and alumina processing, primary aluminium, engineered products as well as flexible and specialty packaging and aerospace applications, Alcan is well positioned to meet and exceed its customers' needs for innovative solutions and service. Alcan employs 70,000 people and has operating facilities in 55 countries and regions.

Alcan has been part of Australia's aluminium industry since 1967, with 60 per cent of its global alumina production coming from this country.

Australia is now Alcan's major capital base outside of Canada and represents a $3.5 billion investment.

Alcan directly employs more than 3,500 people through its Australian interests.

These interests include bauxite reserves in the Northern Territory and North Queensland, 51 per cent ownership of the Tomago Alumina Smelter in New South Wales, and a commercial office in Sydney.

In addition, Alcan's Packaging Group is establishing a new production facility in Adelaide, to produce Stelvin wine screw caps for the Australian and New Zealand markets.

The Technology Transfer Centre

Almost all of QCAT's commercial tenants occupy the Technology Transfer Centre. They have been attracted by the growing research activity and the creation of a critical mass of mining expertise in an attractive, leafy environment.

Advanced Mining Technologies

Advanced Mining Technologies continues to make considerable headway with the introduction to market of its CAS-CAM/RF® Collision Avoidance Technology. A full mine install is underway at the Anglo/Falconbridge – owned Collahuasi mine in northern Chile, while evaluation continues at other mine sites in Australia and the USA. Further success is expected which will generate significant revenues from this development and maintain our CAS-CAM/RF® technology as the market leader, as well as underpin ongoing development.

During the last 12 months has continued to receive orders for its newly released drill guidance system (DGS), which provides both the underground coal industry and surface Coal Bed Methane operators with a state-of-the-art electronic Measurement Whilst Drilling steering tool for gas drainage. The DGS is available in both Intrinsic Safe (IS) configuration for underground and non-IS configuration for surface-to-seam operation. The DGS has set a new benchmark for directional drilling technologies with ongoing sales success in Australia, the USA and China.

Applied Mining Technologies Pty Ltd

Applied Mining Technologies has played 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 are incorporating our 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 advances in automation. In collaboration with major equipment manufacturers and suppliers, we have developed a complete and integrated highwall monitoring and control package incorporating inertial and horizon control technologies.

Australian Centre for Minerals Extension and Research (ACMER)

In 2004-05, the Australian Centre for Mining Environmental Research experienced a number of changes to enhance the Australian mineral industry's capacity to meet the challenges of sustainable development. These changes include gaining of industry-wide financial support of the Centre through the Minerals Council of Australia (MCA), development, in concert with MCA, of a sustainable development extension program, restructure of the Board, and renaming of the Centre to the Australian Centre for Minerals Extension and Research (ACMER) to more accurately reflect its core activities.

The Centre has six industry members (AngloGold Ashanti Australia Limited, BHP Billiton Limited, MCA, Newmont Australia Limited, Placer Dome Asia Pacific Limited and Rio Tinto Limited) with a seat on the Board, which also includes the Ministerial Council on Mineral and Petroleum Resources (representing all state government Departments of Minerals and Energy and the Australian Government Department of Industry, Tourism and Resources), the Australian Government Department of the Environment and Heritage and the Queensland Government Department of Natural Resources and Mines. Additionally, a representative of research organisations, with which ACMER has memoranda of understanding (MOUs), also sits on the Board, together with an Independent Chairman (Dr Ian Gould). MOUs have been signed with ANSTO, CSIRO, Curtin University of Technology, the University of Queensland and the University of Western Australia, which represent a comprehensive range of multidisciplinary skills covering the physical, chemical, biological and social sciences.

ACMER pursues its mission of providing the scientific and technological rigour and support to enable the minerals industry to plan, operate and close mines in an environmentally and socially responsible manner through research, technology transfer and advisory services.

Major research programs include waste rock dump stability, final void use, prevention and remediation of acid mine drainage, mine water management, tailings disposal and remediation, and ecosystem reconstruction.

In 2004-05, ACMER completed five research projects and commenced three others. Completed projects included:

- Bioavailability of Metals.
- Review of Methods for Water Quality Assessment of Temporary Stream and Lake Systems.
- Development of Rehabilitation Completion Criteria for Native Ecosystem Establishment on Coal Mines in the Hunter Valley.
- Good Practice Guidance for Mining and Biodiversity.
- Innovative Techniques for Promoting Fauna Return to Rehabilitated Sites following Mining.

New projects included:

- Optimising Collection, Storage and Germination of Australian Native Plant Species
- Robust Guidelines and Assessment Procedures for Metal-Contaminated Sediments
- Integrating Economic and Biophysical Factors to Assess Grazing Risks for Rehabilitated Pastures in Central Queensland

During the year, ACMER conducted three short courses and seven workshops on a range of environmental and social topics around Australia. These were conducted as part of the Sustainable Development Extension Program conducted in association with the MCA.

Cheron Group

Cheron funds, develops and commercialises early stage automotive technologies. The objective is to exploit opportunities arising in the rapidly evolving global automotive industry. The industry is faced with the significant challenges of increasing competition, demanding customers, rising concerns about fuel costs and availability, and global environmental impacts. Increasing demand for new technology is a key part of the industry's response.

The group's integrated holistic approach entails active technology sourcing, rigorous screening and assessment, provision of the right amount of funding at the right time, application of critical skills as required and a ‘hands on’ control of the development and commercialisation process.

Cheron is currently raising a $30m Managed Investment Scheme to fund a portfolio of technologies and the development of the group.

The group came to QCAT early in 2004 after successful discussions with CSIRO and the Queensland Department of State Development and Industry.

Cheron is keen to build a strong collaborative relationship with CSIRO, with particular focus on the Light Metals and Energy Transformed Flagships

Cheron's proposed second stage development would extend its operations at the QCAT. It would see the establishment of a new fully integrated engineering facility to research, develop, manufacture and test new automotive technologies. Initial discussions have commenced with the CSIRO and Queensland Government on this proposal.

ComEnergy

ComEnergy was formally established in August 2003 with its headquarters at QCAT. A board has been formed under the stewardship of Chairman Mr. John Ward and representatives from CSIRO and the Liquatech Turbine Company.

The primary role of ComEnergy is to commercialise the hybrid coal and gas turbine system patented by CSIRO. The benefit of the system is that it uses mine waste - coal rejects, coal tailings, mine methane including ventilation air - to generate 10 MWh of power and in the process clean up the mine site.

Engineering design of the full scale unit, based on the 1MWh trial unit constructed at QCAT, has now been completed. This will allow the construction of a mine site unit capable of generating 10 MHw of electrical output, and a number of detailed feasibility studies have been commissioned at Australian and Chinese mine sites to establish their suitability for the operation of a 10 MWh plant.

Function

The primary role of the unit is to co-fire low grade fuels (coal rejects, tailings) in a rotary kiln rather than in the traditional furnaces. Firing the fuel by this method allows the addition of fuels such as low concentration methane (as low as 0.4%) which could not be fired in the traditional furnace boiler. Non-combustible material associated with these fuels (rocks) which would foul a traditional boiler are simply rejected once all their fusionable material has been consumed. The long resonance time created by the fuel's journey down the length of the rotary kiln allows for the utilisation of any very low concentration methane to contribute to the combustion process. Low concentrations of methane that would normally be vented to the air such as vent air methane are utilized by ducting them into the kiln, and the venting of these gases to the atmosphere is prevented.

This process allows the claiming of green credits for the NSW (NSW Government Greenhouse Gas Abatement Scheme).

The proprietary software ensures that although the low grade fuels create an irregular flow of heat, the electrical output of the unit is constant.

Biomass

A further development has been the identification of an opportunity for the burning of biomass waste fuels. Currently ComEnergy is negotiating with an Australian company for the establishment of a unit to burn biomass at a site in Queensland.

This process will allow the claiming of Renewable Energy Credits under the Australian Governments EMRIT scheme.

Cooperative Research Centre for Coal in Sustainable Development (CCSD)

The Centre brings together most of Australia's black coal researchers as well as experts in sustainability. Government and industry have committed $61 million over the seven-year period 2001-08 to identify and investigate opportunities for coal chain efficiencies and reducing carbon intensity in energy systems, and providing a better understanding of Australian coal performance in combustion, gasification and emerging sustainable coal utilisation technologies. Other research includes environmental and social assessment, ironmaking, and by-product and waste utilisation.

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

This has been a milestone year for CCSD, with the beginning of new work to support the transition to new advanced generation technologies, as foreshadowed by the CCSD 2003 Prof Chris Fell *Review of CCSD Research Programs* and the 2004 COAL21 National Action Plan in March 2004 *Reducing Greenhouse Gas Emissions Arising from the Use of Coal in Electricity Generation A PLAN OF ACTION FOR AUSTRALIA*, and the commencement of planning for R&D after June 2008 when the CCSD funding agreement ends.

The Australian Government White Paper *Securing Australia's Energy Future* released in June 2004, has provided additional momentum to the introduction of new energy technologies through the establishment of the low emission technology development fund. Climate change and sustainable development are two key issues driving change in the technologies that provide the energy needed for our modern society. The next 10 to 15 years will see major changes in coal fired energy generation. How such change will be supported by R&D for the implementation phase and ongoing operations is the important question currently being addressed by the CCSD Board and COAL21.

To maintain momentum and provide expert advice on the technology transfer of emergent low emissions technologies, CCSD hosted several eminent visitors to Australia that included Mr Maarten van der Burgt (Gasification author ex-Shell, Netherlands), Prof Lars Stromberg (Vattenfall, Sweden), Mr. Thomas Chhoa, Shell Gasification, Dr. Victor Der (DOE, USA) and Dirk Volkmann (Future Energy, Germany), Dr. Krish Krishnamurthy (BOC, USA), Mr Suryanarayan Ramanan (GE Turbines) and Dr. Robert Finkelman (USGS). All participated in well-attended and useful seminars/meetings with industry and researchers on advanced technologies.

Other major CCSD achievements during the year included:

- The provision of technical assessment modelling to the Australian Greenhouse Office for their review of Technical Guidelines for the existing Generator Efficiency Standards.
- Solutions to mitigate mill wearing, caused by heavy minerals, such as free quartz and pyrite contained in the Collie coal, commonly found at Collie A and Muja Power Stations.
- The provision of coal pyrolysis and char reactivity data to Bharat Heavy Electricals Ltd. (India) to design its pressurised fluidised-bed pilot plants.
- Providing the Commonwealth Department of Environment and Heritage with CCSD information on quantifying natural and anthropogenic sourced mercury emissions from Australia.

During 2004-05 there were 17 postgraduate students undertaking PhD training in CCSD and four students have been awarded their doctoral degrees.

GeoTek Solutions

GeoTek Solutions is a geotechnical consultancy specialising in slope stability for open cut mines. Since 1999 the company has operated from the Technology Transfer Centre maintaining strong links with CSIRO's Division of Exploration and Mining through the Sirovision technology.

Sirovision's increased acceptance on mine sites has opened niche opportunities for specialist consulting services using this technology, and GeoTek Solutions has continued to build its small but growing business in this area.

Buoyant economic conditions have meant that GeoTek Solutions has undertaken a number of projects during the year. These have encompassed coal and base metals mines mainly in Queensland but also in Papua New Guinea and Indonesia.

Instinct Television

Instinct Television is an independent production company creating quality factual entertainment for an international market. The company recently signed a distribution agreement with UK distributor Extreme Entertainment for exclusive rights to market the company's new television series “Rob Bredl: Wild Detective”. On a journey of discovery driven by curiosity, Rob Bredl gives us an alternative view of our world and the life that inhabits it.

The company also provides corporate video services to CSIRO, having recently completed a video promotion for CSIRO Minerals Division at QCAT for presentation in Brazil. The company also continues to provide multimedia training support for Advanced Mining Technologies and is in discussion with fellow CSIRO site services and tenants to provide corporate video services.

Instinct Television is currently embarking on research and development into video content delivery methods for a new large screen display system currently in development.

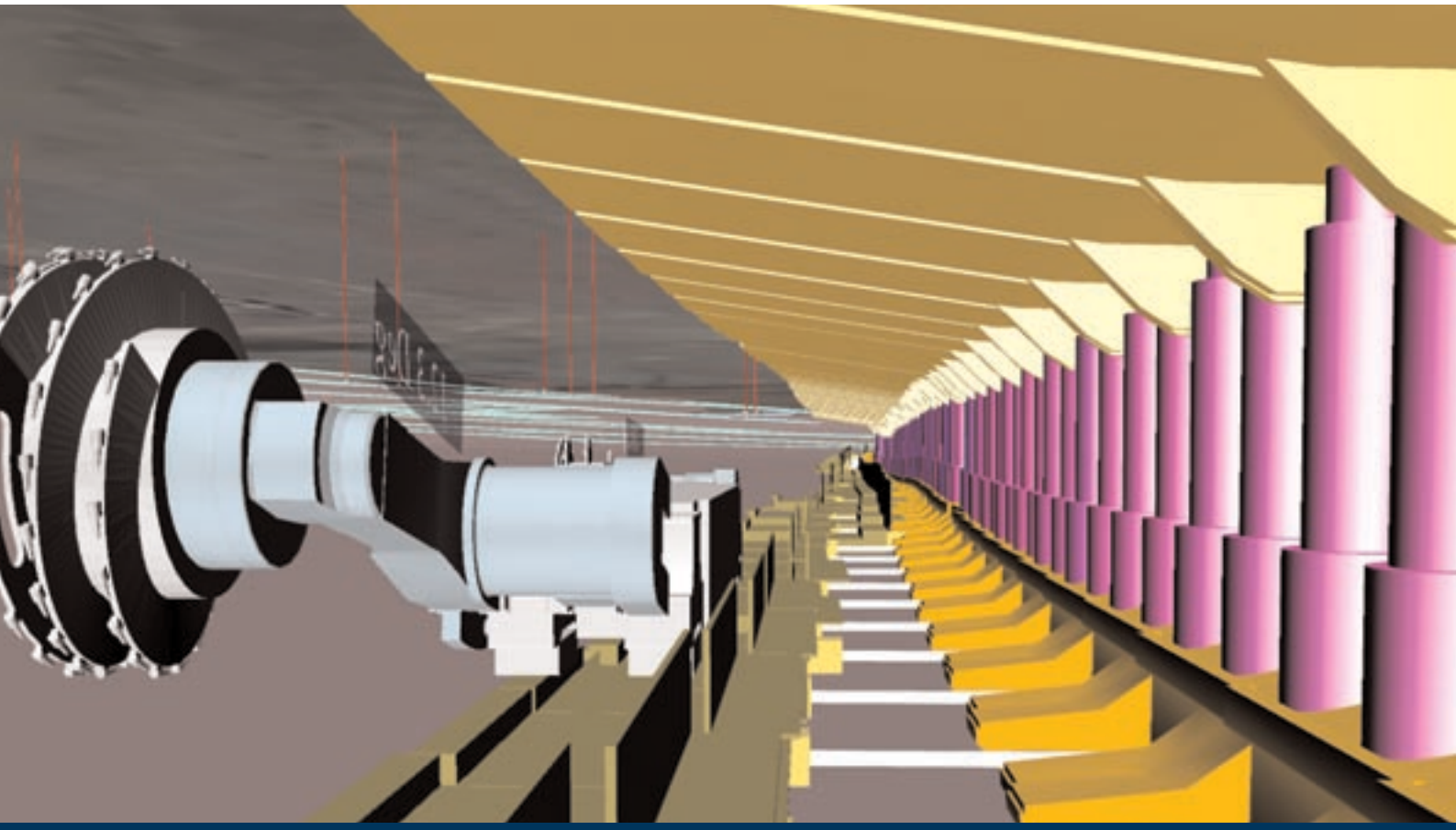
Instinct Television is ideally positioned to produce outstanding television, employing creative and professional crew and post production personnel within its broadcast facility in Brisbane. Instinct Television is a quality provider, ensuring high technical standards and reliable delivery.

The production team at Instinct Television are dedicated industry professionals and quality content creators who have received many industry awards and are recognised as experienced producers of factual content for both Australian and international markets.

Jenkins-Kwan Technology Pty Ltd

Jenkins-Kwan Technology is involved in a broad range of R&D projects. Projects at QCAT have focussed on the development and commercialisation of automated instrumentation for the coal mining industry and coal users. With the assistance of ACARP grants we are extending the capabilities of the MACE®300 coal petrography system, which analyses the organic constituents (macerals) of coal particles by light-microscopy and image analysis. In collaboration with the Julius Kruttschnitt Mineral Research Centre and CSIRO, a new project in 2005 involves the development of image fusion techniques to combine electron microscope analyses of minerals with the MACE®300 analyses of macerals.

Awards



A number of QCAT staff were acknowledged with awards for their efforts during the year.

The 2004 ACARP Award for Research Excellence, underground category

A three-year $4.31 million ACARP-funded project was completed in December 2004. The project team received the 2004 ACARP Award for Research Excellence in the underground category.

A military-grade inertial guidance system is at the heart of the new system that has automated a number of the processes involved in operating a longwall. The major contributions of the project to longwall mining operations were:

- new sensor development for closed loop control of face equipment
- integrated operation of face components through open communication systems
- new data flow and management methods and technologies
- identification of skills and qualities of people required for automated longwall operations
- development of new on-line condition monitoring and fault detection technologies.

The award is made every two years. In presenting the award, it was noted that “The team succeeded in automating the cutting sequence and advancing the maintenance practices on the wall. It is now possible to sit in the mine office on the surface and watch the cutting parameters in real time as a direct consequence of this research project”. The team is based at QCAT and includes Mick Kelly, David Hainsworth and David Reid.

The image on the left is from a 3D model driven by real-time sensor data from the Landmark longwall automation system.

The Achaeus Group Enterprise Workshop Business Award, Queensland

The team was judged against a highly competitive field on their business plan for Sirovision®, a new high-precision 3D digital imaging technology for the mining industry. Sirovision® has applications world-wide as a rock mass structure mapping and analysis system that delivers an unprecedented level of surface detail in models generated from digital photographs taken up to 700 metres from the surface to be studied. It is already in use by five of the world's top ten mining companies.

The Enterprise Workshop Business Award was the first of two awards presented to the Sirovision® team on the one night. The second was the important AusIndustry Innovation Award for the most innovative venture.

Following this win, the Sirovision® team, Andrew Beitz, Alison Gardiner, George Poropat and Phillip Soole from QCAT in Brisbane, and Wayne Robertson from the Australian Resources Research Centre in Perth, travelled to Canberra to represent Queensland at the national finals of the Australia Enterprise Workshop Business Awards.

The Enterprise Development Institute of Australia Enterprise Workshop Program Award

Following their win in the Group Enterprise Workshop Business Award in Brisbane, the Sirovision® team won the national finals of the Australia Enterprise Workshop Program in Canberra. Team leader, George Poropat, said that the win clearly demonstrated that scientists can have a realistic interaction with the business world while still doing and enjoying great science.

Financing Innovation and Growth Marketing Award

This award was presented for the development of a proposal for the commercialisation of software called LCADetail. The software is a life cycle building product assessment tool. Pene Mitchell and Phillipa Watson from QCAT were involved in developing the proposal, together with the Queensland Department of Public Works Principal Scientist, Delwyn Jones, and the business development manager of the CRC-CI Peter Scuderi. The proposal was written through a highly respected business development course. On graduation from the course, the team won the award for the best marketing section in any report. The team is progressing with the proposal and are in discussion with the CRC-CI.

QCAT Steering Committee

The Hon Mike Ahern - Chairman
Department of Premier and Cabinet

Dr Cliff Mallett
Acting Chief
CSIRO Exploration & Mining

Executive Manager
QCAT

Mr Bob Potter
General Manager, Industry Development
Bureau of Mining and Petroleum
Department of Natural Resources and Mines

Associate Professor John Mott
Director
Centre for Integrated Resource Management
The University of Queensland

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

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

QCAT Contacts

Queensland Centre for Advanced Technologies

Technology Court Pullenvale Brisbane
PO Box 883 Kenmore Queensland 4069 AUSTRALIA
t: +61 7 3327 4444
f: +61 7 3327 4455
www.cat.csiro.au

Dr Cliff Mallett
Executive Manager - QCAT
Acting Chief, CSIRO Exploration & Mining
t: +61 7 3327 4440
f: +61 7 3327 4455
e: cliff.mallett@csiro.au

CSIRO Exploration & Mining

Rock Mass Characterisation
Mark Berry
t: +61 7 3327 4570
f: +61 7 3327 4455
e: mark.berry@csiro.au

Mining Systems
Dr Hua Guo
t: +61 7 3327 4608
f: +61 7 3327 4455
e: hua.guo@csiro.au

Geotechnical Support
George Poropat
t: +61 7 3327 4425
f: +61 7 3327 4455
e: george.poropat@csiro.au

Mining ICT and Automation
Greg Rowan
p: +61 7 3327 4179
f: +61 7 3327 4455
e: greg.rowan@csiro.au

Mining and Sustainable Development
Dr Anna Littleboy
p: +61 7 3327 4180
f: +61 7 3327 4455
e: anna.littleboy@csiro.au

CSIRO Energy Technology

Coal Processing
Dr Bruce Firth
t: +61 7 3327 4500
f: +61 7 3327 4455
e: bruce.firth@csiro.au

Coal Utilisation
Dr David Harris
p: +61 7 3327 4617
f: +61 7 3327 4455
e: david.harris@csiro.au

CSIRO Minerals

Iron Ore and Non-ferrous Mineral Processing
Dr Ralph Holmes
t: +61 7 3327 4452
f: +61.7 3327 4682
e: Ralph.holmes@csiro.au

CSIRO Manufacturing and Infrastructure Technology

Light Metals Engineering
Dr Nigel Ricketts
t: +61 7 3327 4638
f: +61 7 3327 4455
e: nigel.ricketts@csiro.au

CSIRO ICT Centre

Autonomous Systems Lab
Dr Peter Corke
t: +61 7 3327 4584
f: +61 7 3327 4455
e: peter.corke@csiro.au

About CSIRO

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is Australia's national science agency. In its 77 year history CSIRO has formed strategic alliances with government, industry, business and communities in 80 countries. CSIRO is dedicated to the application of knowledge and science for real-world outcomes for society and industry.

CSIRO's diverse capabilities at QCAT include mining geoscience, coal and metalliferous mining, geotechnical support, iron ore and non-ferrous mineral processing, light metals engineering, coal utilisation, sustainability and ICT.

Contact Us

Phone	1300 363 400
Email	enquiries@csiro.au
Web	www.csiro.au