



**ACARP EXTENSION
2010 – 2015
CASE STUDIES**

**Heuris Partners
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PURPOSE OF THE CASE STUDIES

ACARP began operations in July 1993 in accordance with an MOU between the Australian Coal Association (ACA) and the Commonwealth Government for the transfer of the NERDDP program to the industry for an initial three year trial period, which has been subsequently extended several times. The current MOU extension concludes on 30 June 2010.

The ACR Board and the ACARP Research Committee have reviewed the benefits of the program and considered the merits of extending ACARP for a further term through to 30 June 2015. These five case studies were prepared as part of this review to demonstrate that ACARP is delivering significant value in terms of financial return on investment, its effectiveness as an agent of change in respect to OEMs, regulators and research organisations, and as a forum to address industry wide issues in a collaborative and effective manner.

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CASE STUDY 1

Treating Acidity in Coal Pit Lakes Using Sewage and Green Waste: Microcosm and Field Scale Trials at the Collinsville Coal Project (Qld)

Central Problem

The research project purpose was to evaluate field scale bioremediation trials using sewage and green waste on a large, highly acidic/high sulphate/high metal content open pit lake. Previous attempts to stimulate sulphate reducing bacterial activity to reduce and precipitate sulphates, return pH levels towards neutral, and cause the precipitation of dissolved metals had failed.

In the absence of effective alternatives to high cost long term “active remediation” involving lime dosing, large pit lakes such as those at Collinsville are likely to remain biologically sterile, hazardous to recreational use and to wildlife and unable to be utilised in industry or agriculture/aquaculture for many decades.

Apart from being an active liability for a period well beyond the typical life span of most mining companies, these pit lakes represent a significant loss of potential environmental and recreational amenity for communities long after the cessation of mining.

While there are numerous anecdotal case study reports of successful pit-lake remediation around the world, there is a paucity of scientific data on the actual remediation activity undertaken, the resulting underlying chemical and biological processes, and the outcomes. The absence of such scientific data is a significant barrier to effective pit lake rehabilitation planning and the acceptance of such plans by regulatory authorities.

Extent of the problem in the Australian coal industry

The water chemistry in the acidic pit lakes at Collinsville represents the most extreme range of high acid/high metal pit lakes found in the world.

Interviews with coal companies active in Queensland and NSW indicate that there are no other known coal company pit lakes in Australia with similarly extreme acid water chemistry. Industry participants interviewed thought there were also no known abandoned underground coal mines with recognised AMD impacts on groundwater or surface waters.

Looking to the future, company representatives interviewed acknowledged that there are some large current open pit operations in Queensland and NSW that cannot be backfilled and so will be closed as pit lakes with some attendant risk of AMD.

While interviewees were broadly comfortable about the lower levels of AMD risk given the Permian origins of the majority of the Queensland and NSW coal measures, they acknowledged that the recent and planned rapid growth of new open pit mine developments brought with it a level of AMD risk that was very difficult to quantify. The ultimately realised level of AMD risk over coming decades will be dependent on the actual mining practices deployed by operators, not the apparent risk evident in mine plans at the time mining approvals are granted.

Interviews with coal companies active in the Collie Basin in Western Australia indicate that there are several large and small acidic pit lakes left over from previous coal mining operations. These tend to be less acidic (pH >3.5-4.0) and with lower sulphate and metal content than the Collinsville lakes. One of these, Lake Kepwari has been the focus of extensive, well planned closure and rehabilitation activities for over a decade. Water qualities have now improved with pH ~4.5, and independent environmental health experts have assessed the water quality as posing no significant risk for public recreational use. Despite this, recent media discussion of the residual public health risk may yet frustrate the operating company’s efforts to have the government accept relinquishment of the pit lake for use as a public recreational facility.

Over the next 2 decades, 2-3 new large pit voids from current mining in the Collie basin are expected to become due for closure. These are expected to have similar underlying water chemistry problems to the existing Collie lakes although mining and rehabilitation practices are expected to reduce the level of AMD problems. While the mining approvals for these operations under State Agreements do not specify water quality end points for closure, the companies involved remain committed to achieving outcomes that maintain local community and government support for their ongoing

business activities. Because of the size of these new pit voids (one is expected to be 100,000 Megalitres) lower cost approaches to accelerating the recovery of water quality are deemed to be important.

Looking beyond the coal sector, AMD related problems in pit lakes and seepage from tailings dams and waste rock dumps is one of the largest environmental challenges facing the mining industry and regulators of the mining industry in Australia. A survey conducted by the Office of the Supervising Scientist, published in 1997, identified the potential for acid generating wastes in 37% of surveyed sites. Despite this risk, the report highlighted the inadequate level of acid/base accounting and waste characterisation across the industry. Interviews with this research project's science advisers suggest that the poor level of knowledge of AMD risks and liabilities identified in 1997 by the Office of the Supervising Scientist remains today. No more definitive analysis of the scope and cost of AMD liabilities in the Australian mining sector is available.

Australian state governments are reported to be demonstrating increasing reluctance to accept mine closure plans and to authorise the relinquishment of rehabilitated mine areas back to the Crown after mine closure when there is some risk of ongoing acid mine drainage.

- This is in part the result of some state governments unwittingly accepting very large and complex AMD liabilities when they accepted relinquishment of certain pit lakes in the 1980's and 1990's. Mt Morgan in Queensland, Rum Jungle in the Northern Territory and Mt Lyell in Tasmania are outstanding examples.
- It is also a result of public health concerns that constrain the ability of mining companies and governments to satisfactorily demonstrate the safety of remediated pit lakes for recreational use.
- There are anecdotal reports of regulators requiring higher environmental bonds for new developments to limit the future financial burden on the community in the event the asset is sold on to less well capitalised operators later in mine life.

An interview with a government rehabilitation scientist involved in the ongoing Mt Morgan pit lake remediation highlighted the need for improved and lower cost remediation methods that can be applied to a wider range of water chemistries in AMD affected pit lakes. Because of the high operating costs and required electrical supply infrastructure, active pit lake remediation was restricted to only the most severe environmental risks within the large portfolio of legacy AMD sites that are the responsibility of the Queensland government.

In conclusion, it appears that the risk of new, severely affected AMD pit lakes like Collinsville is judged by Australian coal industry participants to be low. There is an expectation that some less severely AMD affected pit lakes will result from current open pit operations in Queensland and Western Australia.

Given the evidence of inadequate investment in mining acid base accounting during the 1990's, the recent boom in new open pit coal mine development, and the severe ongoing shortage of experienced mining and environmental staff, the risk of future AMD pit lake issues facing the Australian coal industry may be significantly higher than the optimistic views expressed by industry participants interviewed.

Did the project achieve the research objective?

The project does appear to have achieved the research objective of demonstrating in a field trial the effectiveness of using low cost organic wastes (primary treated sewage and green waste) to achieve sulfate reduction, increases in pH and the establishment of a biological environment (algae) in what was previously a chemical environment.

The process of remediation was interrupted by unidentified effects associated with monsoonal cyclone activity. Recovery commenced again spontaneously after approximately 6-9 months and is now showing accelerated increases in water pH and other measures of water quality.

Funding for an extension to the project has now been sought from ACARP to better understand the processes that led to the remediation interruption and spontaneous recovery, and to understand the constraints to wider applicability.

The project has also demonstrated additional potential benefits may be available from carbon credits due to avoided sewage methanogenesis and carbon capture by the growth in aquatic biota.

Near term impacts of the research project findings

At Collinsville, the mine operator reports 3 areas of direct benefit to the company.

- As a result of the positive field trial outcome, the future liability associated with mine closure and pit lake remediation before and after closure has been significantly reduced. Remediation will likely be achieved to a higher level of water quality, more quickly, at less cost, and potentially create an environmental asset with wildlife values for the local community.
- Recognition of the research project's potential applicability across the company's global mining activities, not just in coal mining. The operating site has been recognized with a global sustainability award within the parent company.
- A deepened level of trust by the local community and regional EPA regulatory staff in the company's commitment to environmental values. Local landowners confidence in long term site water management has reportedly strengthened, the local council is seeking further opportunities for lower cost "win/win" organic waste disposal, and the local EPA have moved from a position of deep skepticism to more positively seeking to learn how to apply the project research findings to legacy sites under the responsibility of the Queensland government.

An interview with the Department of Minerals and Energy (DME) Senior Rehabilitation Scientist at the Mt Morgan pit lake confirmed that the reported project outcomes are likely to be of direct benefit to the Queensland Government at the Mt Morgan pit lake and at the other two major AMD pit lake liabilities the DME are investigating and managing in Queensland – Horn Island in Torres Strait and Croydon in western Queensland.

Potential future impacts of the research project

The potential future impacts of the Collinsville pit lake bioremediation project appear to be large and positive for the Australian coal industry, for the mining industry, for regulatory authorities and the community.

The narrower economic benefits are likely to emerge through more effective and lower cost AMD lake remediation leading to higher quality environmental outcomes. The scope for realization of this benefit across the Australian coal mining industry is assessed to be larger than that recognized in these recent interviews with site environmental managers from Australian coal companies. The economic benefits may also extend to reduced levels of environmental bonds for ongoing operations and new developments where AMD risks have been previously valued using "worst case" scenarios.

It is possible that some economic benefits will also be realised in carbon credits for avoided methanogenesis and carbon capture in pond algal biota. The scale of these benefits will be limited by the number and size of coal industry pits subject to remediation.

The quality of the science in the Collinsville project has been commented on in many of the industry interviews. Given the paucity of publicly available quality scientific data on pit lake remediation globally, the successful wide promulgation to date of the Collinsville research findings through participation in global and national specialist conferences, in the peer reviewed literature and in (forthcoming) scientific books should assist companies and regulators around the world in the design, approval and execution of more pit lake bioremediation projects. As the body of practice knowledge increases, the benefits are also likely to increase through improved processes with applicability to more diverse water chemistries.

In Australia, the largest private benefits will likely flow in the medium to long term to companies in other mining sectors including gold, base metals and iron ore. The number of open pit mines and the potential for AMD problems in current operations is large. The benefits can be anticipated from less restrictive mine permitting, lower environmental bonds, lower remediation and closure costs, and stronger community support for ongoing operations.

To the extent that the coal companies funding ACARP are not part of larger diversified mining houses this likely flow of benefits is a "free ride" to others. In part this reflects the unique status of ACARP as the leading research funding body within the Australian mining industry focused on mining operational improvement, and the only mining sector specific research body to sustain funding for more than a decade.

The public benefits from the wider application of the project findings are also likely to be large. State governments are responsible for existing legacy sites and for future "orphan sites" where environmental bonds may be inadequate to meet the costs of emerging AMD problems. A new set of lower cost bioremediation tools could allow a large number of existing problem sites that are not currently funded for remediation to receive treatment. This would result in a range of environmental benefits to the community.

Environmental regulators are increasingly dependent on the recommendations of the environmental engineering sector for solutions. For the potential public benefits to be realised, barriers to the transfer of leading edge research-based operating practice into the “commodified” products and services of commercial environmental engineering consultancies and contractors need to be better understood and overcome. Until these bioremediation practices become an accepted core offering of the environmental engineering industry, the realised public benefit will likely be constrained.

Licence to Operate

All of the coal industry, research, community and regulatory stakeholders interviewed commented very favourably on the high quality project planning and execution, and on the community and regulatory engagement throughout the project.

Regardless of the specific focus of the bioremediation project, the project managers appear to have demonstrated excellent skills and judgement in building intra-company, coal industry, community and ultimately regulatory support for a research project, and to have delivered a very high quality science based outcome. The project team delivered in full on the company’s environmental commitment.

This experience, if replicated more widely across the industry would assist the industry build trust with local communities divided by concerns for larger, global environmental risks linked to coal use, and troubled by more proximate local fears and risks related to proposed mining projects.

Key Lessons for future ACARP research

1. Strong science and excellent stakeholder engagement throughout the project has enabled a project with a recognized at the outset to have apparent limited scope of application in the coal industry to produce an outcome with much wider potential value across the mining industry in Australia.
2. ACARP and its industry sponsors should look at how to accelerate the rate of take up of this research by government regulators and environmental engineering consultancies. To realise the full economic and reputational benefits for the coal mining industry from leading edge environmental management research requires state government environmental regulators to understand the work and look for opportunities to apply it across their broader portfolio of legacy sites and new mining proposals. Similarly, environmental engineering consultancies/contractors who provide services to environmental regulators and to smaller mining companies need to understand the work.

CASE STUDY 2

Longwall Automation (extension) project

Central Problem

The central problem that the C15002 Longwall Automation Extension Project addressed was the same problem that the earlier C10100 Landmark Longwall Automation Project addressed; the lack of an effective and competitive suite of longwall automation options from the Original Equipment Manufacturers (OEMs).

The lack of such an offer in 2001 (planning phase of C10100 Landmark Project) was considered to be an important contributory factor to the widespread low levels of longwall productivity in the Australian coal industry and the attendant high demands on human exposures to a very hazardous work environment.

While commercial development and application of automation technology in other repetitive heavy engineering manufacturing processes such as automotive manufacture had advanced dramatically over the prior 1-2 decades, leading Australian coal producers at the time were faced with an OEM automation offer that they thought had advanced little beyond the mid 1980's.

Engineering and operations experts in individual coal companies could see the automation opportunity but had insufficient individual incentive to fund the OEM's to do the research. They would not be able to retain the competitive advantage of innovation which was expected to flow through to OEM's and other coal companies. Similarly the OEM's had insufficient individual incentive to take on the technology development risk. One OEM commented that the shift from being a subsidiary of a large coal mining company to an independent equipment manufacturer had significantly reduced their technology risk appetite. . Technology stasis was the inevitable outcome of this dynamic.

The original project therefore involved an attempt to restructure the balance of competitive power and innovation dynamic in the industry between a supplier oligopoly resistant to change and a fragmented customer base seeking change. The approach was to form a customer research funding consortium supported by a leading technology research and development supplier – CSIRO – to develop open standard technologies and to develop new technologies in key areas supporting longwall automation, ready for commercialisation.

That earlier Landmark project successfully demonstrated proof of concept across a number of outcomes essential to achieving a longwall face able to operate automatically within predefined parameters to enhance health and safety and production consistency to lower operating costs and improve return on capital.

The Extension project was deemed necessary to move from proof of concept to the development of commercial prototypes. Without this next step it was judged that a competitive suite of longwall automation offers from OEM's would not occur in a suitable time frame.

The central problem therefore that the Extension project addressed was the same as the earlier project; the lack of a comprehensive and competitive suite of longwall automation offers from OEM's. The subsidiary problem from the research project initiators viewpoint was the low level of longwall productivity. This was seen as multi-factorial and could not be solved by longwall automation alone.

Extent of the problem in the Australian coal industry

To understand the extent of the problem in the Australian coal industry we need to first map the longwall automation “offer” in 2001 prior to C10100 and again in 2005 (completion of C10100) across the key OEM's.

Table 1

Automation capability and Company	2001 Commercial Offer	2005 Commercial Offer (end of C10100)
Automated Longwall Face Alignment		<i>C10100 successfully demonstrated proof of concept</i>
DBT/Bucyrus	Relative/incremental (not absolute) horizontal position control	Relative/incremental (not absolute) horizontal position control

Joy	None	None
Other	None	None
Automated Creep/Retreat Control		<i>C10100 successfully demonstrated proof of concept</i>
DBT/Bucyris	Relative/incremental adjustment possible but no sensing and automatic control	Relative/incremental adjustment possible but no sensing and automatic control
Joy	Ability to do rudimentary creep adjustment but no sensing and automatic control	Ability to do rudimentary creep adjustment but no sensing and automatic control
Other	None	None
“State-based” Shearer Automation		
DBT/Bucyris	“Phase control” offered partial control of haulage but not fully automated.	New shearer control algorithms specified by Beltana were developed and commercialised on a proprietary basis by DBT
Joy	Not known	Not known
Eickhoff	Not known	Not known
Automated Horizon Control		<i>C10100 successfully demonstrated proof of concept</i>
DBT/Bucyris	“Memory/Repeated cut” available but lack of effective sensors in the context of higher machine performance mitigated against operator utilisation of the offer.	Upgraded sensor quality
Joy	“Memory/Repeated cut” available but lack of effective sensors mitigated against operator utilisation of the offer.	No change in offer, waiting on LASC
Eickhoff	“Memory/Repeated cut” available but lack of effective sensors mitigated against operator utilisation of the offer.	No change in offer, waiting on LASC
Real Time Geotechnical Sensing		C10100 developed new shield convergence sensing method, new sensor for measuring X-section change applicable for creep & retreat measurement
DBT/Bucyris	None	No change in offer
Joy	None	No change in offer
Eickhoff	None	No change in offer

Between 2001 and 2005 the only significant additional longwall automation option offered by OEMS was the DBT proprietary offer on automated shearer control.

While Landmark Project C10100 had succeeded in demonstrating proof of concept for automated face alignment, creep control and horizon control, these innovation breakthroughs all required additional development trials to demonstrate a commercial prototype ready for OEM commercialisation.

Did the project achieve the research objective?

The C15002 project research objectives were set in the following areas:

1. Longwall Automation System (Face alignment and creep measurement)
2. Shearer Position Measurement
3. Horizon Control
4. LASC compliant technology development in gate road and shield convergence monitoring, coal flow optimization and void detection
5. Production standard information system
6. OEM commercial agreements.

The full details of the objectives in each area are set out in the C15002 Final Report (May 2008)

As of mid 2008, the attainment status on these objectives is assessed as follows:

Table 2

Objective	Commercial Prototype	Proof of Concept
Modular Shearer position measurement	Commercial product now available from Joy and Inbye	Achieved in C10100
Automatic face alignment	Commercial product now available from Joy.	Achieved in C10100
Automatic creep/retreat measurement	Ready for final field testing q1 2009. Joy and Inbye will offer when CSIRO release approved product.	Achieved in C10100
Horizon Control	Eickhoff system undergoing field tests at Grasree during Q4 2008 Joy and Inbye have signed LASC licensing agreement but development work still required.	Achieved in C10100
LASC compliant geotech sensing	Real time shield convergence monitoring system completed. Demonstration planned at Beltana H1 2009	Coal flow optimization and void detection proof of concept successful. New approaches to gateroad geotechnical monitoring required.
Real time information system	The core development of a non-proprietary software system is complete. OEM's are now seeking to "optimize" and differentiate within proprietary systems as part of their competitive offer.	
OEM Commercial agreements	Joy-CSIRO and Inbye – CSIRO Technology Licence Agreements recently signed covering the full suite of LASC technologies. Negotiations with other longwall OEMS are reported by CSIRO to be well advanced	

Demonstration of commercial prototypes for face alignment is now complete and is being utilized at all 3 test sites. Commercial product is now on offer from Joy and Inbye. Final demonstration of the creep measurement commercial prototype is planned for q1 2009 at one or more demonstration sites. This will complete that work stream.

Commercial demonstration of INS based automatic horizon control has been complicated by the commercial negotiations between CSIRO and Bucyrus. It is understood that the DBT/Bucyrus and CSIRO negotiations are complicated by different views of the value of DBT/Bucyrus prior knowledge. When this commercial issue is dealt with it is expected that DBT/Bucyrus will make available a LASC INS based system. An Eickhoff LASC INS based automatic horizon control system is now under test at Grasree. Joy does not yet have a shearer in Australia with capability to demonstrate LASC horizon control; the first will come on line during 2009.

Major progress has been achieved in real time shield convergence monitoring with a system demonstration planned in 2009. CSIRO are currently looking to secure a commercialisation partner.

OEM uptake of the Automation Information System package is now underway although it is possible this will now progress under a proprietary and competitive approach. This is strong evidence of success towards solving the higher level problem. The announcement of the first LASC umbrella global agreement with Joy is also a major commercialisation milestone.

In summary, the C15002 Longwall Automation (Extension) Project has succeeded in its objective of advancing the commercialisation of Proof of Concept outcomes from the C10100 Project.

- *Commercial automated face alignment systems are now available.*
- *Automated creep control, shearer control and horizon control are now nearing commercial readiness.*
- *Real time shield convergence has been demonstrated so customer demand is now likely to drive OEM /CSIRO commercialisation work.*
- *OEM's now appear to be competing in the development of "hi-fidelity" information systems to support the automation packages.*

- *LASC commercialisation/licensing agreements are now being signed by OEMs*

Near term impacts of the research project outputs

Near term impacts of the C15002 project success at the participating test sites have been identified across a number of areas. These are:

- Reduced employee exposures to high hazard environments.
- Improved longwall production consistency and output levels.
- Improved job quality for staff employed in long wall operations.
- No net job reductions as a result of automation.

Quantitative measures of impact within and between sites have not been made available for this review. Anecdotal reports of reduced personal dust exposures for longwall employees at one site where coal production has increased by 75% during the period 2001-2008 appear to corroborate the reports of reduced employee exposures to high hazard environments.

Similarly, the reports from all test sites of the cessation of “string tests” for twice-daily long wall alignment testing also indicates a reduction in human exposure to the high hazard long wall face. In addition, the half hour of set-up time previously allocated for face alignment testing each test is now likely to be available as additional cutting time.

Depending on the individual longwall productivity, Resource Time, and ROM/saleable tonne yield, the elimination of string tests by itself could allow a long wall operation to produce an additional 435,000 saleable tonnes per year (assuming an increased cutting rate of 130 tonnes per hour over 84 hours per week in a 47 week long wall operating year @ 85% yield) generating an additional sales revenue of A\$54-130 million per annum at 2008 prices (assuming A\$125/tonne thermal coal and A\$300/tonne hard coking coal).

The test site using automatic shearer control reports increased cutting rates as a result of less operator intervention, faster approaches to cut-finish and higher quality of the finish cut. If we assume a conservative 5% increase in the cutting rate is achieved at a site with a baseline cutting rate of 1500 ROM tonnes per hour, an additional 300,000 saleable tonnes per year might be produced (12 hours cutting time per day, 47 week longwall operating year @ 85% yield) generating an additional sales revenue of A\$31-75 million per annum at 2008 prices (assumes A\$125/tonne thermal coal and A\$300/tonne hard coking coal). It is possible that cutting rate increases of 10-15% may be achievable with fully automated shearer control and horizon control, depending on the underground conditions.

As a cautionary note about the value impact from the ACARP project, several interviewees commented that the ACARP project has not been the primary driver to automated shearer control improvements but that it has allowed a better result to be achieved than would have otherwise been the case.

Combining these two areas of operational improvement from automatic face alignment and shearer control, a mine successfully implementing a new automated longwall in 2009 could achieve annual sales revenue benefits of A\$86 million per annum at thermal coal prices of A\$125/tonne. The great majority of this will flow through to EBIT.

Figure 1

Elimination of string lines	
Improvement in Baseline cutting rate (tonnes per hour)	130
Longwall utilisation hours per week	84
Longwall operating weeks per year	47
Yield	85%
Annual saleable tonne benefit from stringline elimination	436254
Sales revenue increase at A\$300/tonne (annual)	\$ 130,876,200
Sales revenue increase at A\$125/tonne (annual)	\$ 54,531,750
5% Increase in Cutting Rate	
Baseline ROM tonnes per cutting hour	1500
Improved ROM tonnes per cutting hour	1575
Longwall utilisation hours per week	84
Longwall operating weeks per year	47
ROM tonne benefit per year from 5% increase in cutting rate	296100
Yield	85%
Saleable tonne benefit from 5% increase in cutting rate	251685
Sales revenue increase at A\$300/tonne (annual)	\$ 75,505,500
Sales revenue increase at A\$125/tonne (annual)	\$ 31,460,625
Combined 5% increase in cutting rate and elimination of string lines	
Sales revenue increase at A\$300/tonne (annual)	\$ 206,381,700
Sales revenue increase at A\$125/tonne (annual)	\$ 85,992,375

Potential future impacts of the research project

The human safety and economic benefits of longwall automation are likely to be only accessible to those sites that are able to establish stable operating and maintenance systems. Without such a controlled base, the benefits of automation are not likely to be achievable.

This suggests that the availability of commercial longwall automation will increase the competitive pressures for consolidation within the underground coal mining sector. Those companies unable to achieve a stable base of high quality operations and maintenance management systems are likely to be at risk of acquisition by those who have mastered these core mining “manufacturing” disciplines. A decline in coal asset prices linked to declining expectations of global coal prices will support this consolidation dynamic.

It is too early to assess how the ultimate value increase from longwall automation will be shared between OEM's and the coal mining companies. Initial data from OEM pricing suggests that the ACARP initiative has led early mover OEM's to compete on new automation equipment pricing, only passing on effectively the LASC licence fees. Maintenance service fee contracts appear to have been significantly increased. As a significant share of the long term value might be eroded by high OEM maintenance fees, ACARP should review the opportunity for future research and development on maintenance systems required by automated longwalls.

Key Lessons for future ACARP research

ACARP is already looking beyond longwall automation to continuous miner automation as the next area for “landmark” research and development. If it has not already been done, it may be worthwhile carefully understanding the lessons that the OEM's have taken from the longwall automation “intervention” by ACARP.

This interaction between an equipment supply oligopoly and an unsatisfied but previously fragmented customer base was also the context for the ACARP C14046 Human Factors Engineering in Large Surface Mining Equipment project that led to the development of the EMESRT initiative. EMESRT has ultimately taken a distinctively different approach to solving the customer-supplier interaction problem compared with the C10100 and C15002 projects.

EMESRT have taken the approach that OEM's remain responsible for competitive investment in new equipment design. By contrast, CSIRO and ACARP took the approach that the costs and risks involved in new automation technology development required an alliance of coal mining customers (ACARP) and CSIRO to develop new technology, working with OEM's.

One of the major Longwall equipment OEM's is likely to have perceived their competitive advantage eroded by successful cooperation between previously fragmented customers and a major independent technology research and development institution. Other OEM's may perceive benefits to their position. The emergence of an ongoing successful technology development alliance in the underground coal mining industry that is controlled by their customers should prompt the OEM's to think deeply about shifting industry structures and how to position themselves individually and potentially collectively for “Round Two”. This has been an uncommon shift of competitive power in such a highly concentrated industry.

Senior OEM executives interviewed made a number of comments and suggestions regarding the expected next round of ACARP/CSIRO automation development. The following lessons can be deduced from their commentary.

- OEM's now have high regard and respect for the technology development capability of the CSIRO/ACARP alliance. Some were skeptical at the outset.
 - Need for ACARP and CSIRO to again put the hard work in up front to secure strategic alignment through the Australian based OEM divisions to their global headquarters. Unless this internal OEM alignment is secured the project is at risk. Need to sit down and have the hard discussions up front.
 - It is very unlikely that OEM's will participate in the same "open" manner in the second round. An OEM who is perceived to have lost competitive advantage would have a strong incentive to not make large investments of time and effort. An OEM who might be perceived to have benefited will have observed how and why their competitor lost ground and seek to avoid the competitor's prior mistake. For example, a rational player would seek ACARP and CSIRO to sit down with each OEM individually to understand and map the technology development strategies already underway within each OEM and to try to then focus the ACARP projects on the gaps. This would allow OEM's to protect their perceived advantages and prevent "free riding" behaviour.
 - Recognise that OEM's need to build and deploy differentiated competitive offers from a core open standard technology innovation. Don't get in the way of the drive to innovate away from the "core" open standard technology innovation. There is little commercial incentive for OEM's to spend the time and money in early mover technology innovation if it is going to be a fixed open standard; it is better to get a free ride when others have done the work.
 - A critical issue for ACARP is to review its approach to the ownership of intellectual property. OEM's see this is a fundamental area where significant change will be necessary to successfully carry through Round 2. Right up front, difficult issues such as the value of prior knowledge will need to be resolved. There is also a critical need to improve the quality and timeliness of the final commercial licensing negotiations. The OEM's commitments have been reportedly put at risk by delays/shifts in position and the very deep frustration this generated in OEM global executive teams. It was suggested this has delayed the commercial deployment of automation packages by more than a year, after all the hard innovation work has been completed. This delay has a major negative impact on the financial returns to OEM investment and arguably causes a significant loss to coal companies unable to get an automation package from their "locked in" OEM.
 - Consider early and periodic engagement between the OEM country champions in Australia and the ACARP technical committee. While there is lots of interaction between OEM champions and individual coal company representatives, there is an absence of interaction at the collective/collegiate level. Such interaction would be beneficial to the project.
 - Consider early engagement with plant operators and operations supervisors in the initial project scoping rather than primarily from technical/engineering managers. This was thought likely to improve the scoping and the operations buy-in.
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CASE STUDY 3

Development of an Improved Methodology for Estimating Fugitive Seam Gas Emissions from Open Cut Mining

Central Problem

The central problem that these projects addressed was the need for a more accurate method for estimating fugitive greenhouse gas (GHG) emissions from open cut mining operations in Australia.

Australia became a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) in 1994. Part of Australia's UNFCCC obligation has been to annually report estimates of GHG emissions, including those fugitive emissions from open cut coal mining operations. Research by the CSIRO in the early 1990's using methane plume measurement provided the basis for the national emissions reporting methodology. This Tier 1 methodology discriminated between open cut coal mines in the Hunter Valley in NSW, the Bowen Basin in Queensland based on average "gassiness" at the "basin" level but the methodology did not provide discrimination at the regional or mine specific level. State specific open cut coal "gassiness" factors have now been accepted by the Federal Government for all Australian states. The methodology is recognised to have very wide uncertainty levels at the individual mine level.

By the late 1990's, some coal companies began to anticipate that fugitive GHG emissions would eventually be charged a carbon penalty at the individual mine level. This would create the need for a more accurate method to estimate GHG emissions at the mine level. This more accurate estimate of mine specific fugitive GHG emissions was necessary for portfolio development planning decisions. Open cut mines were now operating at deeper levels where methane contents might be higher, and new mines were being developed. Unless the financial risks associated with future carbon pricing could be estimated at the mine/asset level, bad portfolio planning decisions might result. Further, the inaccurate allocation of carbon tax liabilities between mines would mean that some companies and mines would be over paying and others underpaying.

At the Federal Government level, there was a similar need to develop a more accurate fugitive emission estimation methodology, moving beyond the 1990's Tier 1 approach, so that Australia's commitments to the UNFCCC could be met. Unless it was able to measure emissions at higher levels of accuracy, the Australian government would find difficulty in measuring emission reductions.

Extent of the problem in the Australian coal industry

Australia's 2005 estimated fugitive GHG emissions associated with coal mining was 22 million tonnes of CO₂e. Fugitive GHG emissions from open cut coal mining were estimated to be 7.8 million tonnes, 35% of the total.¹ Total saleable open cut production in 2005 was 246 million tonnes.² Open cut fugitive GHG emissions per tonne saleable production was 31.5 kg CO₂e (national average).

The cost to the industry from the introduction of an emissions trading scheme depends on carbon prices, permit allocation and sectoral compensation decisions. For the purposes of this analysis we assume a carbon price of A\$20/tonne CO₂e.

For an individual open cut mine producing 5 million tonnes of saleable coal per year at industry average emission levels, annual carbon emission costs at A\$20/tonne CO₂e would be ~A\$3million. The Tier 1 state-based emissions factors have very high levels of uncertainty. CSIRO have estimated that individual mines actual emissions might vary from -50% to +200% of the Tier 2 estimate. This suggests that the annual EBIT impact of CO₂ pricing might vary from A\$1.5 million to A\$9million per mine around the central estimate of A\$3million.

Narrowing this level of uncertainty in mine specific carbon taxation was the challenge that this series of ACARP projects set out to address. Unlike underground coal mining where methane emissions could be measured directly in ventilation returns, a new measurement/estimation approach was required for open cut coal mining.

¹ Australian Government Department of Climate Change: Fugitive sector greenhouse gas emissions projections 2007

² Australian Coal Association

Did the 3 projects achieve the research objective(s)?

The research objectives of the 3 projects evolved sequentially.

Project C9063 was carried out in 2000, 2001 and 2002. It set out to directly measure the levels of methane emissions from uncovered coal seams in the pit floor and from freshly blasted coal. The results demonstrated that opportunistic measurements at various times after coal had been uncovered were not a credible basis for developing a Tier 3 estimation method as the variability was very large. Methane and CO₂ content measurement from fresh boreholes coal samples provided some encouragement. Measures of coal core sample methane content were much higher than those from surface collected samples suggesting a high rate of initial gas-off. Duration of exposure after disturbance was thought to be the major confounding factor in the project. C9063 also provided useful data on the long time-course for gassing off of methane from coal once mined, and the large variation in CO₂ versus methane contributions to emissions. At its conclusion, C9063 had shown that new approaches to measurement would be required.

Project C12072 carried out in 2004 and 2005 set out to investigate the usefulness of direct measurement of GHG content of coal strata and non-coal inter-strata in core samples recovered from exploration bore holes. The project investigated the use of a reservoir approach similar to that used in the oil and gas industry. The objective was “to develop a methodology, in the form of an 'add-on' to existing exploration procedures, which would become a standard method for estimating GHGE from fugitive emissions from mined coal seams and displaced strata from open cut coal mines.”

The outcomes of Project C12072 were a major success. The Project developed a conceptual model for “gas release zones” affected by open cut mining and demonstrated a potential methodology for measuring the GHG content of samples of coal measures and inter-strata material recovered from boreholes. It also highlighted the importance of regional structural geology as a key factor in determining within region variability in the GHG content of the gas release zones. Project C12072 therefore established a conceptual model for fugitive GHG emission estimation that approached Tier 3 levels of accuracy (Tier 2/3)

Project C15076 carried out in 2006-2008 set out to demonstrate the applicability of the new conceptual Tier 2/3 methodology in a number of operating coal mines. Project C15076 produced the following results:

- A working model of seam gas emissions from open cut mines that required knowledge of the in-situ gas content of coal seams and carbonaceous rock in the overburden, and to some extent, into the underburden.
- An approach to planning the bore hole drilling program by partitioning the mine lease into a limited number of gas zones where the coal seams and strata layout and the hydrology suggest similar gas behaviour.
- An approach to gas content measurement of bore hole core samples that measures the mix of CO₂ and methane.

The methodology developed in Project C15076 has now been accepted by the Federal Government Department of Climate Change in the National Greenhouse and Energy Reporting (Measurement) Technical Guidelines 2008 v1.1. The old Tier 1 approach is referred to as Method 1. The new Tier 2/3 approach is distinguished at two levels. Method 2 refers to the application of the CSIRO/ACARP approach when coal borehole selection and coal sampling is done in accordance with general sampling requirements set out in the regulation, while Method 3 refers to the application of the CSIRO/ACARP approach when coal borehole selection and coal sampling is done according to a specific standard.

Taken together, Projects C 15076, C12072 and C9063 have succeeded in an eight year effort to develop a Tier 2/3 fugitive GHG emission estimation approach for Australian open cut coal mining operations. This methodology is now being used by a number of coal mining companies to test the methodology in the hands of mining company staff and gas measurement contractor staff in an operational setting.

Near term impacts of the research projects output

The most important near term impact of the research project is the field testing of the methodology in the hands of mining company staff. This is currently underway and is likely to require a further 12 months work. If the field testing is successful, then the Australian coal mining industry will have a proven Tier 2/3 fugitive emission estimation methodology for open cut coal mining. This will allow more accurate assessments of fugitive emission liabilities at operating mines. Fugitive emissions are thought to constitute 50-70% of all GHG emissions in open cut coal mining.

The impacts of the availability of an improved, more accurate fugitive emission estimation methodology for open cut coal mines will depend in part on how current Federal government policy making translates into specific legislation and regulation.

- Based on current draft regulatory requirements, coal companies will need to choose between continuing to use the old “Method 1” methodology³ and shifting to the new Method 2 or Method 3 methodology by 31 August 2009 when they must register under the new Federal Government National Greenhouse and Energy Reporting Act 2007, the National Greenhouse and Energy Reporting Regulations 2008 (NGER Regulations) and National Greenhouse and Energy Reporting (Measurement) Determination 2008 (NGER Determination). The current draft requirements indicate companies adopting the Method 2 or Method 3 approach will not be allowed to subsequently revert to Tier 2 approaches.
- Additional measurement costs will be incurred by companies adopting the Method 2 or 3 approaches. These costs relate to new gas sampling work at the time of exploration bore holes and potentially, the need for additional exploration bore holes.
- Companies choosing to continue with the Method 1 approach may in the future be required by government to disclose any gas sampling work they undertake to prevent companies “gaming” the system. Ultimately, it is possible the government will require all companies to adopt the Method 2 or 3 approach once it is well established in practice.
- Improved measurement technologies and work practices will likely be required from gas measurement service companies. Existing technologies and work practices are not well suited to the very low levels of gas found in inter-strata and some coal samples.

More accurate assessments of fugitive emission liabilities will also be available for new mining projects.

- Companies will be able to reduce the level of uncertainty in valuing carbon liabilities before approving new investments.
- Mine planning consents in NSW and Queensland require estimates of the carbon footprint. Companies will be able to provide more confident and accurate assessments, and be able to use this information in communication with local communities and interested NGO's.

More targeted application of coal seam drainage investments will be possible ahead of mine development, to identify those projects or parts of projects where it is economic to flare or capture coal seam methane ahead of mining.

In summary, the key near term impacts expected from the projects outcomes are an improved understanding of the expected liabilities associated with open cut fugitive GHG emissions. This will allow companies to improve their mine development planning by allocating capital to mine drainage ahead of mining where appropriate, to make better portfolio investment choices between different coal resources, to ensure that carbon taxes paid to government are accurately assessed, and to improve their representation of carbon risk to state government planning authorities and local communities.

These benefits come at the cost of increased gas measurement expenses and potentially, costs from additional bore holes.

Potential future impacts of the research project

In the longer term, these ACARP projects have established a world leading methodology for measuring fugitive emissions from open cut coal mining. They therefore have the potential to be applied in estimating fugitive emissions for coal mining activities across the world.

While the USA and Canada are pursuing their own national approaches, the establishment of the Australian Tier 2/3 approach and its adoption in national legislation supporting Australia's UNFCCC commitments means that the research outcomes can be promoted internationally.

Australia's major competitors in the international coal trade include exporters from Canada, South Africa, Columbia, Russia, Vietnam and Indonesia, and domestic producers in China and the United States of America.

Harmonisation of emission measurement approaches will eventually likely emerge both within international coal companies operating across multiple jurisdictions, and between national governments.

³ National Greenhouse and Energy Reporting (Measurement) Technical Guidelines 2008 v1.1: Division 3.2.3 Open cut mines. P149

At the company level, the ACARP/CSIRO methodology appears to provide a robust approach that can be applied to a global coal asset portfolio, provided that suitable gas measurement services are available. Companies may choose to pursue this approach for corporate sustainability reporting as part of a competitive strategy to drive improved environmental performance across the global industry.

At the intergovernmental level, Australia now has a world leading position in its approach to measuring and estimating fugitive emissions from open cut coal mining. It is up to the Australian government and its national representatives in the UNFCCC forums to promote the work. By funding the research over such an extended period, the Australian coal industry through ACARP has provided very strong support to the national government. This should provide the industry with a very strong basis of credibility in future “licence to operate” debates and in national policy development.

Key Lessons for future ACARP research

1. This series of projects were initially established and supported as part of a longer term “licence to operate” research agenda.
 - In this example, ACARP-funded research over a ten year period has been required to develop a mine specific methodology.
 - It was only in the last 2 years that the economic importance of the work has been more widely recognized as a result of the political shift towards the near term imposition of carbon pricing on fugitive GHG emissions from open cut coal mines.
 - Without this decade long research effort, the Australian coal industry would now be under great pressure from the Federal Government, state planning authorities and local communities to come up with improved mine specific GHG emission measurements in an impractical time frame. It is likely this would increase the near term costs to the industry and would put the industry into a reactive and unconfident posture against external challenge.

The key lesson from this is the need to anticipate future regulatory requirements and identify where regulatory uncertainty/risk can be reduced by improved information. This must occur a long time in advance of when the regulatory requirements might finally emerge.

Given the diverse membership of ACARP it is likely that not all companies will accept the emerging “licence to operate issues” as a priority at the same time. This highlights the need to maintain a strong ACARP Board commitment to sustaining a “licence to operate” research agenda. Without that Board commitment, there is a risk that shorter term perspectives will dominate to the long term detriment of the sector.

2. The ultimate purpose of any “licence to operate” research agenda is to influence policy makers in state and federal government, and influence key stakeholders in local communities. The experience reported by ACARP company participants closely involved in C15076 is that the highly technical nature of the work made communication with government policy makers a challenge.

Some of the ACARP participants recommended that the original scope of projects such as C15076 should include the development of a Policy Makers Summary and Guide, in addition to the funding of workshops with relevant bureaucrats.

This suggestion is consistent with the commentary on Project C14052 Pit Lake Bioremediation whereby the needs of key regulatory stakeholders must be properly understood and “designed in” to the project scope so as to maximize the benefits of the research.

CASE STUDY 4

Improvement of Human Factors Engineering in Large Surface Mining Equipment Design Project

Central Problem

The central problem that the C14046 “Improvement of Human Factors Engineering in Large Surface Mining Equipment Design” Project addressed was the perceived gap between Human Factors Engineering (HFE) best practice applicable to design of large surface mining equipment and the equipment design as offered by OEM’s to the mining industry.

Analysis by mining companies confirmed that large surface mining equipment (LSME) incidents comprised an important part of the total Australian mining industry experience of workplace injuries and deaths.

Since the late 1980’s many of the large mining companies had been attempting on an individual company basis to work with OEM’s to resolve HFE issues in large surface mining equipment at the design stage. This had not been very successful. Mining companies and local OEM dealers often resorted to more expensive and less effective retro-fit modifications at the time of new equipment delivery.

The LSME OEM global industry structure was and remains highly concentrated. By contrast, during the 1980’s and 1990’s the mining customer base of the LSME OEM’s was highly fragmented. Substantial concentration of the global mining industry has only occurred since the late 1990’s. This has created an opportunity for greater non-collusive cooperation between mining company customers of LSME OEM’s, seeking better integration of HFE into equipment design as a strategy to reduce injuries and deaths.

The large OEM’s are represented on international standard setting bodies and all LSME are built to international standards. OEM’s clearly had and still have the capacity to directly influence international standards. The evident gaps between HFE best practice in LSME as perceived by the mining industry customer base, the time period over which this has been evident, and the international standard compliant LSME offer of the OEMS suggested that there was a problem either of inadequate information available to OEM’s for design improvement or of inadequate incentive structures for OEM’s to improve design, or a combination of the two.

There was a clear need to move beyond the evident inadequacy of international standards and historic OEM design practices for new generations of large surface mining equipment (LSME) to meet customer needs.

The objective of the project therefore was to:

“Identify significant issues and opportunities related to the human factors engineering (HFE) of large surface mining equipment in order to develop site-level design guidance information and engage the suppliers to develop strategies for improvement of high risk design issues”

Extent of the problem in the Australian coal industry

Data provided in the final report confirms that hazardous incidents, injuries and fatalities associated with the use of large surface mining equipment are a major issue for the open cut coal mining industry in Queensland and NSW.

“Coal Services Lost Time Injuries and Fatalities New South Wales Coal Mines (2004-05) report states that, at open cuts, operating earthmoving equipment and other transport accounted for 34% of all lost-time injuries in 2004-05 (Coal Services, 2004-05). If other equipment related areas, such as getting on/off equipment, climbing equipment, equipment repair and maintenance are also considered, the total goes to 58%.”

“The Queensland Government Natural Resources and Mines 2004-05 Safety and Health Performance Report states that in Queensland, between 1 July 2004 and 30 June 2005, vehicle incidents at open cut coal mines involving near misses / contacts, rollovers, or loss of control had been the most common incident type, and it was reported that several cases involved incidents that occurred while a vehicle was reversing, going past, over or near safety rills and actual collisions with vehicles or persons (Queensland Natural Resources and Mines, 2005)”

The final report provided strong evidence supporting the causal link between HFE deficiencies and the hazardous incidents and injuries. This evidence included references to fatal accident investigations and also extensive photographic documentation of design deficiencies across HFE dimensions.

Did the project achieve the research objective(s)?

The C14046 Project research objectives were set in two areas:

- to develop site-level design guidance information on significant issues and opportunities related to the human factors engineering (HFE) of large surface mining equipment, and
- to engage the suppliers to develop strategies for improvement of high risk design issues

“Site-level design guidance information” objective

The “site-level design guidance information” objective underwent substantial revision in the course of the project following the formation of a joint initiative between four large mining companies to develop a much stronger focus on the second objective; “OEM engagement”. (This has now evolved into the Earth Moving Equipment Safety Round Table (EMESRT) which now contracts the Mining Industry Safety and Health Centre at the University of Queensland for technical expertise, facilitation and coordination with the group. In part, this joint company initiative was a result of the C14046 initiative. ACARP also contributed initial financial support to the joint initiative.)

C14046 in collaboration with EMESRT identified 15 HFE priority improvement areas for large surface mining equipment design. These were:

- | | |
|---|--|
| 1. Equipment access & egress | 9. Machine stability/slope indication |
| 2. Working at heights | 10. Guarding |
| 3. Noise | 11. Displays, controls including labelling |
| 4. Whole-body vibration | 12. Tyres & rims |
| 5. Fire | 13. Manual handling |
| 6. Dust | 14. Work postures |
| 7. Isolation of energy, including parking | 15. Confined spaces |
| 8. Visibility/collision detection & avoidance | |

Rather than “site-level design guidance information”, it was agreed to develop “Design Philosophies” as a tool for engagement with OEM's. The intention of the Design Philosophy approach was to establish customer- defined functional objectives, desired risk management outcomes and general design outcomes. Specifically, the Design Philosophy approach sought to leave the detailed design challenge to the competing OEMs and not to try to tell them the answer. The Design Philosophy sheets were supported pictorially by images that depict both the problem and practical solutions developed by companies and third parties.

Two of the 15 HFE Design Philosophy sheets were completed during C14046. Subsequently, all remaining 13 have now been completed.

The development of the Design Philosophy process, the identification of the 15 priority areas for HFE improvement, and the completion of the first two Design Philosophies is strong evidence that C14046 was successful in its first objective to “develop site-level design guidance information on significant issues and opportunities related to the human factors engineering (HFE) of large surface mining equipment”.

“Engage the suppliers to develop strategies for improvement of high risk design issues” objective

The C14046 Research leader facilitated day long workshops with senior design and marketing executives with each of 6 leading OEMs -Terex, LeTourneau, Liebherr, Hitachi, Komatsu and Caterpillar.

One outcome of these workshops with the OEMs was a set of OEM suggestions for an improved interaction between mining company users and the OEMs on LSME design. The key areas were:

- Increased User inputs to relevant Standards
- Improved flow of User needs information to OEM's
- Expanded scope of Design Philosophies
- Development of an Operability and Maintainability Risk Assessment process
- More structured mining industry contributions to OEM Design Reviews

- Influencing company / site equipment selection consistent with the Design Philosophies
- Other
 - Involve more mining companies in EMESRT,
 - Establish an official communication mechanism such as a website,
 - Ensure confidentiality with OEM solutions,
 - Remember that this effort is related to underground equipment too,
 - Don't forget mine design as a contributor to EME risk, and
 - Address regulatory compliance / acceptance of "solutions".

The engagement process with OEMs and the scope of the list of OEM suggestions is evidence that the C14046 project (together with the EMESRT initiative) was successful in its second objective "to engage the suppliers to develop strategies for improvement of high risk design issues".

In summary, C14046 achieved its research objectives.

Near term impacts of the research project outputs

Near term impacts of the C14046 project success have been identified across a number of areas. These are:

- Ongoing development of EMESRT with participants expanding to now include BHP Billiton, Rio Tinto, Xstrata, Anglo American, Vale, Freeport McMoRan, Barrick and Newmont.
- Completion of the 15 high priority HFE Design Philosophies
- Development by users in collaboration with OEM's of the Operability and Maintainability Analysis Technique (OMAT)

EMESRT is currently working with member mining companies to develop techniques for engaging in OMAT exercises with OEMs as part of the OEM equipment design process.

EMESRT is also establishing internet portals to facilitate in the global dissemination of HFE hazard analysis, risk assessment and design documentation.

EMESRT continues to speak at industry forums around the world to engage other users and to continue the influencing of OEM's. Formal yearly OEM engagement meetings have been occurring and are expected to continue through 2009/10.

The 2009/10 action plan for EMESRT is still being established. One area of focus will be to engage with ISO on standards and influence their alignment with the expectations set out in the design philosophies.

In July 2008 three new groups were formed by various mining companies which will follow the approach taken by EMESRT. These will cover Underground Hard Rock, Underground Soft Rock and Exploration Drilling.

Potential future impacts of the research project

The recent 2008 World Minexpo in Las Vegas highlighted some changes in design by all OEM's. Reports from attendees who have been closely involved in C14046 and EMESRT indicate that HFE related designs were being showcased to differentiate their products in the market. Caterpillar held a separate forum prior to Minexpo on Safety and Environment, EMESRT featured in the opening address by Chris Curfmann – President CAT Global Mining, Curfmann openly supported EMESRT and encouraged participants to visit the EMESRT booth at Minexpo.

The displays at Minexpo suggest that the pendulum had swung in favour of HFE design solutions. Significant spending on research continues with EMESRT member companies representatives assisting with OEM's on these projects.

The human safety and economic benefits of improved Human Factors Engineering in the design of large surface mining equipment will only be realised when new more inherently safe OEM products emerge from improved design processes. While the current indications are encouraging, substantial ongoing collaboration between mining companies and OEM's on applied Human Factors Engineering research and development will likely be required.

Key Lessons for future ACARP research

A critical issue for ACARP and member companies is how to engage OEM's in new product development and product improvement initiatives. In planning new ACARP projects, it may be helpful to distinguish between opportunities from creating new incentive structures and opportunities linked to improved information flows.

- In all major coal mining equipment categories, the OEM industry structure is highly concentrated and individual coal mining companies are unlikely to have sufficient incentive or buying power to assert their individual needs or desires for new product design. This suggests that new incentive structures may be required to break the status quo.
- Design processes within OEM's may also benefit from better quality and broader customer information on operability and maintainability issues. This suggests that new information processes linking OEM's and mining company customers may be required to break the status quo.

C14046 has pursued a strategy based on improved information flows. By building a set of hazard analysis processes/tools driven by HFE knowledge/research and by building processes for engaging OEM's using those HFE driven tools, the expectation is that there is sufficient competitive incentive for OEM's to take up the new information regarding opportunities to offer improved customer benefits, and apply it to new and improved product design. A core part of the EMESRT/OEM compact is that OEM's retain the proprietary rights to all their own efforts.

The Landmark Longwall Automation Project (+extension) appears to have pursued a fundamentally different strategy of OEM engagement. The Longwall Automation project sought to develop new LASC technology and an open technology standard that effectively compelled OEM's to either take up the LASC innovations or forge ahead with a proprietary alternative, or risk being left behind. ACARP and CSIRO's commitment to and capability to develop new technology became a very powerful new incentive structure operating on OEM's. CSIRO/ACARP became a significant new player in intellectual property development and control within this machine market sector.

It is too early to judge if the information focused OEM engagement strategy on HFE driven equipment design will result in major improvements to machine operability and maintainability. Evidence to date is strongly supportive. What remains in some doubt is whether the required OEM investment in HFE research and design will be economically justified within the individual OEM's. One OEM executive commented that unless they can see ways to protect their innovations, it might be judged that the OEM investment will be rapidly competed away between OEM's. This might limit the extent of innovation achievable through the information strategy. A very different view was expressed by an executive from another OEM. He believed that the opportunity to really understand the customer benefit from innovation would provide sufficient incentive for their company to invest. The marketing benefit might be much more important than the inability to protect Intellectual Property. If this were the case, the remaining OEM's would probably be driven to follow.

It is possible to assess the effectiveness of the R&D focused / incentive driven OEM engagement strategy on Longwall automation as new and effective commercial longwall automation offers are now available. In that circumstance, it was the ACARP/CSIRO commitment to risk bearing in the initial R&D effort that allowed the problems to be overcome and create a sufficient set of incentives for OEM's to take up the innovations or to invest in their own. What is less clear is whether that model is sustainable into a second round of automation beyond longwalls, given what OEM's have learned from their engagement in the first round on interaction.

From this discussion it is reasonable to conclude that ACARP research project design needs to understand the information and incentive barriers to OEM product innovation in the specific market segments that they are addressing and adjust their engagement strategy accordingly. What works in one market context may not work in another.

Regardless of the information/incentive distinction, the highly concentrated nature of the OEM industry structure makes it critical that ACARP establishes and maintains strong multi-company support throughout any project that requires OEM engagement.

CASE STUDY 5

Improved Coal Wagon Unloading by Reducing Loading Force

Central Problem

The central problem that the C12061 “Improved Coal Wagon Unloading by Reducing Loading Force” addressed was the delay to train unloading from coal “hang up” in rail wagons.

An earlier ACARP project, C10061 “Investigation into Problems of Discharging Queensland Coals from Bottom Dump Rail Wagons” completed in November 2002 had identified five factors that appeared to have a significant causal effect on coal hang up delays. These were:

- coal properties,
- wagon type,
- the consolidating force applied to the coal during loading,
- the position in the wagon where loading commenced, and
- the less frequent but larger consolidation forces during rail travel.

C10061 concluded that the coal properties contributing to stickiness were multi-factorial. The proportion of coal fines and free moisture content were important factors but the problem was too complex to effectively characterise with available data. No practicable intervention opportunities were identified to predict stickiness based on mineralogy or modify the coal properties but tests to characterise risk for individual coals or mixes were developed.

Modern wagon types performed better but no recommendations for modifications to older generations of wagons were made. Recommendations regarding train driving practices were made that might reduce the infrequent but large consolidating forces during rail travel. Recommendations were also made about jackhammering practice and the frequency of jackhammer operation to break up coal arches.

The key recommendation of C10061 was to investigate modification of loading practices to reduce coal hang up delays.

The objective of the C12061 project therefore was to:

- Determine in the laboratory methods for reducing loading forces and hence consolidation in rail wagons.
- Modify the loading method used at a mine and assess the improvement in unloading.

C12061 project was completed in September 2004.

Extent of the problem in the Australian coal industry

The Central Queensland Port Authority (CQPA) estimated during 2003 and 2004 that 24% of trains unloading at the R G Tanna Coal Terminal (RGTT) required jack hammering to release coal hang up in wagons. CPQA estimated that 2% of annual port capacity at RGTT was lost over that period due to coal hang up unloading delays, equivalent then to 800,000 tonnes of coal exports per year.

The problem appears to be largely confined to the northern and central Queensland coal ports of Abbot Point, Dalrymple Bay, Hay Point, RG Tanna CT and Barney Point CT. All are now 100% bottom discharge facilities. Interviews with participants in the earlier C10061 project indicated that the problem was most severe at RG Tanna CT and Barney Point, and present but less severe at Hay Point and DBCT. This suggests the initial extent of the problem might have been somewhat less than 2% of the port capacity across all the 5 ports

Current losses in coal chain capacity from sticky coals are difficult to estimate. No public data was available to directly measure the ongoing extent of coal hang up caused delays in unloading. Comments from QR, RG Tanna CT and coal producers indicate a significant reduction in coal hang-ups has occurred since 2004. If we assume in 2008 that across these Queensland coal terminals the level of sticky coal problems have reduced so that only 1% of port capacity is lost, then the coal hang up problem still has the potential to reduce Queensland coal exports via the northern and central ports in 2007/2008 by ~ 1.6 million tonnes (1% of QR 2007/2008 Queensland coal shipments of 160 million tonnes to these ports).

While these assumptions today are unlikely to be wholly valid it appears that coal “hang up” within rail wagons causing delays in rail wagon unloading was a significant drag on the entire coal supply chain during the early part of this decade. It was causing:

- losses of hundreds of millions of dollars in coal sales,
- reduced asset utilisation and higher labour costs for port operators,
- reduced rolling stock asset utilisation for rail haulage companies,
- a contribution to ballast and points contamination and the risk of wagon derailment for the rail operator, and
- health and safety hazards (noise, vibration, fatigue, manual handling injuries) for unloading terminal staff who have to jack hammer the sides of the wagons.

It also important to highlight the level of externalities regarding the allocation of costs from coal hang-up in the Queensland coal supply chain.

- At least for the RG Tanna and Barney Point Coal Terminals, the costs of managing coal hang-ups are borne by the terminal operator and not directly allocated to those specific trains, train loads or coal producers that are the directly linked to the hang-up.
- QR's economic losses associated with reduced asset utilisation are not directly allocated to either the coal terminal or the specific coal producer for the delay but borne across the entire system.
- The increased risk of coal hang up associated with older wagon designs / aluminium wagons are not priced in to the supply of these wagons.
- The system wide costs of sticky coals or poor loading practice are not borne by the individual coal producer but smeared across the entire system.

The central problem that the research projects sought to address therefore needs to be understood in the wider context of a market structure that failed (and continues to fail) to allocate costs efficiently. At least part of the reason for the inefficient cost allocation was the lack of agreement about the contributory factors to coal hang up and lack of robust and efficient systems to measure coal hang up delays and costs.

Did the project achieve the research objective(s)?

Objective 1: “Determine in the laboratory methods for reducing loading forces and hence consolidation in rail wagons”

The project authors claimed that *“the laboratory experiments established that there are two simple ways for reducing loading forces. These are to:*

- *Reduce drop height*
- *Ensure that coal strikes the front slopesheet of the wagon.”*

This reviewer considers the data presented may not be sufficient to justify a strong recommendation that reducing the drop heights on new or replacement loadouts should be considered a priority. One of the two coal types tested showed no clear relationship of force with drop height. The other test data suggest that if loading is achieved on the front slopesheet that drop height may not be a critical factor.

The point of this comment is simply to emphasise the need to avoid over-interpretation of research results in the conclusions. What is intuitively obvious may not have been demonstrated in the laboratory because of experimental constraints.

The other reported results of the laboratory testing provide strong evidence that the initial impact of loading should be towards the top of the slope sheet to reduce consolidation forces over the doors.

Objective 2. “Modify the loading method used at a mine and assess the improvement in unloading”

The field testing generated many insights into the interaction between train loading practice and the prevalence of coal hang ups:

- The field testing confirmed that focusing the initial impact of loading to the top of the front slope sheet was preferred.
- This outcome highlighted the need for an integrated set of QR loading requirements. Policies designed to reduce the risk of bogie overload were having direct adverse impacts on coal hang ups as loader operators were being encouraged to delay the chute opening so the initial impact occurred over the door.

- The field tests also generated new insights into the interaction between the speed and consistency of train movement during the loading and the prevalence of coal hang ups. In particular, it identified an increased risk of coal hang ups in the latter section of the train when train speed control was impaired.
- The field tests confirmed that use of aluminium wagons of older design increased the risk of coal hang-ups.

In conclusion, the project did achieve the overall objectives. In particular it demonstrated that well designed field trials supported by laboratory research could generate useful insights into the multi-factorial causation of coal hang ups, as well as practical recommendations for changes to train loading practice that would likely reduce the prevalence of coal hang ups and unloading delays.

Near term impacts of the research projects output

The research projects appear to have provided a stronger fact base and understanding about the multi-factorial nature of the coal hang up problem for all the players in the Queensland coal supply chain:

- Coal companies had better insights into higher risk coal mixes/moisture contents and were able to have laboratory tests completed to assess hang up risk prior to and during mine development.
- QR had better insights into wagon design/choice of wagon materials, the interaction between boggy loading policies and hang up risk, and the interaction between train loading speed control and hang up risk.
- Design engineers had better understanding of design improvements for load out heights and loading chutes.
- Coal companies had better insights into loading practice optimization, in particular the importance of initial load onto the front slope sheet.
- Port terminal operators had better insights into jack hammering practices and the measurement of hang ups.

One of the interviewees commented that the biggest challenge at the conclusion of the projects was in getting tangible commitments to change as the participants were reluctant to publicly acknowledge their part of the problem. This observation is consistent with the earlier analysis suggesting that the high level of externalities and the inadequate incentive structures were driving a sub-optimal outcome.

Notwithstanding that comment, it is evident that different stakeholders have made changes as a result of the project outcomes or coincident with the project outcomes that appear to be reducing the risk of hang ups.

QR have continued to buy more stainless steel wagons while continuing to improve the slope sheet and door design , however the aluminium wagons continue in use. QR loco upgrades now provide for improved train speed control during loading, reducing the increased risk of hang up in the rear wagons.

It is not clear that any new loader has been built to incorporate the design recommendations to reduce the drop height. Loader design appears to be optimized around maximizing controlled load rates. One coal company highlighted the reduction in coal stickiness for one of their problem products that has resulted from a shift away from a dozer operated stockpile system to a new stacker/reclaimer, as a result of avoided dozer compaction.

One of the coal company representatives interviewed commented that in addition to all the above, the most important impact of the project results was that it allowed them to justify significant investments into new wagon unloading technology (wagon shaker/vibrator). Their assessment was that the research demonstrated that the most practicable solution to coal hang-ups was a technology change in unloading operations. While that company had previously rejected investment proposals requiring significant changes to unloading facilities (in favour of attempting to change operator work practices), the evident problem complexity and perceived lower reliability of the work practice approach provided strong support for the capital investment business case.

It was also reported that the operator of DBCT has installed a wagon shaker/vibrator at one unloading pit and that a wagon shaker investment is also being considered for Abbott Point.

Sitting behind the anecdotal evidence reported to this review for a net reduction in coal hang up delays is evidence that coal quality has also changed significantly. In the case of one coal producer, mining coals from deeper in the coal measures has resulted in a significant reduction in stickiness for what was previously a problem coal. It was also suggested that the carriage of higher tonnages of low mass/bulk density coals with higher levels of coal fines may be increasing the risk of coal hang ups. This suggests changes in coal quality is an important confounding factor in any attempt to measure the impact of changes in the coal supply chain technology and operating practice.

Quantitative evidence for improved coal hang up outcomes is limited. Unloading at RGT CT still requires jackhammering on approximately 30% of trains but the duration of hold ups is much reduced.

Potential future impacts of the research project

The improved understanding of the factors causing coal hang ups and the emergence of new measurement tools and systems to detect and record coal hang ups and carry back in real time suggests that information problems no longer need to be a barrier to overcoming coal hang up problems.

The deficient incentive structures can now be addressed by the coal supply chain participants with a degree of confidence that hang ups and carry back can be reliably measured, the wagon specific risk factors can be understood and train loading speed risks can be measured and better controlled. This should allow the producer specific risks (coal quality and loading) to be isolated.

It remains up to individual supply chain participants to understand how their long term economic interests can be optimized within the system, to invest in the measurement of their own risk producing activities, and to look to differentiated pricing or other controls to manage their risks. Until the problems of externalities/free-riders are addressed the adverse economic effects on the industry are unlikely to be fully controlled.

Key Lessons for future ACARP research

This sequence of research projects focused on coal hang up (and coal carry back measurement), and on understanding the multi-factorial nature of the problems appear to be excellent examples of high leverage/ high impact industry research funding.

- The economic losses to the industry through supply chain inefficiency are high.
- The evidence for poor incentive structures to pricing of risk is strong.
- There was a very strong need for better information to enable supply chain participants to measure and price risk.
- The research projects have allowed the key causal factors to be identified and for improved real time measures of risk or outcome to be put in place.

Notwithstanding this positive outcome, the ownership of the coal supply chain has become more fragmented since these projects began in 2001. The separation of QR into a below rail infrastructure manager and an above rail train operator, together with the emergence of Pacific National as a competing train operator means that there are now 2 additional rail players with potentially conflicting interests.

The change in ownership and control of the DBCT also means that DBCT economic interests are now cleanly distinguished from coal producer interests. This means that DBCT are likely to be more aligned with Central Queensland Port Authority in seeking solutions to problems such as hang up which reduce asset utilization.

Given the complexity of the competing ownership structures in the coal supply chain it is likely that further opportunities exist for operational research to better understand the multi-factorial causation of other areas of system inefficiencies. By identifying these areas and “unpacking the problems” with good operational research, the stakeholders could achieve an improved information base on which they can make better decisions as profit maximizing agents within the network of interdependent interests.

ACARP could play a leadership role in identifying other streams of research designed to resolve such information problems. One approach could involve a working group lead by ACARP, representatives of all the terminal owners and the rail system players to review the results of all current/recent investigations into coal chain inefficiency in Queensland, to identify areas/problems that can be unpacked by operations research. If this was productive, a similar approach could be applied to the NSW coal chain.

BACKGROUND TO HEURIS PARTNERS

Heuris Partners is a Melbourne based mining and energy industry consultancy established in 2001 by Mike Waller and Anthony Baird. Prior to establishing Heuris Partners, Mike Waller was the Chief Economist and Director of Public Policy with BHP Billiton and Anthony Baird lead the BHP Billiton Corporate Strategy Development function. Richard Knight is the non-executive Chairman of Heuris Partners.

Anthony Baird led the ACARP project evaluation work. His prior work in the coal industry includes leadership of a strategy review of BHP Coal in the late 1990's, a consulting engagement with Anglo Coal Australia that included an improvement project at the Moranbah North underground operation, a consulting engagement with Xstrata Coal on the outlook for global and regional energy pricing, and a recent consulting engagement with BHP Billiton Coal Indonesia focused on sustainable development in central Kalimantan.

Evaluation Framework

The following framework was adopted for the review.

- 1) Identify the central problem the project set out to address;
- 2) Understand the extent of the problem across the Australian coal industry today and the likely extent through the next decade;
- 3) Understand the direct outputs of the project to assess the extent to which the project achieved its research objective;
- 4) Understand the current impacts and anticipated future impacts of the project outputs for the Australian coal industry and other stakeholders; and
- 5) Identify key lessons for ACARP in planning future research.

Data for the review included the initial research funding proposals, the final research report, publically available independent scientific reports to corroborate estimates of problem scope and scale in the industry, interviews with the research project leaders and coal industry sponsors, interviews with representatives of coal companies not directly involved in the research project, and interviews with relevant government, regulatory and community stakeholders.
