ACARP

Australian Coal Association Research Program

FINAL REPORT

Australian Roadway Development – Current Practices

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ACARP

DISCLAIMER

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1. EXECUTIVE SUMMARY

1.1 Background

The report was commissioned in July 2005 by Australian Coal Research Ltd (ACARP) to identify what incremental and step changes can and must be made in roadway development technology and systems that will enable a new generation of Australian longwall mines to be developed, and to also provide significant productivity gains to existing mines so that they can compete with the new generation mines.

1.2 Findings

The key findings in respect to the establishment of efficient, high capacity longwall mines are that:

- In later generation, best practice mines with good conditions it is likely that 15Mtpa mines could be established and sustained without major developments in mining equipment and systems.
- Infrastructure limitations will constrain older mines from making major improvements in mine capacity, while adverse conditions generally associated with depth (eg; stress and gas) pose additional productivity challenges to these mines (and to later generation mines as they mature).
- Technology developments are currently underway that are likely to address a number of key process constraints in the short to medium term, thus providing the potential to improve system capability across all mines.

Major constraints to roadway development were identified as:

- Roof and (particularly) rib support were typically identified as the most significant constraint, unless support requirements were minimal and difficult floor conditions were experienced.
- The cyclic, stop-start nature of shuttle cars and other coal haulers was seen to limit development rates, particularly once haulage distances increase beyond 70m.
- Advancement of the conveyor and panel services was a significant constraint, particularly in mines employing dual continuous miners to advance 2 entry gateroads.
- The routine installation and advancement of ventilation duct is a problem at mines that have not adopted integrated monorail services management systems.
- The logistics of supply, transport, distribution and handling of roof and rib support consumables is an issue at older, extensive mines now, while the achievement of higher development rates will compound this issue at most mines.
- The installation of long tendons (greater than mining height) as a primary support measure is becoming more widespread, yet installation technology and hardware remains fairly rudimentary.
- The physical demands of the work environment and the extent of manual handling required, coupled with an ageing workforce, is not conducive to the achievement and sustainability of high development rates.

- Coal cutting was not seen as a constraint at any mine, however the ability of machines to cut breakaways for cut throughs was considered to be a major failure of all machine configurations.

The key attributes of a new roadway development mining system were identified as:

- Integrated, continuous cutting, bolting and coal clearance system – continuous mining.
- Automated bolting, with self drilling bolts.
- Alternative skin reinforcement and confinement measures to eliminate the use and handling of steel mesh.
- Alternative systems to mine interconnecting roadways (eg; coal auger) or the development of risk control measures to permit the adoption of single entry roadway development.
- Integrated materials supply and logistics with components stored in magazines or cassettes, requiring minimal manual intervention.
- Extensible (monorail mounted) face services (eg; ventilation, power, water, compressed air, pump out).
- An extensible, self advancing panel conveyor.
- High capacity, automated installation of long tendon primary and secondary supports.

An integrated "concept" machine was identified at one site only. Failing to conceptualise a new integrated machine, the application of TBM technology or re-engineering of the Joy Sumps Shearer was generally seen to offer potential as the basis of a new generation, high capacity, integrated development system.

1.3 Industry Constraints

There are a number of either real or perceived constraints that may impact the successful research, development and demonstration of new technology and mining systems:

- The industry's ability and willingness to fund, and its overall capability to sustain research, development and demonstration of new mining systems such as the introduction of tunnel boring machines (TBM), particularly through tight economic conditions.
- The inability of mine operators to commit to major long term development and demonstration of new mining systems and technology as a result of the limited longwall float at most mines, and a scarcity of experienced mining professionals, engineers, supervisors, operators and trades personnel.
- The limited size of the Australian mining equipment market, the OEM sectors propensity to develop new technology as global products, and for that development to be done" in-house" in order to protect intellectual property.
- The lead time from concept to successful demonstration is too long, resulting in a loss of project champions (eg; promotion or turnover) and a diminution of corporate energy and critical mass.
- Overly restrictive legislation limiting the development and application of new technologies (eg; automation and robotics) and the use of light weight materials (eg; aluminium), coupled with the over zealous pursuit of absolute safety first, or resort to prosecution in the event of less than absolute safety.

1.4 Recommendations

What mine operators and mine managers should do to improve development performance:

- Pursue industry best practice roadway development practices and fully embrace the concepts of process control, continuous improvement, and the involvement of all personnel in that pursuit.
- Commit to the development and conduct of a routine roadway development benchmarking process across the industry, and the regular publishing of updated results.
- Commit to the development and conduct of a regular "best practice" roadway development forum to enable development practitioners to share successes and failures and learn of new practices, developments in R&D, and emerging issues.
- Give due recognition to the role of development in the mine's operation and adequately resource the development function to enable it to be properly accountable for its performance.

What mine owners should do to address key constraints:

- Through ACA and ACARP, develop and commit to a long term investment strategy to support and sustain the research, development and demonstration of new mining systems and technology.
- Through ACA and the various State Mining Councils, develop and commit to a long term strategy to develop the industry's skills base and overcome the scarcity of experienced mining professionals, engineers, supervisors, operators and trades personnel.
- Challenge, through ACA and the various State Mining Councils, the restrictive legislative framework being imposed on the industry, and the regulators resort to prosecution in the event of less than absolute safety.
- Fund, support and sustain through ACA and/or ACARP, the conduct of routine roadway development benchmarking studies across the industry, the conduct of regular "best practice" roadway development industry forums, and publication of the results of benchmarking studies and the forum proceedings.
- Challenge mine operators and mine managers if they fail to pursue industry best practice roadway development and do not fully embrace the concepts of process control, continuous improvement, and the involvement of all personnel in that pursuit.

What incremental change initiatives should be pursued by ACARP:

- By end 2005, develop a vision that it will demonstrate by end 2006, a high capacity, integrated mining system that incorporates the then best practice, equipment and technology including; self drilling bolts, automated bolting, continuous haulage, self advancing extensible panel conveyor, and a monorail mounted services management system.
- Pursue and expedite the commercialisation of alternative self drilling bolt technologies and automated bolting systems, including the potential retrofitting of the automated bolting systems to existing continuous miners.
- Facilitate and expedite completion of the Automated Continuous Bolting Machine (ACBM) and associated technologies.

- Develop alternative skin reinforcement and confinement measures to eliminate the use and handling of steel mesh.
- Facilitate the development of an extensible, self advancing panel conveyor.
- Develop a high capacity, automated long tendon installation system for both primary and secondary support applications.
- Develop a mine economics modelling system that enables mines to properly evaluate the full cost of alternate development systems and varying performance levels.
- By end 2006, demonstrate a high capacity, integrated mining system that incorporates the then currently available, best practice technology and equipment.
- Pursue other complementary technology developments including automation and robotics, machine guidance systems, light weight materials, face pumping systems, roadway construction and consolidation, and gas drainage.
- Improve the level of awareness and understanding of technologies being applied in other industry sectors.
- Improve the level of awareness and understanding of roadway development technologies and systems being utilised in mines overseas.
- Develop software that will facilitate and enhance the adoption of the systems approach/ process control.

What step change initiatives should be pursued by ACARP:

- By end 2005 develop a vision that it will demonstrate by end 2008, a high capacity, integrated mining system capable of sustained, continuous production at a level of +10MPOH for greater than 20 hours day.
- By end first quarter 2006 develop a strategy for the development and demonstration of the high capacity integrated mining system, including; sourcing of funds, development of technology, design and manufacture of equipment, conduct of extensive field trials at an appropriate site, and commercialisation of the technology and equipment.
- By end second quarter 2006 develop a specification for the high capacity, integrated mining system and commission the design of a number of alternative systems (eg; Cutting Edge Technologies' concept machine and the IHI and Pacific Tunnelling TBM concepts).
- By end 2006 evaluate and select a design that best meets the industry specification and requirements, and commission an OEM (or OEMs) to develop the technology and manufacture the integrated system.
- By end 2006 establish a collaborative agreement to conduct extensive field trials and demonstrations at an appropriate mine site (eg; highwall), either by using a project team internally funded by the mine owner, or an externally funded mining contractor (by ACARP).
- Project manage the technology and equipment development process through to the conclusion of the field trials and demonstrations end 2008.

2. INTRODUCTION

2.1 Background to the Review

The report was commissioned in July 2005 by Australian Coal Research Ltd (ACARP) to identify what incremental and step changes can and must be made in roadway development technology and systems that will enable a new generation of Australian longwall mines to be developed, and to also provide significant productivity gains to existing mines so that they can compete with the new generation mines.

In 2004 ACARP's Underground Committee recognised that current development rates were failing to keep up with advances in longwall production, and that the introduction of a systems approach to roadway development initiated in 1995, had not delivered the promised doubling of development rates. Further, by 2004 the industry was now envisioning 15 Mtpa mines within the next decade.

A roadmap based on the research and development of new roadway development equipment and technology was formulated and, based on strong support from relevant senior corporate executives, the ACARP Roadway Development Task Group (RDTG) was formed.

Focussing on the key elements of roadway development, namely coal cutting, roadway support, coal clearance and logistics, the RDTG has structured the review to:

- Identify where past wins have been achieved and what lessons have been learnt;
- Identify opportunities for research and development of new technologies, equipment and associated systems; and
- Gain support and commitment for a targeted 7 year research and development program.

Gary Gibson&ASSOCIATES (GG&A) was selected by the RDTG to conduct the review and work commenced end July 2005.

2.2 The Approach Adopted

The approach to the study comprised three main steps as outlined below:

- Copies of ACARP and other reports detailing the conduct or earlier roadway development research and development were obtained for review. A listing of such reports is included in Appendix I.
- A two part template for the conduct of site workshops (reviews) was developed, with Part A seeking to characterise each of the various sites by way of a questionnaire, with Part B focussing on the issues and challenges faced by mine operators in roadway development.

  It was intended that Part A would be completed by site personnel prior to the workshop, with Part B then being administered during the workshop. While mines were requested to provide basic production and productivity data in Part A, the review was not intended to be an industry benchmarking process.

  The template was then vetted by the RDTG before being forwarded to all operating longwall mines. A copy of the template is included at Appendix II with a table detailing mine site responses to Part A and Part B included at Appendix III.

- Discussions were held with representatives of mining corporate offices, mining contractors, OEMs and suppliers, research organisations, and the Inspectorate in both Queensland and NSW. A copy of the notes of interview of these discussions is included at Appendix IV.

The purpose of the overall process adopted was to review roadway development in Australian underground coal mines and establish where the industry is today and how it got there, including:

- Documenting the current status of existing systems and equipment;
- Determining where operators have had wins and losses in roadway development initiatives over the past decade, and capturing the lessons learnt from those initiatives;
- Identifying incremental and step changes in roadway development that the industry considers both necessary and likely over the next decade;
- Identifying where research could produce wins and make such changes possible, and;
- Establishing the level of mine site interest in participating in future roadway development initiatives and research.

2.3 Workshop and Interview Responses

2.3.1 Confidentiality

All the information provided by organisations who participated in the review process has been handled on a confidential basis. No third parties, including ACARP, have had access to the original data and workshop responses were destroyed once the data had been processed and the report compiled.

All organisations participating in the review will be provided with a copy of the final report.

The data is presented in the report in such a manner that no one organisation will be able to identify another organisation's information. Participating organisations have been allocated a code number and each participating organisation will be contacted by GG&A and provided with their own identification number when the final report is released.

In the event that an organisation seeks further information regarding the potential transfer of a best practice or other related matter GG&A will only provide suggested contact details for that party to pursue.

2.3.2 Review Participation

Reviews were conducted with representatives from:

- All operating longwall mines.
- Bolting hardware suppliers – Hilti, Jenmar and One Steel.
- Corporate offices of major mining companies – Anglo Coal, BHP Billiton, BHP Billiton Mitsubishi Alliance (BMA), Centennial and Xstrata.
- Geotechnical consultants – Ground Support Services, Seedsman, Strata Control Technology (SCT), and Strata Engineering.
- Mining equipment OEMs – Alminco, Continental, DBT, Hydramatic, Joy, PJ Berriman and Sandvik
- Mining contractors - HWE, Roche, Thiess, UGM, and Walters

- Research organisations – Cutting Edge Technologies, Eikon, and the Queensland Centre for Advanced Technologies (QCAT).
- TBM OEM/developers – IHI, and Pacific Tunnelling.

In all, some 160 persons participated in the review process, with all workshops and interviews being conducted in person. Site participants included; General Managers, Mine and Technical Service Managers, Production and Development Superintendents, Development Coordinators, Development Engineers (both mechanical and electrical), Mining Engineers, Deputies, Miner Drivers and Longwall Operators, although only a few sites were represented by the broad spectrum of participants listed above.

Interviews conducted with other industry stakeholders similarly comprised a broad spectrum of participants including; Managing Directors, Directors, Principals, General Managers, Business Development, Project and Sales Managers, Researchers, Technical Representatives, and Inspectors.

An alphabetical listing of review participants is detailed in Appendix V. Each of those participants is acknowledged for their contribution to the process.

2.3.3 Data Quality

A variety of key performance indicators (KPI) are used to monitor and evaluate performance while there also appears to be variation in the usage of common terms such as uptime, utilisation, and availability. This leads to difficulties in attempting to perform any qualitative assessment of the data, although it is again noted that the review was not intended as an attempt to benchmark roadway development performance across the industry.

Examples of KPIs used by the industry include:

- *Metres per operating hour* (MPOH) and *metres per week* (MPW) are the more commonly accepted rate indicators, while *time to completed a pillar cycle* (days) is used as an alternate in some instances.
- *Uptime* is reported in minutes per month, or hours per week, or hours per pillar cycle, or is expressed as a percentage utilisation.
- *Time to complete a panel advance* (shifts, or calendar hours) is used to monitor the effectiveness of panel advances in most instances, whilst *man hours utilised* (man hours) is also used at some mines for this purpose.

A number of Part A questions were structured to determine whether overall production and development performance had changed significantly over the last decade, or whether they were likely to change over the next decade. Due to the number of recently developed mines surveyed, the number of corporate takeovers over the past decade, the number of pending closures over the next decade, or the less than 10 year planning horizons reported at many mines, only limited data was available. Consequently it was necessary to gain subjective insights into whether performance had changed or was likely to change in the foreseeable future in the following questions.

2.3.4 Observations

During the workshops and interviews practices were observed or commented upon which are felt to be of real value to this report. As is often the case these observations reflect cultural and experiential attitudes, opinions and actions rather than verifiable facts. An apology is offered if any party or individual considers that they have been incorrectly or inappropriately reported.

2.4 Report Structure

The remainder of this report is structured as follows:

- Main findings of the review are detailed in Part 3;
- The constraints to improved development performance are detailed in Part 4;
- What mine operators and mine managers should do to improve roadway development performance is detailed in Part 5;
- What mine owners should do to address key constraints is detailed in Part 6;
- What incremental change or tactical initiatives that ACARP should be pursue are detailed in Part 7;
- What step change or strategic initiatives that ACARP should pursue are detailed in Part 8; and
- A summary of observations on industry best practice roadway development is included at Part 9.

3. MAIN FINDINGS

3.1 In later generation, best practice mines with good conditions it is likely that 15Mtpa mines could be established and sustained without major developments in mining equipment and systems

Later generation best practice mines with good conditions are typically achieving 300m per week per development unit, or in the case of super unit mines 400m per week per super unit, when mining at heights of 3.0 to 4.0m.

As shown in the table below (and as illustrated in the figures over), a 300m wide, 4.0km longwall typically requires 682m per week of development to sustain a 15Mtpa longwall in a 3.0m seam, which reduces to 585m per week in a 3.5m mining section and 512m per week in a 4.0m mining section.

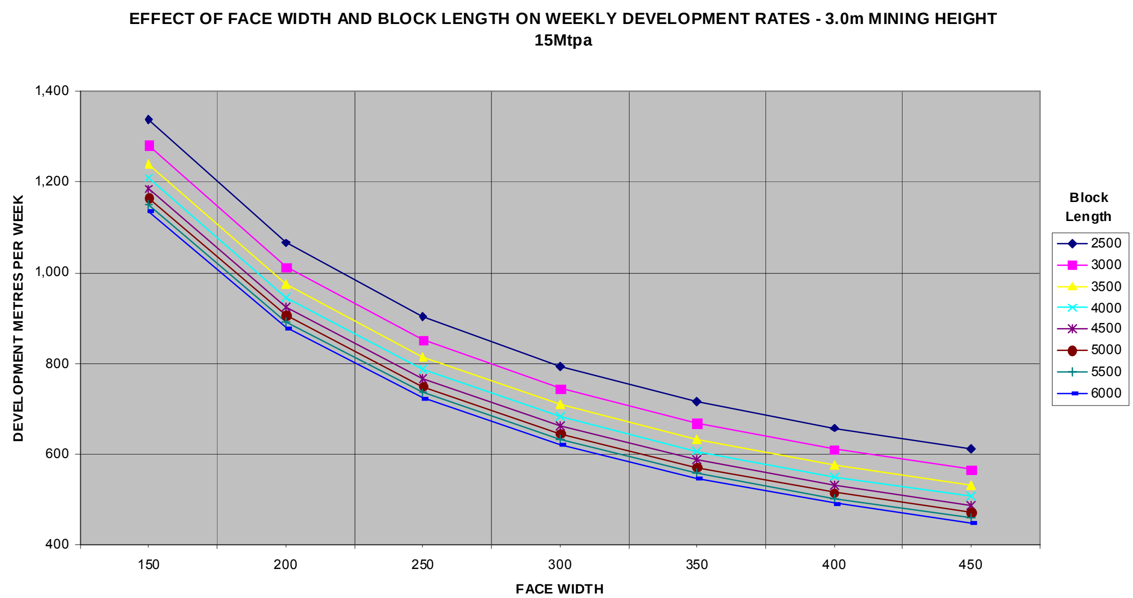
3.0m Mining Height		Face Width (m)						
		150	200	250	300	350	400	450
Longwall Block Length	2,500	1,339	1,066	903	794	716	657	612
	3,000	1,281	1,013	852	744	667	610	565
	3,500	1,240	974	815	709	633	576	532
	4,000	1,209	946	788	682	607	551	507
	4,500	1,185	923	766	662	587	531	487
	5,000	1,166	906	749	645	571	515	472
	5,500	1,150	891	735	632	558	502	459
	6,000	1,137	879	724	620	547	491	448
3.5m Mining Height		**Face Width (m)**						
		150	200	250	300	350	400	450
Longwall Block Length	2,500	1,147	914	774	680	614	564	525
	3,000	1,098	868	730	638	572	523	484
	3,500	1,063	835	699	608	543	494	456
	4,000	1,036	811	675	585	520	472	434
	4,500	1,016	791	657	567	503	455	418
	5,000	999	776	642	553	489	441	404
	5,500	986	764	630	541	478	430	393
	6,000	975	753	620	532	469	421	384
4.0m Mining Height		**Face Width (m)**						
		150	200	250	300	350	400	450
Longwall Block Length	2,500	1,004	800	677	595	537	493	459
	3,000	961	759	639	558	501	457	424
	3,500	930	731	611	532	475	432	399
	4,000	907	709	591	512	455	413	380
	4,500	889	693	575	496	440	398	365
	5,000	874	679	562	484	428	386	354
	5,500	863	668	552	474	418	377	344
	6,000	853	659	543	465	410	368	336

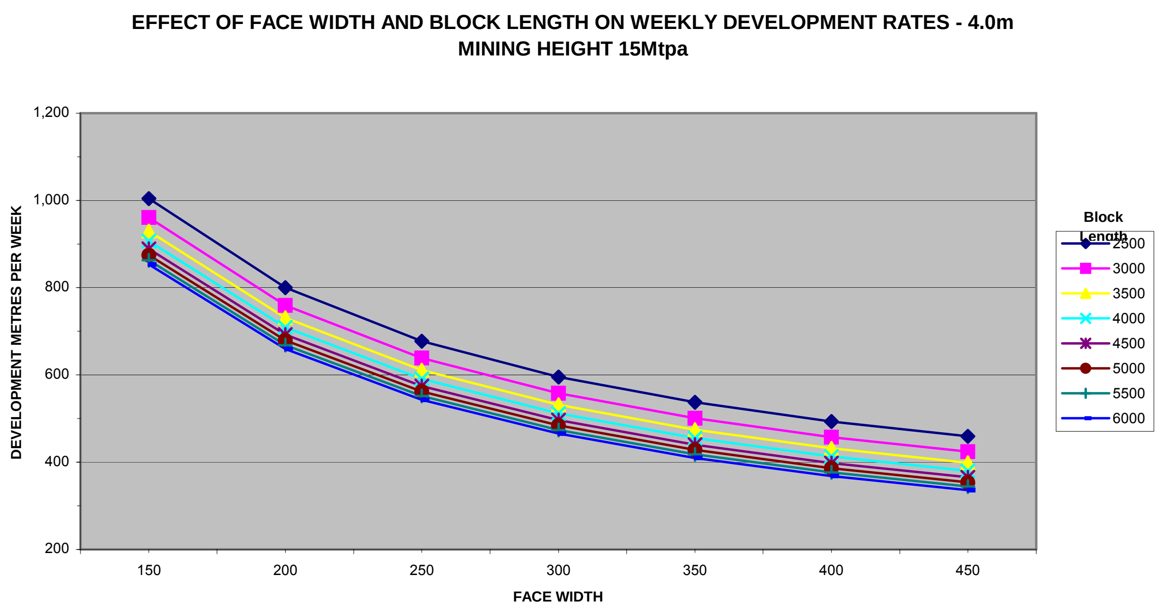
TABLE SHOWING EFFECTS OF FACE WIDTH, BLOCK LENGTH AND MINING HEIGHT ON WEEKLY DEVELOPMENT RATES - 15Mtpa MINE

The adoption of wider faces and/or longer blocks further reduces the development burden, while the adoption of high wall punch longwalls without the associated mains development further reduces the development burden (Note: the model utilised to estimate the above weekly development rates is based on the adoption of a 6 entry mains system with all roadways at 35m centres and all cut throughs at 100m centres).

Therefore it is reasonable to expect that with the deployment of an additional unit in a new generation best practice mine, that longwall production levels of 15Mtpa could be sustained.

It could also be reasonably expected that "average performing" later generation mines achieving say 200m per week per continuous miner, or in the case of super unit mines 265m per week per super unit, could sustain 15Mtpa longwall mines when mining at heights of 3.0 to 4.0m.





It is unlikely that "worst in class" later generation mines achieving say ≥100m per week per continuous miner, or in the case of super unit mines ≥130m per week per super unit, could reasonably sustain 15Mtpa longwall mines (mining heights 3.0 to 4.0m), unless longwall block lengths and face widths were extended to or beyond current technological limits.

3.2 Infrastructure limitations will constrain the potential of older mines to make major improvements in mine capacity, while adverse conditions generally associated with depth (eg; stress and gas) pose additional productivity challenges to these mines (and to later generation mines as they mature).

Older mines as mainly found in NSW have extensive underground workings and suffer from infrastructure limitations in respect to mine ventilation, coal clearance, men and materials haulage and mine access. They are also likely to be mining at depth and subject to high in situ gas and horizontal stress levels, and to have surface features and constraints that limit longwall face widths, block lengths, and overall mine design.

It can also be seen from the previous table that a 15Mtpa capacity, 3.0m high, 3km long, and 200 – 250m wide longwall would generate a significant development burden (1,013 – 852m/week), a burden which would be difficult to sustain at typical development rates of 100m per week in these conditions, or even best practice development rates of 150m per week in these conditions.

This would suggest that the development of a high capacity, integrated roadway development system would be of greater benefit to the older, more challenging deeper mines. These older mines are also typified by an ageing workforce, a workforce which is less likely to be able to sustain high development rates where there is a high degree of manual handling of roof and rib support consumables.

3.3 Technology developments are currently underway which are likely to address a number of key process constraints in the short to medium term, thus providing the potential to improve system capability across all mines.

- Five self drilling bolting systems are currently in various stages of development for application in the coal industry, while there are a number of other self drilling bolts in the civil sector that could be adapted and applied to the coal industry, but are reportedly very expensive:
    - Hilti has recently demonstrated a self drilling dowel at a number of mines. The anticipated price of the bolt may to deter its widespread adoption.
    - Sandvik is expected to shortly announce plans to commercialise the Seedsman self drilling, tensionable, post groutable bolting system. No details of the projected pricing were available, while there is some debate on the relative advantages and disadvantages of post grouting the bolt.
    - One Steel recently committed to commercialise production of a hollow bar suitable for a self drilling bolting system, as developed by Peter Gray through an earlier ACARP project. The rolling of a 20 tonne sample was completed on 7 October 2005, and it is expected that field trials will be undertaken early 2006 after the bolts, drilling rig and resin injection system is assembled, and an underground test site is identified.
    - QCAT has developed another self drilling bolting system for incorporation into the ACBM. Commercialisation of this bolting system was reported to be suspended due to an OEM's failure to complete the design and manufacture of the automated bolting system.

    - Cutting Edge Technologies have also developed a self drilling bolt, and it is expected that the bolt will be commercialised in January 2006 through a local bolt manufacturer.

- Sandvik (VA) will shortly release an upgraded ABM25(S) designed for difficult mining conditions and 4.8m wide roadways. The ABM25(S) is likely to incorporate Hydramatic's automated bolting system, providing corporate approval is given to proceed with their own self drilling bolt system (under licence).

- Joy is mooted to be developing a new generation continuous miner for the global roadway development market, however the nature, capability and timing of the new continuous miner is being kept closely guarded. It was suggested by one respondent that this development has been triggered by Joy's recognition that the likely development of a self drilling bolt in the immediate short term will remove one of the most significant constraints on rapid gateroad development and could potentially change the existing industry/OEM dynamic.

- DBT have recently established a global roadway development group to develop strategies to improve and extend their range of equipment in the roadway development market sector and are examining the potential application of a variety of overseas technologies.

- Both IHI and Pacific Tunnelling have developed concepts and detailed engineering designs for the application of conventional TBM tunnelling technology to underground coal mines, and both are of the view that equipment could be on site in 18 – 24 months.

    - The IHI Mogura is of double O tube (DOT) design for a 3.5m high 6.0m wide roadway, and would utilise the automated, self drilling bolt technology developed for the ACBM. The roadway profile is well suited to longwall mining.

    - Pacific Tunnelling's Lovat TBM is a single tube design for a 4.5m diameter circular roadway, and has been designed to allow limited bolting of the top half of the roadway profile immediately behind the cutter head in difficult ground conditions, in addition to bolts being installed off the normal bolting station. Floor cutters mounted at the machines rear square off the floor while special gateroad support canopies have been designed to operate within the circular topped roadway profile. The machine is modularised to enable re-establishment elsewhere in the mine within 2 weeks of completion.

    - Both machines are designed to achieve rapid advance rates (+10MPOH) and will require a substantial commitment in associated infrastructure to sustain such development rates.

- The ACBM is also stalled as a result of the OEM's failure to complete contracted development of the automated bolting system. This project should be restimulated even if only to get access to the technological developments achieved by QCAT.

- Joy have 2 floor mounted 4FCT systems in operation in US mines with 2 other systems under manufacture for US mines.

- Sandvik is expected to shortly release a roof mounted continuous haulage system after trials of the first underground system are completed at a mine in the USA early 2006.

- Eikon, an Australian based technology developer, has completed the design of a 250m^3/hour coal pumping system that could provide a continuous coal clearance system between the continuous miner and boot end, or even obviate the need to install and extend a development conveyor. The project has received Federal Government funding on a $1/$1 basis to build a prototype however the project is currently stalled pending further industry support.

- Continental is working on the development of a roof mounted monorail based extensible and retractable development/longwall conveyor system, and is expected to release the system late 2006.
- Cutting Edge Technologies also have designs for an extensible conveyor system, although the status of that development is not known at this time.

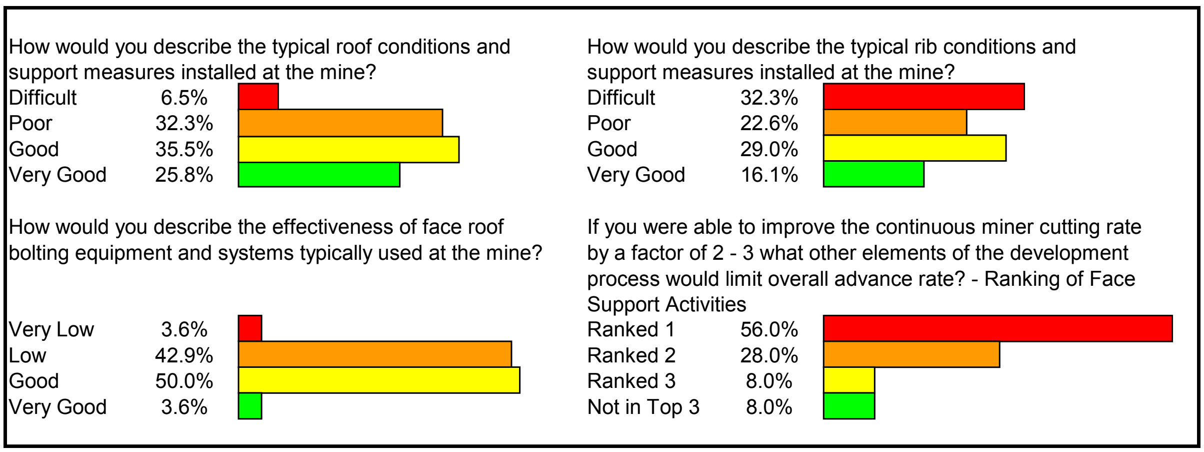
4. MAJOR CONSTRAINTS TO ROADWAY DEVELOPMENT

4.1 Roof and (particularly) rib support were typically identified as the most significant constraint, unless support requirements were minimal and difficult floor conditions were experienced.

At Question 29 and 30 of the mine site review respondents were asked to rank the typical roof and rib conditions and support measures experienced at the mine. The figure below illustrates mine site responses and it can be seen that 39% ranked roof conditions and support measures as difficult to poor, while 56% ranked rib conditions and support measures as difficult to poor, with a significant increase in the number reporting difficult rib conditions.

At Question 45 respondents were asked to rank the effectiveness of the face roof bolting equipment and systems used at the mine, and as seen below respondents ranked it as low to good.

In discussion, respondents noted that roof support design was typically limited by the ability of the continuous miner mounted rigs to install bolts across the full roadway cross section, while high levels of delay were reported on bolting rigs, typically the Aro 4000 Series rigs, while all rigs were reported to require high levels of maintenance support.



At Question 57 respondents were asked to identify what other elements of the roadway development process would limit the overall panel advance rate if they were able to improve the continuous miner cutting rate by a factor of 2 – 3. Respondents were then asked (Question 58) to rank these limiting factors in order of their perceived impact upon panel advance rates (from highest to least adverse impact).

As shown in the figure above, 56% of respondents ranked face support activities such as roof support, roof and rib bolting, bolting and meshing, bolting, and roof bolting as the highest adverse impact, while a further 28% ranked face support activities as the second highest adverse impact. Only 8% of respondents did not rank it in the top 3 factors.

Almost all mines utilise a combination of 4 roof bolting rigs and 2 rib bolting rigs, with notable exceptions being one mine that utilises 2 roof/rib bolting rigs and another that continues to hand bolt on one machine.

As noted in response to Questions 25 and 26:

- Roof bolts vary between 1800mm and 2400mm in length, while roof bolting intensity typically varies from four 1800mm bolts/1.5m to eight 2400mm bolts/m, with six 2100mm bolts/m being the most consistently applied (41%).
- Some 32% of mines reported using 4m or 6m tendons as part of the primary bolting phase, either on a routine basis or as a result of Strata Management Plan trigger levels (mines reported up to 13 different support conditions based on Strata Management Plan trigger levels).
- Rib bolts vary between 1200mm and 1800mm in length, while rib bolting intensity varies from spot bolting one 1200mm bolt/metre/rib, up to three 1200mm, two 1500mm, or two 1800mm rib bolts/m/rib. 67% of respondents noted that they were typically installing two or three bolts per cycle per rib, and in most of these instances full rib meshing was also installed.
- One mine reported undertaking a trial of 3m rib tendons in an effort to control rib deterioration, particularly around intersections.

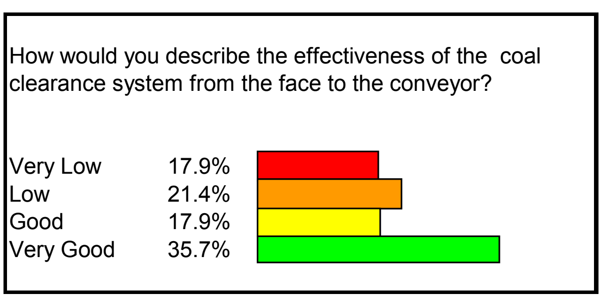
As noted by a support consumables supplier, nearly all mines have gone over to mesh roof modules within the last 2 years, and they expected that mines would similarly go over to full rib meshing within the next 2 years. Further, at this point in time they had not seen any good meshing systems. A number of operators also identified mesh handling and installation as a major issue, and posed solutions such as continuous tensar meshing of ribs or sprayed-on skin reinforcement techniques such as Techflex grout.

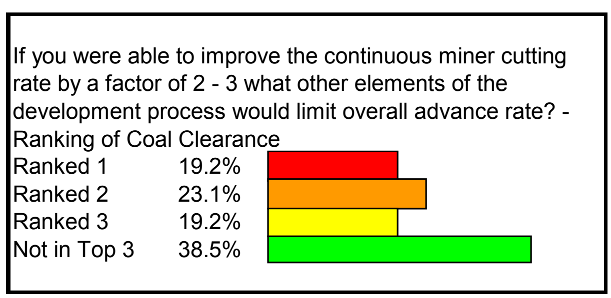
4.2 The cyclic, stop-start nature of shuttle cars and other coal haulers was seen to limit development rates, particularly once haulage distances increase beyond 70m.

At Question 46 respondents were asked to rank the effectiveness of the coal clearance system from the face to the boot end. As seen below face coal haulage effectiveness is largely good to very good, while respondents noted special causes in respect to the very low and low classes, namely aged, low capacity shuttle cars (predominantly very low) or soft and difficult floor conditions (predominantly low).

Again at Question 57 respondents were asked to identify what other elements of the roadway development process would limit the overall panel advance rate, and were then asked (Question 58) to rank these limiting factors in order of their perceived impact upon panel advance rates (from highest to least adverse impact).

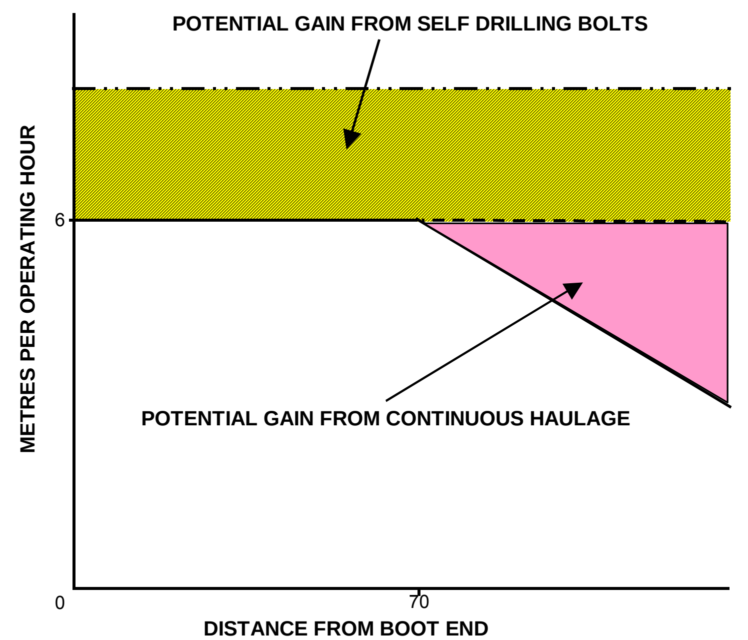
As shown in the figure below, 38.5% of respondents did not rank it in the top 3 factors, while only 19% ranked face coal haulage as the highest adverse impact. A further 23% ranked face coal haulage as the second highest adverse impact.





In discussion respondents noted that the development process became haulage constrained once haulage distances increased beyond 70 – 120m (or 180 – 200m in one instance), with the limiting factor considered to depend upon the intensity of face support measures and whether the face activities were in balance.

An OEM also noted that their modelling of roadway development systems on a mine by mine basis typically identifies that the development process becomes haulage constrained at some 70m from the boot end, and that while limited gains may be made by introducing continuous haulage systems, significant gains could be realised through improved bolting rates with self drilling bolts, as shown below.



COMPARISON OF PROJECTED GAINS FROM SELF DRILLING BOLTS AND CONTINUOUS HAULAGE SYSTEMS

Operators of Joy 12CM configured machines commented that this configuration gave them the ability to balance the cutting/bolting/coal clearance elements of the process by cutting out for a half cycle (typically into one shuttle car) and completing half of the bolting and support cycle during the shuttle car wait period, then completing the cutting cycle and the second half support cycle after the second shuttle car is loaded.

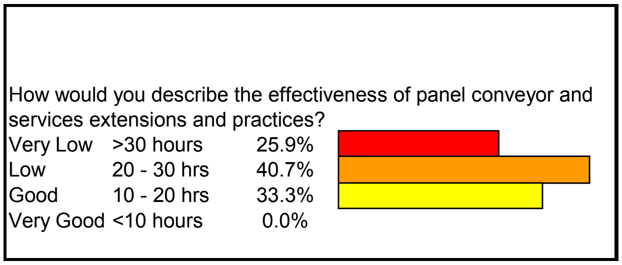
It was also noted that Joy 16SC shuttle cars had been recently introduced into some mines, and that their 18 – 20 tonne payload enabled the face activities to be better balanced.

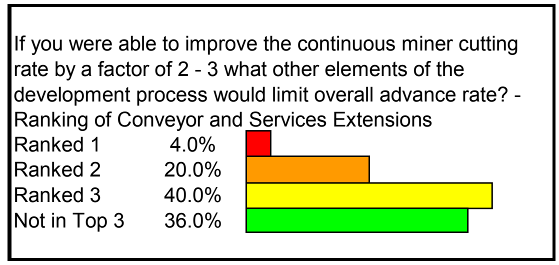
4.3 Advancement of the conveyor and panel services was a significant constraint, particularly in mines employing dual continuous miners to advance 2 entry gateroads.

At Question 48 respondents were asked to rank the effectiveness of the panel conveyor and services extensions and practices. As seen over the effectiveness of panel advances ranges from very low (>30 hours) to good (10 – 20 hours), with the low category (20 – 30 hours) being predominant.

Again at Question 57 respondents were asked to identify what other elements of the roadway development process would limit the overall panel advance rate, and were then asked (Question 58) to rank these limiting factors in order of their perceived impact upon panel advance rates (from highest to least adverse impact).

As shown in the figure below, panel advances are not seen to be as high an adverse impact on development rates as say face support, however the 20% and 40% ranking as second and third highest adverse impact on development respectively indicates that panel advances are an issue at many mines.





From discussion it was noted that:

- Where gateroads were being driven with only one continuous miner unit considerable opportunity is available to operators to complete preparatory works such as the extension of pipework and cabling prior to the belt move, or in some cases, undertake a “ghost” move and advance a second boot end and auxiliary fan to the next position and partially install the belt structure. In these situations the duration of a typical 100m panel advances was reported as 10 – 30 hours, with best practice typically being 10 - 12 hours and the majority being completed in 10 – 20 hours.
- The deployment of two continuous miners to a two entry gateroad, either as a dual or super unit, remove almost all the flexibility afforded single unit panels, consequently the duration of panel moves increases significantly. The majority of these extensions are completed in 27 – 36 hours, although they range from best practice (11 – 12.5 hours, 102m extension) to 48 - 72 hours (130m, 1800mm roof mounted structure).
- The development of fully integrated monorail mounted services management system has enabled a mine to significantly reduce the duration of panel moves, as has the use of a mobile boot end (fitted with conveyor stand insertion device and DCB) in another instance.
- Another group of mines install a temporary development conveyor (nominally 1200mm floor mounted) to expedite the development process, and subsequently recover the conveyor before installing the longwall conveyor.
- The high levels of manual labour associated with panel advances (eg; conveyor structure and idlers, multiple pipework installations, distribution and trailing cables, explosion suppression measures) was seen as a major de-motivating factor impacting development performance – “… *you have done so well in development this week boys we will be able to do an extra panel advance!* …”.

4.4 The routine installation and advancement of ventilation duct is a problem at mines that have not adopted integrated monorail services management systems.

At Questions 57 and 58 respondents identified and ranked those elements of the roadway development process that would limit overall panel advance rates. As illustrated over, ventilation was only specifically identified as being among the top 3 constraints at a limited number of mines however during on site discussions respondents noted the issues with firstly, advancing (and recovering) ventilation ducting, particularly at working heights above 2.8 – 3.0m and secondly, the issue of increased gas make due to higher development rates being achieved, and mines becoming deeper.

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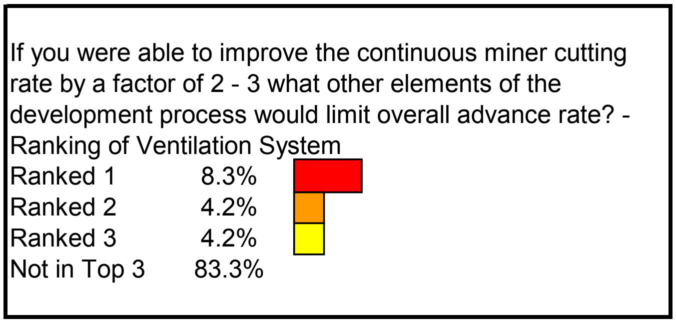
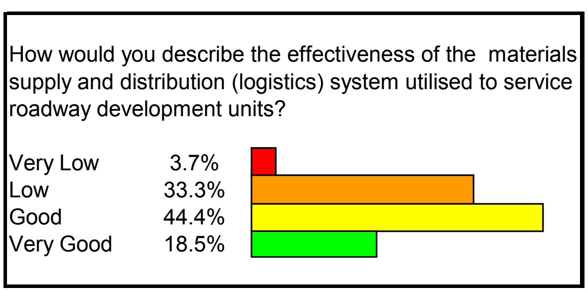


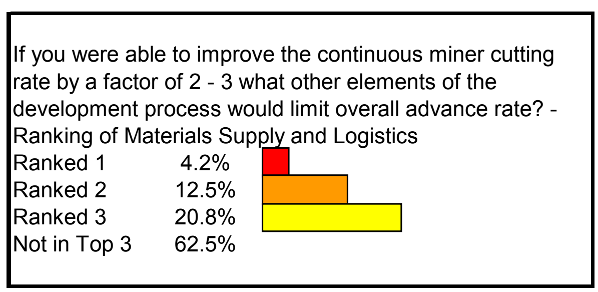
All mines except one utilise an in place mining system with an exhausting ventilation system comprising rigid ducting and an auxiliary fan or fans. A limited number of mines have adopted an integrated monorail services management system, which incorporates the ventilation ducting to remove this issue from the equation, however in the vast majority of cases mines are still required to manually install (and remove) ducting as roadways advance. While a number of mines expressed interest in adopting a forcing ventilation system utilising flexible ducting, they considered that the current design of continuous miners was not compatible with the fitment of dust scrubbers and multiple bolting rigs.

4.5 The logistics of supply, transport, distribution and handling of roof and rib support consumables is an issue at older, extensive mines now, while increased development requirements at other mines will compound this issue at most mines.

In response to Question 47 it was generally considered the effectiveness of the materials supply and logistics system at mines is low to very good, as illustrated in the figure below. Older mines tended to populate the very low to low categories, although two newer generation mines were also ranked in these categories.

Again at Questions 57 and 58 respondents identified and ranked those elements of the roadway development process that would limit overall panel advance rates. As illustrated below, materials supply and logistics was identified among the top 3 constraints by a number of mines.





Ii is likely that latter generation highwall mines will be able to readily manage the logistical issues associated with 15Mtpa mines. However, once choke points are introduced into the system (ie; long, inclined haulage drifts or shafts) it is likely that even the latter generation mines will be challenged by the logistics associated with this scale of operation, unless high capacity logistics management systems are introduced (eg; from the overland transport sector).

Older mines as mainly found in NSW have extensive underground workings and suffer from infrastructure limitations in respect to mine ventilation, coal clearance, men and materials haulage and mine access. While these mines have developed logistics systems to support the current level of operations, they are reportedly labour intensive due to inherent system limitations, and in some cases, the use of a combination of transport systems. Any significant increase in roadway development requirements at these mines is likely to warrant upgrading of the mine's overall logistics system.

4.6 The installation of long tendons (greater than mining height) as a primary support measure is becoming more widespread, yet installation technology and hardware remains fairly rudimentary.

As noted at 4.1 above, some 32% of mines reported using 4m or 6m tendons as part of the primary bolting phase, either on a routine basis or as a result of Strata Management Plan trigger levels (mines reported up to 13 different support conditions based on Strata Management Plan trigger levels). A number of mines are also installing 6m and 8m tendons as a secondary support, closely behind the installation of primary supports.

While some contention may exist among geotechnical engineers as to the benefit of installing long tendons (greater than mining height) as part of a primary support regime, the actual practice of installing long tendons as a primary support measure is becoming more widespread. Installation technology and hardware remains fairly rudimentary, in both primary and secondary support applications, and respondents noted in discussions the need pursue technology and hardware that would enable these supports to be installed as quickly and efficiently as conventional roof bolts.

The development of self drilling bolts and automated bolting systems may allow more intensive primary support systems to be utilised to counter the need for tendon support, or alternatively, will introduce other technical challenges if the self drilling bolt and tendon technologies and hardware are incompatible.

4.7 The physical demands of the work environment and the extent of manual handling required, coupled with an ageing workforce, is not conducive to the achievement and sustainability of high development rates.

A number of mines, particularly in NSW and the longer established Queensland mines, reported concerns regarding the physical demands of the work environment, the extent of manual handling required, and the fact that the mine's workforce was ageing, typically with an average age of 50 years. Further, a number of mines had gone onto extended shift arrangements to facilitate travelling arrangements and/or give personnel longer breaks of work.

This situation was considered not to be conducive to the achievement and sustainability of high development rates and warranted a greater focus on the manual handling aspects of the development process, and the working environment (eg; heat, humidity, noise, whole of body vibration, etc).

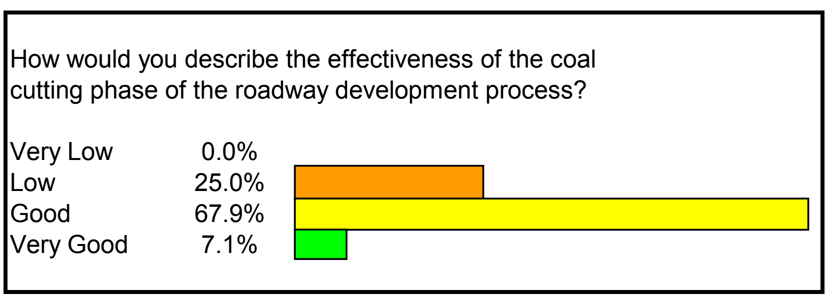
While perhaps not being representative of the overall situation across NSW and Queensland, Table 21 of the Lost-Time Injuries and Fatalities NSW Coal Mines 2003-04 report prepared by Coal Services gives some credence to the concerns expressed by respondents, with details for underground mines included over for reference.

While it cannot be readily determined how these statistics compare to the age distribution of the workforce, it is evident that the 45 years plus age sector comprises a significant portion of those personnel suffering a lost time injury.

	Table 21, Age of Injured Worker, by Hours Lost, 2003-04 NSW (Excludes contractors)			
Age	≥7 Hours	≥35 Hours	≥70 Hours	≥140 Hours
25-29	1.1	0.5		
30-34	4.3	2.9	3.9	4.1
35-39	12.9	13.2	13.6	12.2
40-44	17.2	13.2	13.0	13.3
45-49	21.5	23.0	22.1	16.3
50-54	29.7	33.8	33.8	39.8
55-59	13.3	13.2	13.5	14.3
	100.0	100.0	100.0	100.0
45-59	64.5	70.0	69.4	70.4
50-59	43.0	47.0	47.3	54.1

4.8 Coal cutting was not seen as a constraint at any mine, however the ability of machines to cut breakaways for cut throughs was considered to be a major failure of all machine configurations.

In response to Question 44 it was generally considered the effectiveness of the coal cutting phase of the roadway development process was largely good, as illustrated in the figure below, with operators of ABM20 and 12CM30 configured machines tending to populate the low category. Even though these mines reported low cutting effectiveness, as compared to the machines rated cutting capacity, no mine considered that the machines ability to cut coal constrained development rates, except when breaking off cut throughs.



However, the ability of machines to cut breakaways for cut throughs was considered by almost all respondents to be the major failure of all machine configurations, so much so that a number of operators consider the adoption of single entry drivages as a means to avoid the cut throughs, or alternatively, to utilise a coal auger to drive an interconnecting roadway in either a single entry option or two entry roadway system.

The maintainability of continuous miners was generally seen to be low, as was the overall ergonomic design of machines after incorporation of multiple bolting rigs. Tramming of machines between roadways was considered a major issue, due to the overall size of the machine in the roadway. Clearly different machine configurations were reported to have both advantages and disadvantages, and it was commented on in a number of instances to be more of a Holden versus a Falcon argument, rather than any significantly different technical capabilities. As noted in part 9 of the report however, best practice operations tended to be populated by 12CM configured machines.

Although operators may have considered that the cutting capacity of continuous miners was not an issue, a former OEM executive noted that continuous miner technology in Australia was vastly different from that supplied in USA and South Africa, with continuous miners in those countries having higher installed cutting power, and wider, higher capacity coal clearance systems.

5. WHAT MINE OPERATORS AND MINE MANAGERS SHOULD DO TO IMPROVE DEVELOPMENT PERFORMANCE

5.1 Pursue industry best practice roadway development practices and fully embrace the concepts of process control, continuous improvement, and the involvement of all personnel in that pursuit.

While the review did not attempt to benchmark performance across the industry, it is evident that "best in class" performance levels are typically 60 – 80% higher that the "bottom of class" performance levels within the various categories of mining conditions experienced (ie; comparing good conditions with good conditions, etc). As noted in part 9 of the report, these best practice mines tended to be marked by a number of attributes, namely the rigour adopted in relation to process control, continuous improvement, and the involvement of all personnel in that pursuit.

A number of mines are now embarking upon that journey also, while others remain challenged by intractable cultures, long established practices, and infrastructure constraints. The introduction of a step change in the mining equipment and hardware may generate and foster a cultural change process and assist the development of new practices at such mines, however it is more likely that the new mining equipment and hardware will continue to be operated sub-optimally at the latter mines, albeit at a higher level.

Further, until the majority of mines improve roadway development performance and establish a positive longwall float it is unlikely that many mines could commit to the development and introduction of new mining systems, equipment and technology.

Therefore it is incumbent upon mine operators and mine managers to pursue best practice and establish a basis upon which the benefits arising from the potential introduction of new mining equipment and technology can be properly evaluated and predicted, and the ensuing investment substantiated.

5.2 Commit to the development and conduct of a routine roadway development benchmarking process across the industry, and the regular publishing of updated results.

While a number of respondents raised issues of competitive advantage with the concept of an industry benchmarking process, the vast majority of respondents noted that improved development performance would be engendered by the regular conduct and publication of a roadway development benchmarking study across the industry.

Such a process would require the establishment of commonly agreed measures and the ongoing support and commitment from mine operators and mine managers to be beneficial. As noted by a Coal Services representative, maintenance of industry benchmarking reports such as the quarterly longwall report is difficult if not supported by mine sites.

5.3 Commit to the development and conduct of a regular "best practice" roadway development forum to enable development practitioners to share successes and failures and learn of new practices, developments in R&D, and emerging issues.

It was evident from on site discussions that while development operators may be acutely aware of what goes on at their mine, their level of professed knowledge as to what goes on at other mines, and even mines within the same company, appears to decay exponentially as the distance between mines increases.

A number of respondents proposed that improved development performance would be engendered by the conduct of a regular "best practice" roadway development forum to enable development practitioners to share successes and failures, and to learn of new practices, developments in R&D, and emerging issues. It was noted in a number of instances that the ACARP sponsored outburst, gas drilling and gas drainage workshops were a good example of the communications approach to be adopted for roadway development.

Such a process would again require the commitment and support of mine operators and mine managers to enable employees to participate in and contribute to such forums.

It is also envisaged that the proceedings from such forums could be incorporated into a "body of knowledge" of roadway development practices and learnings, to provide industry with an invaluable reference source.

5.4 Give due recognition to the role of development in the mine's operation and adequately resource the development function to enable it to be properly accountable for its performance.

Roadway development team members are typically frustrated by the lack of recognition given to them for their commitment, efforts and successes, and consider themselves as second class citizens to the longwall. They quote the general managers' first question of the day as "… *how many shears (or tonnes) did the longwall get yesterday (or last night) …*", and identified the various conferences and journals that are targeted at longwall operators. A number of mines were also reported to utilise the development labour pool as the mine's absentee pool, which impacted both performance and continuity, and also gave the wrong signal to mine employees.

As noted at part 9 of the report the better performers exhibited a higher focus on and prioritisation of roadway development, as compared to other operating processes at the mine. Development teams were typically independent of other teams and were held accountable for their performance.

6.0 WHAT MINE OWNERS SHOULD DO TO ADDRESS KEY CONSTRAINTS

6.1 Through ACA and ACARP, develop and commit to a long term investment strategy to support and sustain the research, development and demonstration of new mining systems and technology.

In response to Question 60, respondents were asked what barriers would need to be addressed in order to successfully commission and operate new mining technologies and systems. Over 50% of mines identified that funding of the research and development process as a barrier, both in terms of the overall level of funds necessary to fund development of a new mining system, and the industry's ability to maintain investment in the event of an industry downturn.

An alternative strategy may be to establish a roadway development research trust fund during a buoyant period to ensure identified and agreed projects have guaranteed funding.

6.2 Through ACA and the various State Mining Councils, develop and commit to a long term strategy to develop the industry's skills base and overcome the scarcity of experienced mining professionals, engineers, supervisors, operators and trades personnel.

Again in response to Question 60, nearly 40% of mines identified people related issues as a barrier, including; a lack of technical expertise, skill shortages across all levels of the organisation, lack of project management expertise, inability to maintain project champions, lack of personnel, lack of training resources.

In response to Question 23 mines were asked to identify any challenges experienced at the mine in respect to labour availability and turnover. Some 45% of mines reported issues with the labour availability, particularly in respect to experienced staff, deputies, trades and key mining skills (eg; CM operators), while some 25% identified labour turnover as an issue. This is expected to be exacerbated as increased mine capacity is resourced and ongoing retirements continue at the older, established mines.

OEMs and contractors alike expressed concerns regarding the industry's expectations that they achieve high service delivery standards, yet are unable to maintain experienced personnel due to the continuing attrition of personnel to mines.

The industry has developed a comprehensive Black Coal Competencies framework. However, it appears that it lacks an effective training delivery system to deliver those competencies, and instead relies on an add hoc, piece meal approach by individual companies and mines. It is now becoming an imperative that industry develop a consolidated approach to training delivery to ensure that its short, medium, and long term production objectives can be realised.

6.3 Challenge, through ACA and the various State Mining Councils, the restrictive legislative framework being imposed on the industry, and the regulators resort to prosecution in the event of less than absolute safety.

Also in response to Question 60, some 30% of mines identified legislative issues as a barrier, including approvals processes, statutory restrictions and limitations, and constraints on the use of aluminium underground. These issues were similarly identified by OEMs as a major impediment to the development and introduction of new equipment.

In discussions a number of respondents also expressed concerns regarding the power and authority of the Inspectorate, the NSW Government's pursuit of prosecutions in the event of failures in safety systems, and political influences in the regulation of mine safety in both States.

It was generally considered that if left unchecked the restrictive legislative framework being imposed on industry coupled with the resort to prosecutions would have grave consequences for the industry.

It was also noted the continued adoption of State based mining legislation, guidelines and standards was detrimental to industry, particularly in regard to segmentation and fracturing of the market from am OEM's perspective.

6.4 Fund, support and sustain, through ACA and/or ACARP, the conduct of routine roadway development benchmarking studies across the industry, the conduct of regular "best practice" roadway development industry forums, and publication of the results of benchmarking studies and the forum proceedings.

As noted at paragraph 5.2 and 5.3 respectively, respondents considered that improved development performance would be engendered through the regular conduct of roadway development benchmarking studies and "best practice" roadway development forums across the industry.

The conduct of such benchmarking studies will also provide mine owners with an independent assessment of mine performance to which mine operators and mine managers can be held to account, while the publication of the forum proceedings will establish the basis of a "body of knowledge" of roadway development practices and learnings.

6.5 Challenge mine operators and mine managers if they fail to pursue industry best practice roadway development practices and do not fully embrace the concepts of process control, continuous improvement, and the involvement of personnel in that pursuit.

As noted at paragraph 5.1, it is evident that "best in class" performance levels are typically 60 – 80% higher than "bottom of class" performance levels within the various categories of mining conditions experienced (ie; comparing good conditions with good conditions, etc), while best practice mines tend to be marked by a number of attributes, namely the rigour adopted in relation to process control, continuous improvement, and the involvement of all personnel in that pursuit.

Clearly there are mines that are challenged by intractable cultures, long established practices, and infrastructure constraints. Introduction of a step change in mining equipment in these mines may generate and foster some cultural change, however it likely that the new mining equipment will continue to be operated sub-optimally, albeit at a higher level.

As incumbent as it is upon mine operators and mine managers to pursue best practice and establish a basis upon which the introduction of new mining equipment can be properly evaluated and predicted, it is incumbent upon mine owners to ensure the investment is both substantiated and realised.

7. WHAT INCREMENTAL CHANGE INITIATIVES SHOULD BE PURSUED BY ACARP

7.1 By end 2005, develop a vision and strategy to demonstrate by end 2006, a high capacity, integrated mining system of the then available best practice technology and equipment, including; self drilling bolts, automated bolting, continuous haulage, self advancing extensible panel conveyor, and a monorail mounted services management system.

A number of technology developments are well advanced or are even nearing demonstration and commercialisation. A number of these technologies have break through capability and should be actively supported by ACARP in the final stages of their development. The commitment to demonstrate by end 2006, a high capacity, integrated mining system that incorporates the then currently available best practice equipment and technology is a means to demonstrate that support.

Its achievement will also build support and commitment for ACARP's longer term vision to develop a high capacity, integrated mining system capable of sustained, continuous production at a level of +10MPOH for greater than 20 hours day by end 2006.

The vision and strategy needs to be crystallised by ACARP and then enunciated to all industry stakeholders by end 2005 as a first step in building industry support and commitment.

7.2 Pursue and expedite the commercialisation of alternative self drilling bolt technologies and automated bolting systems, including the potential retrofitting of the automated bolting systems to existing continuous miners.

Studies indicate that current roadway development rates could be improved by 30% or more with the successful development and application of self drilling bolts. Automation of the bolting process can also be readily achieved with self drilling bolts, and in the longer term could lead to man-less faces if integrated storage and handling facilities are incorporated onto the miner/bolter platform and alternative skin reinforcement and confinement measures are developed.

Three different anchoring systems are currently being pursued as part of the development of self drilling bolts, while three different bolt manufacturing techniques are being adopted or developed:

- The Sandvik/Ross Seedsman bolt initially relies upon a mechanical anchoring process, and the bolt is tensionable and post groutable. The bolt is a conventional rolled bar. The bolt is expected to be demonstrated shortly, subject to Sandvik corporate approval.
- The Hilti bolt relies utilises a resin anchor which is encapsulated within the bolt and injected by compressed air on completion of the drilling process. The bolt is manufactured from a pierced billet and is in effect a corrugated tube. The bolt has been demonstrated recently in Australia, and it is understood that over 100,000 bolts have been installed in German mines.
- The QCAT/ABCM bolt relies on a resin anchor although this resin is injected by an on-board injection pump, with the resin being mixed internally within the bolt with a static mixer. The bolt is also manufactured from a pierced billet and resembles a corrugated tube, albeit of smaller diameter than the Hilti bolt.
- The One Steel/Peter Gray bolt also relies on a resin anchor injected by an on-board injection pump and mixed internally within the bolt with a static mixer, however the bolt is manufactured as hollow rolled bar and closely resembles a conventional rolled bar rock bolt, albeit slightly larger in diameter (approximately 27mm). Following a successful trial rolling early this month it is understood that underground trials will be completed early 2006.

Cutting Edge Technologies have also developed a self drilling bolt and expect to commercialise the bolt in January 2005 through a local bolt manufacturer.

It was also noted that there are a number of self drilling bolts used in the civil sector which are commercially available, however the high cost of the bolts has not encouraged any supplier to advance their application in the coal sector.

The advantage of the Sandvik/Seedsman bolt is that it requires few modifications to existing bolting systems to be able to utilise the self drilling bolt, although it does require a secondary grouting phase after mining to achieve the bolts full design capability.

A disadvantage of the QCAT/ABCM and One Steel/Gray bolts is the requirement to incorporate an on-board resin storage, pumping and injection capability on the miner/bolter platform which will require substantial modifications.

The Hilti bolt requires fewer equipment modifications to retrofit the system than the QCAT and One Steel bolts, and overcomes the issue of post grouting as anticipated with the Sandvik bolt. The size of the bolt may discourage its use, while the overall cost benefit of the system is yet to be demonstrated in Australian high capacity development systems.

Given industry support it is likely that there will be potentially three locally developed self drilling bolts available mid 2006 together with the Hilti bolt which is now close to being commercially available in Australia. At this stage of the development process it would appear to warrant support for all systems until a proven system has been developed and the industry is prepared to standardise and rationalise the technology and sources of supply (rather than to rationalise now, before the technology is finalised, as suggested at one site).

Further opportunities for development are a self drilling rib bolting system that is compatible with longwall operations, and the development of alternative skin reinforcement and confinement measures that eliminate the use and handling of steel mesh, and the need for rib bolts at all.

7.3 Facilitate and expedite completion of the Automated Continuous Bolting Machine (ACBM) and associated technologies.

The completion of the ACBM project and its subsequent demonstration is important as much for the finalisation and commercialisation of the inherent technologies as it is important to demonstrate the capability of the industry to undertake and bring such a development to a successful conclusion. Further, finalisation of the project completes one of the three major elements of the rapid entry system first conceptualised in 1995, and could be an essential part of the demonstration of IHI Mojura TBM technology if such a course was chosen.

The realisation of a self drilling bolt, be it Sandvik, Hilti, QCAT, One Steel, or CET, removes one of the two remaining obstacles from the ACBM's development, the other being the design and manufacture of a compatible automated bolting system. The automated bolting technology required for the ACBM is thought to be akin to that required for the One Steel bolt, and can probably spun of into other self drilling bolt applications.

Notwithstanding the above, the functional design of the ACBM still remains current and it is has potential to be applied at a number of mines if it were in fact successfully demonstrated.

It is therefore considered imperative that the industry facilitates and expedites completion of the ACBM project.

7.4 Develop alternative skin reinforcement and confinement measures to eliminate the use and handling of steel mesh.

On the premise that:

- self drilling bolts will be commercially available say mid 2006 (if not earlier);
- automated bolting systems will also be available at that time or shortly thereafter;
- bolt storage and handling technology can be spun off from the ACBM also at that time, and;
- integrated monorail mounted services management systems continue to be refined;

it is evident that the last major barrier to removing personnel from the immediate face area is the material and systems currently used to install skin reinforcement and confinement measures, predominantly steel roof mesh and either part or full steel rib mesh.

A number of operators identified mesh handling and installation as a major issue, while a support consumables supplier noted that they had not yet seen a good meshing systems.

Concerns were also raised in respect to the effectiveness of bolting as a rib support systems. While the application of roof bolts to stratified roof deposits did create a beam effect, a similar mechanism was not evident in respect to rib bolting, whilst rib failure mechanisms were considered to be significantly different from roof failure mechanisms.

A number of respondents identified continuous rolls of tensar mesh as an alternate to current steel meshing systems, others identified spray-on skin reinforcement techniques such as Techflex grout, while others proposed an integrated solution with the application of a TBM mining system and tunnelling ground support measures such as segmented concrete rings.

The removal of this last barrier poses a major challenge, yet provides a significant opportunity to both the developer and the industry generally. The objective is to develop a system that:

- requires minimal human intervention in its supply and installation;
- enables the mining process to advance continuously;
- provides an effective skin reinforcement and confinement measure, yet is flexible and adaptable;
- is longwall compatible, and;
- is cost effective.

7.5 Facilitate the development of an extensible, self advancing panel conveyor.

Best practice operations lose approximately half a day nearly twice a week to advance the panel conveyor and associated services, while most mines lose a full day (or more) once per week to complete the advance. In addition to those production losses, the process is labour intensive, requires extensive manual handling, can readily spiral out of control if detailed procedures aren’t closely followed or floor conditions properly managed, and is generally considered to detract from other efforts to improve development performance.

A number of systems have been developed to facilitate the insertions of structure components and improve the installation processes, based on the use of either a mobile boot end (also used as a platform for mounting the panel DCB), a pantograph fitted to a conventional boot end, or a development tail end at another mine. All were reported to improve the process however at this stage the development of a system to enable the conveyor to be advanced continuously, similar to the retreat of a longwall conveyor, remains to be realised.

Continental Conveyors are currently developing a system and anticipated underground trials in 8 - 12 months, while Cutting Edge Technologies is also reported to have developed a system however the status of that system remains unknown at this time.

7.6 Develop a high capacity, automated long tendon installation system for both primary and secondary support applications.

With some 32% of mines reporting the installation of either 4m or 6m tendons as part of the primary support phase and a number of mines also installing 6m and/or 8m tendons as a secondary support closely behind the primary support phase, the actual practice of installing long tendons as a primary support measure is becoming more widespread, yet installation technology and hardware remains fairly rudimentary. Further, the development of self drilling bolts and automated bolting systems may introduce other technical challenges if the self drilling bolt and tendon installation technologies are incompatible.

Respondents noted the attempted introduction of a German flexidrill system at one mine that was reportedly able to drill holes for long tendons in a single pass. Others proposed the installation of tendons off continuous reels, rather than the current pre-cut bundle system, as a step to reducing materials handling issues. Alminco is reportedly developing an improved secondary support installation system however it is unknown how this will compare with other rudimentary systems currently available.

The development of a high capacity, automated long tendon installation system for both primary and secondary support applications appears to be a breakthrough technological development warranting ACARP support.

7.7 Develop a mine economics modelling system that enables mines to properly evaluate the full cost of alternative development systems and varying performance levels.

It was evident during discussions that mine operators and mine managers understood the cost of development as expressed in $/metre advanced in accordance with the various mine cost reporting systems, and of the losses accruing in the event that longwalls are stood idle due to a lack of longwall continuity.

It was not as evident that there was a good appreciation of the inter-relationship between costs and development rates, or the annualised operating costs of a development unit, and potential cost savings to be achieved from improved development performance. It is also understood that the various companies treat capital differently in respect to the evaluation and justification of major investments in new mining equipment.

The development of a mine economics modelling system should enable mines to properly evaluate the full cost of alternative development systems and assess the impact of improved performance that could result from their adoption.

7.8 By end 2006, demonstrate a high capacity, integrated mining system that incorporates the then currently available, best practice technology and equipment.

Given the status of a number of the technologies identified above ACARP's short term vision should be to demonstrate an integrated roadway development system comprising the then currently available best practice equipment and technology, by end 2006.

In addition to the technology identified above this demonstration should include both continuous haulage systems and new generation shuttle cars in order to properly evaluate the relative merits of both haulage systems. Best practice mines in good conditions may gain considerable advantage from the introduction of continuous haulage systems. However, it would also appear that those mines installing intensive support measures may gain considerable improvement from the application of new generation shuttle cars, based upon the demonstrated capacity of existing shuttle car based systems in best practice mines.

It is envisaged that the demonstration of the continuous haulage based system would be done in collaboration with a best practice mine that exhibits a high level of commitment for the development of such a system, with ownership of the system reverting to the mine after the system is fully demonstrated and any necessary modifications are made to the satisfaction of the mine. The demonstration of a shuttle car based system could be similarly based at a mine committed to that level of technology, with ownership again reverting to the operator upon successful demonstration of the system

While it may be preferred that such systems be demonstrated earlier, current market conditions and manufacturing lead times are likely to limit an earlier target date.

7.9 Pursue other complementary technology developments including automation and robotics, machine guidance systems, light weight materials, face pumping systems, roadway construction and consolidation, and gas drainage.

A number of other technologies were considered complementary to the core roadway development process and warranted ACARP support:

- The development and application of automation and robotics was critical to the objective of removing operators from the immediate face area.
- Similarly, the development and application of machine guidance and seam following technology was also critical to removing operators from the immediate face area, either by way of integration of geological data bases with machine guidance systems (eg; continuous plotting and guidance) or by use of technologies such as ground penetrating radar to log the seam in advance of mining.
- The availability of alternate, light weight materials was also essential to reducing manual handling injuries, reducing costs, and improving flexibility.
- Face pumping systems need to be developed that are capable of dealing effectively with coal slurries, pastes, and coarse material generated at the face and in wheeling roadways, in order to reduce the effect of mine and process water on face conditions and mine roadways.
- Improved roadway construction and consolidation techniques were essential to the establishment of high speed transport systems, the reduction of whole of body vibration injuries, and reduced maintenance costs.
- A continued focus on gas drainage technologies was also essential to ensure that in situ gas levels can be reduced to acceptable levels in advance of high capacity development and longwall extraction systems.

7.10 Improve the level of awareness and understanding of technologies being applied in other industry sectors.

It was generally considered that the coal sector was insulated from other industry sectors and was not aware of technology being applied in or developed for those other sectors, particularly the underground metalliferous and civil tunnelling sectors. Strategies to address this include:

- Conduct technology missions to these other sectors, particularly the underground metalliferous and civil tunnelling sectors, to identify technology that has potential for application in the coal sector, and particularly in the event that TBM technology or long single entry drivages are to be pursued.
- Engage a technologist to conduct underground visits at mines and identify opportunities for transferring current and emerging technology from other industry sectors to underground coal mines.

7.11 Improve the level of awareness and understanding of roadway development technologies and systems being utilised in mines overseas.

It was also considered that overseas mine operators may have developed "best practice" roadway development technologies and systems that may have application in Australian mines, either by way of enhancing current operating practices or by way of providing alternative technology solutions for the 2006 best practice demonstration and/or the 2008 demonstration of the integrated high capacity mining system.

The conduct of a desktop review of overseas roadway development technologies and systems should identify whether any such opportunities exist and, depending upon the findings of that review, may then warrant the conduct of an overseas mission to gain a better awareness and understanding of those technologies and systems, and how they may be applied to enhance current operating practices or provide alternative technology solutions.

7.12 Develop software that will facilitate and enhance the adoption of the systems approach/ process control.

The development of a Windows based process mapping, management, and monitoring system may facilitate and enhance the adoption of the systems approach/process control by providing mines with an integrated suite of management tools and procedures including process sheets, work orders, supply requisitions, performance monitoring, and performance reporting.

WHAT STEP CHANGE INITIATIVES SHOULD BE PURSUED BY ACARP

8.1 By end 2005 develop a vision that it will demonstrate by end 2008, a high capacity, integrated mining system capable of sustained, continuous production at a level of +10MPOH for greater than 20 hours day.

The challenge is understood and recognised throughout the industry, mines in sub optimal conditions will find it difficult to achieve and sustain the level of improvement in development rates necessary to support high capacity longwall mining systems.

There is a strongly held perception across the industry that OEMs lack the commitment and motivation to build a system that will meet Australia's needs, yet while most people in the industry can identify the attributes of a new generation mining system (eg; an integrated, continuous, cutting, loading, supporting, coal clearance system with extensible panel conveyor and monorail mounted services), few however were able to envision that system beyond a TBM, or a re-generated Joy Sumps Shearer.

ACARP is recognised as acting on the industry's behalf, it is well regarded throughout the industry, and its close association with ACA properly positions it to champion the development of a high capacity, integrated mining system capable of sustained, continuous production at a level of +10MPOH for greater than 20 hours day.

The attributes of a new generation mining system needs to be crystallised as vision ACARP, and then enunciated to all industry stakeholders by end 2005 as a further step in building industry support and commitment.

8.2 By end first quarter 2006 develop a strategy for the development and demonstration of the high capacity, integrated mining system, including; sourcing of funds, development of technology, design and manufacture of equipment, conduct of extensive field trials at an appropriate site, and commercialisation of the technology and equipment.

Consistent with that vision ACARP should:

- Conduct an industry workshop or workshops first quarter 2006 to develop an agreed strategy to demonstrate the high capacity, integrated mining system by end 2008.
- Engage an experienced equipment designer and/or manufacturer on a consulting basis to develop an understanding of the project objectives and required outcomes, and maintain a reality check on the overall process.

8.3 By end second quarter 2006 develop a specification for the high capacity, integrated mining system and commission the design of a number of alternative systems (eg; Cutting Edge Technologies' concept machine and the IHI and Pacific Tunnelling TBM concepts).

Consistent with that vision and strategy ACARP should, by end second quarter 2006:

- Conduct further industry workshops to develop an agreed specification for the high capacity, integrated mining system.
- Invite submissions from OEMs/developers regarding the design of such a system by end 2006.
- Commission say two OEMs/developers to produce such designs by end 2006.

Commissioning these designs against agreed industry specifications should enable industry to have fit for purpose equipment developed, and to also demonstrate to OEMs/developers the industry's commitment to the technology and equipment development process.

8.4 By end 2006 evaluate and select a design that best meets the industry specification and requirements, and commission an OEM (or OEMs) to develop the technology and manufacture the integrated system.

In conjunction with the process of establishing a collaborative arrangement to conduct the demonstration, short listed mine operators and their other key mine site personnel should be involved in the evaluation process to ensure that the selected system is "fit for mine".

While it would be preferred that a single OEM be commissioned to develop and manufacture the complete suite of technology and equipment, to ensure that the technology and equipment is properly integrated and that the OEM has the expertise to support the integrated system post development, it may be necessary to select OEMs according to their specific expertise and capability to manufacture discrete technologies or components of the system. This second alternative would increase the level of technical integration and contractual issues.

8.5 By end 2006 establish a collaborative agreement to conduct extensive field trials and demonstrations at an appropriate mine site (eg; highwall), either by using a project team internally funded by the mine owner, or an externally funded mining contractor (by ACARP).

A number of research and development projects have suffered in the past due to conflicting mine development priorities and an erosion of industry support due to delays in the development process, issues not envisaged when the project was conceptualised or committed. Careful selection of field trials and demonstrations sites may assist to reduce this risk, and the level of support and commitment demonstrated by sites should be should be a key determinant in this regard.

The broader adoption of highwall longwall mines may also provide opportunities for field trials and demonstration sites, and minimise issues due to site access constraints and mine logistics. Further, a section of highwall well in advance of projected mine operations may be available to reduce issues associated with any research and development delays. An established mine with a major long term development requirement has also indicated a willingness to conduct extensive field trials and demonstrations, however it not known how the strategy detailed above would meet their mine development needs at the time.

The increased utilisation of mining contractors in the industry may also provide an alternative source of resources to conduct field trials and demonstrations.

8.6 Project manage the technology and equipment development process through to the conclusion of the field trials and demonstrations.

Depending upon the basis of the collaborative arrangement entered into with the mine operator it may be necessary for ACARP to project manage the technology and equipment development process through to commencement of field trials and demonstrations, or even through to conclusion of those demonstrations. Again, the engagement of an experienced equipment designer and/or manufacturer throughout the entire process would be warranted to ensure design specifications and project outcomes are achieved.

9, OBSERVATIONS ON INDUSTRY BEST PRACTICE

9.1 Key factors differentiating best practice mines and others.

During the review process it became evident that there was often a significant difference in regards to reported roadway development rates between mines operating in similar mining conditions and with similar mining equipment. Clearly there are other factors at play. While a three hour workshop at mine sites does not provide an exhaustive basis for reference and comparison there were a number of factors which were considered to differentiate between best practice mines and others, and the following observations on best practice mines are offered:

- Best practice mines exhibit a driven culture, a strong desire to succeed, and a focus on getting things right, all factors emanating from positive leadership models.
- These mines typically had very well defined and very prescriptive development processes, with supervisors held accountable for performance against that process. Performance rates were monitored on an hourly basis against expected standards, and delays were examined to the minute.
- They demonstrated a high degree of involvement of employees across all facets of the operation, from process definition to equipment specification, evaluation, and selection for both new equipment and overhaul, and in the continuous improvement of processes through a structured improvement process.
- Rather than focussing on maximising the utilisation of capital equipment, best practice mines focussed on maximising the utilisation and effectiveness of personnel through the provision of fit for purpose equipment with high levels of reliability and availability engineered into the equipment. This commitment to provide and maintain fit for purpose equipment necessitated higher levels of equipment to permit the routine overhaul and modification of equipment, with surplus plant capacity being available at times for contingencies and breakdowns.
- Best practice mines were more aware of developments in new technology, equipment and systems and were more aggressive in apply those developments to improve safety, productivity and costs.

9.2 Other factors typically evident at high performing mines.

A wide range of performance levels were reported across the various mining conditions experienced in the industry with high performers in poorer conditions typically achieving similar development rates to poorer performers in good conditions. Again, there appeared to be factors which differentiated between better and poorer performers in similar conditions:

- The better performers exhibited a higher focus on and prioritisation of roadway development, as compared to other operating processes at the mine. Development teams were typically independent of other teams and were held accountable for their performance.
- There was typically a strong linkage between development performance and mine incentive schemes at better performing mines. It was generally viewed that the Australian culture was more responsive to performance based incentive schemes than to salaried arrangements.
- Better performers were more likely to have developed balanced, sequential, cutting and bolting processes with 12CM configured machines and high capacity shuttle cars than the alternate integrated cutting and bolting processes utilised for ABM20/25 configured machines. These

latter operators typically noted that this configuration was not effective in high bolting densities (ie;>8 - 10 bolts/metre).

- Better performers were more likely to complete a typical 100m panel advance in less than 12 hours with single continuous miner unit, or less than 20 hours with dual continuous miner panels or super units, as a result of their attention to detail, good planning and coordination, process control and accountability.
- Examples were reported where a lack of effective mine planning had resulted in complex mine designs requiring more extensive mine infrastructure and necessitating additional development and/or development through adverse conditions.

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Appendix I

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C15005

17 October 2005

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Appendix II

Workshop Template

C15005

17 October 2005

ACARP

ACARP PROJECT C15005 AUSTRALIAN ROADWAY DEVELOPMENT – CURRENT STATUS

The site workshop has been structured into two parts, Part A and Part B, with Part A seeking to characterise each of the various sites by way of a questionnaire, with Part B focussing on the issues and challenges faced by mine operators in roadway development.

It is intended that Part A (Questions 1 to 43) will be completed prior to the workshop by mine site representatives with Part B (Questions 44 to 72) then being administered by the Project Leader during the workshop.

Site representatives are asked to complete Part A and provide a completed copy to the Project Leader immediately prior to commencement of the workshop.

Site representatives should respond to each question included in Part A by either inserting appropriate details in the "Condition/Description" column, or circling a number in the "Response" column that best matches the conditions experienced at the mine.

Some questions may not be directly appropriate, particularly where mines have been recently established. In these circumstances site representatives should either respond "N/A", or provide data that is typical of the mine's first full year of operations (and note the year that such data relates to).

Part A responses will be reviewed with participants at commencement of the workshop, before proceeding with Part B.

Site representatives are asked to circulate a copy of the project outline and workshop template to all workshop participants prior to the workshop so that individual consideration can be given to be the content and context of the workshop. Participants may also utilise the "Condition/Description" column/cells to summarise their responses to the various questions.

Responses will be compiled in a project report however documented responses will not be identified by site or individual participant.

Gary Gibson
Project Leader

PART A

ACARP Project C15005 Australian Roadway Development – Current Status

No	Factor	Condition/Description	Response
1	Mine Name?		
2	Seam/s Worked?		
3	Seam Thickness?		
4	Roadway height as mined – Mains?		
5	Roadway height as mined – Panels?		
6	Roadway width as mined – Mains?		
7	Roadway width as mined – Panels?		
8	Pillar dimensions (centres) – Mains?		
9	Pillar dimensions (centres) – Panels?		
10	Number of development units – Mains?		
11	Number of development units – Panels?		
12	Normal crew manning – Mains?		
13	Normal crew manning – Panels?		
14	CM type – Mains?		
15	CM type – Panels?		

PART A

ACARP Project C15005 Australian Roadway Development – Current Status

No	Factor	Condition/Description	Response
16	Roof bolting system – Mains?		
17	Roof bolting system – Panels?		
18	Coal clearance system – Mains?		
19	Coal clearance system – Panels?		
20	Material supply system – Mains?		
21	Material supply system – Panels?		
22	Working arrangements: • Days/week? • Shift duration? • Roster system?		
23	Mine challenges: • Depth? • Seam grade? • In situ and residual gas levels? • Ventilation? • Stress levels and regime? • Labour availability and turnover, industrial, etc? • Mine life cycle?		

PART A

ACARP Project C15005 Australian Roadway Development – Current Status

No	Factor	Condition/Description	Response
24	What other factors may differentiate the mine from other similar mines?		
25	Please specify the typical primary support measures installed in Mains development (ie; number, length, and density of roof bolts, rib bolts, and roof tendons), and the type, sizing and extent of roof and rib meshing and/or straps.		
26	Please specify the typical primary support measures installed in Panel development (ie; number, length, and density of roof bolts, rib bolts, and roof tendons), and the type, sizing and extent of roof and rib meshing and/or straps.		
27	Please specify any secondary support measures normally installed in Mains development (ie; number, density, type and sizing), and the typical time lag between primary and secondary support installation.		
28	Please specify any secondary support measures normally installed in Panel development (ie; number, density, type and sizing), and the typical time lag between primary and secondary support installation.		

PART A

ACARP Project C15005 Australian Roadway Development – Current Status

No	Factor	Condition/Description	Response
29	How would you describe the typical roof conditions and support measures installed at the mine?	Difficult – roof support density intense. Roof typically affected by slabbing or falls of immediate roof at face in both heading and cut through direction. Routinely requires installation of long tendons or additional support as part of roadway development in both heading and cut throughs. Development rates significantly impacted by roof conditions and/or level of primary support installed.	1
		Poor – roof support density high. Roof often affected by slabbing or falls of immediate roof at face, although normally confined to either heading or cut through direction only. Routinely requires installation of long tendons or additional support in affected direction only. Development rates impacted by roof conditions and/or level of primary support installed.	2
		Good – medium roof support density, with increased roof support density in either heading or cut through direction. Installation of roof supports has limited effect on development rates. Additional support may be installed in a second phase separate from the mining operation.	3
		Very good – low roof support density. Development rates not normally constrained by installation of roof supports although additional support may be installed in a second phase separate from the mining operation at times.	4
30	How would you describe the typical rib conditions and support measures at the mine?	Difficult – rib support density intense, typically 2 or more rib bolts/metre/rib with full meshing of ribs. Development rates significantly impacted by rib conditions experienced and/or level of primary support installed.	1
		Poor – rib support density high, typically 1 – 2 rib bolts/metre/rib with extensive (W pattern) meshing of ribs. Development rates impacted by rib conditions experienced and/or level of primary support installed.	2
		Good – rib support density medium, typically 1 rib bolt/metre/rib with single run of rib straps or mesh. Installation of rib supports has limited effect on development rates.	3
		Very good – low rib support density, typically less than 1 rib bolt/metre/rib, spot bolted without mesh. Development rates not normally constrained by installation of rib supports.	4

PART A

ACARP Project C15005 Australian Roadway Development – Current Status

No	Factor	Condition/Description	Response
31	How would you describe the typical floor conditions experienced at the mine?	Difficult - typically wet and soft, major problems experienced with breakaways and coal haulage. Development rates significantly impacted. Requires major commitment of resources and effort to control.	1
		Poor – problems experienced with breakaways, and coal haulage. Development rates adversely affected. Additional resources and effort required at times to control conditions	2
		Good - problems can be experienced with breakaways and coal haulage although effects minimised if good face management practices adopted	3
		Very good - problems rarely experienced with breakaways and coal haulage competent. Development rates not normally affected. Easily maintained	4
32	How many kilometres of roadway development were completed in 1994/95?		
33	How many tonnes were mined by longwall and/or pillar extraction in 1994/95?		
34	What was the typical development rate in 1995 (m/week/CM) – Mains?		
35	What was the typical development rate in 1995 (m/week/CM) – Panels?		
36	How many kilometres of roadway development were completed in 2004/05?		
37	How many tonnes were mined by longwall and/or pillar extraction in 2004/05?		
38	Current development rate 2005 (m/week/CM) – Mains?		
39	Current development rate 2005 (m/week/CM) – Panels?		

PART A

ACARP Project C15005 Australian Roadway Development – Current Status

No	Factor	Condition/Description	Response
40	How many kilometres of roadway development are projected to be mined in 2014/15?		
41	How many tonnes are projected to be mined by longwall and/or pillar extraction in 2014/15?		
42	Projected development rate 2015 (m/week/CM) – Mains?		
43	Projected development rate 2015 (m/week/CM) – Panels?		

End of Part A

PART B

ACARP Project C15005 Australian Roadway Development – Current Status

No	Factor	Condition/Description	Response
44	How would you describe the effectiveness of the coal cutting phase of the roadway development process?	Very low – there is consistent and significant performance gap between the continuous miner's actual and target cutting rates.	1
		Low - there is a consistent performance gap between the continuous miner's actual and target cutting rates.	2
		Good - metres achieved per available hour is approaching the target cutting rate of the continuous miner during parts of the mining cycle (eg; when in straight roadway development)	3
		Very good – metres achieved per available hour is consistently approaching the target cutting rate of the continuous miner.	4
45	How would you describe the effectiveness of face roof bolting equipment and systems typically utilised at the mine?	Very low – roadway development is "roof bolting" constrained and both face roof bolting equipment and bolting systems employed are not "fit for purpose" in the conditions typically experienced.	1
		Low – roadway development is "roof bolting" constrained and either face roof bolting equipment or the bolting systems adopted are not "fit for purpose" in the conditions typically experienced.	2
		Good - roadway development may be "roof bolting" constrained at times however the face roof bolting equipment and the bolting systems adopted are generally "fit for purpose" in the conditions typically experienced.	3
		Very good – roadway development is rarely "roof bolting" constrained and the face roof bolting equipment and the bolting systems adopted are generally "fit for purpose" in both the typical and atypical conditions experienced.	4
46	How would you describe the effectiveness of the coal clearance system from the face to the conveyor?	Very low – even though the typical roof conditions experienced and the support measures installed at the mine are "*difficult*" (refer Question 26), roadway development is "coal haulage" constrained. The haulage system/s employed are not "fit for purpose" in the conditions typically experienced.	1

PART B

ACARP Project C15005 Australian Roadway Development – Current Status

No	Factor	Condition/Description	Response
		Low – even though the typical roof conditions experienced and the support measures installed at the mine are "*poor*" (refer Question 26), roadway development is "coal haulage" constrained. The haulage system/s employed may not be "fit for purpose" in the conditions typically experienced.	2
		Good - roadway development may be "coal haulage" constrained at times however the haulage system/s employed are generally "fit for purpose" in the conditions typically experienced.	3
		Very good - roadway development is rarely "coal haulage" constrained and the coal haulage system/s adopted are generally "fit for purpose" in both the typical and atypical conditions experienced.	4
47	How would you describe the effectiveness of the materials supply and distribution (logistics) system utilised to service roadway development units?	Very low – mining operations are routinely delayed for extended periods due to the unavailability of materials at the immediate working face	1
		Low – mining operations are often delayed due to the unavailability of materials at the immediate working face, even at times when high development rates are not being achieved.	2
		Good - mining operations are delayed at times due to the unavailability of materials at the immediate working face, and generally only when high development rates are being achieved.	3
		Very good - mining operations are rarely delayed due to the unavailability of materials at the immediate working face, even when high development rates are being consistently achieved.	4
48	How would you describe the effectiveness of panel conveyor and services extensions and practices?	Very low – mining operations are consistently delayed for extended periods (>30 hours) to allow panel conveyors and services to be routinely extended.	1
		Low – mining operations are routinely delayed for extended periods of 20 to 30 hours to allow panel conveyors and services to be extended.	2
		Good – mining operations are delayed for periods of 10 - 20 hours to allow panel conveyors and services to be extended.	3
		Very good - mining operations are delayed for periods less than 10 hours to allow panel conveyors and services to be extended.	4

PART B

ACARP Project C15005 Australian Roadway Development – Current Status

No	Factor	Condition/Description	Response
49	How would you describe maintenance effectiveness as it is realised on roadway development equipment?	Very low – mining operations are consistently delayed for extended periods by preventable maintenance delays, even though equipment is routinely stood down for planned maintenance.	1
		Low – mining operations are frequently delayed by preventable maintenance delays, even though equipment is routinely stood down for planned maintenance.	2
		Good – although mining operations may at times be affected by preventable maintenance delays, there is a reasonable balance between preventable maintenance delays and planned maintenance.	3
		Very good – mining operations are rarely affected by preventable maintenance delays while planned maintenance outages are minimised.	4
50	How would you describe the capacity and the effectiveness of the mine's overall coal clearance system?	Very low – roadway development is significantly impacted due to extended and frequent delays associated with the outbye conveyor system. Constraints in the coal clearance system will negate any gains from roadway development improvement initiatives.	1
		Low – roadway development is adversely impacted due to extended or frequent delays associated with the outbye conveyor system. Constraints in the coal clearance system are likely to limit roadway development improvement initiatives.	2
		Good - roadway development is sometimes affected by delays associated with the outbye conveyor system. Constraints in the coal clearance system are unlikely to limit roadway development improvement initiatives.	3
		Very good – roadway development is rarely affected by delays associated with the outbye conveyor system. Overall system capacity and effectiveness is such roadway development improvement initiatives will not affected.	4
51	What factors contributed to the reported increase in annual development over the past decade (eg; additional units, additional shifts or days worked, increased development productivity)?		

PART B

ACARP Project C15005 Australian Roadway Development – Current Status

No	Factor	Condition/Description	Response
52	What factors contributed to the improvement in development productivity (m/week) over the past decade – Mains?		
53	What factors contributed to the improvement in development productivity (m/week) over the past decade – Panels?		
54	What factors are likely to contribute to the reported increase in annual development over the next decade (eg; additional units, additional shifts or days worked, increased development productivity)?		
55	What factors are likely to contribute to the projected improvement in development productivity (m/week) over the next decade – Mains?		
56	What factors are likely to contribute to the projected improvement in development productivity (m/week) over the next decade – Panels?		
57	If you were able to improve the continuous miner cutting rate by a factor of 2 - 3 what other elements of the roadway development process would then limit the overall panel advance rate? - please identify and illustrate.		

PART B

ACARP Project C15005 Australian Roadway Development – Current Status

No	Factor	Condition/Description	Response
58	Please rank these limiting factors in order of their perceived impact upon panel advance rates (from highest to least adverse impact).		
59	If you were able to specify, design, manufacture, commission and successfully operate a new generation roadway development system, what would the system consist of? – please identify and illustrate.		
60	If you were able to specify, design and manufacture a new generation roadway development system, what barriers would need to be addressed in order to successfully commission and operate the new system? – please identify and illustrate.		
61	What "new technology" or "new to the mining industry technology" needs to be developed and/or applied in order to allow you to successfully demonstrate the new generation roadway development system? – please identify and illustrate.		

PART B

ACARP Project C15005 Australian Roadway Development – Current Status

No	Factor	Condition/Description	Response
62	Please rank these “new technologies” or “new to the mining industry technologies” in order of the likelihood of being able to be successfully developed and/or applied (from most likely to least likely).		
63	Please rank these “new technologies” or “new to the mining industry technologies” in order of their potential to positively impact development rates (from most potential to least potential).		
64	Please rank these “new technologies” or “new to the mining industry technologies” in order of the perceived degree of difficulty in respect to the development and/or application of the various technologies (from least difficult to most difficult).		
65	In regards to roadway development, please list and prioritise the 3 most critical issues for research and development over the next 5 –10 years.		
66	What involvement have you had with earlier roadway development improvement initiatives and/or research and development?		

PART B

ACARP Project C15005 Australian Roadway Development – Current Status

No	Factor	Condition/Description	Response
67	How would you describe those initiatives in respect to their success or otherwise?		
68	What learning was gained from these improvement initiatives in respect to issues or matters that we need to either further address, avoid, or capitalise upon?		
69	What level of interest and support is there at the mine to participate in selected research and development over the next 5 –10 years into roadway development?	Very interested in pursuing industry based research and development into step change initiatives (eg; TBM and other integrated mining systems)	1
		Very interested in pursuing industry based research and development of incremental change initiatives (eg; improved cutting systems, improved roof bolting systems, improved coal clearance systems)	2
		Will pursue roadway development initiatives relevant to the mine at a mine site level	3
		Will remain aggressive followers	4
70	What specific research and development initiatives into roadway development would the mine be interested in pursuing on an industry basis?		
71	Would the mine be interested in collaborating with other mines to jointly develop and trial integrated mining systems, or parts thereof?		
72	What other matters are there that the mine would like to bring to the attention of the ACARP Underground Technical Committee and Roadway Development Task Group?		

THANK YOU FOR YOUR PARTICIPATION

ACARP

Australian Coal Association Research Program

FINAL REPORT

Australian Roadway Development – Current Practices

Appendix III
Workshop Responses

C15005

17 October 2005

A C A R P

Appendix III - Workshop Responses

Please Refer to Attached Excel Spreadsheet

Appendix III

ACARP

Australian Coal Association Research Program

FINAL REPORT

Australian Roadway Development
– Current Practices

Appendix IV
Notes of Interview

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Australian Roadway Development – Current Practices

APPENDIX IV

NOTES OF INTERVIEW

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1. OBSERVATIONS FROM THE CORPORATE SECTOR

1.1 Company Organisation C001

Vision

It was envisioned that a future mining system would be one that incorporated significant safety enhancements beyond what is now practised in the industry. Firstly, the development and application of enhanced exploration technologies would provide far better understanding of the roadway and surrounding strata prior to mining, thus enabling pre-emptive strata support measures to be employed to minimise roadway development delays, secondary and tertiary roadway support requirements, and longwall mining delays.

Secondly, improved gas drainage technologies would enable rib emissions to be controlled and the risk of outburst eliminated, even with step change improvements in development rates.

Small diameter shafts would be utilised, particularly in single entry mine development systems, to improve mine ventilation characteristics and provide a source of fresh air to the working panels, as well as providing for improved mechanisms for emergency escape, rapid inertisation, and materials logistics (eg; drop holes).

The application of continuous haulage systems would enable secondary support activities to be carried out in parallel with development operations, whilst the application of an overlap ventilation system comprising both forcing and exhausting fans and scrubbers would enable all activities to be carried out throughout the panel in parallel with the mining operation.

An integrated continuous mining systems incorporating coal cutting, roof support and coal clearance processes combined with extendible panel conveyors.

Roadway Development Focus

It was considered that the prime focus of roadway development research should be to de-bottleneck the development process so that the continuous miner was allowed to mine continuously. The current system was not continuous and had evolved to utilise discontinuities existing in the process, hence we referred to either being support or coal clearance constrained, not cutting constrained.

Working from outbye to inbye, it was considered that the development of the mobile boot end and extensible panel conveyor would provide significant gains given the time typically taken to extend the panel conveyor and associated services. This would require the development of systems to enable conveyor structure and idlers to be inserted into an operating conveyor, either at the outbye or inbye end, and for conveyor belting to be stored in and extended from a LTU storage device similar to the longwall LTU.

The next element comprised the haulage of coal from the continuous miner discharge to the panel conveyor. The continued application of haulage devices such as shuttle cars and battery or diesel haulers limited the system from becoming continuous, hence the development of continuous coal haulage system such as bridge or flexible conveyors or even slurry pumping was considered essential.

It was then necessary to develop technology and systems that would enable the support process to be done in parallel with the cutting process. It was considered that this could be best achieved through the development of independent and discrete narrow continuous miners and bolting machines that would enable roadways to be advanced in two passes. The continuous miner would firstly mine a deep, narrow plunge or sump, which would then be supported by the bolting machine as the continuous miner then advanced the second pass of the face. Protocols would need to be established through a risk management process to enable the continuous miner and bolting machine to operate concurrently in the same working face.

The multiple pass mining system would be greatly enhanced by changing the roadway design to a lower and wider configuration which would also have the benefit of improving rib and pillar stability.

Panel Design and Development Systems

It was envisaged that the industry would go to either a three entry panel design which would enable the application of continuous miners to be optimised, or to a single entry system which would enable tunnel boring machines (TBM) to be applied together with integrated cutting and support, coal clearance, and materials logistics processes.

It was considered that the successful introduction of a single entry TBM based mining system would require a staged development process to address hazards associated with the adoption of a single entry roadway in soft strata, including improved exploration technologies, geotechnical design, emergency escape, gas emissions, and ventilation. The staged approach would also enable the various components of the integrated roadway advance system to be developed and trialed, including automated bolting, continuous haulage, and extensible conveyors.

Alternative Systems and Processes

It was noted that a number of large scale, highly productive underground mines in the US operate in seams of 2.0m or less, and that the equipment utilised is designed to fit within the seam. It was therefore considered that as an industry we should move towards shrinking the size of equipment typically employed to enable roadway design to be optimised from a geotechnical perspective.

It was considered that the mining of narrower roadways as in the concurrent cutting and bolting system proposed above, combined with lower roadways, would enable deeper plunges to be mined and lead to improved development productivity.

Priority Development

It was considered that ACARP’s role is now to fund the development and building of suitable equipment, not fundamental research and development.

Priorities for funding should comprise:

- Continuous face haulage;
- Extensible panel conveyor systems;
- A concurrent cutting and bolting mining system utilising lower, wider roadways, potentially including an ABM14 style machine.

Development of the first two identified priorities was also viewed to be consistent with staged development of single entry TBM based mining systems.

Implementation

It was considered that the next phase of the roadway development project was to do conduct a cost benefit analysis of research and development initiatives based upon cycle times achieved in the current systems and the construction of detailed process maps that defined those systems.

It was also considered that the industry needed to develop a strategic roadway development roadmap that included all elements of the system as envisioned above. The strategic intent of the new roadway development technology and system as detailed within the roadmap should be framed within the context that improving mine safety is the major driver, with new systems also having considerable productivity benefits.

1.2 Company/Organisation C002

Health, Safety and Environment

Current mining technologies and systems require personnel to work at the face in a dynamically changing and hazardous environment, an environment which is relatively unknown prior to exposure of the newly mined working area.

Hazards include a range of mining induced causations such as falls of ground and rib, gas, ignitions, and outbursts, together with a wide range of agencies including slip, twist, fall, struck against, struck by, caught between, etc.

Given that the delineation of a longwall block requires the mining of a set amount of development, improved development rates would reduce the exposure of face personnel to these risks. Further, the exposure of statutory mine officials would be similarly reduced by improved development rates.

Improved development rates could similarly reduce the number of units required to complete a finite amount of development, thereby reducing the extent of planning and coordination required to support the level of operations.

Costs

It was considered that operators do not fully understand the difference between capital and operating costs, particularly in respect to the taxation treatment of the various classes of expenditure, and the implications of such in respect to financial evaluation of alternative mining systems.

Further, it was considered that corporations were typically driven by short term financial indicators that were not consistent with sound long term strategic objectives.

Continuous improvement techniques were being utilised to make operational improvements, however such initiatives were typically of a short term tactical focus and failed to address the overall strategic intent and structure of the mining systems employed.

Mines were not appropriately resourced with financial and process engineering professionals, consequently mining engineers and mine managers lacked suitable expertise and resources to properly evaluate alternative operating and improvement strategies.

Concerns were expressed that the cost of sub-standard development performance was not understood or brought to account, and that managers were often recognised for implementing alternate, less cost effective strategies to address longwall continuity issues (eg; additional units). Similarly, it was considered that roadway development was not sexy enough when compared to the high volume value adding longwall component of the overall mining process, and that effective leadership could not be provided without a full and proper understanding of the overall mining process and the business drivers and business imperatives.

It was considered that proper accountability coupled with performance based remuneration was necessary to establish the behaviours required to drive development productivity and cost improvements.

Production and Productivity

The current roadway development system comprises a number of sequential processes that is self limiting. The industry needs to establish a different system that is based on the execution of a number of parallel and integrated processes.

It was considered that parallel processes incorporating new technology may enable roadway development system to be optimised, and that it will then be necessary to address delays associated with advancing panel services.

It was considered that the application of process engineering and control to the development system was essential to provide a basis for measuring and understanding current systems, as well as providing a basis for evaluating potential system improvements. These tools and techniques were readily available to the industry and had been fully embraced in manufacturing and process related industries.

Personnel

Sociological aspects of the workplace have to be considered in order to address the repetitive nature of the mining process and overcome issues associated with familiarity, boredom, and a loss of interest and commitment over time.

It was likely that a degree of apathy existed in many workplaces due to previous failures to address basic equipment, personnel and system issues. The introduction of new technology and/or system changes in such an environment would required a major commitment and a high degree of sensitivity and perseverance to successfully manage the change process, together with a well developed roadmap for change. Further, senior management buy-in would be necessary to support a 2 – 3 year implementation and change process.

It was also considered that involvement of change specialists would be necessary to provide the detailed planning, execution, project management and support necessary to ensure that new technology and systems were successfully implemented and that an appropriate organisational culture, values and behaviours were developed to maintain and sustain required improvements over time.

While it was recognised that the industry faces considerable skills shortages across all levels of the industry, from miners and trades to engineers and managers, it was argued that unless dedicated project teams were established with the appropriate level of time, resources and corporate support, that potential gains through the application of new technology and systems would not be realised.

Industry Strengths and Weaknesses

The industry was considered to have a lot of experience in roadway development, that we were installing a more intensive support regime, and that we were hurting fewer people in roadway development. While we were very bullish about pursuing ideas that interested us, we were generally not good implementers.

New Technology

The IHI Mojura TBM was considered to have the most potential in respect to a step change in technology that incorporated a capability for parallel processing the various elements of the roadway development system. Further, the machine design specification provided for both a high advance rate and high availability. Its greatest limitation is its inability to mine interconnecting cut throughs, consequently a second process (eg; auger) would be necessary for cut throughs in the event that multiple roadway panels were adopted.

The Mojura was clearly seen to have significant potential in highwall punch mining applications, particularly in the event of single entry development systems being adopted. Consideration of emergency escape issues would be paramount in a single entry development application.

It was noted that Pacific Tunnelling had also completed a conceptual design for a roadway development system based upon the Lovat TBM.

It was considered that any focus on technology solutions in the short to medium term should be around the development of technology that would enable parallel processing of the development system. In the event that a continuous miner was to be utilised as a platform it was considered that technology developments must include as follows:

- Automated bolting with self drilling bolts;
- Integrated cutting and bolting (eg; enhanced ABM);
- Continuous transfer of coal from the continuous miner to the boot end;
- Modification of bolting patterns to limit the number of bolting units required;
- Continuous extension of panel services to allow the continuous miner to continue cutting through the panel advance process.

It was also argued that the formation of discrete groups working on specific discrete elements of the process would facilitate the rapid development of the required technology, although a mechanism would be necessary to facilitate the effective integration of such developments.

Project Implementation

In order to justify the commitment of funds and resources to an integrated research and development program it was considered necessary to firstly define and measure the existing development process/es so that potential improvements could be properly evaluated.

Secondly, a higher level of understanding of mining economics had to be developed to enable the benefits of improved development performance to be fully and properly evaluated. The linkage of development key performance and economic indicators to performance based remuneration systems was expected to facilitate a rapid improvement the understanding of mine economics.

Thirdly, people's attitudes to development would need to be changed and commitment and passion built to do something positive about roadway development. The establishment and maintenance of networks of development practitioners both within larger corporations and across the industry was considered an essential part of this process.

Fourthly, it was considered that any new mining technologies and systems had to be fully envisioned at a conceptual stage to enable it to be communicated to industry stakeholders and build long term commitment to the technology development process.

Finally, adequate time, resources and funding had to be allocated to the process of developing new technology and systems.

Given current coal prices it was considered that the next 3 – 5 years provided an ideal window of opportunity to do something positive regarding roadway development and prepare for the bottoming of the current business cycle.

The establishment and building of corporate support was considered to be one of the greater challenges facing the development of new mining technology and systems. It was considered that it would be necessary to build a cost benefit model that demonstrated step improvements in safety performance that could be achieved form such new mining technologies and systems, whilst also showing a direct and substantial improvement in the corporations bottom line and share price.

1.3 Company/Organisation C003

Roadway Development Issues

Roadway development issues at the various mines in the group included:

Mine A

- Soft wet floor conditions;

- Increasing gas levels with depth;
- Increasing horizontal stresses and increased incidence of rib failure with depth requiring higher ground support densities;
- Extensive secondary support requirements in gateroads, the installation of which is compromised by gas levels and an inability to utilise diesel equipment in return roadways;
- Long gateroads that require the adoption of heat management strategies during summer months;
- Increased development burden due to the increasing incidence of geological structures and an intention to deploy a second longwall face to ensure production continuity when moving longwall faces around structures;
- High turnover of staff impacting the mine's ability to develop a critical mass;
- Under performing development units;
- Bord and pillar (place change) mining introduced to augment production. 9 entry panels being developed on 21 X 23m centres, with a Jeffrey 1038 and diesel haulers. Target development rate is 450m/week.

Mine B

- Initial MRD gas drainage produced high water flows and low gas flows and has resulted in higher than anticipated gas emission levels in initial gateroad development;
- Heat and gas are expected to be a continuing issue in the future and mine design has incorporated 3 entry gateroads resulting in an increased development burden;
- Premature failures on diesel coal haulers;
- Shaft access introduces a number of operational constraints and limitations;
- Statutory issues associated with the mine design resulted in a loss of 6 months development;

Mine C

- Bord and pillar (place change) mining being introduced in a thin seam (1.5 – 1.8m) environment to augment production;
- While the area is undermined by workings from an adjoining mine, trial mining indicated that the seam could be mined;
- 9 entry panels to be developed on 16m centres, with a Joy 14CM and bridge conveyors. Target development rate is 650m/week.

Mine D

- Initial mine development established benchmark performance levels within group, with the operation of two continuous miners achieving 12 – 14kms of development per annum, even though it was not possible to man up two development units at all times;
- Development conditions were favourable and mine successfully applied a systems approach to all facets of the mine operation;
- Mine has now developed into a different geological setting with increased gas and stress levels evident at depth, and "nasty" roof conditions being experienced at times;
- Mine has also intersected a number of undetected (and undetectable) igneous intrusions which have affected both development and longwall operations;

- Mine is achieving 200m/week with two fully manned units and is ahead of its development schedule, although this has come at the expense of fully manning the second unit (budget 1.5 development units);
- The mines immediate future is in the context of difficult geological and geotechnical conditions and higher labour turnover.

Roadway Development Initiatives

The group has actively implemented and participated in a number of roadway development improvement initiatives, and has identified a number of key learnings, including:

Joint Joy Sumps Shearer (JSS) and Flexible Conveyor Transportation (FCT) Demonstration

- The demonstration followed on from a successful demonstration of the roof mounted FCT, with a number of enhancements being made to incorporate panel services within the FCT's monorail system;
- A number of teething problems were experienced with the JSS and it was found that the JSS had not been adequately trialed prior to inclusion in the combined demonstration, which was undertaken in a production panel. It was then recognised that the JSS was not ready for aggressive field trials and the demonstration was subsequently abandoned.
- It was also recognised at this time that production personnel do not necessarily have the patience and commitment to trial and demonstrate new technology. Further, the mine did not have the resources to trial the technology in a non-critical area.
- Involvement of companies and mines in such trials and demonstrations requires a major corporate commitment of people, time and financial resources.

Klockner Becorit Continuous Haulage System

- It was reported that insufficient homework was done on the floor conditions at the mine as the floor conditions were not conducive to the floor mounted continuous haulage system and the system repeatedly slid across the floor into the rib when traversing through cut throughs.

Development Services System

- The monorail based system which incorporated the auxiliary fan and ducting and the continuous miner power, water and air services was reported to be a good case study in the application of engineering design to develop an highly effective system.

Place Change Mining

- The introduction of place change mining was considered very successful in the first four gateroads developed at the mine, with development rates of 25m/shift being consistently achieved;
- Progressive adjustments were made to cut through spacings with the application of simulation software to model and optimise the development system. Similarly, adoption of 3 entry gateroads was considered to provide a significant opportunity for improved development performance;
- Changed geological conditions and higher in situ gas levels have been experienced as the mine deepened, and has resulted in "in-place" mining being introduced to the mine.

Systems Approach

- The systems approach was successfully applied to at least one mine in the group and was reported to have provided a sound basis for productivity improvement at the mine;

- Short interval control was also applied to place change development at one mine, however it was reported as not being a successful intervention due to the absence of any noticeable change of behaviours (although a number of personnel involved in that intervention have since successfully utilised the techniques at other mines).
- The application of 6 Sigma techniques for continuous improvement of roadway development processes was seen as the next major step in improving roadway development performance.

Development Conveyors in Gateroads

- Use of temporary development conveyors for gateroad development was trialed however it was reported as being unsuccessful as no gains were made in reducing delays associated with panel advances;
- It was also noted that cultural change and the application of a systems approach would be fundamental to reducing delays associated with panel advances.

Simulation and Planning Software

- Simulation software has been successfully applied to the optimisation of place change mining and for equipment selection, while the successful application of planning software was also reported.

Roadway Development Group

- A roadway development group has been established across the company comprising all development coordinators, development engineers, and others with technical roles supporting roadway development. The group is sponsored by one of the company's senior corporate managers;
- The group meets three times per annum, with the meetings comprising a site inspection of one of the various mines, presentations by mine personnel at the mine the subject of the visit, and a critique of development operations at the mine by the roadway development group;
- Recommendations are made by the development group to the mine regarding potential development improvement initiatives, with the mine then being free to pursue the recommendations as it sees appropriate;
- The successful development and application of the Development Services System, as noted above, resulted from a recommendation by the roadway development group;
- A lot of internal benchmarking has been conducted by the group, with the group also examining technology development opportunities and innovations;
- The high turnover of staff recently experienced across the group has hampered efforts to maintain and sustain the groups momentum.

Thick Seam Project

- It was noted that an earlier NERDDC thick seam project had been successful due to the level of industry support and funding for the project, and the use of an area of a mine which was separate from other production activities and was not on the mines critical path.

OEMs

The development and introduction of the ABM20 and ABM25 were considered as the most successful OEM initiatives of recent times, however major concerns were expressed regarding difficulties being experienced with OEMs generally in respect to maintenance, technical support and equipment overhauls. While some companies had demonstrated a commitment to improving this situation, with partnering agreements seen as an appropriate mechanism, concerns were held regarding the limited real choices available in the market.

ACARP Roadway Development Directions

It was considered that the major challenges to be faced by the industry were largely about the proper application of management systems, high turnover of staff, and the lack of high quality benchmarking data. The development and regular conduct of an industry wide and industry supported benchmarking process was seen as a major opportunity for ACARP given the level of support from industry for the current review (Project C15005).

It was considered that the roadway development roadmap should include the following (among others):

- Enshrining process control in the development process, to the extent that it is part of the process, coupled with the thorough application of continuous improvement for the ongoing improvement of development processes;
- Improving both the level of accountability for roadway development, and the level of resourcing of development, including provision of development mining engineers to assist in the collation, monitoring and assessment of process outputs and data;
- The development and application of technology and systems including:
    - ABM25;
    - Continuous haulage;
    - Systems to speed the installation of bolts while improving the quality of bolt installation by eliminating the "gloving" of bolts and setting of "bad" bolts (eg; under-drilled, over-drilled, under-mixed, over-mixed, poorly tensioned, etc) – achieving a step change for industry in regards to the quality of bolt installation;
    - Bringing the Autonomous Continuous Bolting Machine (ACBM) to a successful conclusion as a means to moving towards the full automation of roadway development;
    - Systems and equipment to facilitate the breakaway and drivage of cut throughs.

Alternative Roadway Development Systems

Observations were made on a number of alternative roadway development systems, including:

- While the application of TBM to roadway development had some limited support within the company, it was not generally seen as a viable technology at this time.
- Similarly, the application of road headers to roadway development was not seen as a viable technology.
- The company had had major geotechnical issues with narrow chain pillars at one of its mines, consequently the concept of driving wide, partitioned roadways was considered to be too radical to pursue at this stage. However, it was suggested that the technology may be more suited to deeper mines in NSW.
- It was noted that there were major opportunities with the design of new generation high capacity mines to incorporate development of longwall blocks from both ends, thus enabling single development units to be deployed (at each end) without compromising their performance by adopting dual or super units.
- A bord and pillar mining system utilising bridge conveyors was shortly to be introduced into a low seam height application within one of the group's Australian mines.

Overseas Developments in Roadway Development

Observations were similarly made on a roadway development systems employed in mines overseas, including:

- South African mines had, through their ability to capture and utilise data, been able to establish high capacity (1.2Mtpa) bord and pillar development systems.
- Chinese mines had similarly been able to establish 2Mtpa bord and pillar Wongawilli extraction systems.
- American mines were utilising place changing or in-place mining systems with satellite bolters, and in some areas were moving to adopt two entry gateroads in lieu of multiple entry gateroads.
- It was understood that Joy had now focussed on developing the floor mounted FCT system, and that there were a number of mines in the US either using this technology or were about to introduce it.

Corporate Position in Respect to Future ACARP R&D Projects

Respondents considered that it was likely that more significant gains could be made out of the full application of the systems approach, short interval process control, and continuous improvement, than was likely to be achieved out of any step change initiative. However they noted that the company would be open to useful suggestions in respect to participating in future R&D projects and that it would provide opportunities for testing of new equipment and systems. The company also had a number of open cut highwalls that could be accessed to provide “off critical path” test sites.

Feedback to ACARP

Respondents noted that the process of engaging the industry to develop a roadway development R&D strategy was a good initiative and that it should identify the key initiatives to be tackled due to the commonality of problems and opportunities across the industry. Increases in longwall capacity through the introduction of wider longwall faces and longer blocks, together with the adoption of three entry gateroads to ventilate these faces would pose significant challenges to the industry and it was necessary to find a better way of to doing it (development) as it was a slow, costly and dangerous task in its current form.

1.4 Company/Organisation C004

Surface constraints limited the ability to establish economic, productive longwall domains and resulted in lower longwall to development ratios with longwall discontinuities being projected at all mines in the group, even though mines typically employed 4 or 5 development units each. Further, mines were limited by their existing infrastructure and were typically deep mines with high stress and in situ gas levels. Like much of the industry, the company had just come through an extended period of extreme economic hardship and at this time had little surplus capacity and only limited investment capability.

The company had made a considerable investment to upgrade earlier generation ABM20s to the Mark III configuration and considered that viable operations could be established in the current operating environment if the machines were able to achieve the 8MPOH as specified. However, at this design rate it was noted that a lot of roof and rib bolts would be installed, that the nature of the work was arduous and within a confined space, particularly in regards to handling bolts and mesh sheets, and that fatigue would be a major issue, particularly among older members of the workforce. The challenge therefore was seen to be the ability to develop systems that would allow the capacity of the existing continuous miners to be realised in the conditions present within the mines.

It was considered that in order to achieve corporate objectives of lowering development costs significantly over the next 5 years it was necessary to understand the environment in which mines operated, to establish a vision of how it could be done, and for that vision to drive the behaviours necessary to achieve the objective. For example it was proposed that it would be necessary to reduce the number of development units to two at one mine (from four) whilst achieving a 50% improvement in annual development rates to 5kms/annum/continuous miner unit in order to establish viable longwall domains, sustain increased levels of longwall production, and achieve the required development cost reductions.

The challenge faced by operators is that things that are done in development may not be realised for up to three years in advance, consequently the establishment of a roadway development “business model” was considered necessary to understand the economics of the process, and to enable potential development strategies to be evaluated. The model should integrate market prices and costs, and also include longwall extraction to enable optimum mine operations strategies to be similarly evaluated, and appropriate strategies developed. Further, it was not until the full, overall cost structure was understood that opportunities for improvement would be able to be identified and evaluated, or the benefit of increased capital utilisation (eg; provision of an additional continuous miners in a unit) be substantiated. The model could also be utilised to develop strategies aimed at market proofing mines in the event of lower prices.

It was noted that the projected 50% improvement in annual development rates was achievable providing that face machines, mining systems, and the operational focus was got right, and existing barriers were overcome. It was important to understand the operational constraints faced in achieving such a turnaround, and the necessity for developing system capability to enable longer-term strategies to be evaluated and implemented. For example, it was considered that contract development may have to be implemented in the short term, at a cost, in order to take existing development operations off the critical path and allow roadway development improvement strategies to be implemented in a non-critical environment. Further, it may be necessary to establish longer term approval timeframes with statutory authorities in order to enable exploration and gas drainage to be completed so that geological risks and in situ gas levels were reduced to such an extent that ensured highly productive roadway development and longwall extraction of the planned domain.

In respect to operating philosophy it was considered that simplicity, as achieved through improved reliability, reducing units, and reducing operational flexibility, was fundamental to successful operations in the future, as evidenced by situations where improved performance levels were achieved following action taken to rationalise and/or close mines.

The respondents reported on a number of roadway development R&D projects or improvement initiatives that they had been previously associated with including; the Joy FCT and Klockner Becorit continuous haulage systems, bridge conveyors, pipe or tube conveyors, the Kemcoal Beaver, and the introduction of the ABM20 continuous miner. Learnings reported included:

- the FCT and Klockner Becorit systems were considered to be overly complex, and both were considered to have failed to fully address engineering design risk issues;
- the weight of the FCT monorail was considered to be an issue while the FCT was considered to be overly constrictive in the working face;
- the bridge conveyor not only chewed up the roadway floor due to the instantaneous traction control systems employed, but was highly labour intensive requiring 5 bridge operators and had a number of ergonomic issues in its design;
- the pipe or tube conveyors were considered to be a simple effective system, however the concept had not proceeded beyond the specification and design stage at the time;
- the design objectives of the Kemcoal Beaver were fully met with the introduction of the ABM20 to the market;
- the ABM20 is yet to realise the full potential of its design specification.

It was noted that floor mounted Joy FCTs with VVVF drives were now operating in US coal mines, as were bridge conveyors, while Klockner Becorit continuous haulage systems were also operational in trona mines overseas. It therefore appeared that the major technological issue now facing the industry was the development of high capacity, integrated bolting systems.

It was considered that the TBM technology offered the potential for driving fewer, larger roadways which would dramatically improve the longwall/development ratios of all mines in the group, while the possible elimination of cut throughs with the use of augers also eliminated issues associated with breakaways and hole throughs, and similarly improved longwall/development ratios. It was noted that the formation of square section roadways with continuous miners created ground control issues, which may be largely overcome with TBM profiled roadways. Providing roadways were of a shape and dimension that minimised the risks of people falling over, and power cables from falling into wheel tracks, the company held no fixed views regarding roadway cross sections. They were also of the view that longwalls could be designed to manage circular gateroad profiles.

In respect to the potential application of single entry roadway development systems the respondents expressed a high degree of concern in regards to safety issues associated with such systems (eg; entrapment of employees from outbye roadway falls, fire on equipment and conveyors), and questioned whether such roadways would in fact be able to support high capacity longwall mining systems in deep, gassy mines.

Key new technologies or “new to the mining industry technologies” that were considered necessary to support improved development rates included; materials handling systems as used in tunnelling, self drilling bolts, automation of roof and rib bolting, and improved panel advance systems including extensible conveyors.

In regards to roadway development research and development over the next 7 years the respondents identified improved gas drainage, improved bolting systems and the right combination of primary and secondary support measures, and improved coal clearance as the three most critical issues.

Further issues of considerable interest to the company are the development of a secondary support drilling system which does not discharge water onto mine roadways, improved horizon control to minimise penetration of soft underlying floor conditions, and improved water and roadway management systems generally. The major outcomes of an automated bolting system were seen to be a reduction in injuries, a reduction of fatigue, and the opportunity to allow personnel to focus on what needed to be done to make the system work, rather than actually doing the work.

The company reported that it had a considerable focus on site based operational research at this time, however it would be prepared to support industry based research and development programs providing the projects were relevant to its operations and the benefits were clearly recognisable. Further, the company was very prepared to collaborate with other companies and considered that it had a lot to gain in regards to understanding the range and extent of improvement initiatives across the industry.

It was noted that in order to gain a sign off to participate in roadway development R&D it would be necessary to demonstrate that proposed systems were simple, robust, repeatable, were not tied up with all sorts of complexities, and were things that the guys could make work. Further, a total systems approach would be utilised to evaluate potential projects to ensure that both improvements to the overall cycle times and optimisation of the sump depth, mesh spacing and shuttle car balance were achieved.

In regards to what ACARP did well it was noted that it had developed a maintenance strategy during the mid ‘90s that in itself was a simple document, yet contained a wealth of good practice that was still relevant even today. It was recommended that ACARP follow this lead in developing a report on Australian Roadway Development, and document a “body of knowledge” detailing what works well, experiences gained in various situations, one which focuses on the real issues that are going to make a difference and gets it across to people.

It was also considered that ACARP should actively go out to industry and seek the views of industry, as had been done in this instance, and should actively promote the benefits of its research and development activities by itemising the various projects and providing feedback to key players at site level.

It was also proposed that a key role of ACARP was the development of a cohesive industry approach to improved equipment ergonomics, and that ACARP should be instrumental in breaking down existing paradigms held by the OEM sector in regards to this issue.

1.5 Company/Organisation C005

There was general agreement that the major development constraints identified through the review process were typical of the company's operations, namely:

- Roof and rib bolting;
- Coal clearance;
- Panel services (eg; ventilation, power, water, compressed air), supplies and logistics;
- Panel advance including conveyor, transformer, DCBs, and;
- Maintenance

While improved equipment utilisation was considered likely through variation to shift arrangements and roster systems, it was noted that as higher technology was introduced and added functionality was included (eg; machine mounted bolting rigs), the level of engineering complexity increased. Unfortunately, the introduction of multi-skilling had resulted in a deskilling of tradesmen (and up-skilling of operator/ technicians), consequently there was an increasing reliance on OEM support for higher level maintenance functions.

Environmental factors in the work place such as ventilation, gas make, dust and noise were also considered to be limiting factors on development performance, as were human factors such as ergonomics. It was noted that long shifts and an ageing workforce were inconsistent with high performance levels.

In regards to the development of new high performance roadway development systems it was considered that a low cost, simplified TBM based mining system would a worthwhile development, however the TBM would need to be more flexible than those typically engaged in tunnelling applications and be capable of being relocated and recommissioned within two weeks. Regardless of the system, it would be necessary to operate in both hard and soft conditions, provide adequate roof and side restraint prior to installation of permanent supports, and be suited to site specific conditions. Consideration would also need to be given to the ventilation of long single entries, and to the method of completing connecting roadways between adjacent single entries.

It was noted that consideration had been given to the utilisation of a TBM to drive an access drift and one of the more recently developed mines in the group, however it could not be justified at the time due to high establishment costs, even after including the drivage of mains roadways with the TBM.

Again, regardless of the machine platform there was strong support for the development of an integrated cutting and bolting machine with automated bolting and machine guidance systems, the objective being to remove operators from the immediate face area. The Joy Sumps Shearer was seen as the ideal machine platform onto which new and emerging technology could be incorporated.

Opportunities for development of technology included self drilling bolts with fully automated cassette style bolting systems, utilisation of aluminium underground (eg; monorail segments, conveyor structure, pipework and fittings), purpose designed long tendon installation machines, and single pass drilling of longer than seam height bolts. There was also seen to be benefit in introducing another

OEM into the market, particularly in the bolting technology sector (eg; Atlas Copco), to improve the level of technical capability and market competitiveness.

Barriers to the development of such technologies were reported to include:

- Limited market size (only 25 longwall mines);
- The ability of the industry to maintain complex machines on site;
- Environmental factors such as dust, noise and heat;
- Legislative and government standards and guidelines, and differing regulations and standards between NSW and Queensland;
- Reluctance of OEMs to get involved, and issues associated with intellectual property ownership;
- Inability to fully include the effects of soft floor conditions and water issues in design parameters;
- Willingness of mines to fund the purchase of TBMs;
- Availability of non-critical mine areas for the trial and development of equipment and systems;
- Conflict between mine design parameters for efficient longwall operations and efficient roadway development;
- Need to incorporate capabilities in the ideal mining system to enable Mains infrastructure (eg; overcasts, driveheads, LTUs) to be completed.

In regards to future research and development it was noted that research should be focussed on removing industry constraints (eg; use of aluminium, electronics, automation and robotics, reliability in a harsh environment), while development should be focussed on the demonstration and subsequent commercialisation of current and emerging technology (eg; continuous haulage, self drilling bolts, machine guidance systems, automated bolting, installation of tendons at the face, single pass drilling of longer than seam height bolts) and the re-birthing of the Joy Sumps Shearer with current and emerging technology as above.

The company had sites where continuous haulage systems could be readily trialed and was generally interested in pursuing industry and site based technology developments that are relevant to the mines in the group, and where there is a high level of demonstrated OEM commitment to the project outcomes. Mines in the group had previously been involved in a number of step change initiatives, few of which had been realised. Therefore the company was clearly not interested in any blue sky, large $ value commitments to research and development, proposing that it would continue to pursue incremental technology improvements, and rely on ACARP to pursue the blue sky research.

The company's final messages to ACARP were that ACARP should hurry up, and that it should also understand why a number of the earlier projects had not been successful to ensure that such learnings were not repeated.

1.6 Company/Organisation C006

The company noted that the strategy it adopted in taking over recently acquired mines was to drive the longwalls at the various mines to get the most out of them, and this typically resulted in serious deficiencies in mine development being identified. Over the past 18 months the company had initiated a number of improvement strategies to improve development performance throughout the group, and noted a number of key issues that had been undertaken, including:

- Improving ergonomics on face machines, including continuous miner bolting platforms and operator compartments on shuttle cars and LHDs.

- Specifying a new 12CM12 continuous miner capable of sustained production rate of 6MPOH.
- Improving process modelling and process control.
- Reducing conveyor extension times by introducing lightweight, quick assembly belt structure.

The next stage of its development improvement process was to pursue the introduction of continuous haulage systems, including either or both the Joy FCT and Sandvik CHS, automation of the bolting process, improving drilling consumables, and lightweight materials.

The company noted that it had a lot of opportunity to gain further productivity gains from continuous miner based systems before contemplating the development of a new mining system. However, it considered that an industry based initiative through ACARP to introduce and demonstrate technology such as a TBM was an appropriate strategy as such a project was too big for any one company to undertake and remain in business.

OBSERVATIONS FROM MINE OPERATORS

2.1 Company/Organisation C007

The respondent is currently implementing a systems or process control approach into an older mine after having been previously involved with the successful application of this methodology at another mine. While it was noted that performance at that mine, namely 15kms of roadway development per annum with a single continuous miner unit, was rapidly approaching the full capability of the current roadway development system. The older, current workforce did not have the physical capabilities of the younger workforce at the other mine. Similarly, the early generation 12CM12 continuous miners used at the mine are not as productive as current generation continuous miners used at the other mine. As a consequence performance expectations had been de-rated and six weeks into the implementation process development performance has improved from 1.2MPOH to 2.1MPOH, against a target operating level of 2.5MPOH.

The development process has been process mapped through the entire pillar advance and chainage based triggers established to manage and control the process. The objective being to take away the need for deputies and operators to think, and focus the deputies' attention on planning and coordinating the necessary actions in accordance with the process map. Performance is logged on an hourly basis and an end of shift de-briefing is conducted with panel deputies to monitor performance and identify areas for improvement.

It was reported that one of the major factors behind the successful implementation of process control is the establishment of clear lines of accountability for performance between the production or development superintendent and the panel deputy, whilst one of the major barriers to its successful implementation is the dilution of that accountability through the shift undermanager's current role. The respondent further noted that good returns were to be generated from developing deputies' leadership and organisation skills, thereby empowering the deputies to manage the development process.

The respondent considered that the next step in the development of the process control approach is to incorporate the process map into a Windows based computer program to be able to generate "next shift" work orders based upon chainage triggers. Further, the system could be extended to generate supply requisitions for roadway support materials, conveyor hardware for extensions, cables, etc. Further, it was considered that such a development would be one that could be facilitated and supported by ACARP.

In respect to the potential development of mining equipment and systems the respondent considered that it was necessary to develop a system comprising a continuous cutting, loading and coal clearance capability, with equipment such as a TBM or the Joy Sumps Shearer providing a potential basis for future development. However, the respondent was firmly of the view that the ABM25 also provided a suitable cutting and bolting platform, one which could be readily integrated with a continuous haulage system to provide a high capacity, integrated continuous mining system. The respondent noted that he had witnessed a continuous chain haulage system being utilised in a Chinese mine behind a DBT continuous miner with good success.

An extension of the AMB25 continuous mining system approach was to utilise a separate system in each of two adjoining gateroads, with a narrow, extensible conveyor and mobile boot end being utilised in each roadway. Cut throughs at 200m plus centres would then be driven with a conventional haulage system.

The development of push button roof and rib bolting systems would greatly improve the performance capability of the AMB25 continuous mining system detailed above.

In regards to OEM support the respondent observed that Sandvik appeared to have the commitment, interest, motivation and technical capability to successfully take such initiatives forward.

The respondent noted that they were not in favour of pod or cassette based supply systems as they had found that they could restock the continuous miner more effectively using bulk materials trailers, and manually handling the materials onto the continuous miner. It was noted that the mine had only one back injury associated with manual handling process.

2.2 Company/Organisation C008

The respondents noted a number of factors that limited the mine from achieving its full potential, namely:

- The soft floor conditions were exacerbated by high water flows through the coal seam.
- Equipment downtime was far greater than could be expected from a relatively new mine, while the carry over of unresolved commissioning issues impacted the morale of crews, and fostered a lack of urgency at the mine.
- Human factors such as relatively high benefits and conditions and the ability for personnel to be readily reemployed elsewhere exacerbated the lack of urgency and a lack of ownership at the mine.
- A poorly constructed bonus system, which was based on longwall production rather than key drivers such as safety, quality, and development performance.
- An inability to achieve high standards of supervision, due to inappropriate union coverage of supervisors.

An Industry Perspective

It was generally considered that the industry doesn't need more technologically complex, higher powered, bigger equipment, but rather that it should focus on the improving utilisation of existing equipment through enhanced monitoring and maintenance techniques. It was suggested that Qantas would not be prepared to accept utilisation levels of less than 50% for its fleet (currently only 10% of their time "on the ground"), and that the industry should look to other sectors to establish best practice utilisation and maintenance strategies.

It was considered that investors need to take a longer term view of the industry rather than just riding the boom and bust cycle, and develop strategies to address such key issues as:

- Rapid roadway development systems;
- Removing increasingly restrictive and stifling legislative constraints, together with removing the threat of prosecution;
- Developing the next generation of mine managers;
- Developing supervisory, operating and maintenance skills across the industry;
- Developing improved gas drainage technologies that would allow in situ gas levels to be reduced to negligible levels (and also achieve improved utilisation of the energy resource), and;
- Protocols also need to be developed to ensure that ownership of and access to gas reserves and coal seams is streamlined, so that mine development is not constrained by ownership and access issues.

Roadway Development R&D

In regards to future roadway development research and development, respondents noted that the introduction of TBM technology or other similar concepts would provide a roadway development system with high availability levels, the ability to cut, support and haul coal on a continuous basis, and a more competent, self supporting roadway profile. TBMs provided an encapsulated and controlled work environment, one in which there was a lot of potential to introduce a higher level of automation and thereby reduce the level of physical effort required to sustain high development rates.

In getting from A to B, the shortest route was considered to be a single entry, not dual entries and all the issues associated with driving cut throughs. Further, the presence of cut throughs were a constant risk in longwall operations, particularly where stress notching around gate ends was channelled between the face and approaching intersection. Clearly, the drivage of single entry roadways was not a technical issue, single entry rail, road, water and sewage tunnels are driven over many kilometres in Australia and overseas, often in challenging geotechnical conditions.

It was considered that the biggest challenge facing the industry in respect to the potential development of a high capacity roadway development system was its lack of cohesiveness, and its ability to work together constructively to solve key issues. Further, everyone understood the issues and the potential means of addressing the challenges, however no one was prepared to take on the necessary investment to do it, and were prepared to sit back and wait for someone else to do it before attempting to spin off any developments to their own operations.

Therefore, it was considered that the industry should develop a strategy to trial a TBM, preferably in a high wall application, and that the trial should be funded by industry. There would be significant opportunity to offset the development costs of the trial against the coal mined during development and subsequent longwall access provided to the participating company.

2.3 Company/Organisation C009

In response to a briefing of the project and its interim findings the respondent noted that as General Manager at a mine he had supported a 12 month trial of the Joy Sumps Shearer at the mine, during which time some 11,000m of roadway development had been completed with the machine.

On completion of the trial a review and assessment of the machines performance was conducted to determine whether the trial should be extended and/or the machine taken over. The review team reportedly found that in comparison to a 12CM30 the geotechnical benefits afforded by the Joy Sumps Shearer in respect to its roadway profile and close proximity of face support installation did not offset issues associated with the machine being a one off and without ready access to spares and technical support from the OEM. Further use of the machine was suspended and the machine was withdrawn from service.

2.4 Company/Organisation C010

The respondent had been involved in the introduction and development of a number of roadway development improvement initiatives, including:

- Wide-head continuous miners;
- Jeffery 1048 continuous miners;
- Joy Sumps Shearer;
- Narrow roadway drivages;
- Steel and cuttable rib supports;
- Multiple movement bolting rigs (for fitting to continuous miner shovels);
- Mesh modules;
- Cable bolting;
- DMT flexidrill for installation of tendon supports;
- Bunkering/accumulator cars;
- Auxiliary ventilation systems;
- Air and water hose reelers.

The majority of these developments were undertaken in a thick seam, high stress, structured mining environment and were initiated in response to the various challenges experienced in that environment, and most of which have been since adopted as standard industry practice.

In regards to the Joy Sumps Shearer it was noted that some 1,100m of roadway development had been completed at an average mining rate of 4MPOH, with peaks of 6MPOH, in conditions that required 7 roof bolts and 4 rib bolts per metre advance. Although the machine suffered from problems with the traction motors, cutter arm cabling, and on-board inverters at the time, it was considered that with further development and refinement the machine would be capable of 8 – 9MPOH in arduous strata support conditions. It was noted that the machine subsequently undertook trials at other mines which were perhaps not as successful, primarily due to conflicting development priorities and unsatisfied expectations.

While the DMT flexidrill offered the potential to automate the drilling of 8m cable bolts, it was noted that the drill rig was compromised by excessive design risk analysis when the mine attempted to incorporate the drill rig onto an Australian drill platform.

The respondent reported on the development of a pillar development process map at a mine, incorporating all aspects of the 240m pillar cycle for a dual miner 2 entry gateroad panel, using a combination of process control, quality management and continuous improvement systems. The process was externally facilitated, and a suite of standards developed for the pillar advancement process, including the conduct of 120m belt moves and panel advances. Adoption of the standards enabled the belt and panel advance process to be completed in 15 – 20 hours, with 1.3 cycles being completed every week (5 days).

A similar process was adopted at another mine upon recommencement of operations at the mine, with the objective of completing a 240m panel cycle in 7 days with a single continuous miner. Development operations at the mine were progressively reduced from 4 operating continuous miners to 1 as the process became entrenched, with the mine operating on a single continuous miner basis for some 12 months. Also at this mine, the concepts of systems failure investigation was utilised by an external facilitator with an internal development “catalyst team” to develop the specification for a new generation continuous miner, which subsequently was adopted by Sandvik as the basis of the ABM25.

Other challenges at this mine included a high geothermal gradient and 100% relative humidity. The mine developed a fatigue management plan and introduced a three 12 hour shift roster to combat the effects of heat and humidity, and also introduced a series of workshops to educate employees on the necessity of establishing a proper sleeping pattern, following a good diet, and maintaining hydration levels. During this process the crew size went from “starvation” sized crews to “sustaining” sized crews of 8 operators, with crews being responsible for managing annual leave and sick leave internally within the crew.

The respondent noted that his new management paradigm was balanced between TQM, best gear, best people, and best management, with less reliance on strict process control and a greater focus on planing and doing. It was claimed that the industry was putting aggressive control freaks in charge, with many of these individuals being unable to see where the next production opportunities were. The respondent was also adopting a planning, risk assessment approach in order to justify expenditure based on the potential returns achieved from the various risk controls.

The respondent also commented upon differences between longwall mining and development operations, with longwall operations essentially comprising 20% planning and people, and 80% installed capacity and hardware, whereas development was 20% equipment and hardware and 80% teams, processes and people. It was argued that these differences required differing management approaches, with development being more about planning and doing, and therefore required higher levels of planning, influencing, communicating, team building and performance measuring skills. It was also noted that give the extent of the mine involved, with mine operations being some 7 – 8kms underground and accessed via a drift haulage, there was only one chance to get things right on the job.

Management's overall goal at the mine was to develop teams from the local D grade level to Australian representative standards, and this required leadership and coordination, the right equipment, and having "need to do" targets.

The next challenge was to be able to advance a longwall gateroad at +200m per week, and this would require a gap analysis to identify the difference between where they are now and where they want to be. It was also suggested that the ABM25 was the only machine capable of achieving 6MPOH in the difficult ground conditions experienced at the mine (10 bolts/m in roof and ribs, with 2 flexibolts/m).

The mine also measured three key indicators of the effectiveness of pillar advances, namely total cost of all activities, manshifts incurred, and the overall duration, and knew within a few cents of what it costs to do advance a full pillar. Underpinning those measures was the expectation that there would be zero injuries incurred.

In regards to improving panel advances it was noted that in a fire that there was little difference between poly pipe and steel pipe, and in the event that we could overcome our steel paradigm two men could advance all services in 2 hours by utilising poly pipe (off rolls with an underground poly welding station).

In regards to the development process, the respondent noted that the objective was to cut and bolt simultaneously, and similarly, for roof and rib bolting to be a simultaneous process and not in series.

The respondent noted that the industry also needed to be more like a racing car team, and trial different components on the prototype until they got to go as fast as they could, and then engineer the vehicle to build the "fast" components into a continuous racing system.

It was suggested that this was the approach typically adopted in mines in the USA where operators new the capacity (speed) of the various components of the development system, then pushed to get the maximum from the total system. Best mines in the USA reportedly had 65% availability with levels of 55% being typical, whereas in Australia the best was about 45%. Therefore there were significant gains to be made in improving availability in Australian mines. It was also noted that the US focus was on two key measures, uptime and operating rate, while Joy technicians knew the typical range of times taken by individuals at mines to fill a shuttle car. How well did Australian operators know these times?

To achieve high performance it was critical that the process be broken down into individual components, and that nothing be done in series. The secret was considered to be to let critical items be critical, and not let non-critical things hold up the process.

In respect to self drilling bolts it was considered that if these bolts proved effective, it may be possible to adopt a two phase bolting strategy with self drilling bolts being installed in the first phase, with the tendons then being installed in a secondary support phase. This would remove the impact that installation of long tendons has on development rates.

Continuous miners had to be built with high "flitability" incorporated into the design as every minute lost in flitting was considered a sacrilege. A further challenge was to improve the maintainability and reliability of continuous miners. The Joy Sumps Shearer couldn't break through the reliability barrier and similarly, couldn't break through the flitability barrier. In the last 5 years there have been substantial improvements to reliability, however maintainability hasn't improved. We need to understand how we can reduce the 8 hour maintenance window to one. This also needs to be supported by good mine standards and for instance, no running equipment through ponded water or no working in mud. It needed discipline to find out who did it, and to prevent a recurrence.

The respondent also expressed concerns in regard to typical risk assessment processes being adopted in the industry, whereby external facilitators attempt to incorporate safety into systems without first making it efficient. The new risk assessment paradigm should be to make the system go as fast as possible first, and then to make it safe. If it was not possible to make the fast system safe in the short term, accept a temporary modification but continue to work towards finding a fast/safe outcome. It was also suggested that continuous improvement needed to be applied to safety generally, again with the objective of making things fast/safe.

It was also suggested that the industry is weak in leadership and planning generally, and that the solution to this was the involvement of everyone in the quest for excellence and fast/safe. It was also necessary as part of the continuous improvement process to work at barrier removal, which suggested a positive approach to doing something about something that needed to be done, rather than to look at general initiatives to improve processes. Further, if we commit to doing something about something, we need to ensure that it is done in order to build management credibility.

The respondent also contributed to the development of the Pacific Tunnelling Lovat TBM scoping study and noted that a TBM was the only way of getting a true parallel pathing of all the various tasks. Further, the inherent design of the machine kept all the risks at bay.

The respondent noted that it was management's responsibility to create an environment for people to work fast/safe, and in the event that there was an unforseen accident, being able to rapidly respond effectively.

While being a firm believer in the continuous improvement process the respondent did have concerns with its basic intent, that it required continuous improvement and continuous change. Unfortunately over 95% of fatalities and serious near misses were reported to result from changes in processes. It was therefore necessary to have a robust change management processes in place to manage risks associated with continuous change.

In regards to new technology it was suggested that the key areas of focus were:

- Service extensions;
- Machine guidance for ABM25 machines;
- Self drilling bolts and rib bolting, and;
- Coal clearance.

Further, it was reiterated that the industry needs to understand the delays caused by maintenance functions, and to improve utilisation. It was considered that there are many easy wins from the development process, including:

- 12 - 15 hours additional time was typically lost on belt and conveyor moves;
- 3 - 4 hours additional time was typically lost on flitting,
- 6 - 8 hours additional time was typically lost on maintenance functions.

In order to substantially improve performance we need to regain the 24 hours lost in panel and belt moves, flitting and maintenance functions. Further, we had to put fit young guys in panels, and not expose older workers to heat stroke, heat stress, heart attack.

In regards to new equipment and technology it was proposed that if its available we should use it, however in the case of actually developing it, it was suggested that no benefits would be achieved unless we had got availability up to 60% or more, otherwise we would be squandering the technology.

The respondents vision of the future roadway development system incorporated a hermetically sealed tunnelling concept, with a controlled, cool, 75% relative humidity environment with no dust, no noise, barriers between hazards and the workforce, and operating at a +12MPOH rate.

In regards to the support costs of roadways the respondent was of the view that support costs varied in the relationship to roadway width as a fourth order polynomial function ($y = x^4$) and that as a consequence significant gains could be achieved by profiling roadways (eg; TBM, borer, Joy Sumps Shearer) to reduce the span of the invert (roof), and to adopt what could be considered a more natural rounded profile. It was also considered that further work needs to be undertaken to improve our knowledge of roof and rib failure mechanisms.

Where mines experienced water flows from the seam or surrounding strata it was considered that a proactive approach had to be taken to kill the pore pressure with flanking drainage holes, and to then catch the balance of the water make before it got onto the floor.

In regards to training new miners it was considered that training simulators should be used to train people before they go underground, rather than to expose them by training them within a hazardous environment.

2. OBSERVATIONS FROM THE MINE CONTRACTING SECTOR

3.1 Company/Organisation C011

The skills shortage that is evident throughout the entire underground coal sector, particularly in relation to statutory qualifications and trades skills, is considered to be the industry's greatest challenge and threat. Further, the cost of getting a new entrant into the industry was considered prohibitive, while the industry was faced with employing ticket holders because they have a ticket, regardless of whether they can add value in a leadership, management, or supervisory role.

It was stated that employee competencies in the metalliferous sector were developed far quicker and easier than that allowed within the coal sector, and that employees were therefore able to return value earlier in the employment and development process. It was considered that the Black Coal Competencies should be reviewed to similarly enable employees to develop value-adding competencies earlier.

It was considered that the industry should invest in an industry owned and operated training school to address the skills shortage, and to improve overall skill levels through continuing education, training and development. Serious concerns were held regarding the cost benefit of training delivery by both the public sector and by private training providers, while concerns were also expressed regarding the effectiveness of classroom style training with practical, hands-on personnel.

It was noted that the "baby boom" generation were nearing retirement (or had retired), and that the industry faced a serious issue in respect to the skills and experience drain that would result.

While it was once common practice to have a new starter work with an experienced crew to gain experience, the current skills shortage often meant that there were no experienced people to mentor new starters. This further eroded the industry's skills and experience base as inexperienced personnel could not provide a proper role model for new entrants.

It was considered that new strategies were required to recruit "generation X" and "generation Y" to the coal industry as these generations tended to prefer employment in higher and cleaner technology based industry sectors.

Concerns were expressed that the "commute" rosters typically utilised in Central Queensland was creating lifestyle issues with employees that may have serious ramifications for future of the industry.

The equal time rosters have a high component of penalty payments and allowances, consequently incentive schemes have less an effect with employees. Further, it was held that 12 hour shifts were less effective than 8 or 9 hour shifts, with similar performance rates per shift being achieved off 8 or 9 and 12 hour shifts.

The lack of availability and quality of accommodation for employees of contractors was also considered a major deterrent in regards to the recruitment and retention of employees in the contracting sector.

It was considered that a significant opportunity remained in the industry to better apply existing technology through better management (ie; systems approach), and that the contracting sector was generally further advanced in this regard than other sectors of the industry. It was also held that there was typically a lack of focus on de-bottlenecking development systems within those other sectors.

It was also considered that (mining) machines needed to be designed and built in such a manner that the equipment could be maintained and worked on in situ, and alternatively, could be readily brought out of the mine for major repairs and/or modification. Similarly, machines needed to incorporate better systems for electrical testing of flameproof components and circuits underground.

In the event that the industry was to continue with the drivage of 3.5 to 4.0m high roadways operators should give consideration to two pass mining systems with low height machines that would allow a second floor pass to be taken prior to panel advances as a means of improving roadway floor management (and also facilitate the installation of ventilation and face services at the immediate face).

Mining Systems

Considered that TBMs and super unit based systems had potential for further development, particularly in respect to the application of TBMs in highwall punch mine applications.

Research and Development Priorities

The following research and development initiatives were considered priorities in order to facilitate and sustain higher development rates:

- Gas drainage (to reduce both in situ gas levels below development thresholds and to reduce rib emissions);
- Self drilling bolts and automation of bolting;
- Drilling/bolting technologies to allow roof tendons to be rapidly installed at the immediate face, and in secondary support applications away from the face.

Role of Contractors in R&D

Considered that contractors were able to better focus on the application of existing technologies rather than research and development, however providing tripartite or quadripartite arrangements could be established between principals, OEMs, researchers and contractors as necessary, contractors could be successfully utilised for conducting technology demonstrations in trial mines or trial panels.

3.2 Company/Organisation C012

Roadway Development Improvement Initiatives

Respondents made observations on a number of roadway development improvement initiatives that they had been previously involved with, including:

- Short, point anchored roof bolts were used at one mine to reduce bolting times. While reduced bolting times were experienced there were some concerns that the bolting strategy may have impacted subsequent longwall operations.
- A lot of work was undertaken at one mine to refine the design of the ABM25 including ergonomics, bolting platforms, drive motors, etc. Unfortunately, mine operations were suspended and they did not proceed with the placement of an order. Even so, there were unresolved concerns regarding the size of the ABM25 (and ABM20) in the roadway (ie; seen to be too big).
- Point anchor roof bolts and forcing ventilation were used at one mine to facilitate the introduction of place change mining. While there was not a lot that could be done with the continuous miner, a lot of work was undertaken at this mine to reduce process times, improve sequencing, and vary pillar sizes to optimise performance. The owner's limitations on minimum cut through spacings (to suit subsequent longwall operations) did not allow the place changing system to be fully optimised. Difficulties were also experienced getting the right balance between forcing and exhausting ventilation systems in this place change trial.
- The introduction of a monorail services management system at one mine resulted in a statistical reduction of cable damage, although there were no apparent gains in development performance.

- The introduction of a roof mounted FCT to one mine was impacted by conflicting development priorities while the limited trials conducted identified that additional bolts were necessary for monorail hanging bolts, and also identified problems concerning the placement of hanging bolts, and the systems overall ability to transverse cut throughs.
- One development/exploration project did not take advantage of its status as an exploration project to trial different pillar and cut through spacings, and differing support regimes while another similar development contract allowed for the trial of different pillar dimensions, support systems and roadway widths.
- While the adoption of a three heading development system at one mine provided improved flexibility and identified a number of operational advantages, it did significantly increase the development burden.
- The opportunity to utilise temporary development conveyors provided significant benefits to installing wide, high capacity longwall conveyors during development, providing there is adequate lead time to recover the temporary conveyor and install the longwall conveyor. The availability of this lead time was considered to be all about the effectiveness of mine planning.
- The US philosophy appeared to be on keeping the continuous miner mining, and the adoption of surge loaders behind the continuous miner eliminated the coal clearance issue typically reported at Australian mines.
- Longwall operators have learnt the necessity of thorough and detailed planning and preparation for major outages and for routine operations. This learning needs to be transferred to development operators.
- Process improvement initiatives were undertaken at mines to improve panel moves, better sequencing of shifts to improve process time, and long term planning. Similar process improvement initiatives at another mine enabled a single continuous miner unit to produce at higher rates than that previously achieved from a dual continuous miner unit, and resulted in suspension and replacement of the dual miner unit.
- There was only so much that can be done with technology, and there is a need to understand the environment and how the equipment and technology can be best applied to that environment. Clearly there was a need to focus on the non-cutting time to achieve the potential of the system.

The Perfect System

Respondents identified the “perfect” roadway development system as an easily relocatable TBM capable of mining an elliptical roadway profile rather than a circular profile (ie; more longwall compatible), with a separate augering system for driving interconnecting roadways (rather than conventional cut throughs). The machine would be able to mine and form a drain in the floor (preferably) and be remotely controlled with inertial navigation and guidance systems to prevent rework.

Alternatively, it was proposed that highwall mining technology be applied to allow a narrow roadway to be advanced say 500m (in 24 hours), prior to withdrawal of the miner and installation of roadway supports. On completion of the support cycle a second pass would be mined to make the roadway longwall ready. The panel would be advanced in multiple 500m increments, with the 500m limitation being based solely on the size of the equipment and projected power requirements. It was proposed that an inertial guidance system and seam following techniques would be employed, together with a floor mounted continuous haulage system that would run up and over the panel conveyor.

In regards to a perceived requirement to mine three entry gateroads to ventilate and support 15Mtpa longwall mines it was proposed that fewer, larger roadways be mined, and that roadways be profiled to maximise their inherent support capability. The risk with utilisation of a high capacity single entry system such as a TBM was that the eggs were all in one basket in the event of equipment failure or abnormal mining conditions.

The issues impacting the successful adoption of the TBM system were identified as:

- flame proofing of the TBM;
- statutory issues associated with single entry drivages;
- roadway size and profile;
- making the TBM readily transportable and relocatable;
- interaction between the roadway profile as mined, and subsequent longwall mining;
- self assisted escape facilities;
- the turning radii of the system and the ability of the equipment to mine a longwall compatible profile through structures, and;
- the economics of one TBM versus two (or three) continuous miners.

In regards to the application of highwall technology to underground coal mines the issues impacting its successful adoption were identified as:

- power losses when operating equipment over extended distances, and the size of cables necessary to do so;
- the ability to get effective control and feedback when operating at extended distances.

Paradigms and Constraints

It was considered that the industry had a number of paradigms that constrained it from taking advantage of new technology and hardware, or from even considering new systems that may be counter to popularly held beliefs, namely:

- *Avoidance of single entry systems.* The tunnelling sector regularly excavates long tunnels for a variety of civil applications including roadway, railway, water and sewage, and controls the risks associated with their development, and their continued use across extended time frames (ie; plus 50 years).
- *The number, size and location of roadways.* The industry tends to drive multiple roadways of small cross section in-seam, where fewer, larger cross section roadways in and out of seam may provide a more efficient and economic alternative.
- *Wet drilling or bolts and tendons.* Wet drilling is adopted to control dust generation at the expense of floor control issues, whereas other countries adopt dry drilling with dust capture systems.
- *One size fits all legislation.* The advent of enabling legislation permits site specific risks to be identified, managed and controlled, however regulators continue to introduce regulations, guidelines and standards that apply the lowest common denominator at all sites, regardless of site specific risks and safety standards.
- *Prosecution reduces the risk of fatalities and serious bodily injuries.* No mine manager or official would permit or require personnel to undertake an activity that would place the individual or individuals at risk of a fatality, serious bodily injury, or injury, yet the regulators treat any such incident as evidence of negligence and contempt.

Research and Development Opportunities

It was noted that the current generation of continuous miners can cut at the rate of 30MPOH or better. The challenge for the industry, including OEMs, is to develop the associated technologies and hardware that will allow the total system to advance at that rate. This would typically require 120 – 180 roof bolts, 60 – 90 rib bolts, and 30m of roof mesh and 60m of rib mesh to be handled and installed per hour. Therefore the critical areas for research and development over the next 5 – 10 years were identified as:

- Continuous mining, and anything that can be done to integrate the three key components (ie; cutting, support, and coal clearance) and ensure that the process can continue without interruption for an extended period.
- Self drilling bolts combined with automated bolting systems and fast setting resins and grouts.
- Alternative roof and rib confinement techniques including application of continuous meshing.
- Gaining a better understanding of the effects of alternative roadway profiles on support geomechanics.
- Coal clearance systems, together with materials supply and services management systems to ensure supplies can be efficiently transported to the immediate face area and services can be readily and efficiently extended without impacting the mining process.
- Alternative drilling systems to allow longer than roadway height tendons and/or bolts to be drilled in a single pass, together with the ability to transport and install tendon supports “off the roll”, rather than in long bundles as currently utilised.
- Machine guidance systems to ensure roadways are driven on centre and to the correct dimensions to minimise the necessity for rework.
- Similarly, an automated measuring system to facilitate rigorous process control and to minimise rework.
- Research focussed on the development of enhanced hazard reduction systems.

Role of the Contractor in Roadway Development R&D

It was considered that the utilisation of contractors to trial and develop new mining technology and hardware had a number of advantages over past endeavours by mine operators to conduct such demonstrations, namely, that it would:

- allow the mine contractor to totally focus on the trial and demonstration while permitting mine operators to remain focussed on their core processes, thus reducing the numbers of balls that the mine operator has to keep in the air;
- ensure trials and demonstrations were adequately and effectively resourced;
- allow the contractor to develop the technology and hardware as a competitive advantage, and;
- enable the contractor to become a vehicle for transferring the technology across the industry.

In order for a contractor to become involved it would be necessary for the contractor to believe in the system under trial and development, to believe that it could develop a competitive advantage, and for a collaborative approach to be developed between ACARP, OEMs, mine operators, and the contractor.

Issues for ACARP

In conclusion it was noted that it is easier to get support and commitment for technology and hardware development than it is to get process control and software developed and accepted.

3.3 Company/Organisation C013

The respondent noted that the key factors in successful roadway development included:

- Clear defined accountability and responsibility for development;
- Adequate lead time to plan, develop and detail the mining process to be adopted;
- The level of detail defined within the process;
- The level of repeatability within the process (ie; pillar after pillar), and;
- Making it easy for the blokes to cut coal (ie; it is very easy for them to stop cutting).

It was noted that the introduction of an accumulator car at one mine was successful, however considerable difficulty was experienced getting operators to use the system as it was designed, rather than continuing to utilise their pre-existing practices and add the accumulator car onto that process.

It was considered that there was huge scope for the application of TBM technology to coal mines, particularly in high wall punch longwall mines. The circular mining section was inherently stronger than conventional rectangular roadways, although it would be necessary to either in fill or cut out the floor to make the roadway fit for purpose. In a high wall punch longwall mine application the respondent proposed driving two single entries to full distance, and then utilising a conventional continuous miner to cut out interconnecting roadways to meet the requirements of the longwall. In short, it came back to having the lead time to plan and develop the system properly, and having the roadways fit for purpose at handover. While such a system may result in higher development costs being incurred earlier in the overall longwall mining process, gateroad development was considered an accounting expense and should be treated accordingly.

Legislative restrictions and associated guidelines were seen to be the biggest barrier to improved development performance and improved safety. On one extreme there was a highly prescriptive and constrictive legislative framework and on the other an enabling legislative framework that also required appropriate risk controls to be developed and implemented. These requirements were seen to be in conflict with one another and to be inconsistent, and added to the level of over regulation. In addition, the government’s stated intention of pursuing prosecutions in the event of safety breaches has resulted in arse covering rather than effective mine management.

The key to successful mine contracting was considered to be good people, good planning, and good execution (ie; avoiding failure to deliver), while the biggest challenge faced by the contracting sector was the often unrealistic expectations of mine operators concerning the time to plan, prepare and mobilise for contracts. It was also noted that while award restructuring and other initiatives of the 1990’s proposed that significant gains in labour and skills transportability would be achieved, little had been realised in practice. Skills and people were not readily transferable and it typically required up to 4 days to have people inducted and accredited on sites.

It was noted that the company had made significant steps to improve the level of planning and auditing associated with the various works under contract, including:

- Defining work standards and training and skilling personnel to do the job;
- Adequately resourcing the work in accordance with predetermined standards;
- Monitoring, auditing and review work of processes and standards, and;
- Involving people to review and improve work processes and standards

Concerns were also expressed in regards to the lack of involvement of industry management in the development of new regulatory and training standards. This lack of involvement was seen to, by default, allow union policies to prevail to the benefit of training service providers. Given the statutory issues faced by mine management it was perhaps easy to understand why the current unsatisfactory situation had evolved.

4. OBSERVATIONS FROM THE OEM SECTOR

4.1 Company/Organisation C014

Cutting technology is not considered to be the issue, but rather the whole process and infrastructure behind it. Further, the industry typically suffers from a failure to plan and schedule effectively, while the logistical support processes were described as terrible. It was also considered that the industry is too focussed on longwall output, and development is not given adequate priority and resources.

US mines were reported to have higher levels of development focus with each of the various development processes (eg; cutting, coal clearance, roof support, and materials supply and logistics) being adequately resourced and held accountable. Further, the US mines were reported to utilise higher standards of process control in the workplace.

It was considered that Australian mines would not achieve the performance standards achieved in US mines until;

- the longwall and development systems were segregated;
- development operations were adequately resourced (including the materials supply and logistics function);
- process control became more widely adopted;
- planning and scheduling was improved significantly, and;
- personnel were held accountable for performance.

The lack of well disciplined process control, ineffective planning, and poor supply chain management contributed to unacceptable utilisation levels, and it was noted that Australian mines could learn from the OEM sector in regards to the importance of process control, planning, and supply chain management. This sector had introduced resource management procedures to optimise the manufacturing process from time of order through design, engineering, procurement, fabrication, and construction, to ensure the on-time delivery of equipment to specification. It was held that improved continuous miner utilisation would result if the industry adopted similar practices. It was also noted that few open cut operators would accept dragline utilisation levels of 20 – 30%, levels that were typically found in the underground sector for major plant and equipment.

It was also considered that Australian mines tend to minimise manning levels, and as a consequence tend to reduce the utilisation of plant and equipment, and to reduce the overall system capability. By comparison it was noted that in a production environment such as Domino's Pizzas, that all steps of the production process are adequately manned to ensure that the time to produce a pizza was minimised, and therefore overall production was maximised, as well as meeting customer expectations regarding the supply of an on-time, fresh, hot pizza. While it was likely that they could produce pizzas with fewer people, they would be unable to guarantee performance and service levels, factors essential in the fast food sector. It was considered that Australian coal mines also had a lot to learn from this sector.

Australian mines tend to utilise face crews to complete a wide range of production support activities including belt moves, extension of panel services (eg; power, communications, compressed air, water and pump out, etc), supplies, road works, and secondary support, consequently impacting upon continuous miner utilisation. It was noted that few production crews like doing panel moves, and even fewer do it well. The concept of bullgangs is often talked about, but are rarely used or used effectively. As a consequence, equipment utilisation throughout the industry was considered to be generally poor, particularly in relation to LHD's and face equipment. The use of specialist bull gangs for ancillary works would improve continuous miner utilisation, while the use of specialist, dedicated supply crews would greatly improve the utilisation of materials supply LHD's, and would in all probability improve the reliability of delivery, and reduce inventory.

The OEM noted that the company had recently established a global roadway development group to develop a long term vision and 5 and 10 year strategies aimed at meeting the industry's needs for roadway development equipment. While it was stated that the company intended to focus on its current range of equipment and determine what can be done better with that equipment, rather than develop new concepts, it was noted that on a global basis the company's suite of roadway development equipment included continuous miners, TBMs, bridge conveyors, shuttle cars, breaker feeders, and even a composite roadheader/continuous miner fitted with an articulated, slide mounted, cutter head. The roadway development group intended to conduct a workshop in China later this year to identify the needs, drivers, barriers and issues as part of the strategy development process. Clearly, there is a strong view that current continuous miners will cut at rates equivalent to 30tpm, however the associated processes don't allow the machines to advance at anything more than a fraction of that rate.

Issues and challenges proposed during discussion included the development of an integrated machine based on either a TBM or Dosco In-Seam Miner configuration with bridge conveyor, improved ventilation to enable cut through spacings to be extended, other means of mining cut throughs and/or specialist cut through drivage crews, automated bolting and self drilling bolts, and bridge conveyors.

It was recognised that while Australia was in the forefront of roadway development, we have as yet been unable to determine what factors stop us getting development rates twice that of what we currently achieve, and from improving upon those factors, for example, was it roof bolting related or was it the overall system itself?

From an OEM's perspective it would be necessary for the industry to demonstrate that any technology and equipment it required developed as part of the proposed R&D program was not site specific, and had application across multiple mine sites. Further, the OEM sector had invested considerable time and money in R&D, and had incurred considerable losses as a result of ineffective or aborted mine site trials. Trials that were often compromised by a lack of mine commitment and support, conflicting development priorities, unrealistic timeframes, and a lack of on-site planning and resources. Further, it was argued that no other industry develops new products under adversarial, contractual arrangements as is often employed in the underground coal sector.

It was considered that a partnering relationship needs to be built between OEM's and the industry, and that the ensuing arrangements provide for suitable funding, adequate time, and a buy-in of ownership and commitment to agreed projects. As part of the process, all OEMs should be brought together to brainstorm potential technologies, equipment and systems, with the industry then working with selected OEMs to develop the required technologies, equipment and systems in a constructive partnering arrangement. In order to then bring it to a successful conclusion it would require a trial site (preferably separate from other mining activities), a sound underpinning process control approach, good crews, good management, corporate support, and the identification and resolution of any barriers and issues.

Concerns were raised with any arrangements that would in future fund and/or establish a sole supplier basis (eg; Hydramatic).

It was noted that in order to develop the projected 15Mtpa mines it would be necessary to work with the OEM sector, and that could be best achieved by involving the OEM sector in the process of understanding the industry's needs and developing solutions, rather than directing the OEM to manufacture a solution without such involvement and understanding. It was also considered that industry needs to recognise the OEM sector's position on development costs, and that it be prepared to enter into a true, sustainable partnering relationship. Unfortunately, current relationships between the industry and the OEM sector generally were considered to be a sad indictment on the industry.

4.2 Company/Organisation C015

In regards to the development of new roadway development technology and systems the OEM noted that it was necessary to develop an equipment prototype within two (2) years of conceptualisation, and to have a commercial product available within a further 12 months. Any extension of this timeframe would lead to an erosion of corporate support and risk termination of the development process, as experienced on earlier roadway development improvement initiatives. To achieve such timeframes it would be necessary to appoint dedicated product champions at both the OEM's facility and at the mine site, and for the equipment development process to be properly managed as a stand-alone project. Unfortunately to date the industry had generally not recognised the need for accountable product champions and project management expertise, and tended to add such responsibilities to existing roles and functions with a consequent dilution of focus and accountability.

Issues were raised by the OEM in respect to the eventual commercialisation of any technology successfully developed through the ACARP research and development process, particularly in respect to the intellectual property and patents associated with that technology and the ownership thereof. Further, the OEM considered that it was the role of the OEM sector to develop equipment and hardware in response to market forces, rather than government agencies developing equipment as exampled by the Autonomous Continuous Bolting Machine (ACBM).

The OEM considered that the key factors differentiating between the best practice companies and others in the industry was the best practice companies understanding of the development process, their involvement of people, and their "driven" culture. Typically they were very focussed on getting things right, and were likely to expend more on equipment overhauls to ensure that equipment was fit for purpose, had high levels of reliability and availability engineered into the equipment, and the equipment met the needs of operating and maintenance personnel. They were also more likely to embrace new technology and equipment faster and more comprehensively than other companies, and better maintained their equipment so that higher utilisation levels were achieved. Hand in hand with this they were also less forgiving, did not accept mediocrity from people within the organisation or from suppliers, and were understood to suitably reward their good performers.

The OEM also noted that leadership was a key factor in successful organisations generally, and made the observation that leadership at the face had been compromised by increased statutory requirements and a heightened awareness of the individual supervisor's personal liabilities in the event of non-compliance. It was suggested that the industry should develop leadership programs to complement the safety and technical training programs currently being extended throughout the industry. It was also noted that in order to achieve high development rates competent machine operators were required, and that the industry generally faced shortages in this regard. Further, it was felt that in many instances mine workers were not as prepared to undertake the physical demands of the job as had the preceding generation.

In regards to the potential development of 15Mtpa mines the OEM noted that there was equipment available in the marketplace now that would allow such mines to be developed, including high capacity continuous miners and continuous haulage systems, together with world class bolting systems. However, it was likely that tightened departmental guidelines and risk management controls would limit the capacity of existing roof and rib bolting systems as further measures were introduced to minimise the risk of serious injury during the bolting process. The OEM considered that the most effective way of eliminating such injuries was to automate the process, and noted that it produced in Australia, an automated bolting system for use in an overseas trona mine. At this point of time however the system had only been developed to utilise expansion shell anchors, and its application to the coal industry would be limited until such time as an effective self drilling bolt was available.

It was also noted that fully automated bolting machines had a large footprint and would require considerable re-engineering to incorporate them into a continuous miner, As a consequence it was projected that the uptake of fully automated bolting would be limited, whilst some mines may in fact be inhibited from adopting such systems due to machine design limitations and roof support requirements.

The development of a self drilling roof bolt was fundamental to the further development of automated bolting systems and it was considered that if the industry continued to adopt its current stand back approach in respect to its development, the realisation of an economically sustainable self drilling bolt, and hence automated bolting, would be delayed unduly. It was proposed that the industry should identify the most prospective self drilling bolt design concept and facilitate its rapid development.

In regards to coal clearance constraints the OEM noted that their studies revealed that with the existing shuttle car based haulage systems mines generally became coal constrained as haulage distances extended beyond 70 metres. Further, few mines had varied panel designs to optimise the coal haulage although a number of mines were now introducing larger shuttle cars which allowed them to balance bolting and coal haulage cycle times.

The OEM also noted that continuous haulage systems had now gone beyond the prototype stage and that it had two floor mounted systems in operation in US longwall mines, with a further two machines now being built to meet contracted sales. These systems could be readily applied to the Australian industry however concerns were expressed regarding issues associated with site selection and suitability, particularly in respect to the level of commitment and support required at both the site and corporate level to ensure the systems effective introduction and utilisation.

In reflecting upon some 15 years involvement with the OEM it was noted that the introduction of wide-head continuous miners (eg; 12CM11 and 12CM12) fitted with on board bolting rigs had revolutionised the industry at the time, while the subsequent development of the 12CM20 did not meet industry expectations, which then resulted in the development of the 12CM30 to address shortfalls in the design of the earlier machine. It was noted that some thirty five 12CM30 and forty 12CM12 machines were in operation in Australian mines today, and that the industry’s high productivity mines all operated 12CM12 or 12CM30 machines. It was also noted that even though current generation machines were capable of achieving availability levels in the high 90% range, improvements in availability levels had not been reflected in improved development performance at this stage.

It was proposed that while improvements in longwall technology (eg; shearer initiation) had resulted in a less arduous working environment on the longwall face, improvement in development technology had only increased the work load for development personnel with increased bolting demand, the installation of roof and rib mesh, and a requirement to complete up to two panel advances each week. Therefore, it was considered that the industry’s focus should be to develop and incorporate technology that will remove personnel from immediate the working face/or reduce the physical demands of the development process. Automation and robotics had other benefits in that it would reduce the level of human intervention in the work process and would allow the process to operate to the design specification rather than be limited by attitudes, motivation, interest, physical capabilities and skill levels.

It was noted that the level of equipment utilisation in the industry was well below the utilisation levels typically found in the US coal industry, and that this resulted directly from a combination of poor maintenance practices, poor planning, inadequate integration of panel design and process control, and a pedantic approach to roof control as witnessed by an obsession for flat, uniform roof horizons. It was proposed that significant gains could be made by working with selected sites to improve equipment utilisation to levels of 65%, as typically achieved in the US. At this point it would then be appropriate to then move to improve or change the equipment and/or mining process.

A good example of integrated planning, panel and process design at an Australian mine which results in improved utilisation is the adoption of a 5.7m wide continuous miner head which allows the elimination of panel cut outs and niches, and even longwall pump station cut outs.

However, a general observation of the industry was that it was easier to work with a bit of hard steel and develop new equipment than it was to work with and to address the soft issues.

From a manual handling and occupational health perspective face ventilation and the management of generated coal dust were seen to be key issues requiring substantive improvement, and were considered to warrant the commitment of ACARP funds.

It was intimated that the OEM was pursuing the development of improved roadway development systems to address a recognition that it was no longer the industry leader in this field, and further, that its purchase of a local manufacturer of bolting machines was also consistent with its global objective of regaining industry leadership.

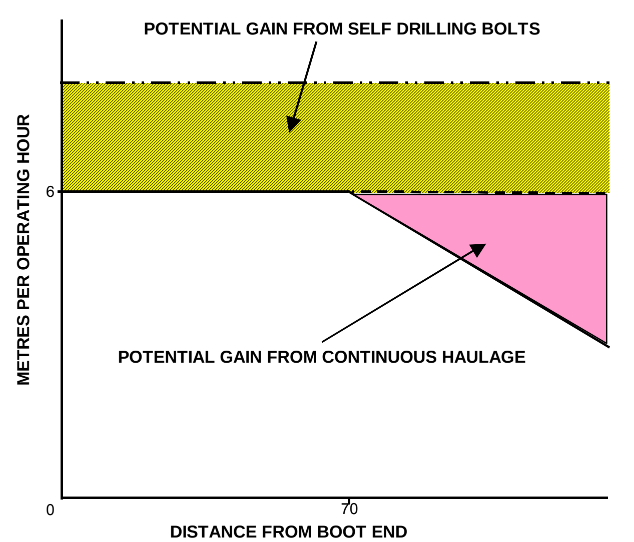
When advised of typical concerns expressed by the industry regarding the perceived lack of OEM support, the OEM expressed strong disappointment that such perceptions were in fact held by industry. The OEM also expressed concerns regarding the sustainability of the current level of activity being experienced in the industry. It further noted that OEMs generally were attempting to standardise equipment to improve manufacturing and supply economics, however mine operators typically wanted to make substantive changes to equipment specifications which limited such economies of scale.

In summary the key issues facing the industry were considered to be automation, equipment utilisation, leadership, people, and process control.

4.3 Company/Organisation C016

The company had developed modelling systems to establish the rated capacity of their continuous miners in site specific operating conditions (eg; seam and cutting height, roadway width, roadways centres, seam gradients, haulage systems employed). Even after significantly de-rating the model they have found that mines typically only achieve some 50% of the rated capacity. They considered that this shortfall is largely due to organisational and human factors, rather than the model or the continuous miners themselves.

Further, their modelling identifies that the development process typically becomes haulage constrained at some 70m from the boot end, and that while limited gains may be made by introducing continuous haulage systems, significant gains could be realised through improved bolting rates with self drilling bolts, as shown below.



COMPARISON OF PROJECTED GAINS FROM SELF DRILLING BOLTS AND CONTINUOUS HAULAGE SYSTEMS

The company therefore considers that the three key factors behind improved development productivity are as follows:

1. Self drilling, tensionable, and groutable bolts (and associated hardware).
2. Continuous haulage systems.
3. Process control and accountability for development.

Based upon this view, the company is now in the process of developing and commercialising a self drilling, tensionable, and groutable bolt, and is working with a another OEM to develop an automated drill rig for installation of the bolts. Subject to corporate approval, they anticipate trials of the bolts late 2005.

The company is also in the process of developing and commercialising a continuous haulage system and anticipates that the first unit will be delivered to a mine in the US early 2006 (rated capacity; 500m^3/hour, 200m haulage distance, 2.1m seam height). The company noted that the technology inherent in the system is based on the application of existing materials handling technology utilised for coal haulage in and around power stations.

The application of process control in mines was considered a mine site function and it was noted that only a few mines had, in their opinion, successfully developed and applied both process control and appropriate accountability systems.

The company also noted that safety, machine ergonomics, and logistic systems also continue to pose ongoing challenges, particularly with an ageing workforce and the higher capacity development systems that will be shortly available. It is expected that these factors will stimulate the development of remotely operated, automated mining systems, systems that could also be applied in hazardous mining conditions such as outburst prone coal seams.

The company welcomed the opportunity to meet with an ACARP representative and noted that the meeting was the first instance of such. They commended ACARP for its continuing involvement and support of industry based R&D, and requested that the company continues to be informed of developments.

4.4 Company/Organisation C017

The concept of utilising a TBM for roadway development evolved from the rapid entry development project first initiated in 1995, and resulted in the scoping of a double O tube TBM which would mine a 6m wide, 3.5m high roadway, as the first of three major components of an integrated roadway development system. The system was designed to advance roadways at the rate of 10MPOH in 17MPa coal, with shields providing initial ground support to minimise delamination of strata prior to bolting from a second module (ACBM).

Design of the TBM (Mojura) has essentially been completed, although final integration of the Mojura, ACBM, and coal transportation system is yet to be undertaken. It was considered that further development of the machine to enable rapid decommissioning and remobilisation was warranted. It was also noted that an automated bolting system was integral to the system, and that it would not be appropriate to proceed further development of the Mojura until such time as the automated bolting system was closer to fruition.

It was anticipated that the Mojura could be built and delivered within 2 years, however given the projected cost of the system the company was not prepared to continue further development of the system until suitable financial commitments had been made. Cost of building the machine had been estimated at +$10 million (2001/02), with a further $12 million or thereabouts for the other modules (including gateroad coal handling system) together with costs of some $10 million to demonstrate the system over a two year period.

While the use of a TBM in an underground coal mine may be a new application for the technology, the technology itself was considered to be well proven and stable. An extensive list detailing the TBMs built since 1960 was provided by way of support. Company support for further development of the project was considered to be strong, and the company had available all the key personnel, equipment designs and files to immediately proceed with development if necessary.

The company would look to retain the intellectual property and patents for the equipment however in the event of machines being built for overseas applications it contemplated royalty arrangements with ACARP for any jointly developed technology.

4.5 Company/Organisation C018

The concept of utilising a TBM for roadway development was first examined in a feasibility study in 1994, which subsequently resulted in a full engineering study being conducted with funding through the Federal Government's AusIndustry program. A full engineering design was completed based upon geotechnical conditions typically experienced at Angus Place and Appin's gas domain, and resulted in fully integrated system for mining a 4.5m diameter circular roadway. While the system was nominally rated at 700m/week in sandstone, the conveyor and materials supply system were considered to be the systems limiting factors, and the system was subsequently derated to 500m/week, or 2,100 m/month.

The system was designed to permit limited bolting of the roadway immediately behind the cutter head (nominal 1.5m from immediate face), and to be disassembled, relocated and recommissioned in another roadway in the mine within 2 weeks of completing a roadway drivage.

To address "fitness for use" concerns that were identified in relation to the use of circular roadways for longwall gateroads, cutters were fitted behind the machine to square off the floor profile, while inserts were designed to fit between longwall roof support canopies and the circular roof section.

It was intended that the machine would be fitted with machine guidance systems incorporating geophysical exploration and logging technology to permit the machine to be kept within seam and on azimuth, and it was noted that the turning radius of the machine in the vertical plane was better than that of longwall systems. It was also noted that TBM technology had also undergone significant development since the concept was first developed, and that TBMs were now considered to be a lot smarter.

Adoption of a single entry roadway development system had the potential to reduce the development burden by 30% or more, although it was noted that the system posed challenges to the industry in respect to second egress issues, and the use of high voltage (33Kv) power supply systems and on-board transformers. It was considered that the industry needed to come to a position in respect to the exposure of personnel in current, low capacity, labour intensive, multiple entry development system, as opposed to lower exposure levels in a high capacity, automated, single entry, development system operating in a controlled environment.

It was projected that a prototype system would cost some $13.5 - $15 million to develop and build, and that given the machine's development capacity it was likely that the machine would need to be employed on multiple sites in order to be fully utilised and to justify it financially. This suggested that the ideal owner would be contractor, however it was projected that 20kms of roadway drivage would be required to amortise its cost, and few contracts of this size have been awarded. Alternatively, it was suggested that it would require a multi-site, coal mine operator who was prepared to offer the equipment to a contractor on a "principal supplied" basis.

The lead time to develop and manufacture a machine was projected as 14 – 16 months, although it was noted that all TBM manufacturers are currently fully committed meeting the demand for machines for high speed, interconnecting railway tunnels in Europe, and for water, sewage, and underground metro systems throughout Asia. Consequently, OEMs would be unlikely to contemplate developing and building prototype machines without firm orders.

It was proposed that a phased introduction and demonstration should be adopted, with the machine being fully developed and demonstrated in a high wall application before transferring it to a conventional underground application. Clearly, the initial demonstration needed to be done in an area that was not critical to the mine's immediate development schedule.

It was also noted that self drilling bolts and an automated bolting system were integral to the success of the machine. In the event that full automation of the bolting process coupled with integration and automation of consumables supply system was achieved, it would be possible to remotely operate the machine from the surface if necessary.

In conclusion it was noted that TBMs had the capacity to eliminate the development challenge posed by new generation, 15Mtpa longwall mines, and that the barriers to the successful demonstration of the equipment was not the technology (because it was well proven), but the industry's concern with single entry roadway development systems, the overall cost of the machines and the size and timing of projects (and contracts), and the ability to establish a collaborative and cooperative arrangement to fund and support the machine's introduction.

4.6 Company/Organisation C019

It was noted that while face bolting hardware and the work platforms upon which the drilling systems were mounted had evolved over the past 15 years, there had been few significant improvements made to the overall mining system in that time. Many of the evolutionary improvements to face bolting systems have been achieved through efforts to improve work processes and reduce hazards in the work place, including:

- ergonomic improvements to and improved functionality of operator controls;
- larger and more functional work platforms;
- rib protection shields;
- mesh handling systems, and;
- better maintenance access and improved maintainability.

One mine had also taken significant steps towards the full automation of bolting, had developed sensing technology for strata logging during drilling, and had adopted variable displacement hydraulic pumps to reduce heat generated from standard fixed displacement pumps.

As a result, the availability of a self drilling bolt was now considered to be the only limiting factor in the full commercialisation of an automated bolting system, and it was noted that a number of alternative self drilling bolts are likely to be commercialised in the short term. Unfortunately, the development of both the hardware and consumables have both been delayed by a lack of industry support and an industry perception that R&D is free, or at worst is an OEM's operating expense. Therefore, it was considered that the industry needed to nominate a champion to drive the final stages of development and commercialisation of both the consumables and the drilling hardware.

Industry Best Practice

It was observed that even though there had been few significant improvements made to the overall mining system, some mines had made significant gains in development performance through the application of a systems approach, and by providing and maintaining fit for purpose equipment. It was considered that there was significant potential to improve roadway development performance throughout the industry by adopting current "best practice". In some instances this would require significant investment to replace aging equipment and to standardise equipment.

It was also observed that mine site personnel at many mines have limited knowledge of maintenance and rely extensively on OEM maintenance support, while best practice mines both own the equipment and any associated problems, and properly maintain the equipment. Again best practice mines tended to involve their people, and as a result the people either accept it because it works, or fix it and make it work if it doesn't.

The industry has been through an extended period of tight economic conditions, which in many instances has left a legacy of higher than normal incidences of equipment breakdowns due to earlier cost cuttings and reduced maintenance levels on front end, face equipment.

An example of less than best mining practice often observed at the face is the sharing of drill steels, drive dollies, and other mining hardware. It was considered that high performance rates cannot be achieved if the total system, including materials, consumables, hardware and equipment is not balanced and properly resourced.

The company had been involved in the scoping of the rapid entry development system and the subsequent development of the ABCM, and was of the view that TBM technology could be successfully applied to the industry. It noted that the Prospect to Guilford water tunnel has been completed with a TBM using best tunnelling practice, and had achieved a rate of 35m/shift for the entire project, based on two 9 hour production shifts and a 4 hour maintenance shift per day.

Departmental Guidelines AND OH&S Requirements

Concerns were raised in respect to the impact of Departmental guidelines on both equipment design and operation, and the high costs met by OEMs in complying with OH&S requirements, including risk assessments, design risk analysis, failure analysis, human error analysis, and a variety of other safety analyses. OEMs were also faced with the issue of weighing up the risk and hazards created every day by current technologies, and those potentially created by the development of new technologies.

The company was also at a loss to explain why in the first 10 years of service of its current roof bolting rigs no reportable injuries had been sustained, while in the last 5 years there had been a dramatic increase in the number of reportable injuries, and as result even more rigorous risk controls being required.

Challenges Of The Next Decade

The industry and OEMs faced a number of challenges over the next decade, including:

- An increased utilisation of second hand equipment due to the inability of the OEM sector generally to meet increased demand levels generated by the current up-turn in coal markets and prices.
- The development of hardware and consumables to allow long tendons to be installed at the immediate face in parallel with and as part of an automated bolting and mining system.
- The development of alternative cut through drivage systems (eg; coal augering).
- The sourcing of proximity sensors that can be utilised in the hazardous zone, and so enable automated mining and bolting systems to be developed.
- The development and refinement of materials handling systems through the entire value chain from manufacture and supply, to delivery and utilisation underground.
- The rationalisation of underground standards across company, regional and state borders to reduce the range of hardware and consumables required to be both developed and maintained.
- The level of time, personnel and financial resources necessary to be committed by OEMs to progress new technology and hardware through the various approval processes and OH&S analyses.

- The development of more effective rib support systems, hardware and consumables.
- Establishing a better understanding and recognition of the R&D process and associated risks and costs within and by the industry, and improving the level of industry funding of R&D.
- Developing and improving the modularisation of equipment to facilitate component service exchange and the ability to integrate new technologies and design within exchange components.
- Providing an improved level of support for mine sites to enable sites to focus on core issues.
- Developing and maintaining skill levels across the industry.

Opportunities For ACARP

Given the above challenges it was considered that there were a number of opportunities for ACARP to pursue, including:

- The development and commercialisation of a self drilling bolt and automated bolting system, together with the development of hardware and consumables to allow long tendons to be installed at the immediate face in parallel with and as part of an automated bolting and mining system.
- The development of alternative strata control systems and hardware, including roof and rib fabrics in lieu of steel mesh.
- A continuing focus on materials handling and machine ergonomics to address issues arising from high capacity roadway development systems, and therefore significant increases in consumables, and an ageing workforce.
- The development of alternative cut through drivage systems (eg; coal augering).

4.7 Company/Organisation C020

The company has been considering development of an extensible/retractable panel conveyor system since the late 1990's and has in fact developed a retractable longwall conveyor system that has been installed in a mine in Central Queensland. With encouragement from two of the major companies it has commenced development of an extensible/retractable panel conveyor system and expects that the system will be trialed within 8 – 12 months.

The design concept incorporates a system fully roof mounted on a monorail, with conveyor modules being inserted in or withdrawn from a station located immediately inbye the LTU, or in the event of longer systems, midway along the conveyor system. The conveyor modules will be preloaded into structure cassettes prior to insertion, or loaded into an empty structure cassette as the conveyor is retracted. A longwall LTU will allow considerable distances to be advanced (or retracted) prior to insertion (or retraction) of additional conveyor belting.

The system would require installation of a monorail as part of the development process, and would need to be designed to interface with both the development services and longwall services monorail systems.

The company noted that the sector is fiercely price competitive and that margins are low, which is typical of high volume, low value products. Therefore the company intends to protect any intellectual property developed as part of the system, and noted concerns that the company had in respect to ownership of intellectual property in the event that industry based funding such as ACARP was utilised for developing the system.

The company would require support from the industry by way of providing a site to install and trial the system.

4.8 Company/Organisation C021

In response to a request to provide details concerning the high speed bi-directional materials transporter noted as part of the Rapid Gateroad Development System noted by another respondent, the company provided a general arrangement drawing and 3D models of the machine.

It was noted that the concept had been developed to provide a rapid transport system in older, formerly rail mounted Chinese mines, and that some 22 units were now under construction in China for that market, with a further 40 units scheduled for 2006. The machine has a side mounted, bi-directional operators cabin and is fitted with a 5 speed transmission that allows four or two wheel drive operation in either direction.

It was also noted that the company has designed an 8 tonne forward control cab chassis truck for use in Chinese mines, with the truck platform being adaptable for a wide range of operating configurations and including a 20 tonne low loader. The company is contracted to build 1,200 units in calendar year 2006.

In regards to rapid roadway development in Australian mines the respondent noted that in his experience Australian mines have yet to recognise the benefits from and necessity of establishing and maintaining high standard travel roadways. It was noted that roadway maintenance was usually one of the last tasks to which labour was allocated to in Australian mines, and as a result roadways deteriorated, personnel were injured, equipment was damaged, and high vehicle maintenance costs were incurred. Other mines where high standard roadways were established and maintained reported significantly improved longwall changeout times, and low levels of vehicle damage and repair.

One factor observed to limit the industry's commitment to high roadway standards was the high capital cost of explosion protected, diesel powered road graders and compactors. The recent publication of *AS/NZS 3584.1:2005 Diesel Engine Systems for Underground Coal Mines, Part 1 – Fire Protection Heavy Duty* permits the operation of fire protected diesels in underground roadways in certain circumstances, rather than explosion protected diesels as is now the case. Adoption of this Standard is expected to lead to significant capital cost reductions in roadway maintenance vehicles and improved maintainability of those vehicles, and therefore permit their more widespread adoption throughout industry.

5. OBSERVATIONS FROM THE GEOTECHNOLOGY SECTOR

5.1 Company/Organisation C022

In reflecting over developments of the past 10 years it was considered that even though there had been developments in hardware, the quality of installed bolting had probably deteriorated. It was held that a combination of continuous miner design and hand held bolting previously allowed bolts to be installed in the optimum position from a strata control perspective when in difficult conditions, whereas the current generation continuous miners with on-board drill rigs did not have the capability or flexibility to install bolts in the optimum position in difficult conditions.

In support of this position it was noted that any deterioration in ground conditions now evident may be as a direct consequence of less efficient support systems being utilised, rather than as a consequence of any changes to the geotechnical environment. Therefore, the challenge of any new technology or systems was to ensure that support measures could be installed in the optimum geotechnical position, either as a result of the inherent equipment design, or as a result of other systems being able to be rapidly deployed and utilised in the event of conditions changing beyond that incorporated in the equipment design.

It was held that from a geotechnical perspective the development of new roadway development technology and systems was an iterative process that required firstly conceptualising the mining system, then geotechnical evaluation of that mining system in order to identify risks and controls, followed by design of a support regime for the conceptualised roadway shape. It was held that the geotechnical profession was of sufficient maturity and technical capability to satisfactorily develop any potential concepts that may be proposed.

A further step in this iterative process was the economic and financial evaluation of the various mining systems to establish the cut off limits for each of the identified systems. In order to minimise the risk of becoming locked into current paradigms it was proposed that a “think tank” be held to conceptualise a number of alternate systems, and that the geotechnical sector be firstly given the challenge to proceed the iterative development process.

In regards to the current status of the industry it was noted that increases in OH&S standards over the past decade has resulted in higher levels of strata control measures being installed, with the installation of full (roof and rib) or partial (roof only) meshing of the roadway now being the norm in many mines, with a consequential impact on development rates. Installation of rib support measures was clearly the slowest part of the current cycle, while it is necessary to increase the length of rib bolts as mines deepened. It was also that while there was a greater range of secondary support measures available to the industry, the continuous miner, roof bolting, and coal haulage processes were essentially the same while the incidence and extent of roof falls had not diminished.

In looking to the future it was projected that mines would become progressively deeper, and that the conditions currently experienced in the deeper Bowen Basin mines would be generally typical of all mines. On that basis it was likely that roadways would be fully meshed, that management of gas emissions would be significant issue, and that with the likely adoption of wider faces and longer longwall blocks three heading gateroads would probably be required to manage gas and heat issues through increased ventilation. Further, it was projected that cut through spacings would increase in order to minimise primary and secondary support requirements and that improved ventilation measures would be required to ventilate these longer development roadways.

It was noted that a number of studies had been completed for clients to examine ways of improving development rates, and that while the concept of TBMs had been broadly canvassed, companies had not been prepared to date to make the necessary commitment to a step change in technology. In respect to the future, particularly in the thick Bowen Basin measures, it was considered that larger cross section roadways, typical of what can be excavated by TBMs, may become a reality as they offered the potential to improve ventilation characteristics and even reduce the number of roadways required. Further, TBM technology would allow Mains roadways to be mined out of seam in more stable ground conditions, although it would require better information of ground conditions and strata orientation ahead of mining to optimise strata support and ensure roadways were properly aligned and oriented.

It was considered that larger cross section roadways would probably require longer bolts and tendons to effect ground control, with the installation of these longer supports at least partially facilitated by the drivage of larger cross section roadways. In short, going to larger cross section roadways would pose challenges, however it would provide increased space and remove constraints previously limiting the size of equipment that could be utilised to address those challenges.

In the event that larger section gateroads were to be formed with TBMs, consideration would need to be given to the gate end support system utilised for longwall extraction. Such a solution could be engineered, and it was contemplated that an integrated support system incorporating the immediate maingate end and the area immediately outbye the face may improve gate end strata management.

It was considered that chain pillar design would evolve as the mines' environment changed over time, and that yield pillars would become a necessity as mines deepened. However, this would also require improved gate road support systems to ensure continuity of longwall extraction.

A technical challenge faced by the industry as the use of longer tendons increased, was the development of drilling equipment that could sustain high development rates while installing a more intensive tendon support regime. Further, machine ergonomics currently limited the application of equipment and hardware in and around the face area.

It was recognised that if we don't do things differently deeper mines would result in increased gas levels, increased stress levels, and increased delays for support installation, both in development and secondary extraction. It was suggested that forward drilling and injection systems may be developed to stabilise ground prior to mining, while developments in injection technology may allow ribs (and/or roof) to be injected and/or sprayed for skin reinforcement, rather than meshed. Clearly this would require the development of people friendly chemicals combined with the application of automation and robotics. Further, the development of automation and robotics will be necessary to overcome human physical limitations which would otherwise limit what we are able to do in the future.

It was suggested that one of the consequences of tight economic conditions of the past decade has been the tightening of operating budgets, and hence a tightening of costs and the resulting flow on effect to strata support R&D budgets, both in terms of fundamental research and applied research by Australian consumables suppliers. As an example it was noted that R&D into bolts and resins had been shut down in Australia, and that while development of a number of Australian self drilling bolts has been on the cusp of commercialisation over recent years, only the development of a competing overseas product may restimulate local development.

Whilst ACARP's efforts to challenge the status quo of roadway development in Australia was recognised, it was noted that tight economic conditions of the last decade had not stimulated any serious challenge of roadway development rates. Therefore, it was questioned whether the recent improvement in the economic environment would in fact cause a fundamental change in our behaviour.

Further, development rates had in effect flat lined, as evidenced by plans to increase the width of longwall faces, and it was suggested that any successful step change in roadway development technology may require an integrated international approach to develop and resource the technology and systems. Alternatively, it was suggested that significant gains may come from the cobbling together of proven individual components and the development of some complimentary technology that could integrate a complete system. As an example it was proposed that a fit for purpose continuous miner could be utilised at the front end of an integrated mining system, which included a purpose designed roof and rib support installation platform. The refinement of existing technology and hardware could be built into the price of new equipment whilst the development costs of the complimentary, integrating technology could be funded through expanded ACARP funding.

In regards to the longer term needs of the geotechnical sector it was noted that current geotechnical training programs were developing a number of competent strata control engineers. However, the potential value of the revenue stream from 15mtpa mines in the future was such that a greater commitment to the development of geotechnical sciences and resources was required to mitigate the financial risk associated with these mines. Further, it was considered that there was an emerging shortfall in respect to higher level rock mechanics and the level of scientific knowledge required to challenge the fundamentals of the relevant sciences, particularly in the context of the potential step changes required.

It was noted that a 5% success rate for R&D was considered good and that every effort should be made to ensure that any resulting development was within the 5% successful sector, and not the other 95% sector.

In summing up the current status of roadway development it was considered that cutting power was not the issue, but more so the effective application of a systems approach to the development process in order to optimise the utilisation of the current people, equipment, and support processes. From a geotechnical perspective it was considered that the most significant challenges to be addressed are the capacity and ability to deal effectively with varying face conditions, and the improvement and maintenance of high standards of primary support installation.

5.2 Company/Organisation C023

In reflecting over developments of the past 10 years it was considered that place change mining could be widely adopted in Australia providing there are no faults or the roof doesn't consist of thinly bedded laminites. It was considered that if a roadway would span across 5.5m then the roof did not require bolting, and therefore would be amenable for place changing. Further, it was considered that we had the tools to identify whether place change mining could be adopted. Unfortunately, insufficient attention had been given to determine whether place change mining could be adopted.

In regards to the effectiveness of roadway support design it was considered that both good design and atrocious design is currently being done, with some bolting designs being terribly inefficient and leading to the installation of secondary supports within the primary bolting phase, with a considerable impact upon development rates. Further, it was considered that there was a lack of appreciation of some of the fundamentals of support design, with differing views regarding where and when bolts and tendons should be placed.

The lack of a defined, traceable body of knowledge regarding the design of strata support in coalmines has resulted in geotechnical consultants providing widely different recommendations to specific sets of circumstances, to the extent that mine operators could change the support pattern by simply changing the geotechnical consultant.

While concerns had been raised by industry concerning the gloving of bolts, it was stated that in all probability every bolt being installed was probably gloved. The issue is not whether bolts were gloved or not, but whether the system works. The system was considered to work in most instances, even though gloving of bolts was evident and even though bolt anchorages could not be properly designed.

The problem with low development rate across the industry was considered not to be the roof, but the rib. Fatalities and serious injuries had result from rib failures, while ribs often proved difficult to drill due to broken coal and hole closure. Consequently, there is a need to better understand both the laws of physics, and rib failure mechanisms. In the meantime, contemporary practice is to move towards full rib confinement, while it is projected that we will see complete skin restraint within 5 years.

Further, we have learnt that in thick coal seams vertical stresses are higher than horizontal stresses, and that brittle rock failure can occur in these seams at depths greater than 150m. We cannot in 2005, continue to have people bolting within 2.0m of the immediate face, and putting people into the situation where they are exposed to rib failure. Bolting processes need to be automated, while increased emphasis needs to be given to the work environment and the weight of consumables to make the environment more conducive. When automated bolting is achieved, more bolts will be able to be installed and the problems of roof and rib failure will largely go away.

It was projected that the move towards full rib confinement with mesh will lead to conflict between development and longwall operations as longwall operators attempt to deal with mesh wrapped around shearer drums and the risks posed to hydraulic seals and glands by small pieces of mesh.

It was noted that mines are tending to align longwall blocks to minimise the effects of stress notching on the maingate end. This resulted in faces often being aligned parallel to the cleat, with resultant slabbing off of large slabs of coal onto the AFC, and potentially exposing the longwall to roof falls in front of support canopies. It was considered that improved tendon support design now enables gate ends to be more effectively supported than in the past, which allows longwall design to be varied to suit the longwall operation (ie; realigned to minimise face slabbing), particularly given that most operators are now installing tendons in the maingate as an insurance factor.

It was considered that the evolving role for on site geotechnical engineers under the current regime of strata management plans is becoming too onerous, often requiring almost 24 X 7 site coverage to provide advice and support to deputies and mine officials in the monitoring, interpretation and analysis of real time data. Further, the young geotechnical engineers often being channelled into these roles don’t have the necessary experience to make the calls required by the plans. It needs to be recognised that when conditions are capable of being detected through monitoring, the condition is already in a state of failure. Therefore, more responsibility needs to be given to front line supervisors to respond to observed triggers, while better design needs to be applied to prevent the state of failure from occurring.

In conclusion, it was considered that we needed to reassess the fundamentals of coal mine ground support again and develop a textbook or defined, traceable body of knowledge regarding the design of strata support in coal mines, thus enabling ground support engineers to develop and apply sound engineering design to their everyday challenges.

5.3 Company/Organisation C024

It was proposed that the greatest opportunities for improving roadway development performance in the short to medium term from a geotechnical perspective was from:

- Reducing bolt density;
- Reducing bolt length; and,
- Routinising the use of tendons as a primary support in appropriate conditions.

However, while it was considered that most mines had some fat in their strata management plan, it was also held that most mines do not know how to manage their strata and are “fighting fires” on a daily basis. Strata management plans and processes need to be improved at many mines, particularly in NSW. Further, mines must learn to proactively manage their strata management plans and processes on a 24 hour basis, with direction being provided to face operators through a simple TARP system. It was considered that current problems were largely cultural, combined with a lack of discipline and a massive people issue.

It was considered that until such plans and processes were in control, it was unlikely that any move could be made to reduce bolt density or bolt length.

It was noted that mines in the US tended to adopt wider, lower roadways, and typically utilised yield pillars and/or yield and abutment pillars. It was considered that some Australian mines could similarly adopt yield pillars in order to reduce the development burden, albeit at the expense of increased gateroad secondary support. It was also noted that Australian mines continue to experience difficulties supporting tailgate roadways and consequently increased the size of chain pillars as a control mechanism, at the expense of an increased development burden.

Further opportunities were available to reduce the development burden by splaying pillars as the depth of cover increases (resulting in longwalls being fanned out), and to review the design of main roadway pillars and barrier pillars, both of which were now considered to be significantly over-designed.

From a global perspective it was noted that high productivity mines (US) were more likely to utilise three entry gateroad systems while low productivity mines (UK) tended to utilise single entry systems. Australian longwall mines nearly all used two entry gateroads and were generally considered to have medium productivity levels by comparison.

In regards to the potential development of new mining systems it was noted that:

- While all UK statistics suggested that advancing longwalls were a dog, a desktop study may be warranted to assess the impact of developments in strata support on gateroad stability and maintenance. It was noted that with this system difficulties may be experienced getting geotechnical engineers to sign off on the use of roof bolts as a support mechanism.
- Similarly, a desktop study of the application of TBMs was warranted, although an earlier study in 2002 reportedly found that initiatives to utilise TBMs in mines in UK, Germany and Canada had all failed.
- The profiling of roadways to arch the roof and rib intersection (ie; TBM) was not seen to be a benefit in stratified and laminated deposits typical found in Australian mines.
- The application of dual entry yield pillars (wide, segregated pump packed roadways) was considered to offer potential, however it was noted that there had been little experience with yield pillars in Australian mines.

Geotechnical R&D Strategy

In regards to the development of a short term R&D strategy for geotechnical aspects of roadway development it was noted that:

- Developing effective strata management plans and systems was a fundamental issue to ensure that operators were working to a set of rules that enabled appropriate support measures to be installed as and where required, and to provide a controlled environment where alternative support strategies could be properly evaluated.
- The development and commercialisation of a one-step bolting process (eg; self drilling bolt) would provide significant gains in regard to development productivity and the quality of finished support.
- While it was considered that yield pillars could probably be successfully applied in Australian mines, other than in those that experience high horizontal stress levels, insufficient data was yet available to give guarantees regarding the design and efficiency of yield pillars and/or dual entry yield pillars (ie; wide, segregated, pump packed roadways).
- A lot was to be learnt by visiting and studying mines in the US to see and understand what they do in roadway development. It was considered that US mines were typically better than

Australian mines in respect to yield pillar and pre-driven recovery roadway design (although they were considered to lag Australian mines in respect to roof support design and installation).

- Australia had an aversion to single entry roadways, however single entry roadways were considered to offer considerable benefit, particularly in the deeper mines of the southern NSW coal field. In this region high horizontal stresses notched around longwall faces and were subsequently channelled between the retreating face end and cut throughs immediately outbye the face, resulting in significant roadway deformation and closure, or even roadway collapse. Further work was warranted in these mines to assess the suitability of single entry roadway development systems.
- Further work was warranted to develop more effective rib support systems.
- The industry had all the secondary support measures it required, however the challenge was to work out where it should be applied and to optimise its installation.
- Pre-driven longwall recovery roads were again under consideration, and had in fact been used recently. It was considered that further R&D was warranted to ensure roadway support design was both suitable and effective.
- The conduct of desktop studies on alternative mining systems noted above was also warranted.

In conclusion it was noted that if the industry was starting to look outside the square in respect to mining and support systems, it would be necessary to get the fundamentals right (eg; strata management plans, hardware, and management systems) and to utilise those mines where controlled roadway support systems were considered to be well established.

6. OBSERVATIONS FROM THE RESEARCH, OPERATIONS AND SUPPLY SECTORS

6.1 Company/Organisation C 025

Autonomous Continuous Bolting Machine (ACBM)

The 1995 ACARP Roadway Development Workshop resulted in the formation of a strategy to develop a narrow heading, remotely operated roadway development machine that included an integrated roadway support, ventilation, and coal haulage system. The concept evolved to utilise a TBM for roadway drivage, a second roadway support module, and an extensible conveyor system (mobile boot end). The various stakeholders developed designs for each of the three major components, however Industry based support for the total system lapsed in the late 1990's due to the then tight economic circumstances. The project was subsequently restructured to continue with the development of the second, roadway support module, the Autonomous Continuous Bolting Machine (ACBM), with further development of the roadway drivage component (IHI Mojura TBM) then being suspended.

The ACBM was designed to incorporate self drilling bolts and an automated bolting system however finalisation of the machine was delayed as a result of deferment of commercialisation of an Australian self drilling bolt, and a failure of an OEM to complete development of the automated bolting system. Researchers have continued to develop an alternate self drilling bolt and the associated automated materials handling system. While a number of technological breakthroughs have been achieved, demonstration of the machine is still subject to completion of the automated bolting rigs. Given the limited choices the industry currently has in the bolting rig OEM sector, support for the introduction of a third OEM into this sector is considered warranted.

Clearly the ACBM concept is not one which can be incorporated into existing mining systems at all mines, however the application of the various technologies (eg; self drilling bolt, automated bolting rigs, automated materials handling system) can potentially be readily incorporated into other roadway development systems.

Roadway Development R&D

Potential roadway development systems and technologies that warrant further research and development over the next decade include:

- Automation and robotics.
- Application of high wall mining technology for machine guidance, monitoring and control.
- Continuous haulage systems (face), and long entry (gateroad) continuous, extensible haulage systems.
- Automated bolting and materials handling systems, and extending such systems to current mining platforms.
- Alternative cut through breakaway and completion by either making existing technology more flexible, or developing different technology.
- Working with OEMs to remove roadblocks and de-bottleneck existing equipment and earlier technology developments.
- Alternative development systems such as wide, segregated (pump packed) roadways.
- Secondary support characterisation to identify and optimise support requirements through the application of geophysical exploration techniques, ground probing radar, and bolt/drill sensing.
- Improving gas drainage technologies to enable high capacity mines to be established in deeper, gassier reserves.

- Ventilation systems including overlapping forcing and exhausting systems and dust scrubbing systems.
- Wireless technology for interpersonal communication and equipment monitoring and control.
- The development and use of on-board continuous monitoring and machine diagnostic systems.
- Coal pumping and transportation systems.
- Alternative geotechnical design with narrow (eg; 4m thick) barrier pillars between adjacent single entries (as utilised in Chinese mines).
- Advancing/retreating longwalls, or even advancing longwalls.

Barriers To Successful R&D

A major barrier to the successful development of the identified systems and technologies is the sheer magnitude of investment required. Clearly, the Australian industry cannot support the development of all the potential system and technology developments identified.

To this end it was recommended that a scoping workshop be held to develop and prioritise a roadmap for roadway development R&D. It was also considered that the total cost of roadway development in Australian mines was not fully understood and appreciated, and that there was a considerable risk that inappropriate R&D strategies would be developed without a better understanding of these costs.

It was also considered that a further major barrier to successful R&D was a failure of companies involved in such demonstrations to have a comprehensive, systems approach in place. Further, major opportunities still remained in the industry to fully embrace and further develop the systems approach at mine level.

Learnings From Earlier R&D

A number of learnings from earlier research and development projects were identified, including:

- In the event that overseas companies were to be involved in the R&D process it was recommended that any contracts be written in Australia by ACARP or its Australian project managers, rather than allowing the contracts to be written by overseas based companies.
- When involving OEMs in the R&D process there is a danger that competitive advantage may overcome any potential gains from a collaborative teamwork approach, therefore measures should be adopted to ensure that the OEMs do not internalise the development process.
- The need for an agreed basis for engagement of OEMs in the development process, and for the subsequent commercialisation of any technology arising from the process should be established at project inception.
- The need to develop a clear understanding and agreement of the scope, what it is going to cost, when it can be delivered, and what the tangible outcomes will be when realised.
- The need to be aware of the rapidity of technology developments, particularly in the fields of communications and monitoring.

Other Matters For ACARP

Other matters that were considered to warrant further action included:

- ACARP to facilitate a benchmarking study across the industry to establish industry standards and performance levels, and to subsequently update the data on a quarterly basis through an industry development journal.

- The RDTG should be expanded to include technologists so that proper guidance can be given directly to the group.
- ACARP should facilitate a joint industry approach to the OEM contracted to develop the ACBM's automated bolting rig and encourage the OEM to complete the contracted works.

6.2 Company/Organisation C026

Rapid Gateroad Development System

The company was established to apply technology from the overseas mining and high wall mining sectors to improve gateroad development rates in Australian mines. It was noted that continuous miner technology in Australia was vastly different from that supplied in USA and South Africa, with continuous miners in those countries having higher installed cutting power, and wider, higher capacity coal clearance systems. Further, it was noted that 18 tonne capacity shuttle cars were now only being introduced into Australia, while 18 and 20 tonne shuttle cars had been operational in South Africa for 20 years or more.

The company has developed a rapid gateroad development system based on the application of higher capacity continuous miners and shuttle cars for the drivage of gateroads, and utilisation of a coal augering system to complete interconnecting 1.8m diameter circular roadways.

The company has built and supplied two coal augers into mines in Australia, one of which is principally Australian made. The company now owns and operates both coal augers, and has been operating a highwall auger mine in the Newcastle region in order to demonstrate to the Australian industry that it has the augering technology and experience to successfully apply the technology to an underground roadway development system.

In the Newcastle application two 1.8m diameter auger holes are driven separately for distances up to 200m, one hole above the other, in a thick and gentle dipping seam, while the second auger has operated successfully in a mine in Central Queensland with the seam dipping at up to 19^0. The auger cutter head design comprises two concentric cutter rings, with the outer ring cutting the hole profile and the inner ring cutting the core out. This results in the outer annulus of coal (approximately 650mm thick) falling out in blocks rather than being milled off the face as with a continuous miner cutter drum, and results in minimal fines generation. This design also results in continuous contact between the cutter picks and coal, rather than the cyclic hammering of cutter picks against the face as with a continuous miner cutter drum, and results in improved pick wear.

In the proposed rapid gateroad development system, a high capacity continuous miner is utilised in each of the two gateroads, with a 20 tonne shuttle car operating behind each of the miners. Coal is conveyed by the shuttle cars to a discharge hopper installed immediately behind the shuttle car, with a coal auger being used to transfer coal through the interconnecting roadway to a chain conveyor system, which then transfers coal from both faces onto an extensible panel conveyor as illustrated over.

Materials supply cassettes are transported into the two headings with a purpose designed high speed bi-directional cassette transporter, with cassettes being off loaded with the transporter's Hiab crane or loaded directly onto a monorail supply system that transports the cassettes from behind the coal transfer auger station to the continuous miners.

The 35m long auger holes are drilled in less than 30 minutes, which enables the auger rods to be stored and utilised in the active coal transfer hole until such time as the next auger hole is to be driven. A second auger is used to complete the inbye auger holes, with auger rods being withdrawn from the outbye auger hole (by the first auger) and transferred to the inbye auger on the materials supply monorail. Coal from the second auger is loaded directly onto the chain conveyor as the hole is being drilled, and is discharged onto the panel conveyor.

The auger holes are self-supporting, which allows the holes to be used as an emergency escape route if necessary. Further, the breakaway and hole through points (intersections) are similarly 1.8m diameter and are not expected to require any additional roof support, while studies indicate that auger holes do not interact from a geotechnical perspective, providing holes are drilled no closer that twice the auger diameter.

The spacing of auger holes is limited by the length of the chain conveyor system and given that longwall AFCs are up to 400m long there appears to be no practical limitation on auger hole spacing. From a longwall ventilation perspective, the spacing of holes at say 20 – 30m would facilitate Z ventilation systems and overcome risks associated with the loss of the face return roadway.

While it is anticipated that the panel conveyor would be moved forward in increments equivalent to the auger hole spacing, a continuously extensible panel conveyor system would be necessary to complement the system and enable high advance rates to be achieved. The company has designed a system to enable insertion of belt components and extension of the conveyor while it is in operation.

Self Drilling Bolts

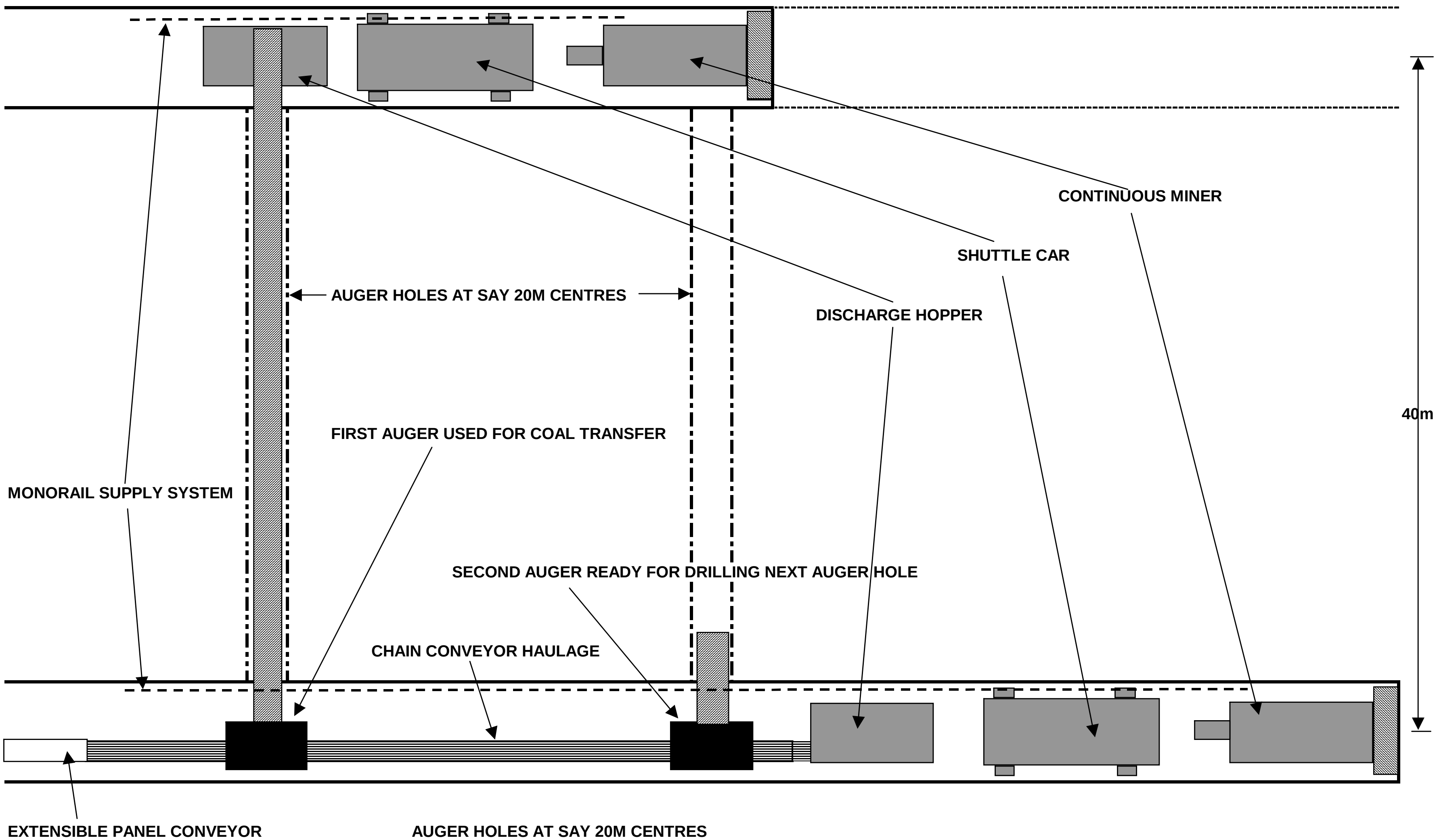
It was noted that the use and installation of self drilling bolts was a fundamental step to the achievement of high development rates, and that the company had also designed a self drilling bolt with a resin injection system. It expects that the bolt will be commercialised January 2006 through a local bolt manufacturing company.

It was proposed that the adoption of automated bolting systems would enable the bolting platform of the continuous miner to be redesigned to allow four roof bolting and four rib bolting rigs to be operated concurrently, with operators only required to install the self drilling bolt in the bolters and arm the drilling rigs, before triggering the drilling and bolt installation process remotely.

The company has a concept design for a continuous bolter/miner that incorporates the above bolting system and hardware on a separate, drive through bolting platform. The cutter head comprises two auger or borer heads and mines a roadway profile typical of a twin borer continuous miner (Goodman or Marietta) or a double O tube TBM (Mojura).

It was noted that in meetings with senior executives of Joy Manufacturing that Joy had indicated a recognition of both the potential of self drilling bolts and the competitive advantage (or threat) that would be gained by development of the first continuous bolter/miner machine.

In conclusion the respondent stressed his 25 year long passion for developing a truly continuous miner, and expressed a view that the OEM sector may not consider the development of a high capacity truly continuous miner system as being in their best interest. Therefore, in the event that ACARP was to sponsor the development of such a system it was recommended that a former OEM executive be involved in the machine development process to address potential OEM barriers.



RAPID GATEROAD DEVELOPMENT SYSTEM WITH AUGERING OF INTERCONNECTING ROADWAYS

6.3 Company/Organisation C027

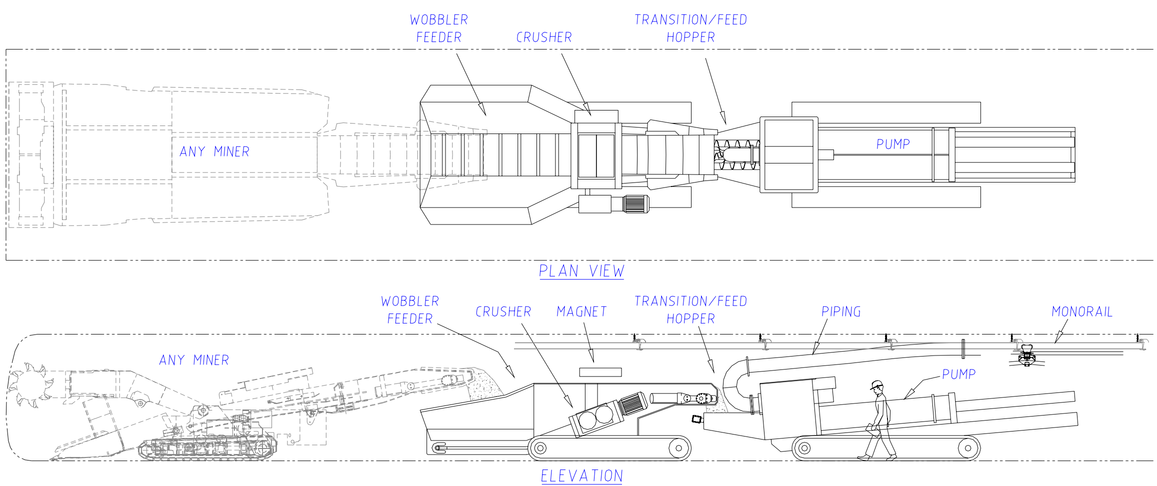
CoalStream – Materials Transfer System

In response to an initiative by a former major mining company to develop a Rapid Advance Development system for their operations the company obtained a Federal Government START grant to develop an alternative continuous materials handling system for the transfer of coal from the continuous miner to the panel conveyor.

The initial system concept was based upon the application of pneumatics to transport crushed coal from the continuous miner to the conveyor, however detailed evaluation of the system identified a number of deficiencies with the pneumatic system. Consequently, the use of a hydraulic transportation medium was evaluated and selected, and detailed design of the total was completed.

The main components of the system are:

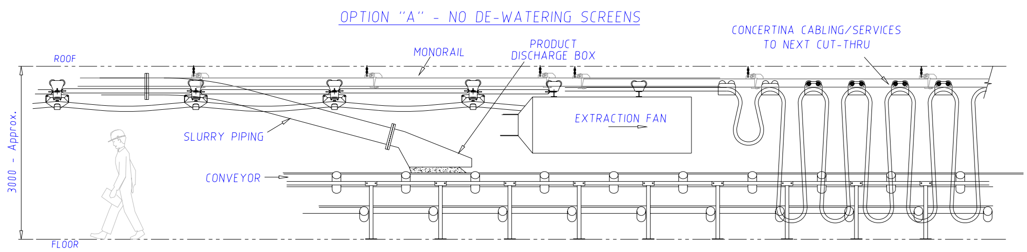
- Mobile crusher/feeder;
- Mobile positive displacement pump/s (pumping rates nominally 250m^3/hour each);
- Articulated self propelled chassis module on which the crusher and pump/s are mounted;
- Monorail mounted discharge coal pipeline (nominally 250mm diameter), with all other face services mounted on the monorail (eg; power, water, compressed air, ventilation).
- Monorail mounted dewatering system and coal transfer (if required)



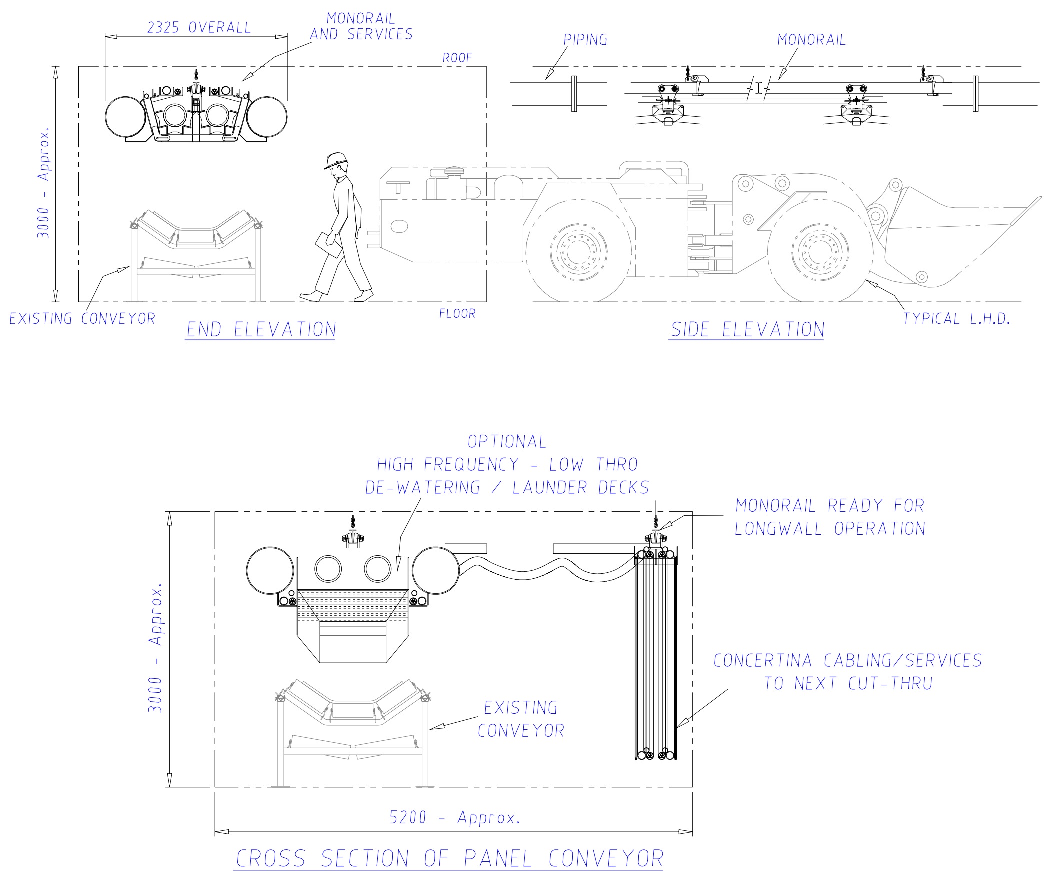
Sizing and Pumping Module

The system loads coal directly from the miner and then sizes, mixes and pumps the coal through a series of pipelines to a dewatering station located above an outbye conveyor. This allows full access to all roadways and enables support activities to be conducted whilst production is underway.

The system is a combination of existing equipment adapted or modified for a new application, with the individual technologies already well proven in other industry sectors. The company has developed, integrated and refined the process so that the full benefit of the system can be realised in an underground coal mining environment. It is expected that the system would substantially improve safety, reduce maintenance, improve development flexibility, and improve roadway development rates by 50% or more.



Delivery System



Service Module (Two Views)

In searching for the "ideal" materials transfer system for underground coal development the company surveyed key players in the industry to determine a list of factors that would constitute such a system. The system was evaluated against all these factors and met all requirements listed. As shown on the table over, other potential and existing haulage systems were also evaluated against these factors, and the CoalStream materials handling system ranked well.

The mining company supporting the project was taken over and the new owners elected not to pursue development of the technology. Assembly of the prototype and development of the process has therefore been suspended until such time as further industry support is obtained.

The Systems Are Rated 1 - 5, With 5 Being Highest And 1 The Lowest.	CoalStream System Potential Method	Pipe or Tube Conveyor Potential Method	FCT Existing Method	Shuttle Cars Existing Method	Bridge Conveyor. Existing Method
1. Safety Improvement	5	4	4	2	3
2. Capacity to handle highest rates of advance of miners	4	4	5	3	5
3. Capacity constant with distance from boot end	5	5	5	2	4
4. Continuous Production	5	5	5	2	4
5. Panel Extensions Not In Critical Path for Gate Road Advance	5	4	2	2	2
6. Maximum Access to Face and Roads	5	5	3	3	2
7. Minimum Impact on Roads	5	5	4	1	3
8. Flexibility of Operation, Layout & Transfer Distance	5	4	3	3	2
9. Maximum Mobility, ie Speed of Flitting, Turning Radius, Grades	4	4	4	5	3
10. Minimum Moving Parts for Safety & Maintenance	5	3	3	2	3
11. Simple to Implement: ie. Assess, Approve, Purchase, Install, Train, Operate, Maintain, Upgrade	4	4	4	4	4
12. Cost Competitive to Buy, Operate, Maintain, Upgrade	5	4	3	4	3
13. Minimum Risk of Damage From Other Machinery	5	4	3	3	3
14. Maximum Reliability and Built-in Redundancy	4	3	2	2	2
15. Ability to Handle Various Grades of Material	4	4	5	5	5
16. Utilise Existing Technologies for Simplicity and Assimilation	4	4	3	5	4
17. Ability to Upgrade and Adapt as Other Technologies Improve	5	4	4	3	4
18. Ability to Carry Other Accessories, to Value-add - eg, Bolting, Pumping, Supplies, Ventilation	5	5	3	2	2
19. Independent of wet/dry floor conditions	5	5	5	1	2
TOTALS	89	81	70	54	60

6.4 Company/Organisation C028

The company principal has been involved in the development of a self drilling bolt for over 15 years, with much of the work being completed through an earlier ACARP project. The focus of the research has been to develop an integrated bolting system, including self drilling bolt, resin anchor, and the associated drilling and bolting hardware, with the objective being to produce a bolt that has at least the same tensile strength, shear strength and load transfer capability as existing solid bar roof bolts, and also be cost effective in comparison to existing roof bolts.

A hot rolled, hollow bar has been developed, as opposed to the pierced billet processes employed to produce other self drilling bolts, and it is expected that the resulting bolt will meet all the above design criteria. A local manufacturer has developed rolling equipment to produce the hot rolled hollow bar and it is expected that a trial production run of AX grade bolts will be completed earlier October 2005.

All other design aspects of the bolt have been completed, including drill bit insert and static resin mixing system, while the company has teamed up with other local companies to develop a low viscosity resin, and resin injection and drilling hardware. It is expected that underground trials will be completed shortly, before moving to make the necessary modifications to a continuous miner mounted bolting system to enable large scale trials to be conducted at the face.

It is likely that further ACARP funding will be sought to enable the necessary equipment modifications to be made and for the conduct of the large scale trials. Industry support will also be necessary in terms of making a continuous miner, mine personnel, and mine real estate available for the trials.

The associated company will proceed with the development of drilling and resin injection hardware for the preliminary trials and for outbye bolting applications, although it does not expected to develop the technology and hardware for continuous miner mounted drilling/bolting systems. It is therefore evident that an opportunity exists for another OEM to develop this technology in association with the bolt designer.

It is also evident that there is a high degree of synergy between the various technologies associated with this self drilling bolt system and the QCAT self drilling bolting system as developed for the ACBM. Consideration is warranted in respect to consolidation of the two self drilling bolting systems to expedite development of a cost effective, locally produced self drilling bolting system.

6.5 Company/Organisation C029

The company is involved with a local researcher that is developing a self drilling bolting system, and is currently working to develop a bolter chuck that can be utilised for both drilling, resin injection, and tensioning of the bolt. The company is also the licensee of American drilling hardware and grouting systems, and will modify drilling hardware and develop the resin injection system for the underground trials.

While the company intends to proceed the development of drilling and resin injection hardware for outbye bolting applications, it is not expected to develop the technology and hardware for continuous miner mounted drilling/bolting systems.

As noted earlier, there is a high degree of synergy between the various technologies associated with the hot rolled bar self drilling bolt and the QCAT self drilling bolt and consolidation of the initiatives is warranted.

6.6 Company/Organisation C030

A meeting was attended whereby participants and potential financiers of OneSteel's self drilling bolt considered commercialisation of the bolt. It was noted at the meeting that a rolling of 20 tonne of the hollow bar was to be performed on 7th October 2005 and that from that rolling it was anticipated that sufficient bar for some 1,000 self drilling bolts would be available for manufacture into bolts ready for an underground demonstration (outbye) probably in January 2006.

It was noted that OneSteel's mission was to be hollow bar manufacturers, and not a manufacturer of roof and rib bolts. Consequently the bolt developer would need to make arrangements with a bolt manufacturer to produce and supply the market on a commercial basis, once the underground demonstration had been completed.

It was also noted that in order to commercialise the product that a complete system would need to be developed and provided to the industry, including the mounting of automated self drilling bolting rigs on continuous miners. To that end it was intended to pursue industry support to allow for the fitting of automated self drilling bolting rigs on a continuous miner, and for the conduct of a full production based demonstration in the second quarter 2006.

PS: It is noted that the scheduled rolling of the bar on 7th October 2005 was completed successfully, and a further rolling of AX grade bar is scheduled early December 2005.

6.7 Company/Organisation C031

During a demonstration of the OneStep self drilling bolt system it was noted that over 100,000 of the bolts had been successfully installed in mines in Germany, and the bolt was now considered to be available for the world wide mining market. Due of the grade of steel utilised in manufacture of the bolt and technical aspects associated with the resin injection system it was intended to import product into the Australian market direct from Germany.

Australian coal industry geotechnical consultants had conducted a geotechnical evaluation of the bolt, and a copy of the evaluation was provided for reference.

6.8 Company/Organisation C032

Observations From The Support Consumables Supply Sector

The respondents noted that a monthly audit service was provided to mines to enable the standard of support installation practices to be monitored, with bolt encapsulation length, torque and spin time being the key indicators monitored. The respondents observed from their routine visits underground that:

- Bolt encapsulation length remains a problem primarily due to operator practices. The hydraulic bolters utilised today have the capacity to get the bolt up the hole through the resin, and can over-pressurise the resin if inserted too quickly, resulting in up to a 20% loss of resin into fissures, and a consequential loss of encapsulation length. The problem was particularly evident where there was a mismatching of operators, with the slower operators tending to catch up by minimising the mixing time and inserting the bolt too rapidly.
- The development of push button programmable controls was a major step forward in minimising operator error and improving the standard of installation.
- Torque was consistently 8 – 10 tonnes, which was considered to be a great improvement on that achieved with hand held bolting (up to 3 tonnes).
- Nearly all mines had gone over to mesh roof modules within the last 2 years, and they expected that mines would similarly go over to full rib meshing within the next 2 years. At this point in time they had not seen any good meshing systems, while they observed that longwall abutment loading tended to cut the mesh unless butterfly plates were used in the initial installation process.

- Approximately 60% of mines had strata support consumables loaded off site into materials pods.
- All mines excepting one had adopted four roof bolting rig configurations, with additional rib bolting rigs. The two rig set up was markedly slower than typical four rig configurations.
- A lot of support design is based on what the machines are capable of, rather than what needs to be installed for effective ground support. While the perfect machine can be designed for perfect conditions, how effective will such machines be in the difficult conditions often experienced.
- Some mines were moving to install long tendons in the primary mining phase, while others were moving towards two phase bolting systems with minimal bolting in the primary phase backed up with more intensive monitoring and secondary bolting capabilities. The benefits of two phase bolting systems were sometimes eroded by failures to keep the second phase bolting up to date, which subsequently impacted panel advances.
- While there were major advantages to be realised from monorail services handling systems, few mines have given serious consideration to their application and realised those advantages.
- There were too few technical support staff on sites resulting in personnel being over-stretched, and available data not being used to monitor and improve performance.
- The use of TARPS as part of strata management plans results in additional support being installed as the ground reacts to the mining process.
- While there were opportunities available for industry personnel to improve their knowledge of strata control, the courses available lacked sufficient engineering depth and there appeared to be no commonly accepted body of knowledge of coal mine strata control.
- Geotechnical consultants tend to have ‘flavours of the month”, and do not appear to know enough about strata support consumables and don’t necessarily understand strata failure mechanisms.
- Grass roots improvement teams appeared to work well, providing agreed actions were implemented and followed up.
- Operating crews appear to develop subconscious limits (eg; 15m/ shift) and tend back towards these limits over time, regardless of incremental changes made. It was considered that in some mines a step change in equipment and technology would be necessary to break down paradigms.
- People were more responsive to training now than in the past, however new entrants were often being inducted with older crews rather than the best crews, and were learning how to break the rules rather than how to follow them.
- The automation of support processes would result in people being taken out of the face, which would be an “industrial” issue at some mines, but would also require higher technical skills to support their use. The introduction of such technology would also require extensive training to be implemented as part of the introduction process.

In regards to the development of self drilling bolts respondents noted that:

- Some of the bolts being developed had significantly larger cross sections, which would impact through the entire supply chain. Further, it was imperative that bolt strength characteristics be maintained.
- They found that it was difficult to determine whether post groutable bolts were in fact effectively grouted, and noted that failure rates of up to 65 – 70% were evident on post grouted bolts and tendons, either as a result of closure of the hole and/or closure of the grout tube, or through poor operator practices.

7. OBSERVATIONS FROM THE REGULATORY AND SERVICES SECTORS

7.1 Company/Organisation C033

Key issues facing the industry in respect to the development of a more productive, higher capacity development system were considered to be:

- a high incidence of injuries associated with the handling of mesh modules and ventilation ducting;
- the likely increase in situ gas levels and outburst propensity as mines were progressively developed deeper over the next decade;
- the efficacy of current rib support measures, and;
- the ability of humans to sustain high development rates in systems that required high levels of manual interaction and labour.

Consequently the respondent proposed a roadway development system that incorporated many aspects of the high wall mining system that has been demonstrated at Moura in Central Queensland. The proposed system included as follows:

- The drivage of 2.5 to 3.0m wide roadways with an adapted high wall mining system to complete a pillar of panel advance, before stripping out each pillar of panel advance to its final dimension of say 5.0 to 6.0m width in a second pass.
- The system would include inertisation of the first driven pass to provide an extinctive, non explosive atmosphere, thus eliminating the need for installation of ventilation ducting during the first development pass.
- Ventilation of the second stripping pass could also be completed without resort to the installation of ventilation ducting by utilising the mine's normal ventilation through the completed 2.5 to 3.0m wide first pass roadway circuit.
- Before stripping out the first pass it would be necessary to support the first driven pass. This could either be completed by unmanned, automated bolting machines operating in the inertised atmosphere, or alternatively by manned bolting machines after re-ventilation of the section of roadway to be supported with a forcing ventilation system utilising flexible ducting.
- The major challenge of the proposed system was the high advance rates typically achieved by high wall mining systems (up to 300m per shift), and the ability to support exposed roadways at an equivalent rate.
- The drivage of interconnecting cut throughs may also pose a challenge, however the utilisation of on-board machine guidance systems would enable the mining unit to self steer through cut throughs, while either the "add-car" or the "archveyor" based coal clearance systems could be adapted to facilitate coal haulage through the cut through, albeit that it may be necessary to drive the cut through at an angle less than 90^0. Reduced development rates during the cut through drivage phase may not be a major issue if rates typically achieved in high wall mining could be achieved in "straight" drivages underground.
- Given the ability to mine with unmanned equipment in an unventilated, inertised atmosphere it would be possible to limit the number and spacing of cut throughs, thus overcoming many of the concerns expressed in relation to the adoption of single entry drivages (and also minimising any rate losses in the drivage of cut throughs).
- Inertised atmosphere could be sourced from either an adjacent longwall goaf area, which in turn was recharged from a surface mounted inertisation plant via a borehole to the goaf, or directly from the surface mounted inertisation plant via an underground reticulation system.

- The provision of an on-board dust scrubbing system on the mining unit was also considered worthwhile to minimise and control the generation of float dust in the roadway, while the application of an on-board dust crusher coupled with the pneumatic transportation of coal was seen as a possible alternate to roadway inertisation and more conventional coal clearance systems.

While it was recognised that the proposed mining system could not be applied in all mines, it was considered that the drivage of 2.5 to 3.0m wide first pass roadway could be contemplated in nearly all mines, particularly if the cutting profile was varied to incorporate arching of the rib and roof intersection.

It was considered that perhaps the most significant challenge facing the successful adoption of the proposed system was the industries ability to embrace and apply new technology, and its ability to manage complex systems. The development and introduction of such a system would require the identification and appointment of a project champion with vision, passion, perseverance and persistence, together with high levels of corporate support. These attributes were often seen to be lacking in earlier step change initiatives, while the industry had yet to learn the broader aspects of effective change management. Similarly, industry had not demonstrated an ability to effectively manage complex systems.

The industry was commended for its support of initiatives for development of a self drilling bolt and automated bolting. In respect to the development of new technology or the application of “new to the mining industry” technology it was considered that the following areas were worthy of development and/or application;

- High wall mining systems, particularly machine guidance and control systems that allowed machine operation from remote, air conditioned control rooms, together with roadway inertisation;
- High capacity underground inertisation systems that could be utilised to support 300m/shift development rates;
- Skin reinforcement technologies to improve roadway reinforcement, such as thin skinned cementitious compounds or membranes;
- Improved support and reinforcement technologies to improve support of the rib/roof intersection and minimise sloughing of coal ribs off joint and cleat planes;
- Lightweight high strength materials as an alternate to aluminium.

While it was accepted that the respondent may have paradigms regarding safety issues associated with the mining of long, single roadways it was considered that mining systems based on long, single roadways could not be justified from a human or economic risk perspective, nor was it considered likely that single entry systems could effectively ventilate high capacity longwalls in deeper, gassier reserves.

Concerns raised by industry in respect to perceived legislative barriers and constraints were discussed generally and the respondent noted that the Department was prepared to step outside the square providing it could be demonstrated that the risks of any proposed system or variation to an existing system could be properly managed, and that the proposer had the intent and capacity to so manage the risks. By way of example it was noted that the use of aluminium below ground had been allowed subject to controlled conditions and controls, whilst the utilisation of off road four wheel drive vehicles underground had also been similarly allowed subject to controlled conditions and controls.

It was also noted that the department concerned had been instrumental in introducing a number of improved safety measures in mines following earlier mine disasters and ensuing inquiries, measures such as emergency escape, inertisation and improve ventilation controls which were often resisted at the time, but had since proved their worth. It was also suggested that in some instances industry professionals proved to be less than professional in respect to the management of risk and their duties to shareholders and employees by failing to recognise and address the inherent risks of their proposals, or by failing to implement other available safe, cost effective controls.

In regards to the development of common legislation and standards across the industry and state borders it was noted that legislators like any other organisation had ownership of their own standards and policies, and wanted their standards to be universally adopted. Further, the adoption of a less prescriptive legislative framework would require the industry to be able to demonstrate that it could in fact be self-governed. While Queensland had been able to adopt a less prescriptive approach due to the industry being able to demonstrate its commitment to appropriate standards of self government, it was felt that such a level of trust had not yet been developed in NSW, consequently a higher level of command and control was warranted.

7.2 Company/Organisation C034

Key issues facing the industry in respect to the development of a more productive, higher capacity development system were considered to be:

- *The failure and/or damage to equipment caused by the incomplete design and/or failure to complete operational risk analysis of the total mining system*. It was noted that over the past four years some 2,000 shuttle car cables were damaged per annum in NSW, with a further 3,000 other cables also damaged each year. Investigation of notifiable occurrences by the Inspectorate found that 90% of incidents could have been prevented by improved design and/or better positioning of cables.
- *An undeserved reliance on radio systems to provide an infallible remote control system.* The Department was reported to have significant concerns with the high number of unplanned movements resulting from radio remote control systems.
- *The ability to maintain roadways behind the face in the event that high development rates are achieved.* It was noted that in many mines where poor floor conditions resulted from water make and/or soft floor strata mines had not developed adequate measures to maintain roadways behind the face, which resulted in increased risk of injury to personnel and damage to plant.
- *The reintroduction of earlier generation continuous miners without adequate temporary roof support systems.* The timber jacks fitted to most earlier generation machines were not considered to provide effective temporary roof support.
- *Inadequate temporary roof support systems for use with place change mining systems.* Recovery of continuous miners from deep sumps in the event of a breakdown necessitated the installation of adequate and suitable temporary roof support prior to installation of permanent support measures. Few of the currently available temporary roof support systems were seen to be adequate and suitable.
- *Inadequate measures to pre-drain tight coal experienced at some mines in the Southern region of NSW.* Unless measures are developed to pre-drain this tight coal high development rates are considered to be superfluous, as roadways will not be able to be advanced where residual gas levels are in excess of outburst thresholds.
- *Introduction of Departmental guidelines for bolter design and operation.* It is anticipated that the Department will shortly release MDG 35 which is aimed at reducing the incidence and severity of injuries resulting from the use of on board bolting rigs.
- *Adoption of full life cycle risk management.* A more comprehensive application of full life cycle risk management across all aspects of the development process would significantly reduce design issues before manufacture.

Issues warranting further consideration by the industry to improve development performance were considered to include:

- The use of tunnelling sector technology, and in particular TBMs, to develop a continuously advancing and supporting roadway development system.
- The use of augering systems to mine interconnecting roadways in lieu of conventional cut throughs.
- The development of automated bolting systems.
- The application of continuous haulage systems such as FCTs or bridge conveyors.
- The use of surge loaders and/or accumulator cars (or bunkering systems).
- Self steering devices and/or proximity sensing technology to enable emergency escape vehicles to be utilised in a visually impaired environment.
- Optimisation of pillar centres and the utilisation of pantech sleds and monorail mounted development services.
- Review and inclusion of all activities associated with the rapid roadway development process, including materials and logistics system, services, and conveyors.
- The use of metalliferous sector technology such as man-less, remotely operated haulage system.
- Ultrasonic, laser or other coal fracturing/mining technologies.
- The use of technology consultants to advise on other current or emerging technologies that may be applied to the development process.

In discussion of the potential application of TBMs to coal mines, and for single entry drivages in general, it was noted that the Department's only view in respect to single entry drivages was that controls appropriate to the risks had to be developed, implemented and maintained. Given a heightened level of risk associated with entrapment and fire in such roadways it would be necessary to demonstrate that strata control and fire suppression measures were adequate and appropriate, while improved rapid escape measures would also be viewed favourably. It was noted that the difference between the civil tunnelling and metalliferous sectors and the coal sector was the risk of secondary explosion in a coal mine.

It was also noted that other sectors of the industry may have differing views in relation to single entries, and that it would be necessary to be aware of and to properly address any "political" issues that may arise as a consequence of an announcement of the proposed introduction of a single entry gateroad development system.

It was evident that the Department held fairly fixed views in relation to the use of aluminium underground, stating that it had to be coated with an approved coating (and there were no currently approved coatings available) or to be kept contained within a suitable protective container. It was suggested that the industry wanted to relax constraints on the use of aluminium underground in order to increase the capacity of equipment which would result in the increased weight of components, whereas the Inspectorate was of the view that industry should look to optimise the capacity of equipment rather than simply increase capacity and increase the weight of components (eg; why install a 5,000tph peak loading system if a fully optimised 2,000tph system would provide 99% of the system requirement).

7.3 Company/Organisation C035

Quarterly Reporting of Industry Statistics

The respondent advised that Coal Services would be prepared to compile a quarterly report similar to or as an extension of the report as published in the Australian Longwalls journal, with the report being provided on a fee for service basis (the Australian Longwall's quarterly table is similarly provided on a fee for service basis).

However, it was noted that the full quarterly longwall report which details statistics such as longwall commencement and finish dates, and average shiftly, daily and monthly production levels on a mine by mine basis was suspended late 2004 due to difficulties being experienced sourcing data from mine sites. It was intended to continue with the annual equipment survey (January each year) and to only provide overall tonnage statistics on a quarterly basis as reported in the above journal.

Injury Statistics

Copies on annual reports detailing injury and accident statistics were provided for review and it was noted that a detailed analysis of injury statistics could be undertaken to identify any injury or accident trends specific to roadway development that would warrant consideration in the proposed roadway development research and development strategy.

ACARP

Australian Coal Association Research Program

FINAL REPORT

Australian Roadway Development – Current Practices

Appendix V

List of Participants

C15005

17 October 2005

ACARP

LIST OF PARTICIPANTS

Darren Abraham, Walter Mining
Charlie Allan, United Colliery
Neil Alston, Centennial Coal
Matt Armstrong, Tahmoor Mine
Greg Bacon, Kestrel Mine
Jon Balcomb, Crinum Mine
Greg Banning, Springvale Colliery
Bill Barraclough, Dept of Planning, Infrastructure and Natural Resources
Steve Been, Moranbah North Mine
Phil Berriman, P J Berriman
Glen Birchall, Appin Colliery
Matt Borghero, Mandalong Colliery
Mike Bottling, Henry Walter Eltin
Gary Bowman, Dartbrook Mine
Dennis Bromley, Moranbah North Mine
Alan Bruce, Crinum Mine
Steve Burgess, Centennial Coal
Bob Butcher, Thiess Contracting
Grant Case, Roche Mining
Jonathon Caunt, United Colliery
Paul Charlton, Hydramatic Engineering
Dan Clifford, West Cliff Colliery
Ray Coppins, Newstan Mine
Peter Corbett, Angus Place Colliery
Peter Craig, Jenmar
Ken Cram, Coal Services
Sandy Damodaran, Kestrel Mine
Tony De Santis, Metropolitan Colliery
Gary Dewhurst, Alminco
Greig Duncan, Austar Mine
Grant Edmunds, Moranbah North Mine
Glenn Everett, Roche Mining
Sean Egan, Glennies Creek Coal
Mike Fabjanski, Strata Control Technology
Mathew Fellowes, Austar Mine
Takashi Fukui, IHI
Frank Fulham, Roche Mining
Winton Gale, Strata Control Technology
Tim Gaudry, Jenmar
David Gibson, Beltana Mine
Roland Gienau, Hilti
Wayne Goodall, Moranbah North Mine
David Goodwin, Continental Conveyors

Ken Gorman, Tahmoor Mine
Warren Gratich, Southern Colliery
Peter Gray, Ground Support Services
Jim Grebert, Springvale Colliery
Wayne Green, Metropolitan Colliery
Hua Guo, Queensland Centre for Advanced Technology
David Hainsworth, Queensland Centre for Advanced Technology
Anthony Hake, Moranbah North Mine
James Hannigan, Walter Mining - Dendrobium
John Hayward, Mandalong Colliery
John Hempenstall, Centennial Coal
Frank Hendricks, Dendrobium Mine
Bill Henever, Hilti
David Hetherington, Oaky Creek Coal
Tim Hobson, Dartbrook Mine
Dave Holt, Moranbah North Mine
Patrick Humphries, Queensland Centre for Advanced Technology
Bill Huuskes, Metropolitan Colliery
Lawrie Ireland, West Wallsend Colliery
Graham Johnson, Dept of Planning, Infrastructure and Natural Resources
Heath Johnstone, 545 Global
Paul Jones, Hydramatic Engineering
Gary Jones, Oaky North Mine
Andrew Jones, Oaky No 1 Mine
Mike Kelly, Queensland Centre for Advanced Technology
Bob Kennedy, Dept of Planning, Infrastructure and Natural Resources
Ian Kraemer, Thiess Contracting
Geoff Lee, OneSteel
Glen Lewis, Xstrata Coal
Alex Lim, Southern Colliery
Brian Lynne, Dept of Natural Resources and Mines
Col Mackie, Kestrel Mine
John Martin, Southern Colliery
Col McBean, Henry Walker Eltin
Greg McKay, North Goonyella Mine
Ken McLaren, UGM Engineers
Phil McNamara, Austar Mine
Rowan Melrose, Sandvik
Jim Middleton, BHP Billiton Illawarra Coal
Richard Mills, Walter Mining - Moranbah North
Guy Mitchell , BHP Billiton Mitsubishi Alliance
Gary Morrissey, Dendrobium Mine
Paul Mulley, DBT Australia
Gavin Murray, Mandalong Colliery
Andrew Myors, Centennial Coal

Jim Nearly, Dendrobium Mine
Dick Niehaus, Appin Colliery
Darren Nicholls, Baal Bone Colliery
Fred Nicholls, Mandalong Colliery
Brian Nichols, Glennies Creek Coal Mine
Greg Niewenhaus, Kestrel Mine
Ray Nolan, Crinum Mine
Rae O'Brien, Springvale Colliery
David Oliver, Angus Place Colliery
John Pala, Palaris Mining
Chris Pallas, Newstan Colliery
Matt Payne, Kestrel Mine
Allan Phillips, Metropolitan Colliery
Vic Pierce, Tahmoor Mine
Chris Puckering, Crinum Mine
Allan Purse, Newlands North Mine
Gerhard Rauch, Hilti
Brad Reed, OneSteel
Phil Reed, Henry Walter Eltin - Broadmeadow
Allan Reed, Oaky No 1 Mine
Richard Reid, Beltana mine
Jim Richardson, United Colliery
Bruce Robertson, Anglo Coal
Barry Robinson, Anglo Coal
Greg Rowan, Queensland Centre for Advanced Technology
Steve Rowland, Broadmeadow Mine
Glen Rundle, Dartbrook Mine
Owen Salisbury, North Goonyella Mine
Mick Sams, Joy Manufacturing
Ron Sanders, Kestrel Mine
Peter Seears, Cutting Edge Technologies
Ross Seedsman, Seedsman Geotechnics
Ralph Shale, IGrow
Peter Shepherd, Grasstree Mine
Sam Shikama, IHI
Terry Sinclair, Oaky North Mine
Steve Smith, Eikon CoalStream
David Stone, Newlands North Mine
Andrew Stuckey, Walter Mining - Dendrobium
Harry Sutton, North Goonyella Mine
David Sykes, Dartbrook Mine
Gavin Taylor, Tahmoor Mine
Gerry te Velde, Hydramatic Engineering
Dan Teal, BHP Billiton Illawarra Coal
Rob Thomas, Strata Engineering

Jason Thomas, West Cliff Colliery
Aaron Trevis, Eikon CoalStream
Neil Tuffs, Southern Colliery
John Turner, Newstan Colliery
Bernard Vandeventer, Broadmeadow Mine
Barry Wairing, IHI
Jeremy Wallace, United Colliery
Geoff Watson, Southern Colliery
John Weaver, Metropolitan Colliery
Darren Webb, Sandvik
Grant Whitbourn, Broadmeadow Mine
Doug White, Central Colliery
Ben Williams, Henry Walter Eltin - Broadmeadow
Rob Williams, North Goonyella Mine
Tom Wilson, OneSteel
Sean Wood, Moranbah North Mine
Murray Wood, Ulan Mine
Andrew Worth, Hilti
Brant Wright, Joy Manufacturing
Barry Wright, Sandvik
Lloyd Zenari, Pacific Tunnelling
Martin Zgrajewski, Crinum Mine