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Movements of personnel and materials in Australian underground coal mines

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ABSTRACT: With the desire to optimise the development of roadways in underground coal mines as operations expand, it logically followed that any increase in the development rate will require more efficient logistics management, especially the timely supply of roof support materials (bolts, chemicals and mesh) to each active face area. Logistics management in general was not considered as a key issue when initial or long-term planning of an underground coal mine is undertaken. It is traditionally assumed that whatever production targets are set that logistics can keep up or that it is retrospectively managed after an identifiable bottleneck.

INTRODUCTION

Retreat longwall mining is currently regarded as the safest and most efficient underground coal mining method, should geological conditions permit. Along with the advances in longwall mining, came the need to improve and streamline roadway development which in turn enhanced the need for efficient and timely transportation of people and materials, into and around a mine. Hence a benchmarking study was undertaken with the support of ACARP into the current trends and aspects of logistics within underground coal mining operations (Walker et. al., 2020).

It is apparent that methods of transportation within underground coal mines have changed significantly over the last fifty or more years. Track or rail transport systems were considered the most effective transport system up to the late 1970's, whereas more recent operations utilise rubber tyred diesel transport. It is apparent that current trends and thinking tend to determine the transportation systems used in any mine as opposed to strategic long term operational requirements. With this come a number of intrinsic limitations, for example a decision to use a shaft and bulk winder, as opposed to a drift and conveyor, to transport coal out of the mine, usually involves the use of underground storage bins and/or bunkers facilities to ensure mining operations are not directly limited by the haulage capacity of the shaft. This allows the ore/coal system to operate "in balance" with some trunk belts capable of 5,000 tph operating with significantly lower utilisation and some winders capable of only 800 tph but with significantly higher utilisation. Similarly or conversely, the capacity of a conveyor system needs to be adjusted to ensure "outbye" or main trunk belts can easily handle all the coal delivered from panel or face belts. In certain instances, an underground bunkering system or bin of sufficient size may need to be considered to maintain material clearance balance.

In this regard current and future mine planning will have to incorporate changes in technology along with historical decisions or constraints to optimise coal movement out of the mine, along with personnel and materials transport to and from each working face. The legacy of past decisions will ultimately determine current and future decisions along with what systems are at any point in time the "flavour of the month" or "favourite of the day".

With current underground coal mines there are several additional factors which act as constraints or limits upon mining activities, and these will have to varying degrees, impacts on logistics management for the mine. These relate to such things as statutory approvals or rights to mine which have limits on the total amount of coal to be mined, hours of operation, surface vehicle movements particularly LHD's picking up ballast and reversing at night in an urbanised environment and vehicle movements to and from the mine site etc. These constraints, while not always directly affecting the movement of personnel and materials, need to be considered in any planning process used to improve logistics management within the industry. In short, good planning is very much a multi-faceted task.

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STUDY CONSIDERATIONS

To develop a clear understanding of how logistics management is being considered and managed within current underground coal mining operations, a standardised questionnaire was developed. This was subsequently modified for use with underground hard rock/metal mines. Key operational personnel for eleven coal mines and two metal mines were interviewed, and observations taken. These operations were prioritised for the following reasons:

1. Perceived uniqueness.
2. High productivity.
3. Perceived complexity.
4. Operational reputation.
5. Operational physical size.
6. Need for diversity in parent company ownership.

Some operations matched this criterion that were not able to be interviewed. This was partially due to timing, location, physical accessibility, or if a company already interviewed was already perceived as a close substitute. As to be expected there was also a broad spectrum in availability of personnel between operations with some operations giving significant time and effort to assist us, whereas other operations could only afford limited time and personnel to discuss issues with us. Operations are numbered for confidentiality purposes.

It was apparent that in the initial and earlier stages of mine planning the primary logistics considerations related to the movement of product out of the mine, through product beneficiation and then on to port and or markets. The movement of personnel and essential supplies into and around the mine was largely not identified and considered as something that would naturally occur. This approach was similar to attitudes identified from interviews and visits to non-mining, industrial operations where logistics was largely considered to be an issue of distributing finished products to customers, both wholesale and retail.

RESULTS

The transport systems utilised at mines visited are summarised in **Table 1**. A summary of results of mine visits and feedback from the study questionnaire are provided in **Table 2**.

Table 1: Production ranges by operation by transport type

Transport Type from surface	Current Mine Production Min	Current Mine Production Max
Dolly Car + Rail		<=2.5Mtpa
Dolly Car + Shaft	2.5 Mtpa	4.0 Mtpa
Dolly Car	2.5Mtpa	4.0 Mtpa
RTV	4.0 Mtpa	8.4 Mtpa

ROM Mtpa

Coal operations varied in production from 2.5 Mtpa through to 8.4 Mtpa. Interestingly the highest producing operation also had the highest distance from the portal to the start of the production district.

Table 2: Summary of findings for all interviewed operations

Mine No.	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	M#1	M#2
ROM Mtpa	4	2.5	2.5	4	6.5	5	2.5	4	6.4	5.25	8.4	10	1.1
DOC	600	500	520	430	130	350	240	500	350	270	350	860	1800
ACCESS	Drift and Shaft	Drift and Shaft	Drift	Drift	Adit	Drift	Drift	Drift	Drift	Adit	Drift	Decline and Shaft	Decline and Shaft
TRANSPORT													
BOTTLENECKS CONSIDERED IN MED to LONG TERM PLANNING	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Lighting	Infrastructure	Partial Mains and Infrastructure	Infrastructure	Partial Mains and Infrastructure	Partial Mains and Infrastructure	Infrastructure	Infrastructure	Infrastructure	Infrastructure	LED Mains and Infrastructure	LED Mains and Infrastructure	Infrastructure	Infrastructure
Concrete Travel Roads	No	No	No	No	Mains + Partial Gates	Gates	Main @ 50%	No	Gateroads	As needed	Intersections and as needed	No	No
Labour Numbers for delivery	10 (2 per shift)		10 (2 per shift). Dolly Car Drift and Pit Bottom Supply Person. Deliveries run by panel	5 (1 per shift). Delivery from portal to UG Warehouse Hub and then panel picks up from there	Deliveries run by panel	10. (2 per shift) Dolly Car Drift and Pit Bottom Supply Person. Deliveries run by panel	Deliveries run by panel	6. (1 per shift) Portal to UG warehouse, then panel takes from there. Grader operator	Deliveries run by panel	Deliveries run by panel	Deliveries run by panel		4. Stores truck driver
Time to First Prodn (mins)	75	70	75	75	75	35	100	80	45	60	110	60	65
3 Biggest Logistical Impediments	1. Supplies Labour 2. Implement Management 3. Tyranny of Distance	1. Winding process, limited nos on winding. 2. Height and width of roadways clearance. 3. RTV to rail.	1. Machine Reliability 2. Labour 3. Drift bottleneck	1. Labour 2. Machine Reliability 3. Implement Management	1. Mine Design Pit Bottom significant distance from Portal 2. Road conditions / Road Maintenance 3. Management of implements (tracking batteries not large enough)	1. LHD reliability 2. Prioritisation 3. Materials not delivered to the right spot at the right standard.	1. Machine reliability 2. Implements management (no implement tracking) 3. Labour (culture)	1. Road Conditions 2. Labour transport 3. Tyranny of distance	1. Road Conditions and water management 2. Poor Payload 3. Machine Reliability	1. Machine Reliability 2. Labour (numbers and culture) 3. Lack of planning		1. Clearance time on blasting, uranium in the orebody moving ventilation (no series ventilation) 2. Equipment reliability and the number (12 jumbo, 20-30 trucks and workshop space) 3. Surface - UG shift offices - then using taxis around to get to the face. Moving people hundreds at a time.	1. Lack of local stores. Equipment has to be delivered from overseas or interstate at high cost. 2. Lack of trained trades. 3. Blockages at the surface store due to deliveries
Streamlining Ideas	1. Inbye supply runner	1. Better ordering system 2. Customised Machinery and Implements	1. Better way to transfer between transport types 2. Tracking of PODS and Implements	1. For every Machine to have a trailer. 2. Inbye HUB UG warehouse needs to be well laid out	1. Concreted and well lit Roads 2. IPOD Ordering	1. Cloud System for movement and tracking 2. Digital Tag boards	1. Live Tracking live of all implements, looking at tracking material movement using an APP. 2. Amazon Ebay style dispatching.	1. Concreting the roads 2. More Payload	1. More Payload 2. Concreting and Lighting	1. Secondary warehouse closer to panel 2. Single use loader trips must be eradicated (going in full, coming out empty)	1. New Streamlined Access	1. SAP Logistics completely transparent across pit. 2. UG Store needs to be a Store	1. UG stores closer to operations. 2. Implementing an ordering and management system in the underground store.

Depth of Cover and Access Type

Ranged from 130 m to 600+ m. This question was asked to determine a correlation between depth and access type (drift, shaft, adit). In short there is no real definitive correlation as operations have started shallow and maintained their portal to face RTV capability whereas if they were new deep operations now, they may be better served by high-capacity winding and drift systems closer to actual operations.

There was a preference for portal to face continuous RTV capability in the higher producing operations with 100% of respondents that produced greater than 5Mtpa being drive in/out. Dolly car access was associated with initially deeper operations, but respondents typically found that this transfer of personnel to rail or RTV had some upside with streamlining opportunities including larger turnout shunts and cranes for more efficient transfer of materials. Rail was associated with the lowest producing operation but utilised this legacy for large batch delivery of supplies. It should be noted that although this operation was the lowest in production this was in no way a reflection of how the pit was managed its “can do” attitude we observed which was a credit to that operation given the licence to operate, distance, complexity and logistical constraints it had to continuously overcome.

Lighting

Low voltage LED lights are now the preference over traditional fluorescent lighting in Mains. 60% of all operations exceeding 4 Mtpa included lighting in mains at least partially. Whilst of the remaining 40%, 20% of operations exceeding 4 Mtpa felt lighting was a streamlining priority.

Concreting

Concreting with a proactive water management approach was undertaken on travel roads in some form in all operations producing greater than 4Mtpa. Some operations concreted all Mains, whilst some preferred to concrete Gates. Six of the mines with travel times to face of seventy minutes or greater did not concrete the travel roadways. Interestingly the highest producing operation only concreted at intersections on an ad-hoc basis. One previously operating high producing pit that has since closed famously declared that they were able to maintain longwall productivity with a single continuous miner because all travel roadways (and belt roads) including all gates were concreted enabling, high speed travel, and significantly greater CM utilisation. Concreting is considered a priority for more streamlined delivery of labour and materials along with the potential to improve machine reliability, improve water management, reduce tyre and machine wear and tear and reduce muscular skeletal injuries.

Labour

As foreseen in preliminary meetings, labour was difficult to ascertain. Labour for materials delivery was absorbed by the production panel. When not managed by the panel, labour for deliveries ranged between 1 and 2 people per shift. As to be expected every operation identified a critical shortfall in labour during longwall changeout.

TTFC and Delivery times to face

Total Time to First Coal (TTFC) was unsurprisingly proportional to distance travelled with the maximum distance travelled from portal to face being 18km ranging from 35 to 110 minutes with an overall average of 71 minutes (median also equals 75mins). Many operations use this window for Bull gang or equivalent preparation work which should yield a higher mean time to failure / delay during cutting. Nonetheless the cost of labour alone (even if machine utilisation remains high) is a justification for further research into higher speed travel methods.

Materials delivery time ranged between 45 minutes for the newest operation through to 4 hours with an average of 90 mins from portal to face laydown area. Respondents identified the following initiatives to reduce delivery times in the near to mid-term with a view to revolutionising delivery methods (autonomous / drone / monorail) in the mid to long term:

- Dedicated Inbye and Outbye travel roads;
- concreted well maintained and lit roads;

- smarter operation of LHDs with higher tonnes hauled per machine movement;
- automated light and tag board section;
- utilisation of 4th gear on LHD;

Some operations also focussed heavily on tonnes hauled per machine with easy to set up cardinal rules that whenever an LHD was travelling to or from the face (to or from pit bottom) a trailer must be attached hauling in or out increasing the tonnes hauled per machine movement significantly. The need to increase or maximise pay-load per journey was a significant concern and seen as a potential limitation with rubber-tyred diesel transport systems.

Biggest Logistical Impediments

Respondents were asked "what were in their mind the top 3 impediments to streamlined movements of materials and personnel for their particular operation?" The top responses were shown in **Table 3**.

Table 3: Distribution of top three logistical impediments per site

	% of operations identifying this in their top 3 impediments.
Labour (culture or availability)	67%
Machine Reliability	58%
Implement Management	33%
Portal / Pit Bottom Bottlenecks	25%
Distance	25%

Several control officers (although not all) complained about the cultural issue of labour utilised in the logistics chain. That for example very little care was taken in delivery and laydown, or that there was a significant lack of urgency by these outbye personnel. It could be argued particularly for the top two (Labour and Reliability), better road conditions would increase speed of delivery in turn reducing labour demand and reduce machine wear and tear. Better road condition management needs to be carefully planned out. Roadway maintenance practice of throwing ballast at a road problem may be a great short term solution but has the capacity to significantly restrict critical airway dimensions which has been experienced, where a 3.3m high roadway decreased to 2.1 m by constantly filling the roadway with ballast (boiling frog style) and in turn pushing up the main vent fans very slowly towards stall.

Respondents were asked "what were in their mind the top 3 impediments to streamlined movements of materials and personnel for their particular operation?" The top responses were shown in **Table 4**.

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Streamlining Ideas

Respondents were asked "If they could do just one thing to alleviate logistical pressures at their operation, what would that be?" Responses were grouped and are shown in **Table 5**.

Several respondents had tracking of implements as a priority but had experienced problems with implementation due to locations on machines being prone to being ripped off or battery capacity being too small and therefore not lasting long enough. Payload was also identified as a priority with one operation looking at the idea of multiple trailers being hauled with trailer braking systems that would allow higher payloads therefore increasing payload per kw. A specific concreting idea was to create a designed for purpose automatic concrete layer where an agitator and automatic screed was fabricated and driven slowly down the roadway to create high speed laying of concrete.

Table 5: Distribution of top two answers per site to streamline logistics

	% of operations identifying this in their top 3 impediments.
Increasing payload	46%
Better tracking of implements, machinery, material stocks and personnel	38%
Fit for purpose UG Warehousing	38%
Transparent real time ordering and dispatching	31%
Concrete and Lighting	23%

Many of the underground warehouses were nothing more than a cut through. Many respondents wished for a well-lit, concreted inbye warehouse utilising a previous gate road belt chamber with crane facility for high-speed transfer of materials to be stored or retrieved.

A streamlined cloud-based ordering system was lower down in priority partially because IPODS/IPHONES (nicknames) in the newer operations were already being utilised and therefore had addressed this. The vision from respondents and the research team was to be able to order supplies in real time, track personnel and implements and the supply of materials, stock in surface or underground warehousing and communicate with surface staff.

FINDINGS

Based upon comments provided to the questionnaires and in conjunction with observations from the site visits the following findings have been identified:

Logistics management in general is not considered as a key issue when initial or long-term planning is undertaken:

The movement of personnel and materials in and around the mine, is at best poorly understood and in general is not considered as a key issue. The focus behind mine design and layout in any long-term planning, is to optimise coal production and transport of product from the mine and assume that all necessary materials will be supplied in a timely manner. In general terms it is assumed that the supply of materials will happen as per general industry expectations.

The need to improve logistics management is only considered when travel times to the face exceed 30 minutes and when production has the potential be adversely impacted by waiting on supplies:

There is no apparent cost/benefit study undertaken to identify mechanisms to improve logistics management and thereby show it as a direct improvement in production and profit. Often, possible logistics improvement strategies are a luxury and as such are one of the first items to be sacrificed in any cost cutting exercise.

Any improvements to logistics management are largely left for workers to resolve with minimal direct input from management:

The need for improvements associated with transporting personnel and materials in and around the mine is often seen as a problem to be solved by the outbye support personnel and support crews. While some consideration is given to the reduction of manual handling by supply crews, inherent inefficiencies due to double handling and manual handling at the face tend not to be considered, as “this is the way we have always done it”. Similarly issues such as the reliability of machinery or vehicles is considered a problem for the workshop to address with little to no consideration to the tasks expected to be performed by these machines.

The age of mine can determine the amount of double or multiple handling of supplies and thereby impact upon efficient logistics management:

This is particularly the case where shaft or drift (dolly car) access is the mechanism used to access the coal seam and materials are transferred from one mode of transport to another. The need to “retrofit” modern day mining systems or methods within older more established mining operations is a challenging exercise. Often this will primarily focus on the transport of coal from the face to the surface, with the efficient movement of personnel and essential supplies receiving a lower level of consideration and importance. Hence multiple changes in transport mode and multi handling.

The pay load capacity of rubber tyred machines is seen as a major limitation on efficient logistics management:

Several mines identified that payload limitations were a significant constraint to the efficient handling of supplies. It was noted that the current trend to use diesel powered rubber tyred machinery in preference to rail track transport systems is the direct cause of this constraint. Also, the use of un-braked trailers is a contributing factor as the load capacity of each machine is limited to the overall braking capacity of the transport vehicle and trailer. Mine equipment manufacturers should be encouraged to design and manufacture suitable trailers with braking systems so the potential to increase the payload capacity of the haulage machines is increased.

The use of rubber tyred machines and their corresponding load limitations has led to the need for multiple journeys into and out of the mine and associated inefficiencies in logistics management:

It was apparent that this dependence on rubber tyred diesel machines and the need for multiple journeys can in turn result in:

- increased wear and tear on machinery,
- deterioration of roadway conditions,
- greater need for roadway maintenance,
- greater potential for health and safety issues to arise.

RECOMMENDATIONS

Following on from the findings several possible actions that have the potential to improve logistics management have been identified below as recommendations. These represent mechanisms which could be implemented to improve logistics and in general terms adopt an approach that reduces the range of variables impacting on logistics management, and wherever possible, simplify and standardise processes and procedures. These recommendations to improve logistics management have been divided into three categories (Short-term; Mid-term and Long-term).

Short-term

1. **Incorporate logistics management issues (the efficient movement of personnel and material in and around the mine) into the long-term planning schedule.**

Mine workings are continually expanding and as such travel distance will increase. As the size of a mine increases the time required to transport personnel and essential supplies from the surface to a development face will increase, and hence the potential for bottlenecks to occur, along with production delays. The planning cycle for a mine must take into consideration these factors, so that steps to overcome future problems with logistics management are initiated and implemented before any production delays occur. This can include items such as separate transport roads, the use of concrete to stabilise the floor and permit higher travel speeds, the use of internal laydown areas or “hubs” where necessary supplies can be readily accessed, etc.

2. **Standardise the equipment used to transport personnel and supplies within the mine.**

The use of standardised equipment is a logical step in reducing or overcoming potential bottlenecks and their resulting impacts on logistics management within a mine. It is understandable that as a mine develops and expands new and different items of machinery can become available and might be trialled in a mine. However, the larger the diversity of a transport and haulage machines fleet and its related equipment, the greater the potential to induce bottlenecks and delays. Time lost by accessing specialised equipment can be overcome by ensuring a standardised approach to all logistics-related machines.

3. **Use computer-based tracking systems on all transport machines and trailers involved in moving personal and materials within the mine.**

Technology to track and/or follow each piece of equipment used for transporting personnel and supplies within the mine exists and has been adopted by some operations. This in conjunction with a standardised approach can simplify and streamline logistics management and ensure any production delays are minimised.

4. **Use computer-based technologies within the mine to place orders for supplies necessary for continued production.**

Any procedure that each panel deputy must undertake to order essential supplies and materials, can impact on the overall production cycle and production rates. With current technology, these supplies can be ordered by computer underground, direct into the stores and supplies system, thereby overcoming double handling, order inaccuracies and any subsequent delays that could occur with a paper-based ordering system.

Mid-term

5. **Illumination of all traveling roads.**

Some mines have taken to illuminating either all or part of the travelling roads underground. This has generally been considered an unnecessary cost with installation, ongoing maintenance and operational costs being identified as issues. However, the use of LED lighting systems would appear to negate such concerns. With the installation of lighting along these roadways there exists the potential to reduce near misses and or collisions, improve safety, reduce the potential to lose or mislay equipment and reduce travel times.

6. **Concreting and/or stabilisation of travel road floor.**

This has the potential to reduce wear and tear on machinery, reduce travel times and reduce accidents and injuries, especially for the machine operators. In addition, other operational benefits have been noted such as improved management of water with a more efficient and reliable pumping system.

7. **Establish separated travel roads in and out of the mine, constructed and maintained to industry best practice.**

A single roadway for the transport of personnel and supplies is a basic bottleneck where one machine will have to stop to allow another machine to pass. Segregated roadways overcome this problem and do away with the use of “Section Controls”, and generally reduces congestion within the mine.

8. Use of automated lights to warn when a vehicle is approaching or operating within the vicinity of an intersection.

The use of proximity devices at key locations along the roadways permits the activation of an automated warning that a vehicle is approaching, leaving, or operating with the vicinity of an intersection. Hence the driver of a machine is aware of such activity and can take the necessary precautions. This is a more reliable approach to the use of "block lights" which have the potential to be incorrectly activated or de-activated due to human error.

9. The use of braked trailers to increase the load carrying capacity of each machine.

The load carrying capacity of all machines used underground is limited by the weight of the machine which in turn determines its total braking capacity. Generally, the trailers used underground are not equipped with brakes so a standard LHD machine is limited to a load on the front forks or duckbill and one loaded trailer. It is considered that the use of purpose-built braked trailers will allow more trailers to be coupled to the one machine, with a corresponding:

i. Increase in payload and potential reduction in journeys required;
ii. A saving in fuel usage;
iii. Reduction in atmospheric emissions;
iv. Redeployment of machines and personnel with an increase in material haulage productivity;
v. Faster overall average safe speeds with a reduction of total numbers of machines on roads.

10. Develop dedicated laydown areas or supply hubs for most frequently required panel supplies.

The establishment of specially designed and purpose-built supply centres or hubs underground have the potential to reduce travel distance and time to access essential panel supplies.

Long-term

11. Development of an automated computer-based ordering system for essential face supplies.

Different from the utilisation of just a cloud-based ordering / communication system, this is a significantly more holistic approach using the Internet of Things (IOT) technology to track everything across the operation, personnel, materials, implements, ventilation and gas quantities, stocks and spares and locations, availability and utilisation to name a few. The subset of this would be, for example, the ordering system, which would track (not just computer ordering in contrast to paper-based and phone calls) all essential materials from the time they enter the mine site to their installation underground. Such a system would be capable of providing the location of any batch of supplies within the mine, where within the transport network they are and an estimate as to when they could be delivered to a specific site.

12. Development of a fully automated transport system that provides high speed access to each face location, along with the transport of essential supplies.

Such a transport system would be dedicated to supplies so that the delivery of materials was not affected by other activities within the mine such as movement of personnel and coal. Initial concepts might incorporate the use of an easy to install monorail (possibly in the belt road) that was capable of shuttling supplies from an internal supply hub direct to the face.

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REFERENCE

Walker, D., Harvey, C., Baafi, E., Porter, I. and Kiridena, S., Benchmarking Study of Underground Coal Mine Logistics, ACARP Project C28021, 2020.