A CONCEPTUAL STUDY INTO THE IMPLEMENTATION OF A NEW INITIATION SYSTEM AT BLACK MOUNTAIN MINE

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I hereby declare that this assignment is my own unaided work and I have referenced all the sources I have used. It is being submitted in partial fulfilment of the requirements for the course PSC 411 (Project) at the University of Pretoria, Pretoria and I thus accept the rules of assessment of the University and the consequences of transgressing them.

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ABSTRACT

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This project was done in order to assess the need for a new blasting initiation system at Black Mountain Mine. The initiating method that is currently used by black mountain mine is that of the delay fuse which is considered by the DMR to be unsafe, considering that the miner has to be on the face in order to initiate the explosives. It is for this reason and more that black mountain had considered the use of centralised blasting in order to make the process of initiating much safer. This study compared the options that are available by means of doing research and evaluations in order to come up with an optimal solution that is suitable for Black Mountain mine. This study also looked into the financial implications of implementing alternative systems. The benefits thereof were evaluated as well as the financial gain of these systems.

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CHAPTER 1

MOTIVATION FOR THIS STUDY

The use of explosives is a vital part in the mining industry to be able to break the rock into manageable sizes. It can be a very dangerous process that may result in injuries or fatalities if not properly executed. The current blast initiation system is fraught with difficulties at Black Mountain mine. Accidents have occurred and will continue to occur if the system is not changed to a more reliable and less dangerous system. This chapter examines the initiation system currently used at Black Mountain as well as alternative systems that are considered to be much safer.

1. INTRODUCTION

1.1. General Information

1.1.1. Locality

Black Mountain Mine is part of Sesa Sterlite Vedanta Company. The mine is situated in the small town of Aggeneys between Poffader and Springbok in the Northern Cape Province 280 km west of Upington town, South Africa (BlackMountain,2015). The mine comprises of the Black mountain mine, concentration plant and the Gamsberg project. Black mountain mine consists of three shafts; Deeps shaft, Broken hill shaft and Swartberg shaft.

Figure 1 Location of Black Mountain Mine (Sterliteindustry, 2012)

1.1.2. Production and mining method

The primary minerals mined at Black Mountain are zinc, copper, lead and silver which is by product. The mine has been operational for the past 30 years and it employs about 1500 people including locals and foreigners. This mine was initially owned by Gold Fields who then sold it to Anglo American who then sold it to Vedanta resources early 2011.

The mine currently produces about 1.69 Mt per annum from the deeps shaft, which is the main focus at the moment. The production levels at deeps are between level 40 and level 50, life of mine scheduled till 2020. The Swartberg shaft produces 0.36 Mt per annum and the resources there are nearly depleted.

1.1.3. Mine access

The Deeps shaft is approximately 1800 m below the ground, to access the workings the mine makes use of a man cage which can carry 63 people at a time, and they also use a decline shaft which is 15 km long. The mine approved light duty vehicles (bakkies) are used to drive down the decline with a maximum speed of 16 km/h. To hoist the material underground the mine makes use of two skips, which has a capacity of 23 tons each.

1.2. Project background

Blasting is a very dangerous process but due to progressive innovation of explosive manufacturing companies the dangers have been minimised. The current initiation system used in Black mountain mine is the capped fuse igniter cord initiation system (CFIC). This system consists of a stay-a-light 30 minutes delay starter which is used to initiate the capped fuses, which then initiates the detonating cord. One of the dangers of using this system is the possibility of an unintentional detonation.

1.2.1. Safety

Safety at Black Mountain mine is an important factor, but also challenging. The safe use of explosives and explosives accessories is an important issue to be addressed given the incidents that has been reported on this mine pertaining to explosives. To date from the previous year 3 incidents were reported pertaining to explosives.

The first incident was due to lack of communications between successive shifts, whereby a miner blasted a face late and the people from the other shift were not aware of it and as such they went in to the face prematurely only to have a blast go off 100m in front of them. The incident report is attached in Appendix A

The second incident was the one whereby one mine blasted earlier than a miner at a lower level in which the blast fumes are extracted to; as a result the people on the lower level were exposed to blasting fumes. This is a problem caused by both lack of communication and unreliability of the current blasting system, as well as the shaft clearance system.

The third incident was due to a misfire whereby after washing down the face and scaling down, a loader came to load the material and as he was loading one of the misfires went off. This is now a major problem that not only places the life of the loader operator in jeopardy but also damages equipment.

1.2.2. Legislation

Mining as dangerous as it may be it is important that the employer creates a safe environment for the employee. It is for this reason that the DMR must see to it that the mines adhere. Due to the dangerous nature of explosives more so the capped fuse initiating system, the AEL explosives company is no longer manufacturing the capped fuses and also because it has become very expensive to manufacture (van Wyk, 2015)

All of these incidents contribute to lost time injury because of all the investigations that needs to be done. This then cost a lot of money to the company due to stoppages. The cost to compensate the people also costs the company unnecessary amount of money that was not planned for. It is for the above mentioned issues that the mine considered a new initiating system that would be much safer.

1.3. Problem Statement

Investigating the implementation of a new blast initiation system in order to improve blasting quality, safety and productivity at Black Mountain mine

1.4. Objectives and methodology

Table 1: Objectives and methodology

Objective	Methodology
Comparing alternative systems to the current system	Literature study, site visit and observations
Detailed study on the implementation plan of the alternative blast initiation system	Literature study, personal correspondence with underground personnel and explosives companies
Draw up an implementation plan for the alternative systems applicable to this mine	Site visits, observations, personal correspondence with underground personnel and explosives companies.
Make an estimation of the capital that will be required for the implementation of the alternative systems	Observations, site visits and literature survey and personal correspondence with explosives company to get quotes
Review the work place blast clearance system	Site visits and personal correspondence with shaft and underground personnel.
Influence of human error	Literature study and observations

CHAPTER 2

2. LITERATURE STUDY

This chapter evaluates the current blast initiation system used by black Mountain mine. The alternatives systems that are available in the market are also evaluated.

2.1. The capped fuse igniter cord blasting system

This system consists of a stay a light 30 minutes delay starter combined with a detonating cord and pyrotechnic detonators. The starter is initiated using an open flame, the starter then burns for 30 minutes allowing enough time for the workers to evacuate the area.

2.1.1. Stay-a-light

The stay alight 30 minutes delay starter is used in order to allow sufficient time for the miner to evacuate the face before the blast goes off. This product is not classified as an explosive and it is also not water resistant as a result if it is exposed to water it will not burn. An igniter cord is used to connect the stay-alight to the capped fuse. Table 2 below highlights some of the advantages and the disadvantages of using the stay-a-light.

2.1.2. Capped fuse

The capped fuse is a 2 minutes delay fuse used to ignite the detonating cord which in turn sets off the in hole detonators. This detonator is highly cap sensitive therefore poses a risk for unintentional detonation.

The occurrence of the small scale fall of ground at the mine are an issue to consider, due to the fall out height of these rocks and also taking into consideration that the rocks at this mine have a density of 4 g/t this may not only cause cut offs, they can lead to unintentional detonation.

Unintentional detonation may result in employees being injured or even worse fatalities. Other risks that are associated with unintentional detonation include people being exposed to noxious gases and also lead dust that are emitted during blasting.

This system is however cost effective because it eliminates the need for costly infrastructures, it is an easy to use system that requires only a flame and a starter. It is a very flexible system that can be adopted for any mining conditions.

Table 2 the advantages and disadvantages of stay a light system

Advantages	**Disadvantages**
Cost effective	Impact sensitive
Not complicated	Not very reliable therefore loss of blasts
	Emission of noxious gases
	Not waterproof

2.2. Centralized blasting system

The centralized blasting system is a computerized blasting system which allows for blasting to be initiated from a computer on surface. The main components for this system include a blast controller (computer), blast control unit, terminator and tagger.

According to (Sasol 2015) the centralized blasting is safer because it reduces the number of lost blasts and improves control over seismicity; it is more reliable due to the fact that it offers real time information for both underground and surface. This system is accurate, flexible and cost effective.

The system consists of a centralized blasting unit which connects to the faces using a harness wire. The blasting unit is then connected to a computer on surface. This is an electronic system therefore it makes use of electronic detonators. The electronic detonators are connected to the terminator using harness wire, this system is limited to electronic detonators therefore the mine must use electronic detonators for initiation of the shock tube system.

This system is compatible with the different kinds of system that are used in the market currently. This means that a mine does not have to convert to electronic in-hole detonators to be able to use this system.

2.2.1. Harness wire

The connection between the BCU and the computer can be done using optic fibre cables or copper armoured cables (Figure 2). Each of these options each has their own benefits and their short comings. The decision to use either copper or optic fibre will depends on the needs of the mine.

Figure 2: Harness wire (copper wire) (Enslin 2015)

According to (Damico, 2011) the following differences exist between copper and fibre optics.

Bandwidth

Fibre cables have far greater bandwidth than copper cables more so when using the single mode cable than the multimode cable. The fibre optic cables eliminate the need for earthing.

Attenuation and distance

The fibre cables can cover a distance range of 300m-40km while the copper cable has a limit of 100m, due to the design of the fibre cable very little signal is lost and more data can be transferred over the great distances

Immunity and reliability

Fibre cables core is made of glass which makes it immune to electromagnetic interference because glass is an insulator therefore it does not create problems when installed next to electrical equipment. The fibre cable can withstand being submerged under water and can withstand fluctuations in temperature but the same cannot be said for the copper wire.

Design

Due to the design of the fibre cables they are much easier to handle, and they are much easier to test than the copper cables but the problem is that they are much harder to terminate.

Cost

The capital cost of fibre is much higher than that of copper wires mainly because of the skills required but in terms of maintenance fibre is less costly to maintain than copper therefore it may be concluded that in the short run copper is more expensive but optic fibre is less expensive in the long run.

The connection between the BCU and the terminator, as well as the connection between the terminator and the detonator uses copper wires (Figure 2). The difference though is the size of wires that are used. The connection between the BCU and the terminator use 1.8mm copper wires while the connection between the terminator and the face uses 0.63mm wires.

Despite all the benefits that the fibre wires have, they also have their down falls ((Barber, 1998). Fibre is more expensive per meter than copper. The cables are more fragile than copper and they can be affected by certain chemicals. These cables are sensitive to radiation and may be opaque if they are exposed to such. The fibre optics cannot be easily be conjoined therefore they require some special skill.

2.2.1. Electronic detonators

The centralized blasting system is an electronic system that can only use electronic starters. There are 6 types of electronic initiators currently available in the market (Figure 3**)** which includes the smartshot, quickshot, digishot, driftshot and net shock detonators. The type of initiator used is dependent on the type of in-hole detonators used, for the shock tube system the only electronic initiator that can be used is the net shock detonator.

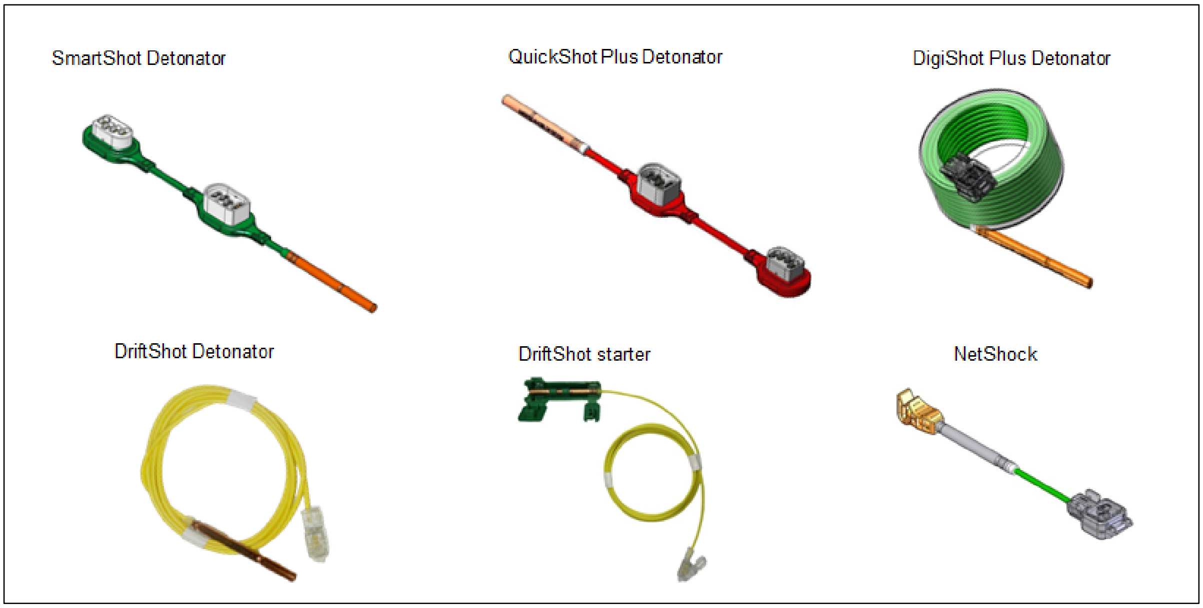


Figure 3: Electronic detonators (Enslin 2015)

The delay of electronic devices is achieved electronically using a computer chip to control the delay timing **(**Cardu and Giraudi 2013). The electronic detonators are programmable in ms increments and have delay accuracy (scattering) as low as 0.1 ms. The use of these devices can improve safety which in turn cut costs and optimize blasting.

The electronic detonators can only be initiated by designed control equipment and not by any other power source such as battery or cap lamps (Enslin, Laubscher and Slabbert, Infomine 2010) and the CB system has proven to reduce lost blast rate from 4% to 1%.

Table 3: Comparison of firing system (Cardu and Giraudi 2013)

	Electronic	**Electric, with pyrotechnic delay elements**	**Electric, with pyrotechnic delay elements**	**Non-electric with detonating cord and pyrotechnic delay elements**
Max number of possible detonation times	up to 3000 (up to 200 per line)	usually 20	ideally unlimited	ideally unlimited
Accuracy in actual detonation time setting	± 0,1 ms	± 10 ÷ 20 % of the nominal interval	± 10 ÷ 20 % of the nominal interval	± 10 ÷ 20 % of the nominal interval
Duration of time intervals between explosions	minimum 1 ms	from 8 to 30 ms (SP) from 250 to 500 ms (LP)	from 25 ms (SP) from 100 to 500 ms (LP)	
Number of detonators needed for a blast	The same as charges	the same as charges	the same as charges (not considering connecting units)	1; dependent on the number of needed delays
Max number of detonators that can be used in a blast	up to 3000	Depending on blasting machine, up to 1000	depending on connections, up to 200	ideally unlimited
Max duration of the blast	up to 15 s	up to 10 s	up to 7 s	up to 4 s
Number of kinds of detonators needed for a blast	1 type	the same as detonation times	the same as detonation time	1 type

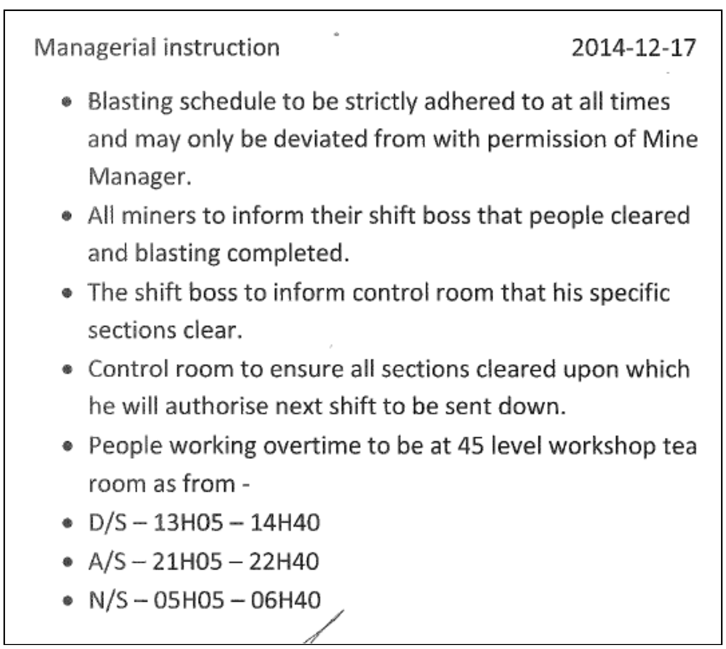
Table 3 above compares the electronic detonator to the electric and the non-electric detonators. In all the categories that are being compared, the electronic detonator can be seen to perform better or the same as the other options that are available. Table 4 below highlights the advantages and the disadvantages of the electronic detonators.

Table 4: Advantages and disadvantages of electronic detonators (Cardu and Giraudi 2013)

Advantages	Disadvantages
Higher precision	Higher cost per detonator
Improved blast results	Intensive training for use
Reduced ground vibration	
Possible limitation of detonators per shot	

2.3. Blast clearance system

Current procedure for clearing the shaft at this mine is that, all the workers must go to level 45 waiting place (Figure 4). There are two different shift systems that are operational, the cut and fill crews same as the development crew work three shifts a day. The blast hole crew and the backfill crew on the other hand works 2 shifts a day.


Managerial instruction 2014-12-17

- Blasting schedule to be strictly adhered to at all times and may only be deviated from with permission of Mine Manager.
- All miners to inform their shift boss that people cleared and blasting completed.
- The shift boss to inform control room that his specific sections clear.
- Control room to ensure all sections cleared upon which he will authorise next shift to be sent down.
- People working overtime to be at 45 level workshop tea room as from -
- D/S – 13H05 – 14H40
- A/S – 21H05 – 22H40
- N/S – 05H05 – 06H40

Figure 4: Blast clearance (BMM 2014)

The crews that are working 3 shifts a day it is not a problem for them to clear out of the shaft because at that time when blasting needs to occur it is also their time to knock off. As for the back fill and the blast hole people they need to go to the waiting area for the blast to clear off. The working places that are going to be blasted are then barricaded off.

The blasting times for the mine are 05:00, 13:00 and 21:00. The allowed time for the fumes to be cleared is 45 minutes. These are the time for which the shift change occurs and the relieving shift assumes that 45 minutes after the blast went off it is safe to go in and work. This applies for all the other workers that include the construction crew, engineering crew and the technical services department people.

When a miner sees that he might not have enough time to blast he can then leave the face uncharged. If for any reason the miner then decides to blast late it must then be communicated with the mine overseer to ensure that the relieving shift is aware of the situation. Considering the fact that the miner is a human being then it can be expected that deviation from procedure will occur.

2.4. Human error

The human factor is the act of doing something unintended that is unacceptable. Research shows that this is one of the major contributors to safety and reliability. This is something that must be taken into consideration when dealing with people. Good system can be put in place but if people decides to deviate from the plan either by mistake or planned for then it does not help.

According to (Gutierrez 2010) 88% of industrial accidents that occur are due to unsafe acts of fellow workers, 10% are caused by unsafe conditions while the remaining 2% includes unavoidable accidents. One of the contributors to human error is drug abuse and this includes alcohol.

According to the human factor theory (**Error! Reference source not found.**) there are three factors that contribute to human error which are overload, inappropriate response and inappropriate activities. Overload refers to mainly factors out of work, inappropriate response and inappropriate activities both refer to misjudgement of risk and subsequently lead to complaisance.

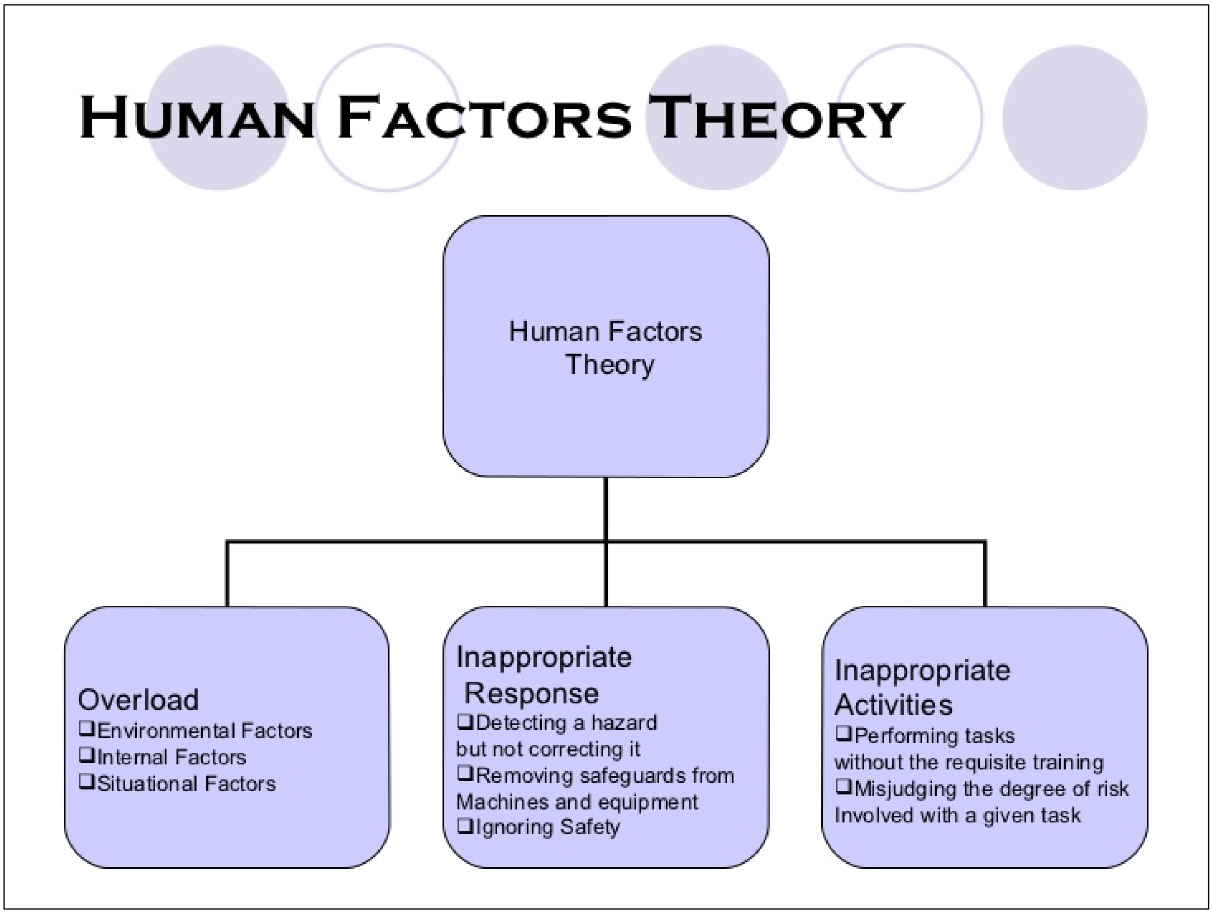


Figure 5: Human factor theory (Gutierrez 2010)

2.5. Shot exploder system

The shot exploder is a portable electric current source that is used to initiate electric detonators according to (Farlex 1963). It is a portable initiation tool that is suitable for both underground and surface operations. The primary current source for the unit can be that of a dynamo, magneto, capacitor or a battery. The unit is connected to the electric detonator using blasting cables.

The blaster can stand up to 3km from the face and initiate the blast. In order to connect the detonator and the shot exploder permanent copper wires can be used, and then from there copper wires that need to be replaced daily can be used. The box is not able to indicate to the user if there is any fault with the wires.

Table 5: Benefits and short comings of the shot exploder

Benefits	**Short comings**
Easy to use	Costly wires
Safe	Costly maintenance

2.6. Digi-shot system

The Digi-shot exploder is a portable electronic source that is used to initiate an electronic detonator. This system can be used for both underground and surface operations. It allows for blasts to be initiated from a safe distance using copper wires. Same as the shot exploder the electronic detonator can be connected to the Digi-shot using copper wires.

The Digi-shot exploder can detonate a maximum of 300 Digi-shot detonators (van Wyk 2015). A tagger is used to program the delays. The Digi-shot boxes make use of rechargeable batteries that need to be charged daily. The system has full functionality testing meaning that it can detect if there are faults on the blasting cables. The benefits of using this system are highlighted in Table 6.

Table 6: Benefits and short comings of the Digi-shot (AEL 2014)

Benefits	**Shot coming**
Easy to use with minimal components	Costly wires
Reliable	Short life battery
Safe	
Full functionality testing	

CHAPTER 3

RESULTS

3. RESULTS AND EVALUATION

This section summarises the main findings discovered during the investigation. These are the results from the literature study that was done, site visits as well as personal correspondence. These results addresses the objectives that were set.

3.1. Current system against the proposed system

Form the literature study that was done it showed that the proposed centralized system is much better than the current system used by the mine in a lot of ways.

The centralized blasting system allows for the blast to be set off from surface, blasting all the panels at once. This makes this system much safer because it removes all the people from the face before initiation of explosives can occur. This means that the risk of exposure to gases emitted by the stay-a-light initiator can be eliminated.

The CBS system uses an electronic starter which is far more reliable compared to the pyrotechnic detonator. The electronic starter is not impact sensitive therefore there is no risk of unintended detonation. During the site visit it was observed that miners use two detonators on each face to ensure that if the one fails then the other is there for back up.

The reliability of the system ensures that all the faces are blasted at the same time making sure that scenarios like the incident that occurred the previous years do not repeat themselves. The risk of having miners blasting at different times is eliminated when this system is in place.

3.2. The CBS system

3.2.1. Wiring

The centralized blasting system can be connected using either fibre optics cable or the copper wires. The current data transfer system in Black Mountain Mine is the fibre optics therefore considering all the benefits of the fibre optics as mentioned above it would be best that the mine continue using optic fibre. Taking this option would mean that the mine does not have to incur additional charges to establish the copper wires.

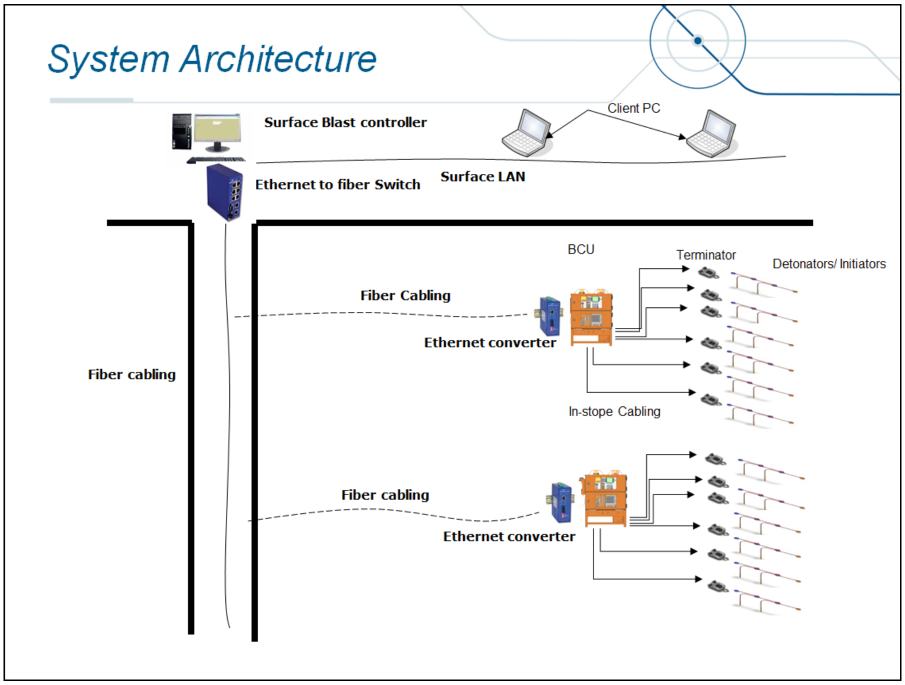


Figure 6: Fiber optics centralized blasting system (Ensilin 2015)

This system in a way uses both copper and optic fibres. The optical fibre is for the Ethernet connection between the blast control and the blast control unit. Because the blast control is a copper component, there will be needs for convertors. The convertors convert Ethernet to copper and vice versa. The connection between the blast control unit, the terminator and the face is that of copper wires (Figure 6). These are 0.63/0.71 mm armoured cables.

3.2.2. Wire route

The current working levels at Black mountain are 40, 42, 43, 45, 46, 47, 48, and 49. The main work level where there is a waiting place and the workshops is level 45. The current route for the fibre wires are displayed in Figure 7 below.

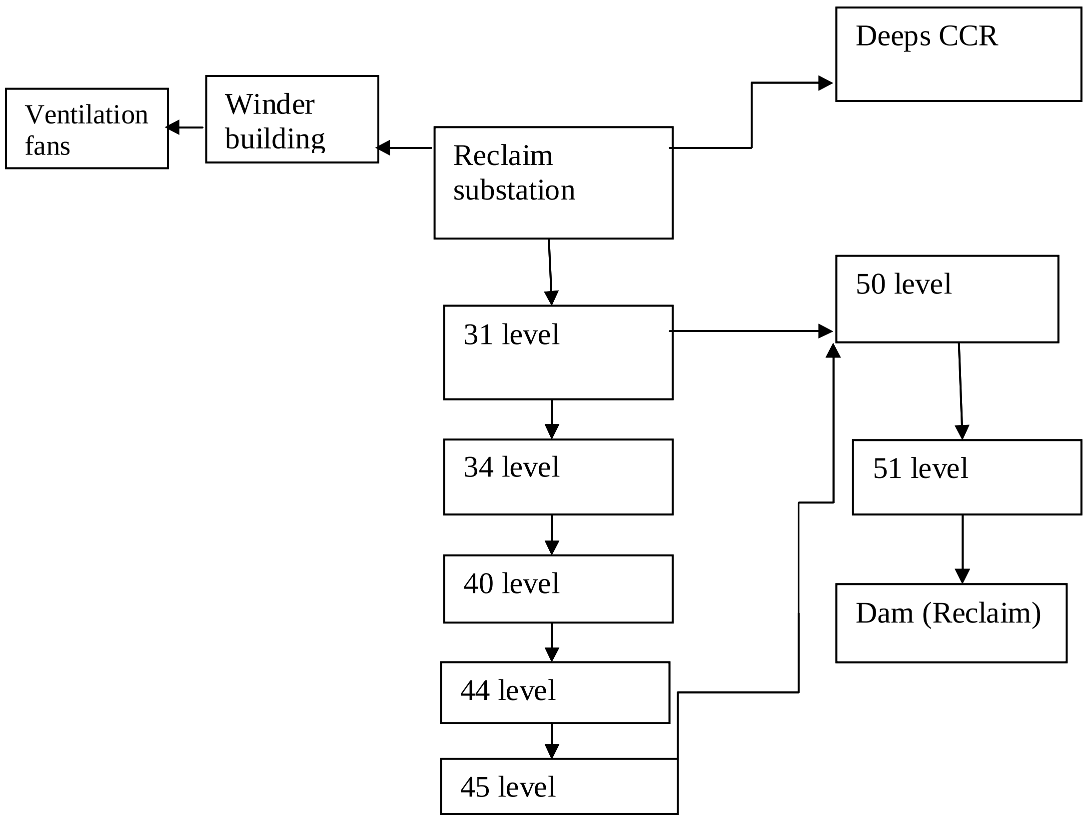


Figure 7: Route for the current fibre network

Form the above figure it can be seen that the wire system does not extend to other levels and in this case they will need to be extended in order to make the CBS connection possible.

The connections and all the extensions for this system for the fiber optic wires will be done by a contractor that has been working with the mine. The contractor needs to go and determine if there are available ports on each level to connect the BCU. Once that is done the AEL company will come and connect the rest of the system.

3.2.3. Required components

The components that are required for this system differs depending on whether it is connected using copper wires or optic fibre wires. The copper connection requires much more components than the optic fibre system. The components for optic fibre are as follows

- Blast controller
- Convertor
- Blast control unit
- Terminator
- Tagger

As mentioned in the literature survey optic fibre is better than copper in a lot of ways and due to some of the short coming, the copper connection will require a few more components and they are as follow

- Blast controller
- Modem
- Network splitter
- Dual channel Network repeater
- Blast control unit
- Terminator
- Tagger

Implementing the CBS system using copper would be a bit cheaper for black mountain mine if there was infrastructure for the copper according to the quotation given in appendix B.

3.2.4. Location of the blast control unit

The blast control unit is a component of the centralized blasting system which connects the blast controller to the face. This component has 6 ports and therefore it can blast 6 electronic detonators. The BCU makes use of the blast key as a safety device to ensure that once the miner has connected the faces he can then alert the blast controller that the faces are ready to be blasted.

This unit can be placed a maximum distance of 1 km from the face. It is important that this unit is placed at a safe area where it will not be damaged by the rocks during a blast as well as moving machinery. These components are supposed to lasts in the mine for as long as the mine is operational. Considering safety of the units and the distances from the faces the options that are available for the sitting of these units is at one of the blasted cubbies as can be seen on appendix E.

The green dots on the maps in the appendix indicate the position of the BCU, and the red path show the paths that will be used to access the working areas. From the plans it was determined that furthest working face was less than 700m which complies with the requirement that the BCU must not be more than 1000m away from the face.

The other possible position to put the units would be at the entrance of each level next to the electrical substation. The problem with this option though is that positioning the substation there may have an influence on the signal transmission. It for this reason that it is advised that the mine must put the unit at least 50 m away from the electricity substation (Ensilin 2015).

3.3. Shaft clearance system

Looking at the current shaft clearance system it is clear that there is not enough communication between the different shifts as well as communication with the other department. This not only causes problems but it has also resulted in an incident. The use of explosives requires that people must evacuate the working place before blasting occurs, the current system though does not guarantee that people will be out or that people will not go into the stopes prematurely.

The use of the Stay-a-light with the fuse combination is all subject to pyrotechnic cluster this means that they may not operate as specified. One of the other short coming of this combination is that there is no way of making sure that everybody blasts at the specified time. This does not only delay the subsequent processes it also means that there is a risk of people coming in to the working stopes before the stopes are cleared out.

Mine incidents not only necessitates the need for investigations that may take time, it also means that the stopes may be closed and as a result the mine loses out on production. The injured people also need to be compensated more so when they are dead.

3.4. Costs

3.4.1. Misfires

The cost of blasting is one of the major contributors to the mine total costs. The cost for reblasting a face is computed below taken from (captain). These costs are computed for a 5m by 5m face, the hole lengths are 4.9m with an expected advance of 4.5m. The holes are spaced at 0.8m on dip and on strike. The Figure 8 below shows that the number of holes that needs to be charged is 61 in total, the figure also shows the firing sequence of the holes.

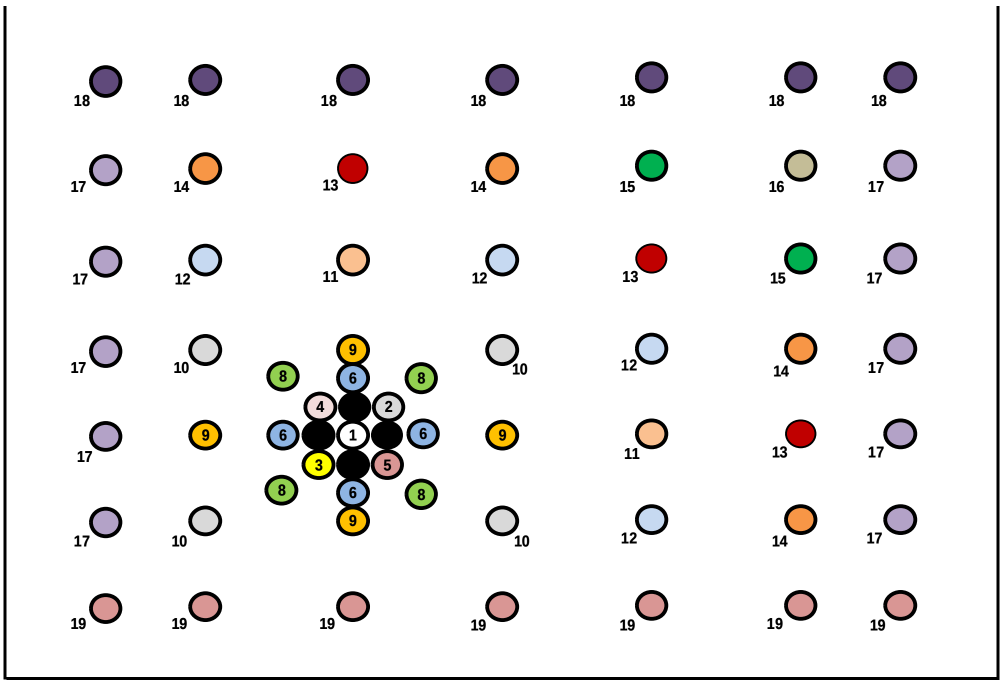


Figure 8: 5m x5m Face (Mohlake 2013)

The cost for blasting a face according to (Mohlake 2013) is R4900. The amount of tones per blast is approximately 450. The selling price for the metals that are produced at the mine is in the range of R700 – R1000 per ton, assuming that 400 tons of the 450 blasted tons then in can be concluded that the mine makes averagely R350 000 per face that is blasted.

3.4.2. CBS system

Looking into more detail about the CBS system it can be noted that incorporating this system will introduce changes. The current capped fuse together with the stay-a-light will be replaced with an electronic detonator and the tables below show the cost incurred by this change. Table 7 below shows the costs for the accessories that need to be replaced that are currently being used.

Table 7: Cost for accessories CFIC

Item	**Items/face**	**Cost (R) /each**
Stay-a-light	1	R2.16
Capped fuse	2	R21.33
Igniter cord	1	R 5.45/0.5m
Total		**R50.27**

Table 8 below shows the costs for the CBS accessories that are going to replace the current accessories used in the CFIC system. The blasting cost for a single face will increase by R170.00, this is an increase of about 3.5% per face.

Table 8: Accessories cost for CBS

Item	**Items /face**	**Cost (R)**
Net shock electronic detonator	1	R192.40
Telephone wire	1	R28/20m
Total		**R220.40**

Table 9 below shows a criterion matrix that was used to compare the detonators that are used in the different systems. The table shows that in terms of safety, reliability and compatibility the net shock detonators is much better, same as the digi-shot but the capped fuse detonator is much cheaper though.

Table 9: Criterion for comparing detonators

Criteria	Net-shock detonator	Capped fuse	Shot exploder	Digi-shot
Compatibility	Yes	no	Yes	Yes
Reliability	Good	Bad	Moderate	Good
Cost	High	Low	High	High
Safety	Excellent	Bad	Moderate	Moderate

Table 10 below shows the costs for the components that are going to be needed for the installation of the CBS system. All of these components will be installed by AEL free of charge. The total costs for the components will then be R761.317.10 and adding a 10% contingency this amount can be expected to be R837 448.81. A detailed explanation of the costs is included in the appendix.

Table 10: Cost for the CBS components

Items	Costs
Product software	R 71 070.75
Products hardware	R 427 010.20
Training	R 70 522.85
Spares	R 75 773.10
Product training	R 116 940.20
TOTAL	**R 761 317.10**

The table below shows the costs for copper wires for the CB system. The table shows that the total amount of permanent copper wires will be 5470 m while the copper wires that will require constant replacement will be 720 m. The costs thereof are tabulated as well on the table.

Table 11: Wire lengths and costs

Wire	Total meters	Total cost
1.8 mm Copper	5470	R8 916.10
0.63 mm Copper	720	R1 152.00
Total		R10 068.10

3.4.3. Digi-shot system

The digi-shot system requires copper wires that connects the detonator to the blasting box. These wires can be extended up to 3 km from the face. These wires may require to be replaced very often and therefore it is best that they are placed as close as possible to the face. The exact distances to each face is included in appendix.

The capital cost for this system is shown in Table 12 below. This cost includes the cost for the components as well as the costs for the permanent and the temporary copper wires.

Table 12: Capital cost for the digi-shot system

Capital	Cost
components	R528 776.65
Copper wires	R1 152.00
Total	**R 529 928.65**

The tables below summarises the costs for the accessories of this system. The capital cost includes the cost for the digi-shot unit and the permanent copper wires. Table 13 shows that the cost for the accessories that will need to be replaced on a daily basis, these costs will increase the blasting cost by 2.8%.

Table 13: Accessories for the digi-shot system

Item	Items / face	Cost (R)
Digi-shot detonator	1	R163.50
Telephone wire	1	R28/20m
Total		**R191.50**

3.4.4. Compensation

The consequence of a misfire or an unintended detonation can either be an injury or a fatality, both of these will cost the mine an enormous amount of money to compensate either the injured person or the family of the deceased. The amount of money that the mine might need to pay out is estimated on the table below (Table 14).

Table 14: Compensation criterion (Carstens 2015)

Compensation criteria	Amount
FAC	R350
MTC	R500
LTI	R800 up to R1 000 000
Fatality	R1 000 000 – R20 000 000

3.4.5. Lost time cost

When a fatality occurs on a face, the face has to be barricaded for investigations therefore no mining can take place. This stoppage can last for about 3 days up to 6 weeks. The amount of money that would be lost from not blasting a single face for this period is between R2 – R28 million.

4. CONCLUSIONS

The current initiation system used at this mine is not safe and not reliable. The CB system is not only safe but it is also reliable due to the fact that this system makes use of electronic detonators and also because the explosives are initiated from a point of safety on surface. The digi-shot system also uses the electronic detonator which is more reliable but the safety of the initiator is not really guaranteed. The shot exploder which is almost the same as the digi-shot and it also does not guarantee the safety of the initiator.

The implementation of the CB system will require that the current fibre network to be extended to the other levels. The 0.63 mm copper wires will be limited to 20 meters in order to reduce the daily costs which could easily become a lot of money for mine. The digi-shot system as well as the shot exploder system will require the copper wires, the initiator can stand up to 3 km from the face but it would still be safe to initiate from where the BC units were supposed to sit.

The costs for the CB system is well over R1 million rand and the cost for the digi-shot is half the price of the CB system. Considering that a mine might be liable to pay up to R20 million rand per fatality these prices are a small amount to pay.

The current blast clearance system at the mine does not in any way that all the people have evacuated the working area before the blast goes off. The best solution really is to ensure that all the people in the mine work the same shifts so that it is possible to ensure that all the people have evacuated from underground before any blasting can take place.

Mining is a business and it is important that all the options that are available to optimise production and minimise cost are evaluated. The implementation of the CBS system will address the major problem that the mine is facing that is the safety issue, it will also improve the blasting quality due to the use of more reliable detonators.

CHAPTER 6

5. RECOMMENDATIONS

- It is recommended that the mine switch to the centralized blasting system as this would improve safety. The capital cost for the implementation of the centralized blasting system is justified considering the amount of money that may be potentially lost.
- Further studies to be done on the implementation of electronic in hole detonator in order to improve the blast quality of the face.

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Chapter 7

7. APPENDICES

7.1. Appendix A

SOP 000 Black Mountain Mining (Pty) Ltd BMF 011

sesa sterlite
a vedanta company

BLACK MOUNTAIN

TOGETHER WE MAKE IT HAPPEN
Copper, lead and zinc is what we think

SAFETY INCIDENT FLASH REPORT

Incident Classification	☐ Fatal ☐ LTI ☐ RWC ☐ MTC ☐ FAC ☐ Damage ☒ HPI	
Date and Time of Incident	2014-12-16 22:45	
Nature of Injury or damage	N/A	
Site	Underground	
Where did Incident Occur	Deeps 46 Level North West	
Name of Injured Person	Miner: ID Coetzee Operator: CJ Damon	
Name of Employer or Contractor	Black Mountain Mining (PTY) Ltd.	
Position	Miner – Tramming Section, Operator – Tramming Section	
Years in Current Position	6 Months	
Potential Severity Classification	☒ High	Potential fatal or definite loss of quality of life.
	☐ Medium	No threat to life but possible loss of quality of life.
	☐ Low	Insignificant incident – unlikely to have any lasting consequences.
Repeat Incident	☐ Has happened before ☒ Similar to another incident ☐ First known case	
Golden Rule	Golden Rule 1 - Safety Fundamentals	

1. Description of Incident

On 16th of December 2014 at approximately 22h45, the Miner Immanuel Coetzee and the Operator Christopher Damon went to Deeps 46 Level North West to declare the area safe for loading. After they started the ventilation force fan at the gulley stand situated at the stope entrance, they proceeded by LDV to the face. When they were in proximity of the force fan, the blast went off exposing them to the concussion of the blast. This resulted in two FAC's for the Mining Tramming Section.

SOP 000	Black Mountain Mining (Pty) Ltd	BMF 011

2. Root Cause Analysis

Immediate Cause	**Conditions**	None
	Acts	• Blasting out of scheduled blasting time • Inadequate communication between production and tramming crews • Breakdown in blasting clearance procedures • Confusing instructions to the Onsetter with regard to the transporting of employees underground
Basic Cause	**Job**	• No token system – std. that specify the method, communication, etc. when lighting up at blasting time • Only one LDV used to conduct the blasting contributed to blasting outside of scheduled time
	Personal	• No permission was obtained from the Mine Overseer to blast later than specified blasting time
Control / Failure	System failure in that the Blasting Clearance procedure did not prevent the incident.	

3. Learning Points from Incident

- Formalised communication structures need to be in place regarding blasting activities
- The inadequacies in the blasting clearance procedure needs to be addressed immediately
- The miner is very dependent on the use of a LDV to initiate within specified blasting time
- Initiation by physically lighting fuses results in various potential hazards, as opposed to electric detonation

4. Corrective
(associated with immediate & basic causes)

1. The miner must contact the control room before lighting up
2. No blast shall take place outside of blasting time, without the permission of the mine manager
   a. Persons deviating from this instruction will be subject to instant dismissal
3. The miner must confirm that all blasts have detonated prior to giving the all clear to the control room
4. All shift bosses sign for section clear at the control room at the end of the shift to declare their area safe
5. The banksman must not take the next shift u/g until he receives the all clear from the control room
6. Employees that remain underground during blasting time shall proceed to dedicated Safe Area and report the number of people, with names, to control room prior to light up time. These persons will be notified by control room when it is safe for re-entry.
7. The blasting shift boss must communicate to their cross shifts (Production **and** Tramming) the areas that have been blasted.

SOP 000 Black Mountain Mining (Pty) Ltd BMF 011

5. Preventative

(associated with system / control failures)

1. Guard to be placed at the Broken hill decline to prevent people from entering the mine at firing times. Guard must also ensure that all persons sign in and out of the mine.
2. A biometric system must be installed at the Broken hill decline, and all operators entering the mine must tag in. Failure to tag in will result in a written warning. Spot checks will be required by supervisors to ensure that all persons have signed / tagged into the mine.
3. Chalk board stating the time of light up to be left at the barricade to the area
4. Bio-metric tagging system to be installed at 45L. All persons must be in a safe area (45L or Surface) prior to a blast being taken. This will be confirmed by the control room.
5. Electronic detonator to be used to initiate blast, so that the blast can be confirmed immediately. Procedure and training will be required.
6. Centralised blasting system to be installed
7. Ventilation fixed monitoring points to be installed u/g to monitor blast fumes
8. Seismic system to be used to confirm blast initiation times. Periodic checks to be carried out to ensure compliance with blasting times, and action to be taken as per item 2 above if deviations are found.

6. Assurance:

Assurance is required for at least all incidents with a High Potential Severity

"We the undersigned, hereby confirm that the above-mentioned incident has been properly investigated, the root cause(s) identified are correct, accountability for the corrective action has been assigned and that these corrective actions will be implemented / scheduled for implementation."

....

OPERATIONS MANAGER or HOD DATE

....

GENERAL MANAGER DATE

7. Disclaimer / Descargos

The information contained in this document is for the consideration and use of the parties who receive it. It is not prescriptive and shall not be interpreted to impose any legal duties on or to attach any liability to such parties. No responsibility is accepted by Black Mountain Mine (PTY) Ltd. or any of its subsidiaries or associated companies for any loss or damage whatsoever arising out of the use of, or adherence to or the lack thereof of any part of this information.

For further information contact: HDippenaar@blackmountain.co.za

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a vedanta company

BLACK MOUNTAIN

TOGETHER WE MAKE IT HAPPEN
Copper, lead and zinc is what we think

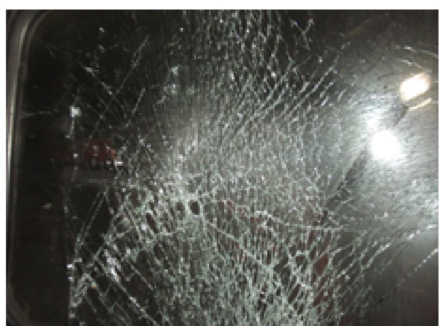
SAFETY INCIDENT FLASH REPORT

Reference Number	R-A-012-14	2014-00012-01
Incident Classification	☐ Fatal ☐ LTI ☐ RWC ☐ MTC ☒ FAC ☐ Damage ☒ HPI	
Date and Time of Incident	2014-10-27	10:35
Nature of Injury or damage	Injury: FAC –ears; Damages: Front window was shattered, the scoop bucket as well as some of the shark tooth on the bucket was damaged.	
Site	Underground.	
Where did Incident Occur	Deeps 47 Level West Lift 5 ramp.	
Name of Injured Person	Timotheus Swartz.	
Name of Employer or Contractor	Black Mountain Mining (PTY) Ltd.	
Position	Operator: Scoop, Water Truck, Grader, and Dosser.	
Years in Current Position	10 Years	
Potential Severity Classification	☒ High	Potential fatal or definite loss of quality of life.
	☐ Medium	No threat to life but possible loss of quality of life.
	☐ Low	Insignificant incident – unlikely to have any lasting consequences.
Repeat Incident	☐ Has happened before ☐ Similar to another incident ☒ First known case	
Golden Rule	**Safety fundamentals – GR 1**	

1. Description of Incident

The scoop operator attempted to load a big rock which fell from the bucket, in the process an explosion occurred, below the bucket on the left hand side. The explosion shattered the LHD (S17) front window and there was also damaged recorded on the bucket. The operator was examined by the Occupational medical practitioner and the observation was classified as a First Aid Case.

The explosives found on the accident scene after the explosion took place.



The fractured front window of the scoop caused by the explosion.

2. Root Cause Analysis

Immediate Cause	**Conditions**	• Explosive boxes are far from workings and in some places not on the normal route in-and-out from the workings which means that due to time constraints this condition to contribute to the abandoning of explosives.
	Acts	• Fail to comply with standards/procedures • Fail to make the area safe • Fail to take preventative action • Incorrect explosive control • Non adherence to standards
Basic Cause	**Job**	• Not trained on revised job procedure • Inadequate communication of standards • Inadequate maintenance of standards • Procedure not used for training purposes • No relevant task observation done
	Personal	• Inconvenience of obtaining correct tools • Habit/personal preference • Inadequate involvement/leadership to prevent incident • Deviation that lead to incident previously ignored
Control / Failure	PDI as well as a FAC as a result of poor explosive control - Gross Negligence	

3. Learning Points from Incident

- Section 55 instructions issued by the IOM were not adhered to in that the explosive standards, procedures and training were not revised as no proof could be handed in with the investigation.
- There were some of the mining sections which did not adhered to the Section 55 instructions issued by the IOM in that there must be explosive boxes installed in their relevant sections.
- There was a breach in the explosive control book keeping in that there is no proof of accurate explosive control as per Legislation for the last three months.
- There was a breach in Legislation in that explosives were abandoned.
- The Shift boss duties regarding inspections on explosive control, issuing and storage did not identify any explosive deviations.
- Mine overseer duties with regard to explosive control and the close out of the Section 55's by the IOM were not done.
- There was a breach of a Section 55 removal of old explosive packaging from underground. This is also a breach of our explosive risk assessment.
- Supervisors condoned the breaches in explosive standards.
- The left over explosives found on the accident scene were cartridge (200X32 Magnum Plus). These explosive cartridges were already punctured/prepared for the insertion of the "nonnels".
- There was a breach of BMM standard in that the explosives were not destroyed as per standard, but instead abandoned.

4. Corrective
(associated with immediate & basic causes)

- Explosive searches were conducted in all the workings to ensure that all abandoned explosives are obtained and properly locked away.
- New explosive risk assessments, procedures, and standards to be placed on the Safety System, Spagging forms to be filed, and training to be conducted in this regard.
- All the mining sections conducting blasting operations to ensure that their sections are equipped with explosives and old explosives boxes to comply with IOM Section 55 and to ensure compliance with Legislation.

5. Preventative
(associated with system / control failures)

6. Assurance:

Assurance is required for at least all incidents with a High Potential Severity

"We the undersigned, hereby confirm that the above-mentioned incident has been properly investigated, the root cause(s) identified are correct, accountability for the corrective action has been assigned and that these corrective actions will be implemented / scheduled for implementation."

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For further information contact: HDippenaar@blackmountain.co.za

7.2. Appendix B

	Project Cost - COPPER				
AEL SAP Code	**Material**	**Unit**	**Unit Price**	**Quantity**	**Total Price**
	Annual Software License Fees				
792	BLASTWEB ANNUAL SOFTWARE MAINTENANCE LICENSE	YR	R 9,261.00	1	R 9,261.00
794	BLASTWEB SERVER CONFIG ANNUAL SOFTWARE MAINTENANCE LICENSE	YR	R 5,880.60	1	R 5,880.60
					R 15,141.60
	Product Software Purchase				
791	BLASTWEB SOFTWARE	EA	R 29,394.90	1	R 29,394.90
793	BLASTWEB SERVER CONFIG	EA	R 24,497.10	1	R 24,497.10
					R 53,892.00
	Products Hardware				
200630	ED (MDF): BLAST CONTROLLER	EA	R 18,553.05	3	R 55,659.15
203782	ED(MDF):USB LEASED LINE MODEM	EA	R 3,127.80	0	R 0.00
203763	ED(MDF):BCU CONVERTER	EA		0	R 0.00
203754	ED(MDF):BCU REPEATER	EA	R 20,508.80	0	R 0.00
203366	ED (MDF): BCU	EA	R 46,959.90	10	R 469,599.00
203171	ED (MDF): QUICKSHOT BLAST KEY (RED)	EA	R 729.30	10	R 7,293.00
202972	ED (MDF): SMART KEY (YELLOW)	EA	R 729.30	10	R 7,293.00
202456	ED(MDF): QUICKSHOT TAGGER	EA	R 13,942.50	2	R 27,885.00
200544	ED:NETWORK SPLITTER DR12500	EA	R 521.30	6	R 3,127.80
203711	ED (MDF): BCU TERMINATOR 2-WIRE	EA	R 588.90	60	R 35,334.00
					R 606,190.95
	Product Training Centre				
200630	ED (MDF): BLAST CONTROLLER	EA	R 17,178.75	1	R 17,178.75
203782	ED(MDF):USB LEASED LINE MODEM	EA	R 3,127.80	1	R 3,127.80
203763	ED(MDF):BCU CONVERTER	EA		0	R 0.00
203754	ED(MDF):BCU REPEATER	EA	R 20,508.80	0	R 0.00
203366	ED (MDF): BCU	EA	R 46,959.90	1	R 46,959.90
203171	ED (MDF): QUICKSHOT BLAST KEY (RED)	EA	R 729.30	1	R 729.30
202972	ED (MDF): SMART KEY (YELLOW)	EA	R 729.30	1	R 729.30
202456	ED(MDF): QUICKSHOT TAGGER	EA	R 13,942.50	1	R 13,942.50
200544	ED:NETWORK SPLITTER DR12500	EA	R 521.30	1	R 521.30
203711	ED (MDF): BCU TERMINATOR 2-WIRE	EA	R 588.90	3	R 1,766.70
203980	ED(MDF):NETSHOCK 2-WIRE TRAINING PUCK (HEAT SHRINK)	EA	R 52.65	60	R 3,159.00
					R 88,114.55
	Advised Product Critical Spares				
203365	ED (MDF): BCU UI MODULE	EA	R 22,243.00	1	R 22,243.00
203782	ED(MDF):USB LEASED LINE MODEM	EA	R 4,708.60	1	R 4,708.60
203364	ED (MDF): BCU POWER SUPPLY MODULE	EA		1	R 0.00
203767	ED(MDF):CONVERTER UI MODULE	EA			R 0.00
203764	ED(MDF):REPEATER UI MODULE	EA	R 312.00	0	R 0.00
203780	ED(MDF):BCU BACKUP BATTERY	EA	R 4,708.60	0	R 0.00
203756	ED(MDF):BCU VOICE COMMS MODULE	EA	R 19,874.40	0	R 0.00
203755	ED(MDF):BCU VOICE COMMS UI MODULE	EA	R 729.30	0	R 0.00
203171	ED (MDF): QUICKSHOT BLAST KEY (RED)	EA	R 729.30	2	R 1,458.60
202972	ED (MDF): SMART KEY (YELLOW)	EA	R 13,942.50	2	R 27,885.00
202456	ED(MDF): QUICKSHOT TAGGER	EA	R 521.30	1	R 521.30
200544	ED(MDF): NETWORK SPLITTER DR12500	EA	R 588.90	0	R 0.00
203711	ED (MDF): BCU TERMINATOR 2-WIRE	EA		12	R 0.00
					R 56,816.50
	Product Training		**9449.7**		
154	ENGINEERING TRAINING	EA	R 9,449.70	4	R 37,798.80
155	USER TRAINING	EA	R 3,543.80	4	R 14,175.20
156	MANAGEMENT TRAINING	EA	R 9,449.70	1	R 9,449.70
382	SOFTWARE TRAINING	EA	R 9,231.30	4	R 36,925.20
					R 98,348.90
	TOTAL INSTALLATION COST				**R 918,504.50**
	COST SUMMARY				
	Annual Software License Fees		Compulsory		**R 15,141.60**
	Product Software Purchase				**R 53,892.00**
	Products Hardware				**R 606,190.95**
	Product Training Centre		Optional		**R 88,114.55**
	Advised Product Critical Spares				**R 56,816.50**
	Product Training				**R 98,348.90**
					R 918,504.50

	Project Cost - OPTIC FIBRE OPTION				
AEL SAP Code	**Material**	**Unit**	**Unit Price**	**Quantity**	**Total Price**
	Annual Software License Fees				
792	BLASTWEB ANNUAL SOFTWARE MAINTENANCE LICENSE	YR	R 9,261.00	1	R 9,261.00
794	BLASTWEB SERVER CONFIG ANNUAL SOFTWARE MAINTENANCE LICENSE	YR	R 5,880.60	1	R 5,880.60
					R 15,141.60
	Product Software Purchase				
791	BLASTWEB SOFTWARE	EA	R 29,394.90	1	R 29,394.90
793	BLASTWEB SERVER CONFIG	EA	R 24,497.10	1	R 24,497.10
					R 53,892.00
	Products Hardware				
200630	ED (MDF): BLAST CONTROLLER	EA	R 18,553.05	3	R 55,659.15
203782	ED(MDF):USB LEASED LINE MODEM	EA	R 3,127.80	0	R 0.00
203763	ED(MDF):BCU CONVERTER	EA		0	R 0.00
203754	ED(MDF):BCU REPEATER	EA	R 20,508.80	0	R 0.00
203366	ED (MDF): BCU	EA	R 46,959.90	10	R 469,599.00
203171	ED (MDF): QUICKSHOT BLAST KEY (RED)	EA	R 729.30	10	R 7,293.00
202972	ED (MDF): SMART KEY (YELLOW)	EA	R 729.30	10	R 7,293.00
202456	ED(MDF): QUICKSHOT TAGGER	EA	R 13,942.50	2	R 27,885.00
200544	ED:NETWORK SPLITTER DR12500	EA	R 521.30	0	R 0.00
203711	ED (MDF): BCU TERMINATOR 2-WIRE	EA	R 588.90	60	R 35,334.00
					R 603,063.15
	Product Training Centre				
200630	ED (MDF): BLAST CONTROLLER	EA	R 17,178.75	1	R 17,178.75
203782	ED(MDF):USB LEASED LINE MODEM	EA	R 3,127.80	0	R 0.00
203763	ED(MDF):BCU CONVERTER	EA		0	R 0.00
203754	ED(MDF):BCU REPEATER	EA	R 20,508.80	0	R 0.00
203366	ED (MDF): BCU	EA	R 46,959.90	1	R 46,959.90
203171	ED (MDF): QUICKSHOT BLAST KEY (RED)	EA	R 729.30	1	R 729.30
202972	ED (MDF): SMART KEY (YELLOW)	EA	R 729.30	1	R 729.30
202456	ED(MDF): QUICKSHOT TAGGER	EA	R 13,942.50	1	R 13,942.50
200544	ED:NETWORK SPLITTER DR12500	EA	R 521.30	0	R 0.00
203711	ED (MDF): BCU TERMINATOR 2-WIRE	EA	R 588.90	3	R 1,766.70
203980	ED(MDF):NETSHOCK 2-WIRE TRAINING PUCK (HEAT SHRINK)	EA	R 52.65	60	R 3,159.00
					R 84,465.45
	Advised Product Critical Spares				
203365	ED (MDF): BCU UI MODULE	EA	R 22,243.00	1	R 22,243.00
203364	ED (MDF): BCU POWER SUPPLY MODULE	EA	R 4,708.60	1	R 4,708.60
203767	ED(MDF):CONVERTER UI MODULE	EA		0	R 0.00
203764	ED(MDF):REPEATER UI MODULE	EA		0	R 0.00
203780	ED(MDF):BCU BACKUP BATTERY	EA	R 312.00	0	R 0.00
203756	ED(MDF):BCU VOICE COMMS MODULE	EA	R 4,708.60	0	R 0.00
203755	ED(MDF):BCU VOICE COMMS UI MODULE	EA	R 19,874.40	0	R 0.00
203171	ED (MDF): QUICKSHOT BLAST KEY (RED)	EA	R 729.30	2	R 1,458.60
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200544	ED(MDF): NETWORK SPLITTER DR12500	EA	R 521.30	0	R 0.00
203711	ED (MDF): BCU TERMINATOR 2-WIRE	EA	R 588.90	12	R 7,066.80
					R 50,878.10
	Product Training				
154	ENGINEERING TRAINING	EA	R 9,449.70	4	R 37,798.80
155	USER TRAINING	EA	R 9,449.70	4	R 37,798.80
156	MANAGEMENT TRAINING	EA	R 3,543.80	1	R 3,543.80
382	SOFTWARE TRAINING	EA	R 9,449.70	4	R 37,798.80
					R 116,940.20
	TOTAL INSTALLATION COST				**R 924,380.50**
	COST SUMMARY				
	Annual Software License Fees		Compulsory		**R 15,141.60**
	Product Software Purchase				**R 53,892.00**
	Products Hardware				**R 603,063.15**
	Product Training Centre		Optional		**R 84,465.45**
	Advised Product Critical Spares				**R 50,878.10**
	Product Training				**R 116,940.20**
					R 924,380.50

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AEL Mining Services

09 March 2015
Vendanta – Black Mountain Mining (PTY) Ltd
Private Bag X01
Aggenys
8893

Attention: L Korope

Dear Lebo

Quote for Explosives Accessories

Please find prices as requested for O'Kiep.

Accessories

304310	NetShock 2 Wire	4,809.85

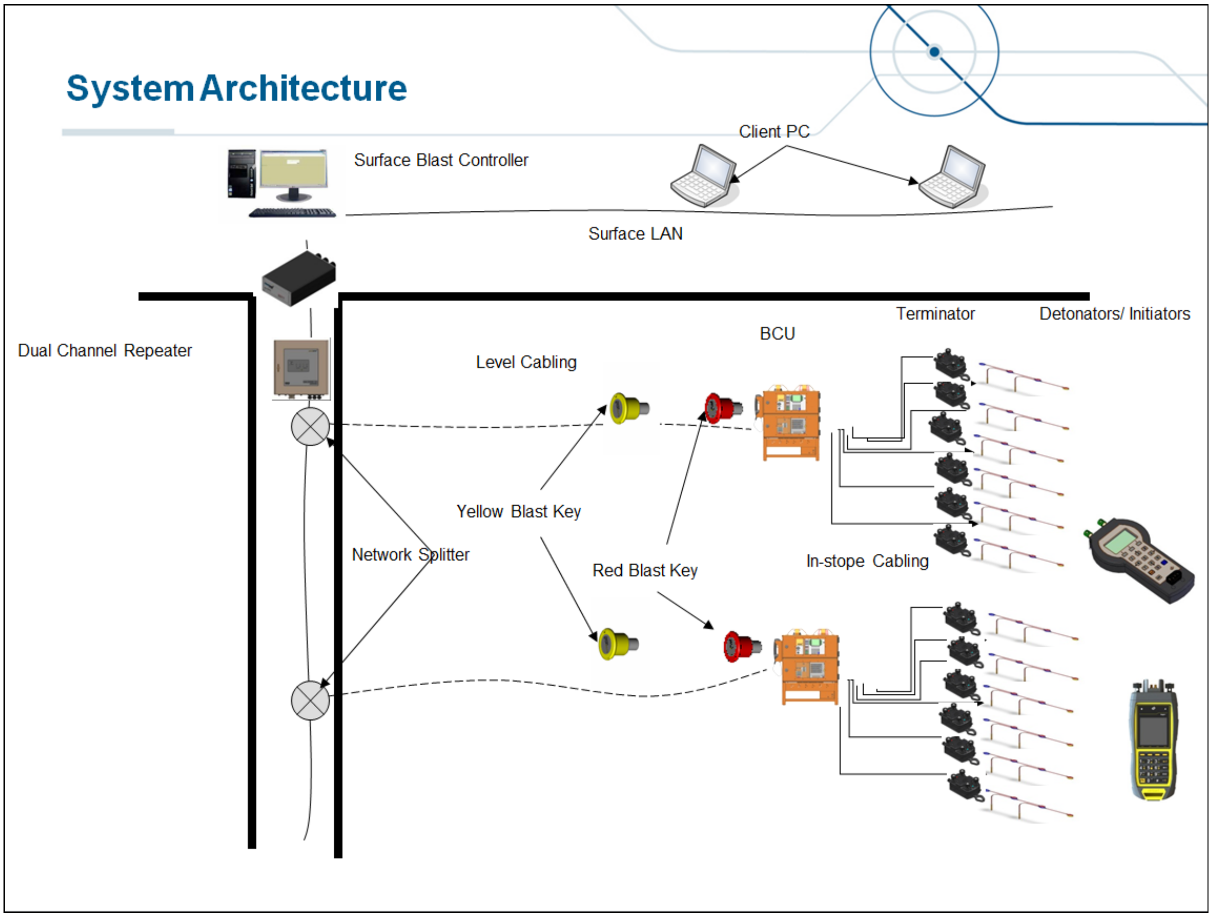
Hope you find this in order, please do not hesitate to contact me if you require anything else. Prices are valid for 2015 and are exclusive of VAT.

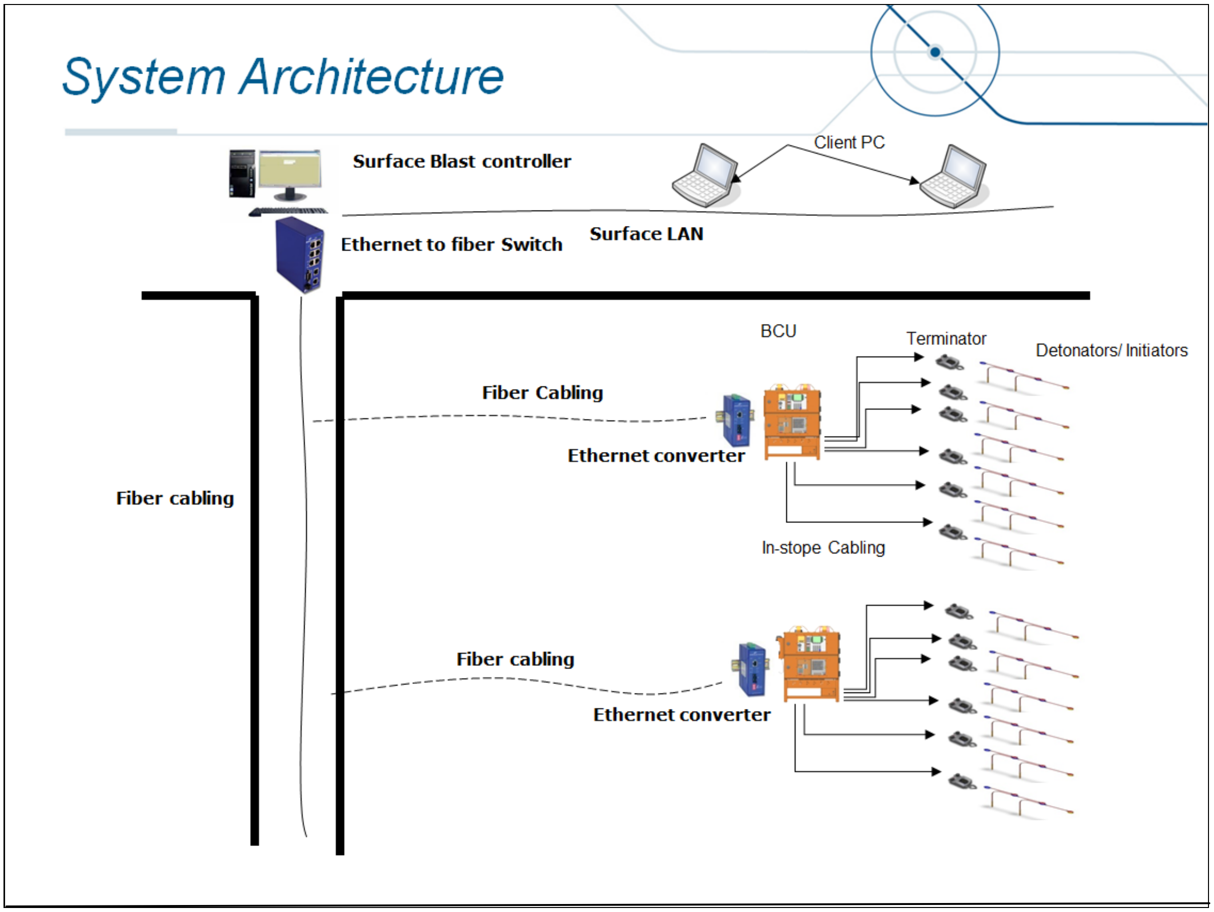
Yours sincerely

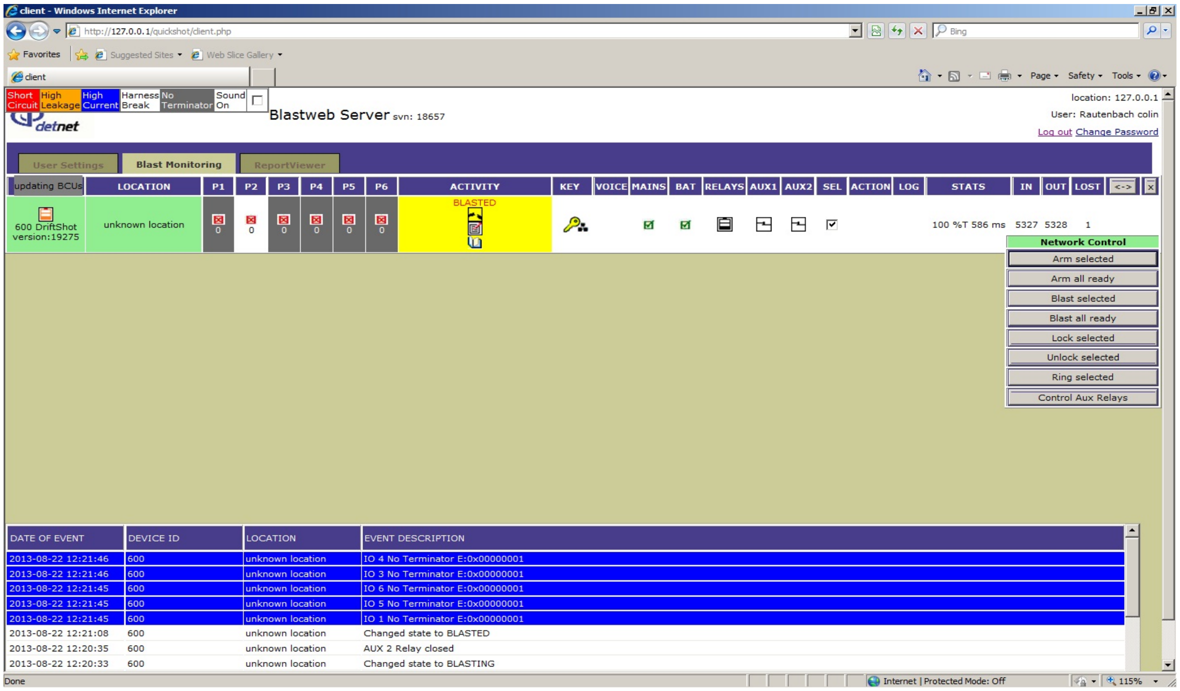
Nic Dreyer
Regional Manager
Northern Cape – Northern Region

Direct Tel: 082 788 9049
Email: Nic.Dreyer@aelms.com

7.3. Appendix C




System Architecture
Surface Blast controller
Client PC
Ethernet to fiber Switch
Surface LAN
BCU
Terminator
Detonators/ Initiators
Fiber Cabling
Ethernet converter
Fiber cabling
In-stope Cabling
Fiber cabling
Ethernet converter


client - Windows Internet Explorer
http://127.0.0.1/quickshot/client.php
Short Circuit
High Leakage
High Current
Harness Break
No Terminator
Sound On
Blastweb Server svn: 18657
location: 127.0.0.1
User: Rautenbach colin
Log out Change Password
User Settings
Blast Monitoring
ReportViewer
updating BCUs
LOCATION
P1
P2
P3
P4
P5
P6
ACTIVITY
KEY
VOICE
MAINS
BAT
RELAYS
AUX1
AUX2
SEL
ACTION
LOG
STATS
IN
OUT
LOST
600 DriftShot version:19275
unknown location
BLASTED
100 %T 586 ms
5327 5328 1
Network Control
Arm selected
Arm all ready
Blast selected
Blast all ready
Lock selected
Unlock selected
Ring selected
Control Aux Relays
DATE OF EVENT
DEVICE ID
LOCATION
EVENT DESCRIPTION
2013-08-22 12:21:46 600 unknown location IO 4 No Terminator E:0x00000001
2013-08-22 12:21:46 600 unknown location IO 3 No Terminator E:0x00000001
2013-08-22 12:21:45 600 unknown location IO 6 No Terminator E:0x00000001
2013-08-22 12:21:45 600 unknown location IO 5 No Terminator E:0x00000001
2013-08-22 12:21:45 600 unknown location IO 1 No Terminator E:0x00000001
2013-08-22 12:21:08 600 unknown location Changed state to BLASTED
2013-08-22 12:20:35 600 unknown location AUX 2 Relay closed
2013-08-22 12:20:33 600 unknown location Changed state to BLASTING
Done
Internet | Protected Mode: Off
115%

7.4. Appendix D

T.S.I communications

Physical: TSI House, 64 Sabax Road, Aeroton, Johannesburg, South Africa
Tel. No: (+27-11) 494-1400
e-mail: tsicom@global.co.za
Postal: P.O.Box 1092, Southdale, 2135, South Africa
Fax No: (+27-11) 494-2800
Reg. No.: CK 94/12935/23

SALES QUOTE

Customer

To Name: Lebogang Korope
Company: Black Mountain
Phone: 054 983 9516
Fax: 086 562 7636
LKorope@blackmountain.co.za

QUOTE NR BMNTLK15-03-01
DATE March 4, 2015
CUSTOMER Ref N/A
EXPIRATION DATE March 18, 2015

SALESPERSON	SHIPPING TERMS	Validity	PAYMENT TERMS	email	Delivery	Vat	ROE Rate
Piet Pretorius	Delivered	14 Days	COD alternitave 30 Days for approved accounts	srep@global.co.za	1 Weeks	Excl VAT	N/A

NR	QTY	Description	unit	Unit Price	% Disc	R/Disc	Nett Total
1	500	Yellow/White 0.75mm 2 Core Wire for Blasting purposes per 500 mtr rolls	pm	R 1.40		R 0.00	R 700.00
2						R 0.00	
3						R 0.00	
4						R 0.00	
5						R 0.00	
6						R 0.00	
7						R 0.00	
8						R 0.00	
9						R 0.00	
10						R 0.00	

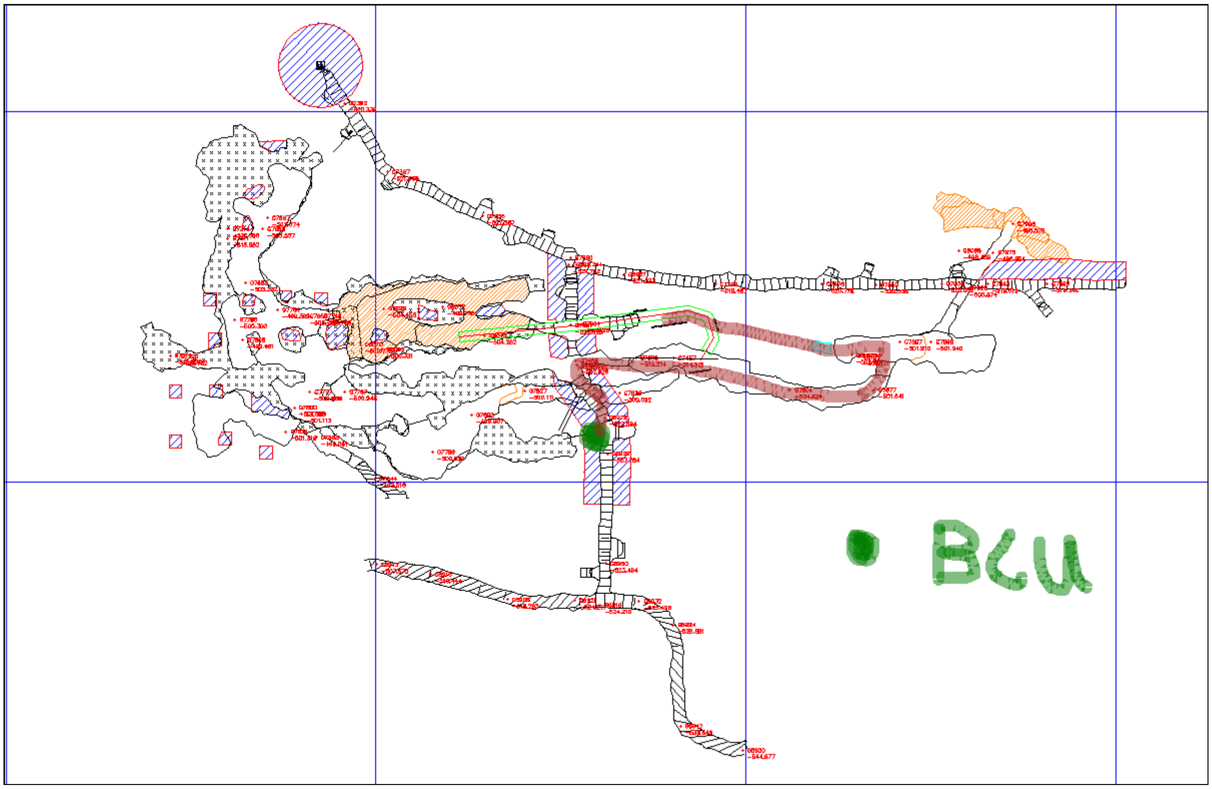
SUBTOTAL	R 700.00
SALES Tax	R 98.00
Total	R 798.00

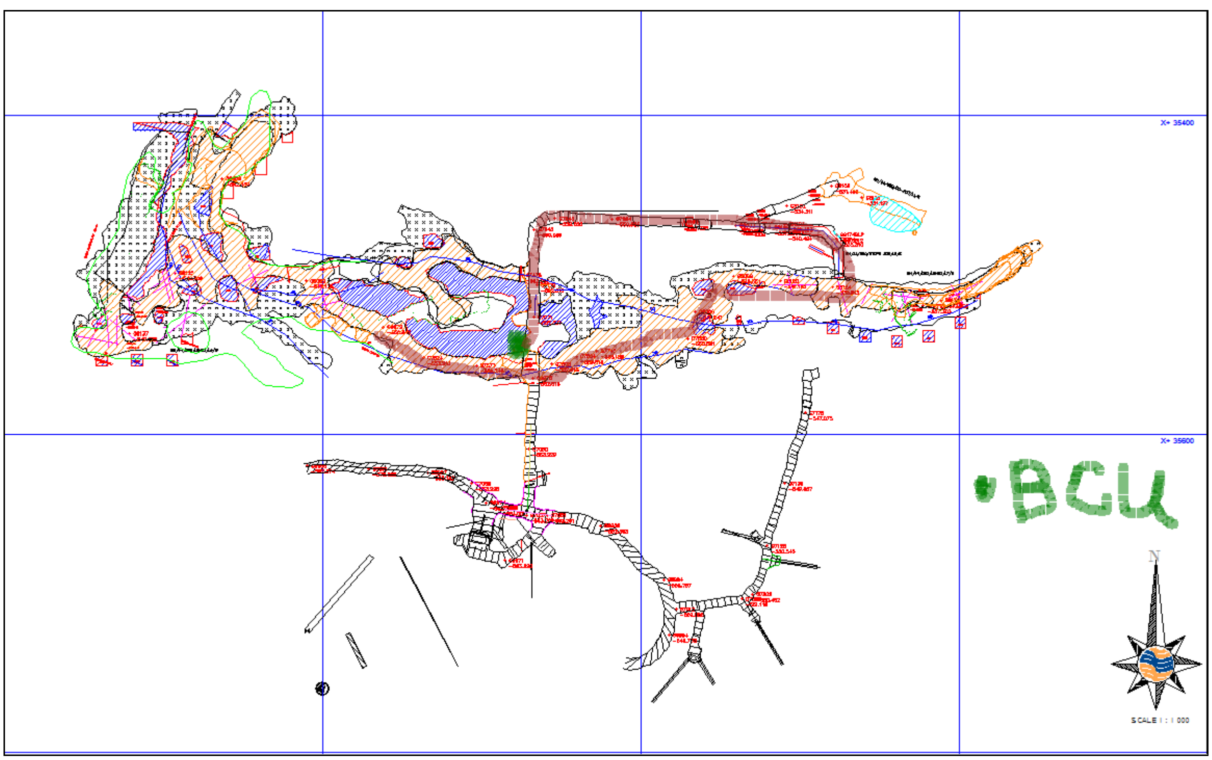
Terms And Conditions

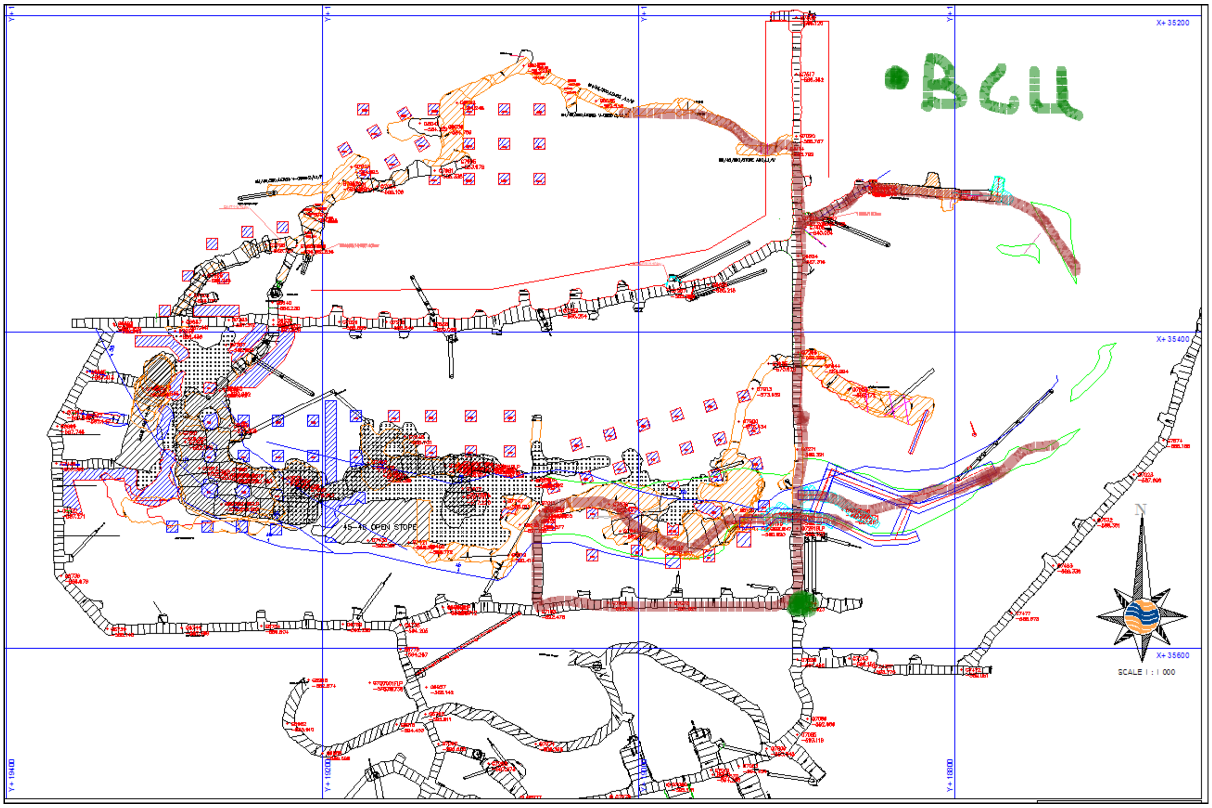
Regards

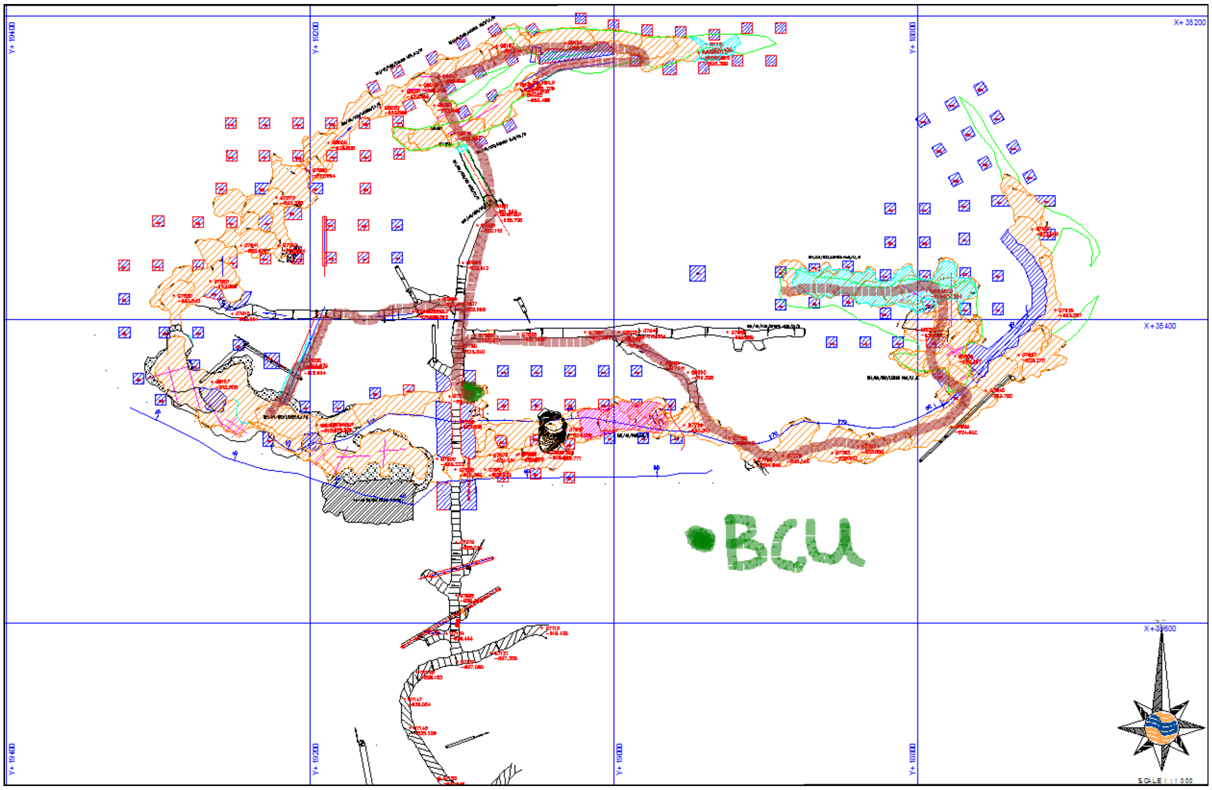
Piet Pretorius

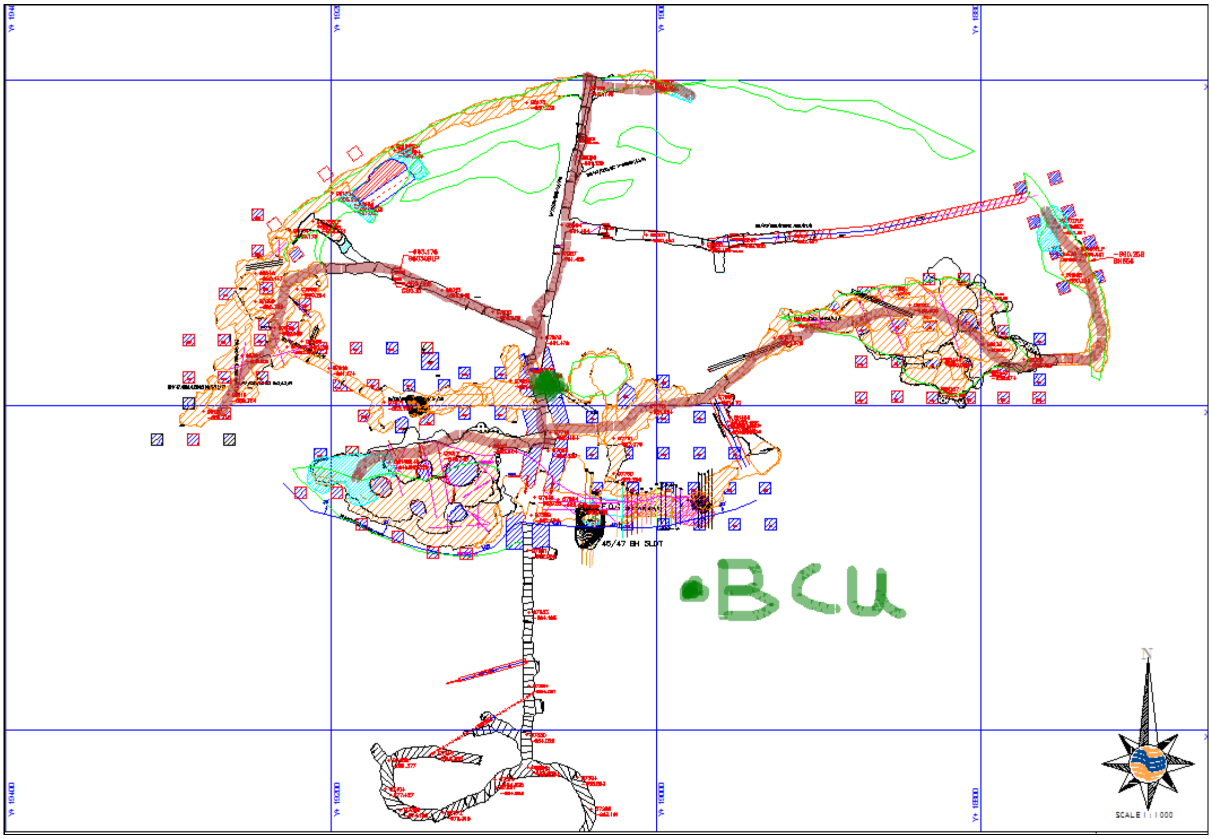
7.4. Appendix E

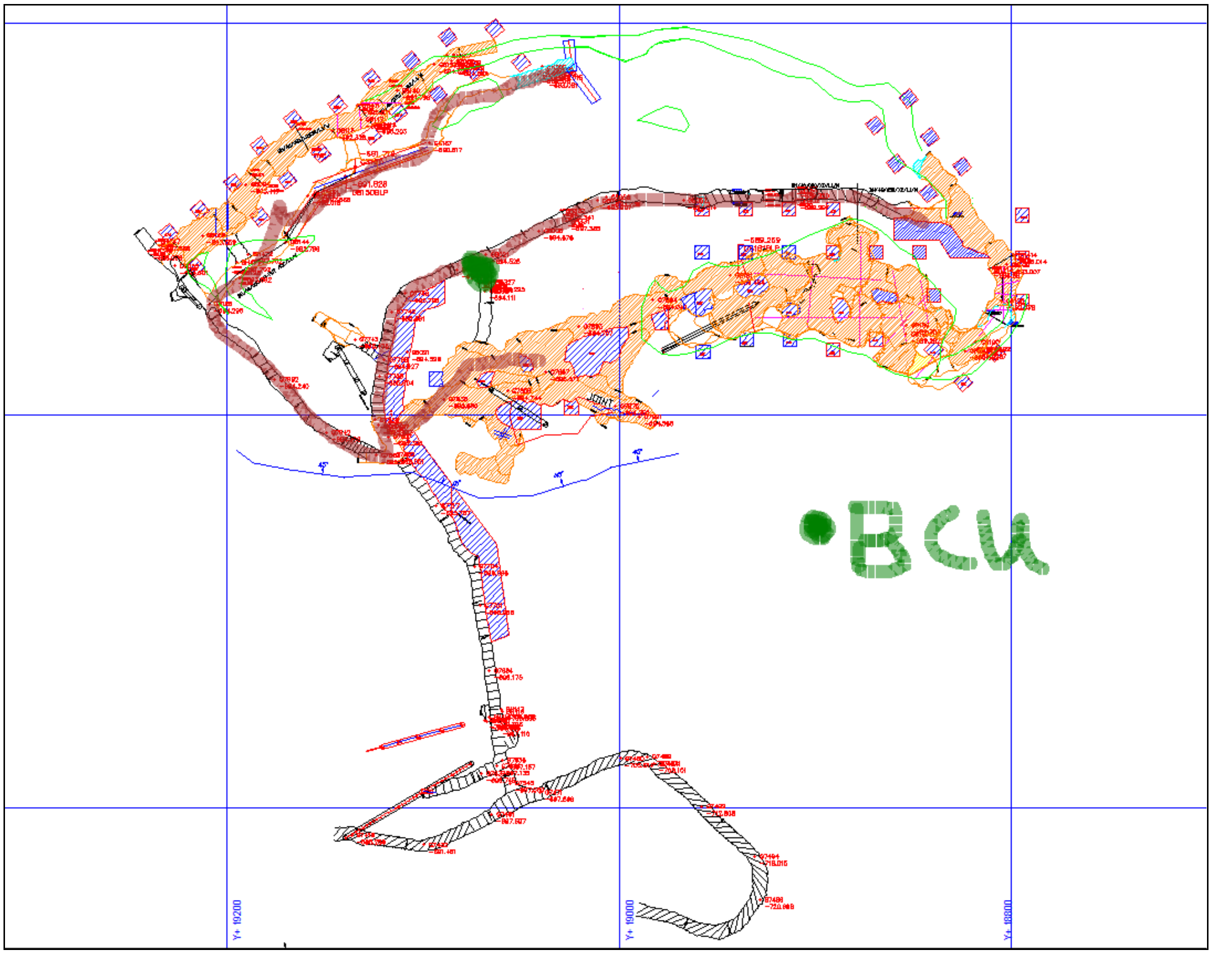




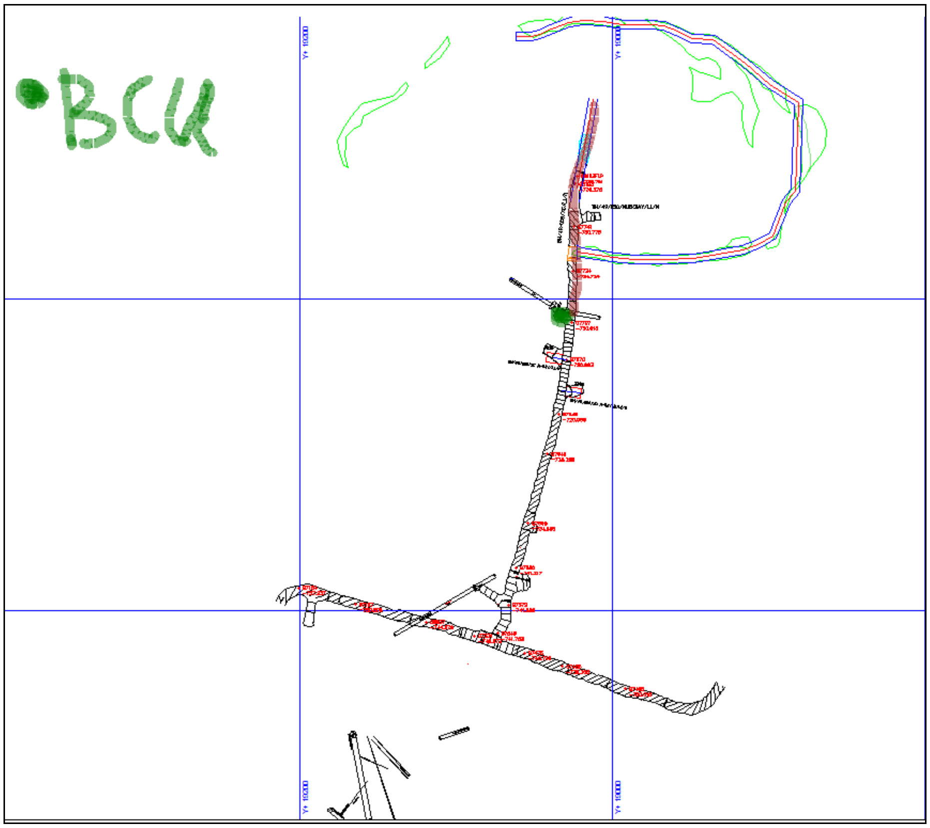

•BCU
15-45 OPEN STOPE
SCALE 1 : 1 000


•BCU


BCU
45/47 BH SLOT
N



•BCu


•BCU

7.5 Appendix F

AEL Mining Services

O'Kiep Depot
Nababeep
PO Box 437
Springbok
South Africa, 8270

Tel +27 27 713 8597
Fax +27 27 713 8598

aelminingservices.com

AEL Mining Services

16 March 2015

The Manager

Black Mountain Mine

Private Bag X01

Aggeneys

REF No: BMM 2015/16/03/RR6

Attention: Lebogang Korope

<u>Cost Estimation - Confidential</u>

Dear Miss. Lebogang Korope

On behalf of AEL, thank you for your enquiry. I am pleased to quote price as detailed below.

Product Description	Product code	Standard unit Packaging	Unit Price	Quantity required	Total Price
Shot Exploder: AEL Model 181	200145	1	R12 821.88	1	**R 12,821.88**

<u>Validity of Product Prices</u>
This quote remains firm until April 15, 2015.
AEL conditions of sale apply.

<u>Exclusions</u>
All prices quoted exclude VAT and Delivery costs from Okiep Depot, Nababeep to Black Mountain Mine, Aggeneys.

<u>Orders</u>
Submit your orders by fax for the Attention of the Magazine Master on fax number +2727 713 8598. The phone number is +2727 713 8597.

Should you require further information or assistance, please do not hesitate to contact me.

Thank you

Yours Sincerely,

Raymond Van Wyk
Explosive Engineer
Open Pit & Massive Mining; Northern Cape + Namibia; Mobile SA: +27 82 453 1146 Nam: +264 811 427 090; Fax: +2727 713 8597; Email: Raymond.VanWyk@aelms.com

Any recommendation, statement or suggestion relating to the product or the use thereof, contained herein is given in good faith and believed to be accurate, but the buyer shall satisfy himself of the suitability of the product for it's own particular purpose, even it that purpose has been specified by the seller. Any expressed warranty or condition, statutory or otherwise, is specifically excluded. African Explosives Limited will not be liable for any damage of whatsoever nature of kind, whether direct, indirect or consequential, suffered by the buyer or any other party, howsoever arising, even if such damage is caused by the negligent act or omission of African Explosives Limited.www.aelms.com

AEL Mining Services

O'Kiep Depot
Nababeep
PO Box 437
Springbok
South Africa, 8270

Tel +27 27 713 8597
Fax +27 27 713 8598

aelminingservices.com

Mining Services

23 March 2015

The Manager

Black Mountain Mine

Private Bag X01

Aggeneys

REF No: BMM 2015/23/03/RR7

Attention: Lebogang Korope

Cost Estimation - Confidential

Dear Miss. Lebogang Korope

On behalf of AEL, thank you for your enquiry. I am pleased to quote price as detailed below.

Product Description	Product code	Standard unit Packaging	Unit Price	Quantity required	Total Price
ED(MDF):3.0M DIGISHOT(102) AFRICA	304487	102 units	R 163.50	1 case	R 16,677.35
IEDCAR:CU 2.0M	204368	800 units	R 22.31	1 case	R 17,850.67
WIRE PVC COAT TT ,69MM RED/BL 300M COIL	200222	1 roll	R 1 121.88	1 roll	R 1,121.88

AEL Mining Services

O'Kiep Depot
Nababeep
PO Box 437
Springbok
South Africa, 8270

Tel +27 27 713 8597
Fax +27 27 713 8598

aelminingservices.com

Mining Services

20 February 2015

The Manager
Black Mountain Mine
Private Bag X01
Aggeneys
Northern Cape
8256

REF.NO. BMM 2015/02/22/RR2

Cost Estimation - Confidential

Dear Mr Opperman

On behalf of AEL Mining Services, thank you for your enquiry. I am pleased to quote prices as detailed below.

Product Description	Product code	Unit Price	Quantity required	Total Price
DIGISHOT BLASTER 300 S	303410	R 9 966.33	1	R 9 966.33
MAINS CHARGER (8 PIN CONFIGURATION)	304186	R 368.73	1	R 368.73
CE4 TAGGER V3 (DIGISHOT) 2 WIRE	305904	R 14 746.60	1	R 14 746.60
CE4 EXTENDED BATTERY PACK (DWG-104470)	305747	R 796.58	1	R 796.58
DIGISHOT SMARTKEY RED	303160	R 716.38	2	R 1 432.76
DIGISHOT SLING BAG	202586	R 175.50	1	R 175.50
4-2 WIRE (POGO) CONNECTOR CONVERTER	305161	R 343.85	1	R 343.85
			TOTAL	R 27 830.35

AEL Mining Services

O'Kiep Depot
Nababeep
PO Box 437
Springbok
South Africa, 8270

Tel +27 27 713 8597
Fax +27 27 713 8598

aelminingservices.com

AEL Mining Services

16 March 2015

The Manager

Black Mountain Mine

Private Bag X01

Aggeneys

REF No: BMM 2015/16/03/RR6

Attention: Lebogang Korope

<u>Cost Estimation - Confidential</u>

Dear Miss. Lebogang Korope

On behalf of AEL, thank you for your enquiry. I am pleased to quote price as detailed below.

Product Description	Product code	Standard unit Packaging	Unit Price	Quantity required	Total Price
Shot Exploder: AEL Model 181	200145	1	R12 821.88	1	R 12,821.88

7.6. Appendix G

Product software	**Each**	**No units**	**Total costs**
Blast controller	R 17 178.75	1	R 17 178.75
Blast web software	R 29 394.90	1	R 29 394.90
Blast web server configuration	R 24 497.10	1	R 24 497.10
TOTAL			**R 71 070.75**

Products hardware	**Each (R)**	**No units**	**Total costs (R)**
BCU	46959.8	8	R 375 678.40
RED key	729.3	8	R 5 834.40
YELLOW key	729.3	8	R 5 834.40
Tagger	13942.5	2	R 27 885.00
Terminator	588.9	20	R 11 778.00
TOTAL			**R 427 010.20**

Spares	**Each (R)**	**No units**	**Total costs (R)**
BCU Ui Module	22243	1	R 22 243.00
BCU power supply module	4708.6	1	R 4 708.60
BCU back up battery	312	1	R 312.00
BCU voice com module	4708.6	1	R 4 708.60
BCU voice coms UI module	19874.4	1	R 19 874.40
Red key	729.3	2	R 1 458.60
Yellow key	729.3	2	R 1 458.60
Tagger	13942.5	1	R 13 942.50
Terminator	588.9	12	R 7 066.80
TOTAL			**R 75 773.10**

Training	**Each (R)**	**No units**	**Total costs (R)**
Blast controller	17178.75	1	R 17 178.75
BCU	46959.8	1	R 46 959.80
Red	729.3	1	R 729.30
Yellow key	729.3	1	R 729.30
Terminator	588.9	3	R 1 766.70
Net shock training pack	52.65	60	R 3 159.00
TOTAL			**R 70 522.85**

Product training	Each (R)	No units	Total costs (R)
Engineering training	R9449.7	4	R 37 798.80
User training	R9449.7	4	R 37 798.80
Management training	R3543.8	1	R 3 543.80
Software training	R9449.7	4	R 37 798.80
TOTAL			**R 116 940.20**

Level	Face	Copper wire (1.8 mm)	Cost(R)/m	Total (R)	Copper wire (0.63 mm)	Cost(R)/m	Total (R)
42			1.63	0		1.6	0
			1.63	0		1.6	0
43	1	250	1.63	407.5	40	1.6	64
			1.63	0		1.6	0
44	1	580	1.63	945.4	20	1.6	32
	2	280	1.63	456.4	20	1.6	32
			1.63	0		1.6	0
45	1	120	1.63	195.6	40	1.6	64
	2	400	1.63	652	40	1.6	64
	3	360	1.63	586.8	40	1.6	64
	4	390	1.63	635.7	40	1.6	64
			1.63	0		1.6	0
46	1	510	1.63	831.3	40	1.6	64
	2	170	1.63	277.1	40	1.6	64
	3	360	1.63	586.8	40	1.6	64
	4	190	1.63	309.7	40	1.6	64
			1.63	0		1.6	0
47	1	200	1.63	326	40	1.6	64
	2	120	1.63	195.6	40	1.6	64
	3	180	1.63	293.4	40	1.6	64
	4	440	1.63	717.2	40	1.6	64
			1.63	0		1.6	0
48	1	160	1.63	260.8	40	1.6	64
	2	460	1.63	749.8	40	1.6	64
	3	220	1.63	358.6	40	1.6	64
			1.63	0		1.6	0
49	1	80	1.63	130.4	40	1.6	64
TOTAL				**R 8 916.10**			**R 1 152.00**