ANGLO PLATINUM WORLD LEADER IN PLATINUM

Optimisation of a Mechanised Platinum Mining Section

by

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EXECUTIVE SUMMARY

The introduction of Extra Low Profile (XLP) mechanised equipment within Anglo Platinum is an important strategy to improve safety and minimise the cost of their mining operations. The purpose of this project is to analyse and improve the XLP section's production performance at Waterval Central Shaft.

In this project the XLP section is considered to be a business unit which forms a small but integral part in the functioning of Waterval Central Shaft. The analysis focuses not only on the processes within the XLP section, but also on the business strategy, organisational structures, systems and resources which are related to the XLP section. This ensures that proper insight is gained into the business unit's functioning and that it is not just considered to be an isolated system.

Making use of an extensive range of Industrial Engineering tools and techniques, a solution has been designed for the problems experienced within the XLP section. The solution entails the introduction of two backup XLP machines to the existing fleet, changes in staff structures and supplier relationships as well as a more disciplined approach to the mining cycle, maintenance and pre-development.

Should this solution be implemented, it will enable the XLP section at Waterval Central Shaft to perform to its potential. Anglo Platinum will be able to extend the introduction of XLP equipment to other mines, recognising that the modernisation of their mining operations improves safety and cost-effectiveness.

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LIST OF ABBREVIATIONS

ASD	Advanced strike drive
KPI's	Key performance indicators
LHD	Load Haul Dump Truck
LP	Low Profile
UG2	Upper Group 2
XLP	Extra Low Profile

1 INTRODUCTION AND BACKGROUND

1.1 Mining Background

Anglo Platinum is the world's largest primary producer of platinum, accounting for about 38% of the world's annual production. The company has mining operations in South Africa, Canada, Russia, Brazil and China (Anglo Platinum Annual report, 2007).

Anglo Platinum's Waterval Shaft is located in the Rustenburg Section of the Bushveld Complex in South Africa. The Bushveld Complex is well-known for its large proportion of the world's platinum and palladium resources. It hosts three different ore bodies, the Merensky Reef, the Upper Group 2 (UG2) Reef, both of which can be traced on surface for 300 km in two separate arcs, and the Plat Reef, which extends for over 30 km (Cawthorn, 1999).

The Merensky Reef has been the principal source of platinum since it was first worked in 1925. However, the other reefs have grown in importance, so that by 1999 the Merensky Reef accounted for just over 50% of all the platinum-bearing ore processed in South Africa.

Exploitation of the UG2 began in the 1970s and has steadily increased. In 1999 it was the source of 42% of ore processed by Anglo Platinum. The Plat Reef, briefly mined in the 1920s, was not exploited on a large scale until 1993.

One of the biggest challenges of mining the UG2 is that the reef is very narrow (60-80cm). A large amount of injuries occur at the stope face of narrow reef mines. Mining companies realise that they have to develop new mining technologies to improve safety. One of the new technologies currently being employed is the mechanisation of the mines' underground operations.

According to Croll (2004), mechanisation is the use of powered machinery to replace manual labour. Within the mining context, mechanisation refers to human operators being given machines to assist them with stoping functions. However, it does not refer to the use of hand-powered tools such as drills.

Figure 1.1 Anglo Platinum's operations in the Bushveld Complex

1.2 Project Background

Anglo Platinum introduced mechanisation into the mining environment in order to improve injury-free production, and reduce the costs of their mining operations. Low Profile (LP) machines were tested in 2001 which can perform stoping functions at heights of 1.8m. Each of these machines is operated from a remote control device by an operator sitting in a safe position a few metres from the machine. The LP suite did however not prove to be very cost effective due to the following reasons stated by Harrison (2006):

- Narrow UG2 reef channel widths of 60-80cm
- Excessive dilution due to 100-120cm waste cut
- Ineffective waste sorting techniques
- High operational costs per ounce of platinum

Anglo Platinum solved these problems by replacing the LP machines with Extra Low Profile (XLP) trackless machines. The XLP suite was tested at Waterval from December 2003. The XLPs solved the above-mentioned problems by:

- Allowing the mine to achieve trackless mechanised stoping at heights below 1.2m with the associated safety benefits.
- Reducing the stoping height form 1.8m to <1.2m, resulting in less dilution and improved ore grades.
- Potentially improving the profitability when compared to conventional and other mechanised operations.

However, the XLP suite still did not meet the target performance of 2200m^2/month. In August 2004 it did achieve 2200m^2, but the average for 2004 was only 1420m^2/month.

1.3 Problem Definition

In 2006, after converting the XLP section from a Room & Pillar layout to a Breast layout and employing longer panels (21-25m) the XLP section finally achieved the target performance with an average production rate of 2374m²/month at less than R160/ton. The other key performance indicators (KPI's) were also met and the XLP suite proved to be reliable and able to perform to expectations. The New Mining Technologies (NMT) department of Anglo Platinum declared the project a success.

Inexplicably, the XLP section performed very poorly in 2007. All the KPI's were down and the section could only achieve an average production rate of approximately 1000m²/month.

This project will investigate the factors that influenced the drop in performance. All the KPI's, organisational structures, processes, systems and resources associated with the XLP section will be examined to optimise the system for higher production performance and reduced operating cost.

1.4 Project Aim

The aim of this project is to analyse and improve the production rate of the XLP section at Waterval Central Shaft.

1.5 Objectives

The project objectives are threefold:

- Analyse the current performance of the XLP section at Waterval Central Shaft.
- Identify why the XLP section is not meeting the target monthly production rate of 2200m² per month.
- Determine how the XLP section's production rate can be optimised.

1.6 Project Scope

The analysis and design will be predominantly from an operational perspective. The way the XLP section measure up to the expected production performance levels will be evaluated. The strategic business goals, organisational structures, processes, systems and resources supporting the XLP section will be investigated to optimise the system for higher production performance and reduced operating cost.

The XLP section is a business unit that forms a small but integral part of the Waterval Shaft system. The scope of this project is limited to the XLP section itself. However, the effect of the rest of the mining system on the XLP section will also be taken into consideration.

2 LITERATURE REVIEW

This chapter will review the literature and the theoretical aspects of XLP mining which have distinct inputs, outputs, process steps and variables. The findings of other related studies will also be reviewed.

2.1 XLP Mining Benefits

According to Harrison (2008) XLP mining has the following benefits:

- Safety is improved because the operator is removed from the sharp end of the face.
- There is an improvement in productivity by more accurate drilling, higher face advance and production rate per employee due to the fully mechanized stoping and development.
- It is more profitable than conventional mining.
- Components of conventional stoping are replaced (e.g. Dozers are used instead of scrapers to clear the stope face from ore).
- It has the potential to mechanise at stope widths of <1,0m and at reef dips of 18 - 22° gradient.

2.2 XLP Suite

The XLP suite currently consists of the following equipment.

Table 2-1 XLP Equipment Suite

Equipment Name	**Quantity**	**Purpose**
Axera XLP Drill Rig	1	Stope face drilling
XLP Roofbolter	2	Stope face bolting
XLP Dozer	1	Stope face cleaning
LP Axess dev rig/bolter	2	Drilling and bolting of all stope development
LP Load Haul Dump	2	Loading of all stoping and development
LP Multi Purpose Vehicle	2	Loading and transport of all material
LP Jeep	1	Men and small material transport
Total XLP section	**11 units**	

The technical specifications for the Axera XLP Drill Rig and the XLP Roofbolter are included as Appendix C.

2.3 Process Steps

The following process steps are identified for XLP mining by Harrison (2006):

2.3.1 Stope Face Drilling & Blasting

The stope face is drilled with XLP Drill Rig where the explosives can be inserted. The face is drilled at a 90° angle to allow for throw blasting of at least 40% of the ore into the Advanced Strike Drive (ASD). The ASD serves as a channel from which the Load-haul-dump truck (LHD) collects the ore. Shock tubes and emulsion explosives are used for charging up after the drilling is complete. The drill holes are 1.94m in length and there is an advance rate of 1.77m/blast at the stope face. Blasting only takes place on day shifts and night shifts with a 40 minute re-entry period.

2.3.2 Stope Face Cleaning

The stope face is cleaned by the XLP Dozer by pushing the broken ore into the ASD. A Low Profile Load-haul-dump truck (LP LHD) collects ore in the ASD from where it is hauled to the tipping point. The LHD accesses the strike conveyor through dip tramming raises spaced 70m apart. The strike conveyor belt is maintained at a maximum of 80m from the face. Stope sweepings are carried out by the dozer, which is able to clean on the dip between the permanent rows of support.

2.3.3 Stope Face Roof Bolting

Roof bolt support is put in place by the XLP Roofbolter. The way the stope face is supported is based on the rock quality structures, joint angle and spacing, the filling condition and the hanging wall stratigraphy of the specific site.

2.3.4 Stope ASD Drilling, Blasting and Bolting

The ASD area is drilled and bolted with a LP Axess Rig and the ASD is advanced at 2.0m/blast. The bolting standard is done according to rock engineering recommendations.

2.3.5 Stope ASD Loading and Ore Removal

The ore from the ASD is loaded by the LP LHD and transported to the strike or dip belt tipping point, approximately 75m from the loading point.

These five process steps repeat in the same sequence every stope cycle (see Table 2-2). One process step is carried out per panel per shift. It will therefore take five shifts to complete one cycle at a specific panel. After every shift the equipment travels to the adjacent panel where it will complete the same task during the next shift. Every step in the process is critical in order to keep the cycle going. Therefore, if a problem occurs at one of the panels and the scheduled task cannot be completed during the shift, the work at all five panels need to be stopped to prevent everything from going out of sequence.

Table 2-2 A five-shift XLP stope cycle

	Panel 1	**Panel 2**	**Panel 3**	**Panel 4**	**Panel 5**
Shift 1	Drill & blast	Cleaning	Roof bolting	ASD drill, blast, bolt	ASD load & ore removal
Shift 2	Cleaning	Roof bolting	ASD drill, blast, bolt	ASD load & ore removal	Drill & blast
Shift 3	Roof bolting	ASD drill, blast, bolt	ASD load & ore removal	Drill & blast	Cleaning
Shift 4	ASD drill, blast, bolt	ASD load & ore removal	Drill & blast	Cleaning	Roof bolting
Shift 5	ASD load & ore removal	Drill & blast	Cleaning	Roof bolting	ASD drill, blast, bolt

2.4 Logistics

Men and material can access the XLP section from the top. Access is also available from each ASD and dip raises provided every 70m on strike.

XLP equipment move from panel to panel by travelling up-dip from the stope face and out at the top of the panel. It then enters the new ASD and stope face through the down-dip strike pillar holing. The overall face shape must be in line and the cycle of mining strictly adhered to in order to avoid excessive travelling distances of XLP equipment from panel to panel.

The planned rate of production requires only one panel to be blasted per shift. Therefore the XLP Drill Rig and Roofbolter only need to travel to one panel per shift. This will preferably be the adjacent panel. Allowance has been made for travelling time from panel to panel for all trackless mining equipment. The round trip distance varies between 20m and 150m depending on the points of travel. The average round trip distance is 85m (Harrison, 2006).

2.5 Ergonomics of XLP mining

A detailed investigation into the ergonomics risk factors associated with XLP mining was conducted by James et al. (2005). Underground evaluations were performed to examine the working conditions of the XLP operators. The following ergonomic risk factors were identified in the study:

- The operators experience discomfort in the lower back during all the process steps where XLP equipment are used. This can be attributed to the operators having to work in the kneeling position due to the low stoping height (approximately 1.2m).

- Discomfort is also experienced in the shoulder regions due to the pulling of the heavy power cable of the XLP.

- The remote-control consoles used by the operators are not clearly marked and they are frequently covered in dirt. This makes it very difficult to read the labelling on the control and increase the possibility of errors.

- Operators complained about the viewing angles and line of sight around the XLP machines. During drilling operations the operator are required to move closer to the machine to ensure that the drill bit are correctly positioned at the face. This provides a potential risk if the operator moves too close to the working mechanisms of the drill rig.

- Hazardous areas of the XLP machines are not properly marked.

2.6 Earlier Investigation on XLP Performance at Waterval

Botha (2006) performed a critical investigation and evaluation of XLP equipment used on Waterval Central Shaft. The purpose of his investigation was to highlight the factors facilitating the poor performance of the XLP suite and to give possible recommendations for solving the problem.

The focus of the study was merely on the processes itself and did not take into account the effect of the business strategy, organisational structures, systems and resources associated with the XLP section.

The following recommendations were made by Botha (2006):

- The mining layout should be corrected by aligning the faces, moving the strike belt within 50m from the nearest face and having electrical boxes installed between adjacent panels.

- A qualified artisan should be employed for each production shift. The operator can then communicate with him via radio should problems arise with the equipment.

- The mining sequence need to be restored.

2.7 Industrial Engineering Methods, Tools and Techniques

2.7.1 Gap analysis

Gap analysis is used to assess the client's performance relative to the expectations of its customers, or relative to the performance of its competitors (Chase et al., 2006). At its core are two questions:

- Where are we?
- Where do we want to be?

A gap analysis will be executed on the XLP section. The XLP section's actual performance will be compared to the target performance benchmarked by Anglo Platinum.

2.7.2 Ishikawa Diagram

Ishikawa diagrams graphically illustrate hypothesised relationships between potential causes and the problem under study. Once the Ishikawa diagram is constructed, the analysis would proceed to find out which of the potential causes were in fact contributing to the problem (Chase et al., 2006).

Ishikawa diagrams will be used to investigate the cause of the problems experienced in the XLP section. It will give a good overview of the problem and its contributing factors.

2.7.3 SWOT Analysis

SWOT analysis is a simple framework for generating strategic alternatives from situation analysis (Rwigema et al., 2005):

- **S**trengths: Attributes of the organization that are helpful to achieving the objective.
- **W**eaknesses: Attributes of the organization that are harmful to achieving the objective.
- **O**pportunities: External conditions that are helpful to achieving the objective.
- **T**hreats: External conditions that are harmful to achieving the objective.

This method is not only applicable to the corporate level but also to a business unit such as the XLP section. It will highlight the internal and external factors that have an influence on the performance.

2.7.4 Business Modelling

Business Modelling is the activity of representing both the current ("as is") and future ("to be") processes modelling of an enterprise, so that the current process may be analysed and improved (Scheer, 1994). According to Chase et al. (2006) the analysis of processes will give valuable insight into the process capacity, cost and throughputs. It will become clear what the interdependencies between the processes are.

The business processes relating to the XLP section have been mapped using the IDEF0 (Function Modelling) and IDEF3 (Process Description Capturing) languages.

2.7.4.1 IDEF0 Method

According to the National Institute for Standards and Technology (1993), the IDEF0 method is used to specify function models ("what to do"). It allows the user to portray a view of the process including the inputs, outputs, controls and mechanisms.

- Inputs are resources consumed or transformed by the process;
- Outputs are the things created through the consumption/transformation of the inputs by the process;
- Controls are the elements guiding the processes: policies, guidelines. standards, laws;
- Mechanisms are the agents that accomplish the actions (activities) contained by the process.

Figure 2.1 Generic IDEF0 Diagram

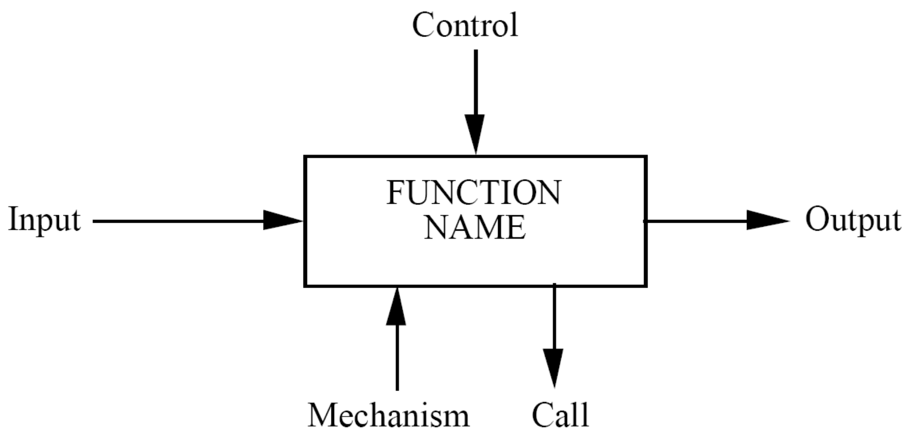


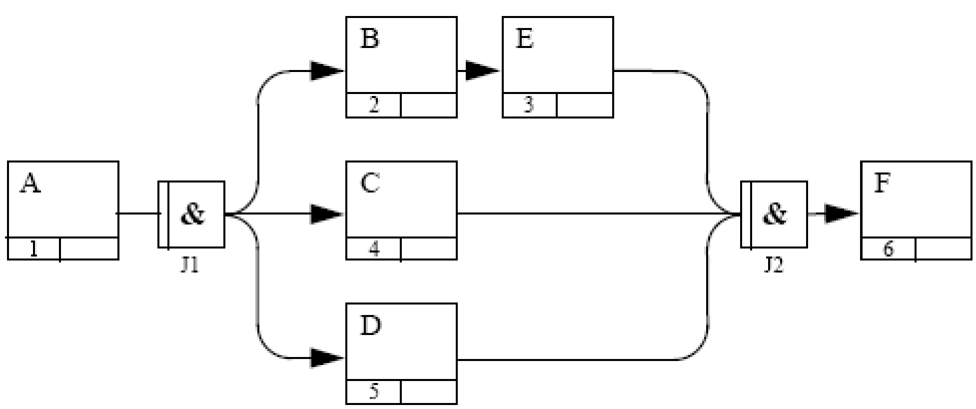
Figure 2.1 presents a generic IDEF0 diagram. Resources that are used in the process but that are not consumed or transformed by the process are represented as controls rather than inputs.

The diagram shows the activation of activities, not the flow of activities. The diagrams may also be decomposed into lower level diagrams. The hierarchy is maintained via a numbering system that organizes the parent and child diagrams.

2.7.4.2 IDEF3 Method

In this description, the process knowledge captured with IDEF3 is organized within a scenario. The basic IDEF3 syntactic unit in this case is an UOB (Unit of Behaviour). Depending on the surrounding structure, UOBs may become functions, activities, processes, etc. An UOB may be decomposed in other UOBs and may also be cross-referenced with IDEF0 activities (Mayer et. al, 1995). A generic IDEF3 Process Flow Diagram is shown in Figure 2.2 where A, B, C, D, E and F are the UOB's.

Figure 2.2 Generic IDEF 3 Process Flow Diagram



2.7.5 Monte Carlo Method

The Monte Carlo method is often used to develop static models of systems with significant uncertainty in inputs. It uses randomly generated data and computer simulations to approximate solutions to complex problems.

Static models with variable inputs will be developed of all the XLP processes. Sensitivity analyses will be done to determine the different inputs' influence on the process performance.

2.7.6 Theory of Constraints

Theory of Constraints (TOC) is an overall management philosophy geared to help organisations continually achieve their goals. It consists of the following five steps described by Chase et al. (2006):

1. Identify the system constraints. No improvement is possible unless the constraint or weakest link is found.

2. Decide how to exploit the system constraints. Make the constraints as effective as possible.

3. Subordinate everything else to that decision. Align every other part of the system to support the constraints even if this reduces the efficiency of non-constraint resources.

4. Elevate the system constraints. If output is still inadequate, acquire more of this resource so it no longer is a constraint.

5. If, in the previous steps, the constraints have been broke, go back to Step1, but do not let inertia become the system constraint. After this constraint problem is solved, go back to the beginning and start over.

TOC may prove to be a useful tool in the XLP section as it will ensure that the XLP section is in a continuous process of improvement.

2.7.7 Ergonomics

According to Chase et al. (2006) ergonomics is the term used to describe the study of the physical arrangement of the work space together with the tools used to perform a task. In applying ergonomics, we strive to fit the work to the body rather that forcing the body to conform to the work.

An ergonomic risk assessment on operating XLP equipment was already performed by James et al. (2005). A summary of this study can be found in Section 2.5 of this document. In this project the correlation between the ergonomic risks and the XLP section's performance will be evaluated.

3 WORK METHOD

This chapter explains the framework which will be used to execute the project.

3.1 Ceenex Business Engineering Model

The ***Ceenex Value-Based Business Engineering Model©*** (see Appendix A) will be used as a roadmap to carry out the project.

The model identifies three Client Business Focuses:

- *Strategic* – the long-term plan of action designed to achieve a particular goal
- *Operational/Functional* – short-term decisions
- *Transactional* – day-to-day business

The Business Engineering Objects identified within these focuses are the following:

- *Strategy* – long-term decisions
- *Structure* – the hierarchy of elements within the company
- *Processes* – sets of activities that transforms inputs into outputs
- *Systems* – collection of parts that interact with each other to function as a whole
- *Resources* – people, equipment, facilities, funding, etc required for the completion of a project activity

The model describes the workflow method that will be used as follows:

1. *Assess* the current state of affairs
2. *Envision* where the client wants to be
3. *Design* a solution to achieve this objective
4. The client *decides* whether to implement this solution
5. The solution is *deployed*
6. *Support* is provided

3.2 Application of Ceenex Business Engineering Model

The XLP section can be regarded as a business unit consisting of the five business engineering objects identified in the Ceenex model. The focus of this project is primarily at an operational level. The scope is limited to Step 1 through to Step 4 of the Ceenex workflow method:

3.2.1 Assess

The current state of affairs in the XLP section will be assessed by not only analysing the processes within the XLP section, but also looking at the business strategy, structure, systems and resources relating to the XLP section.

All of these business engineering objects can play an integral role on the performance of any business unit. They all need to be assessed individually and collectively in order to gain proper insight into the business unit's functioning.

3.2.2 Envision

Envisioning the desired objectives will require input from the client. Their future expectations of the XLP section will be determined. The KPI's gives some indication of what the section should deliver.

3.2.3 Design

Once the XLP section has been thoroughly assessed and the desired objectives determined, the solution will be designed.

3.2.4 Decide

The client will decide if the solution should be implemented.

4 DATA ANALYSIS

This chapter is a summary of the data that will be used as a benchmark for the XLP section's production performance.

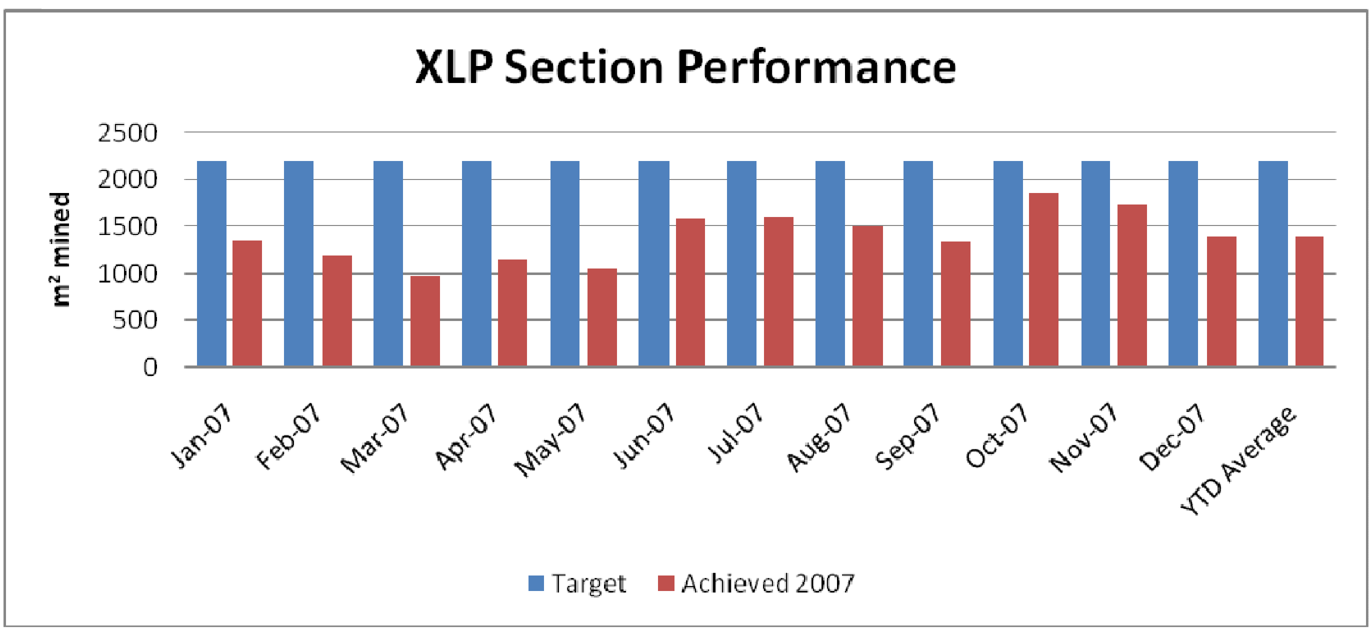
Table 4-1 lists the key performance indicators (KPI's) and their target values as identified by Anglo Platinum for the Waterval XLP section. The actual results achieved in 2007 are also given.

Table 4-1 Waterval XLP section KPI's

Description	Target	Achieved 2007
m^2/month	2200	1398
Tonnes to Concentrator/month (2200 x 1,41 x 3,79)	11 800	8110
m^2/in stope employees	55	35
m^2/total employees	34	21.5
Stoping width (m)	120	141
Grade	2.94	3.94

Figure 4.1 provides a breakdown for the m^2/month achieved by the XLP section in 2007.

Figure 4.1 XLP Section Performance 2007



The target performance values for the various pieces of equipment within the system are specified in Table 4-2. The actual values achieved in 2007 are also given. The monthly performance breakdowns of these machines are given in Appendix B.

Table 4-2 Equipment Performance

Equipment	Description	Target	Achieved 2007
Drill Rig	Holes drilled/shift/rig	126 holes/shift/rig (21m face/3,2hrs)	48.75 holes/ shift/rig
Roofbolter	1,6m bolts/shift/bolter	25 bolts/face/shift (21m face/4,1hrs)	9.609 bolts/shift/bolter
LHD	Tons loaded/shift/LHD	123 tons/shift/LHD (Face+ASD/4,92hrs)	93 tons/shift/LHD
Axess Dev Drill Rig	Drilling (ASD) Drilling (Raise) Bolting (ASD) Bolting (Raise)	39 holes/shift –1,62hrs 34 holes/shift – 1,46 hrs 6 bolts/shift – 0,72 hrs 5 bolts/shift – 0,65 hrs	22.64 holes/shift 3.3 bolts/shift

Availability and utilisation targets have been specified for all the machines in the XLP suite. These are listed in Table 4-3. The actual availability and utilisation achieved in 2007 is also given.

Table 4-3 Equipment Utilisation

Equipment	Description	Target	Achieved 2007
Drill Rig	Availability Utilisation Percussion hrs (3,2/*6,2hrs x 18/23)	85% 41%	68% 21.77%
Roofbolter	Availability Utilisation P/pack hrs (4,1/*6,2hrs x 18/23)	85% 18%	71.8% 10.23
Dozer	Availability Utilisation Engine hrs (3,5/*6,2hrs x 18/23)	85% 56%	73.45% 18.55%

(Harrison, 2007)

Looking at this historical data it is clear that there must be a problem somewhere in the system. None of the targets for any of the machines were met during 2007. The reasons for this is analysed and discussed in the next chapter.

5 ASSESSMENT

This chapter describes the tools and techniques that have been applied during the assessment of the XLP section. The results of the various assessment methods are also provided.

5.1 Business Modelling

Business Modelling is the activity of representing both the current ("as is") and future ("to be") processes modelling of an enterprise, so that the current process may be analysed and improved (Scheer, 1994). According to Chase et al. (2006) the analysis of processes will give valuable insight into the process capacity, cost and throughputs. It will become clear what the interdependencies between the processes are.

The business processes relating to the XLP section have been mapped using the IDEF0 (Function Modelling) and IDEF3 (Process Description Capturing) languages.

5.1.1 IDEF0 Method

In Figure 5.1 a summary of the hierarchy of the functions performed within the XLP section is presented.

The IDEF0 model and decompositions for the XLP section are illustrated in Figures 5.2 - 5.7.

Figure 5.2 IDEF0 Model Browser

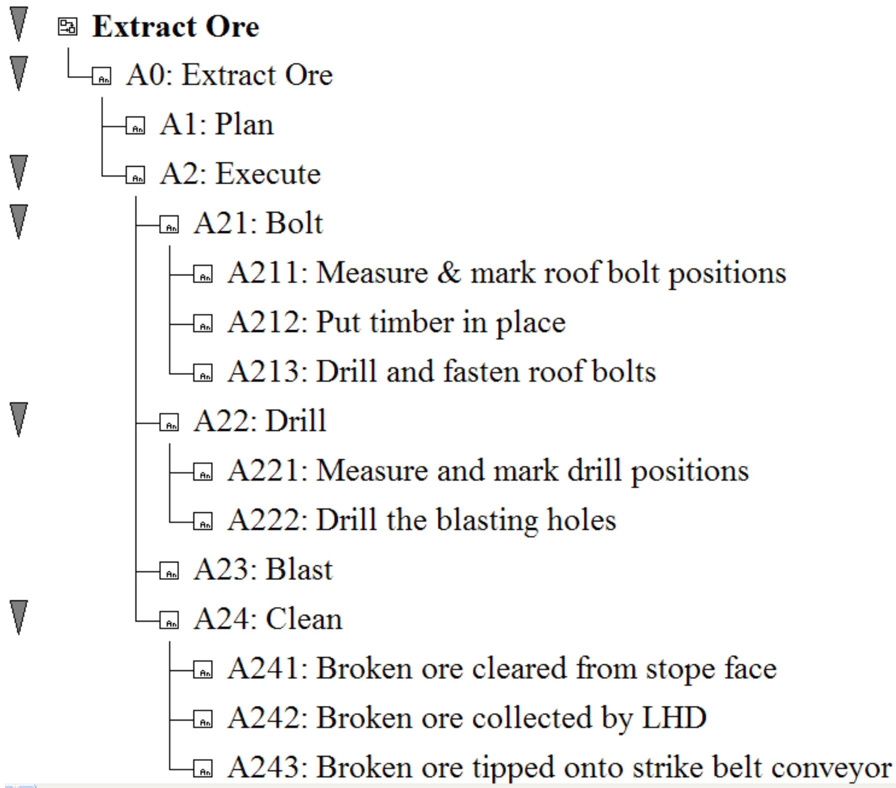


Figure 5.1 A0 Context Diagram

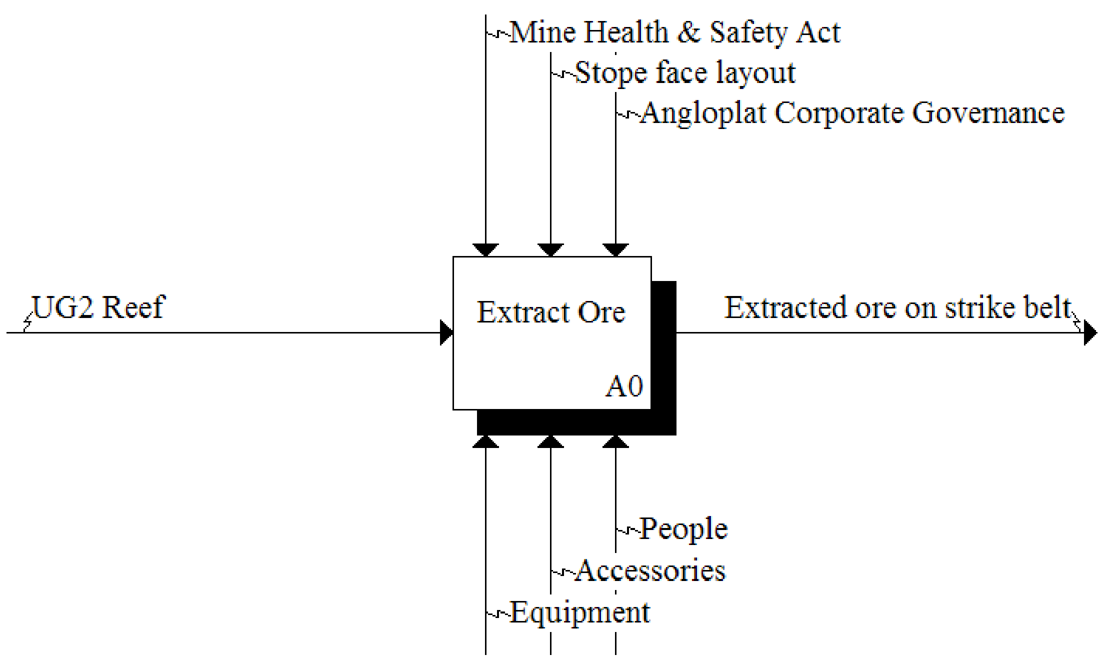


Figure 5.3 "Extract ore" decomposition

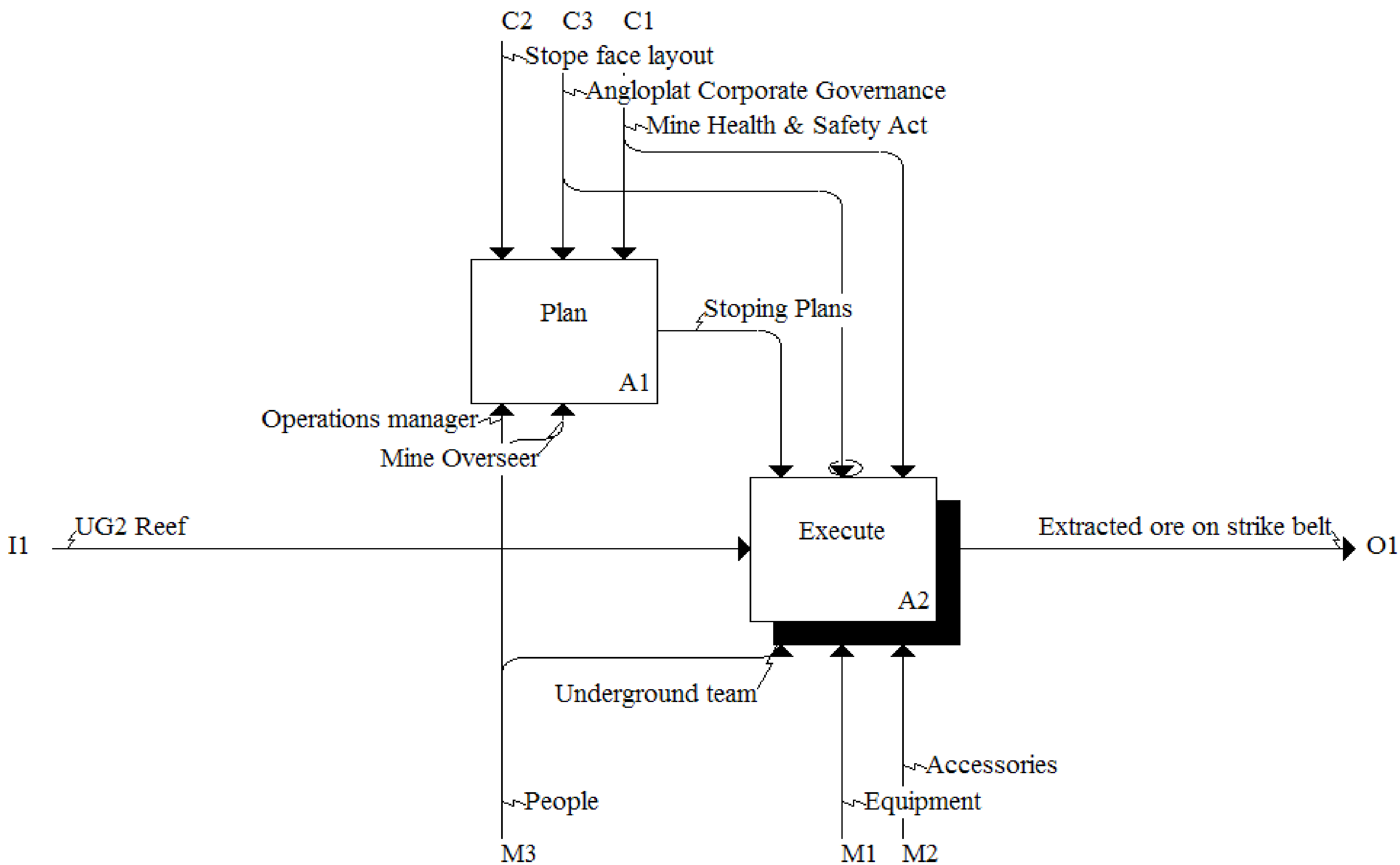


Figure 5.4 "Execute" decomposition

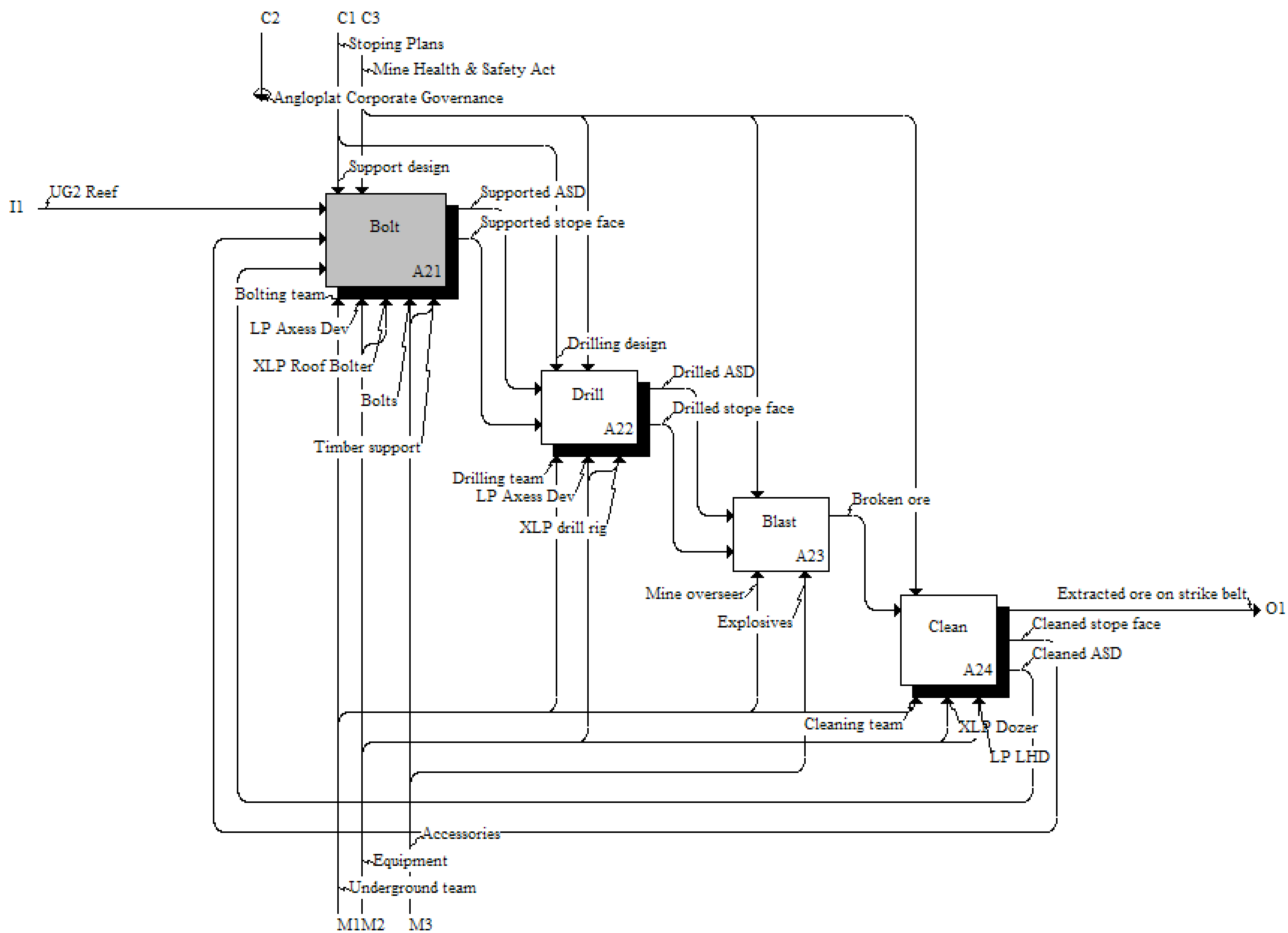


Figure 5.5 "Bolt" decomposition

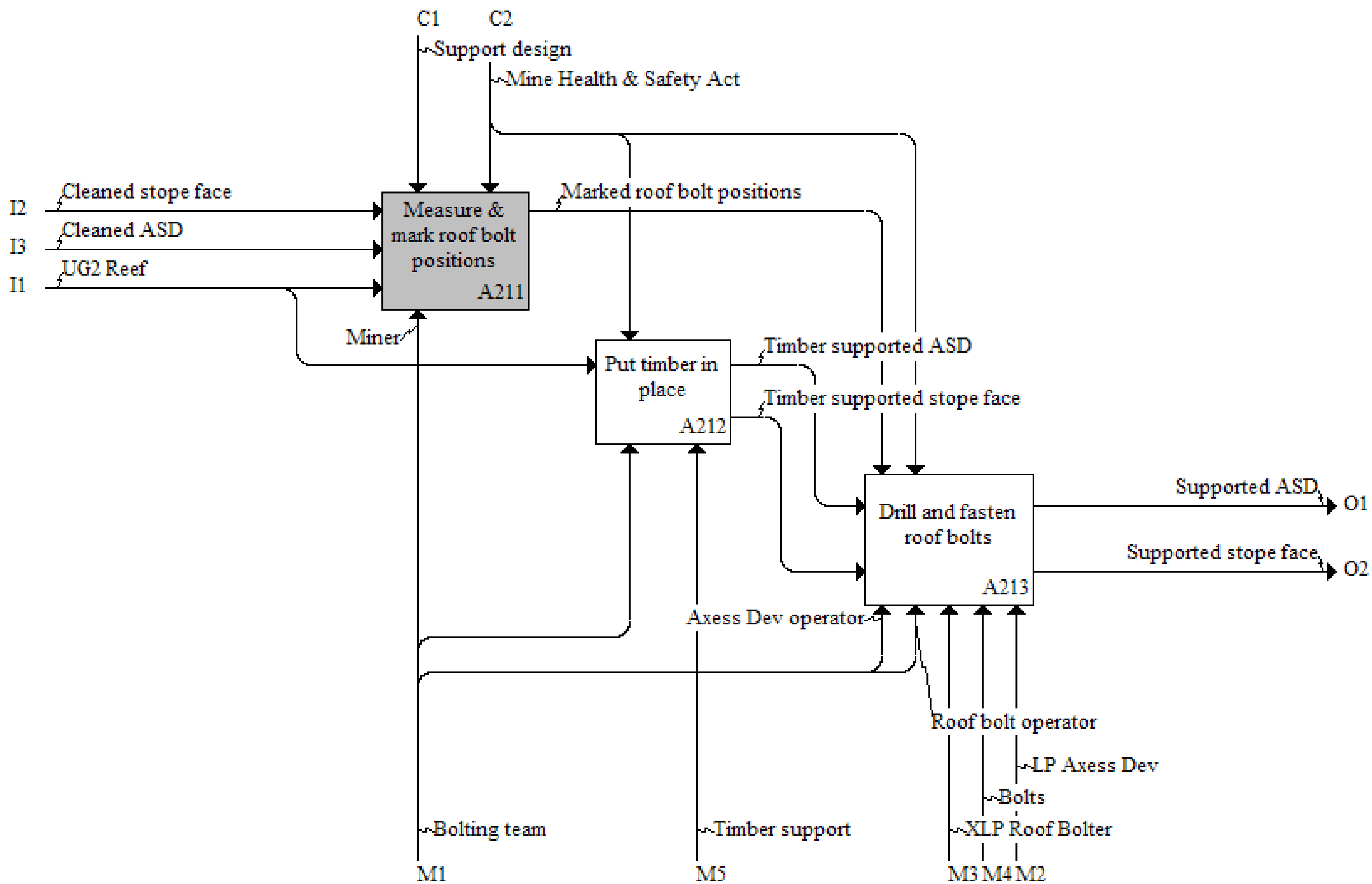


Figure 5.6 "Drill" decomposition

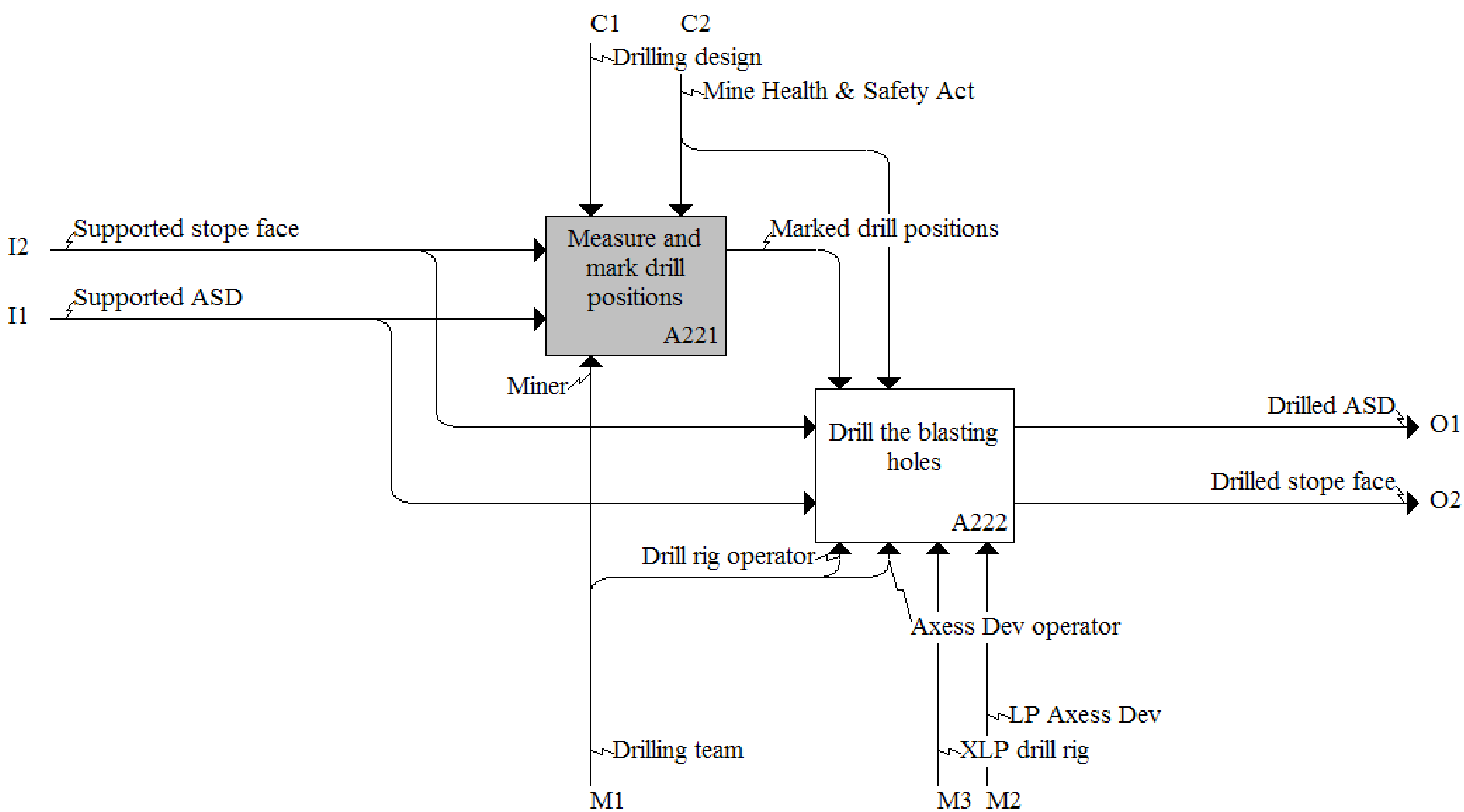
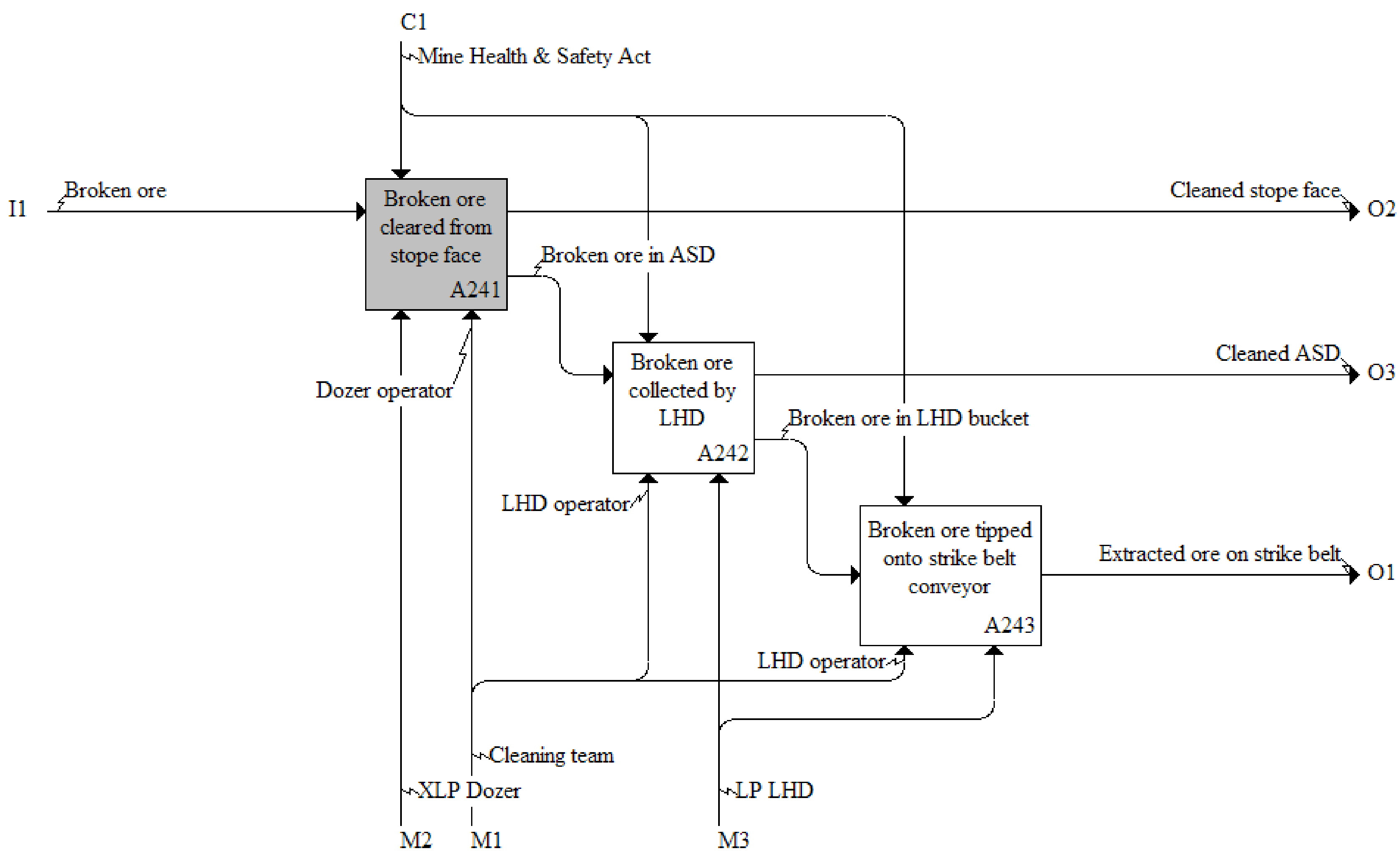


Figure 5.7 "Clean" decomposition



5.1.2 IDEF3 Method

Figure 5.8-9 on the following pages presents the IDEF3 model for the XLP process.

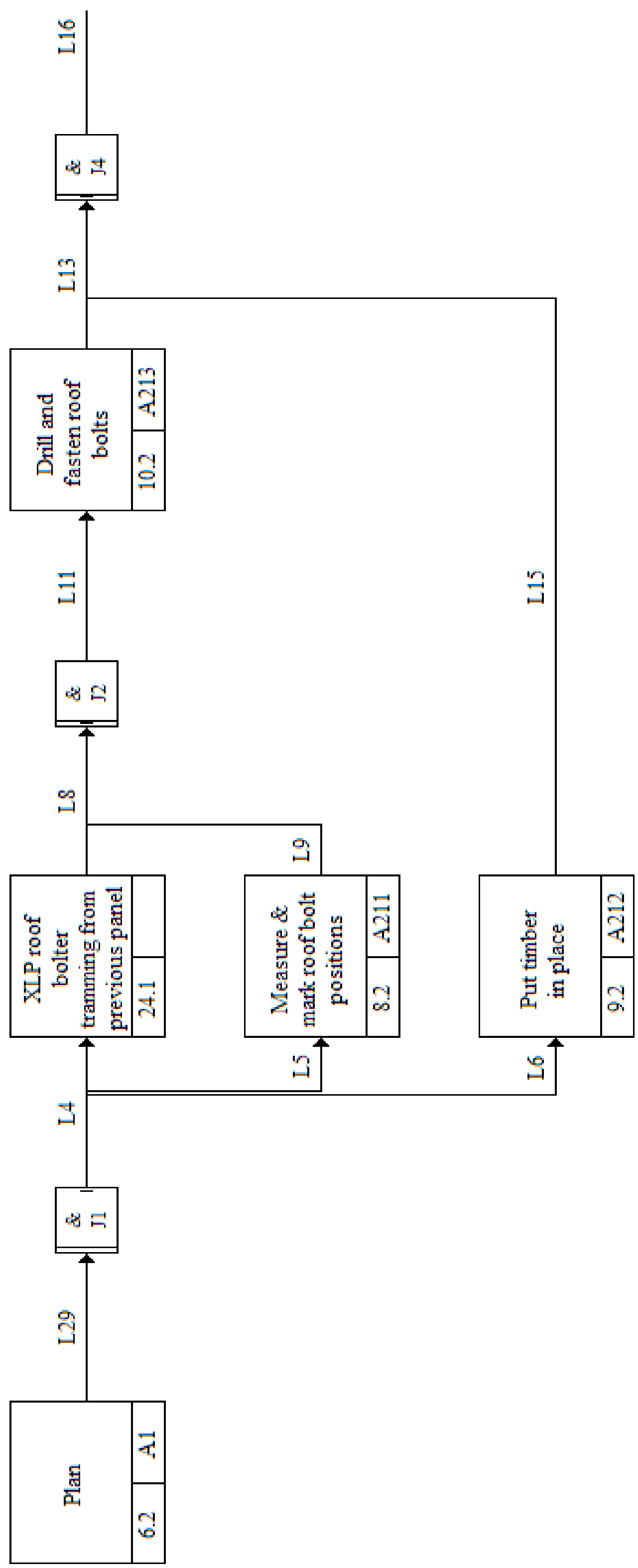
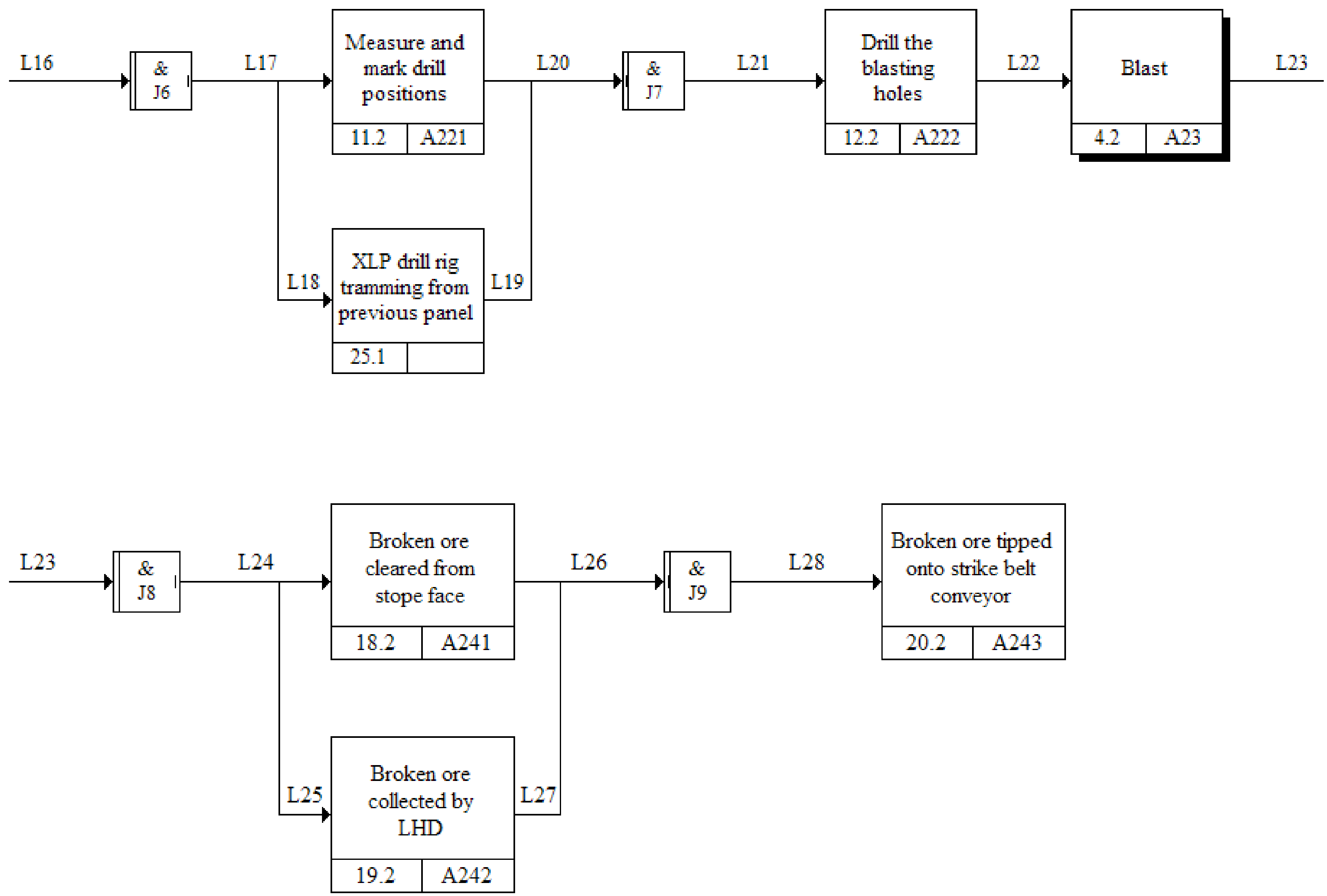


Figure 5.8 XLP Process

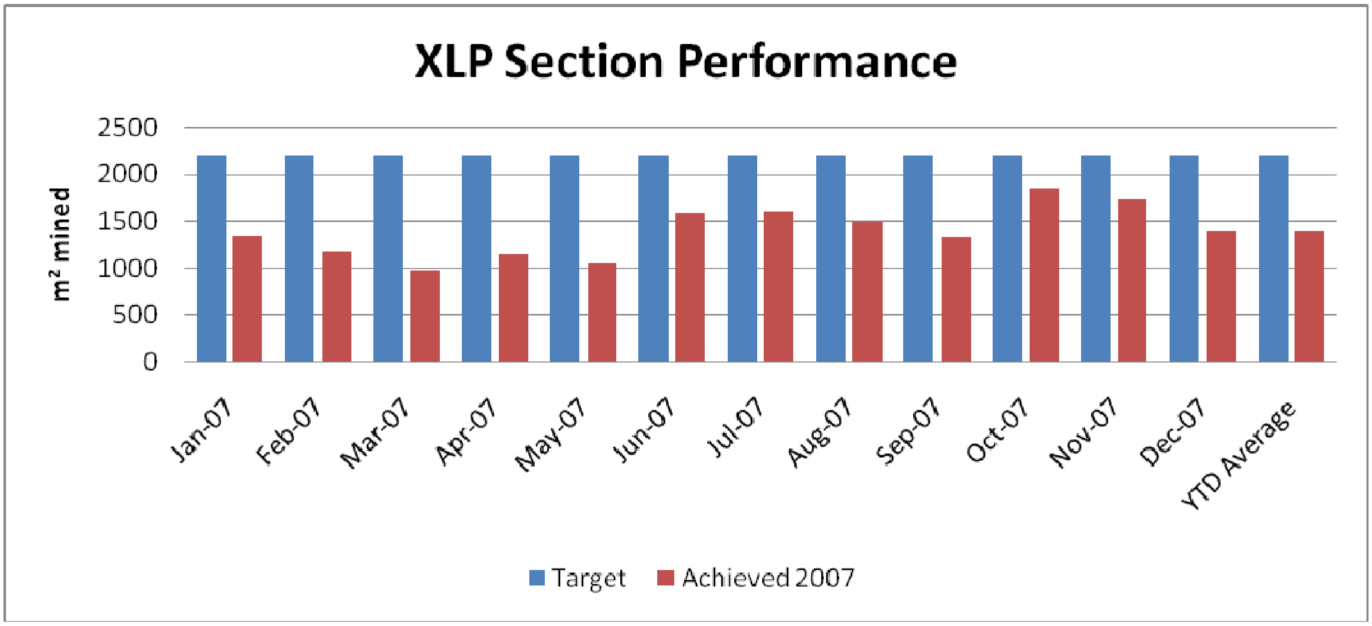
Figure 5.9 XLP Process (continued)



5.2 GAP Analysis

A gap analysis has been executed on the XLP section. The XLP section's actual performance has been compared to the target performance benchmarked by Anglo Platinum. The XLP section is clearly unable to consistently meet the target monthly production rate.

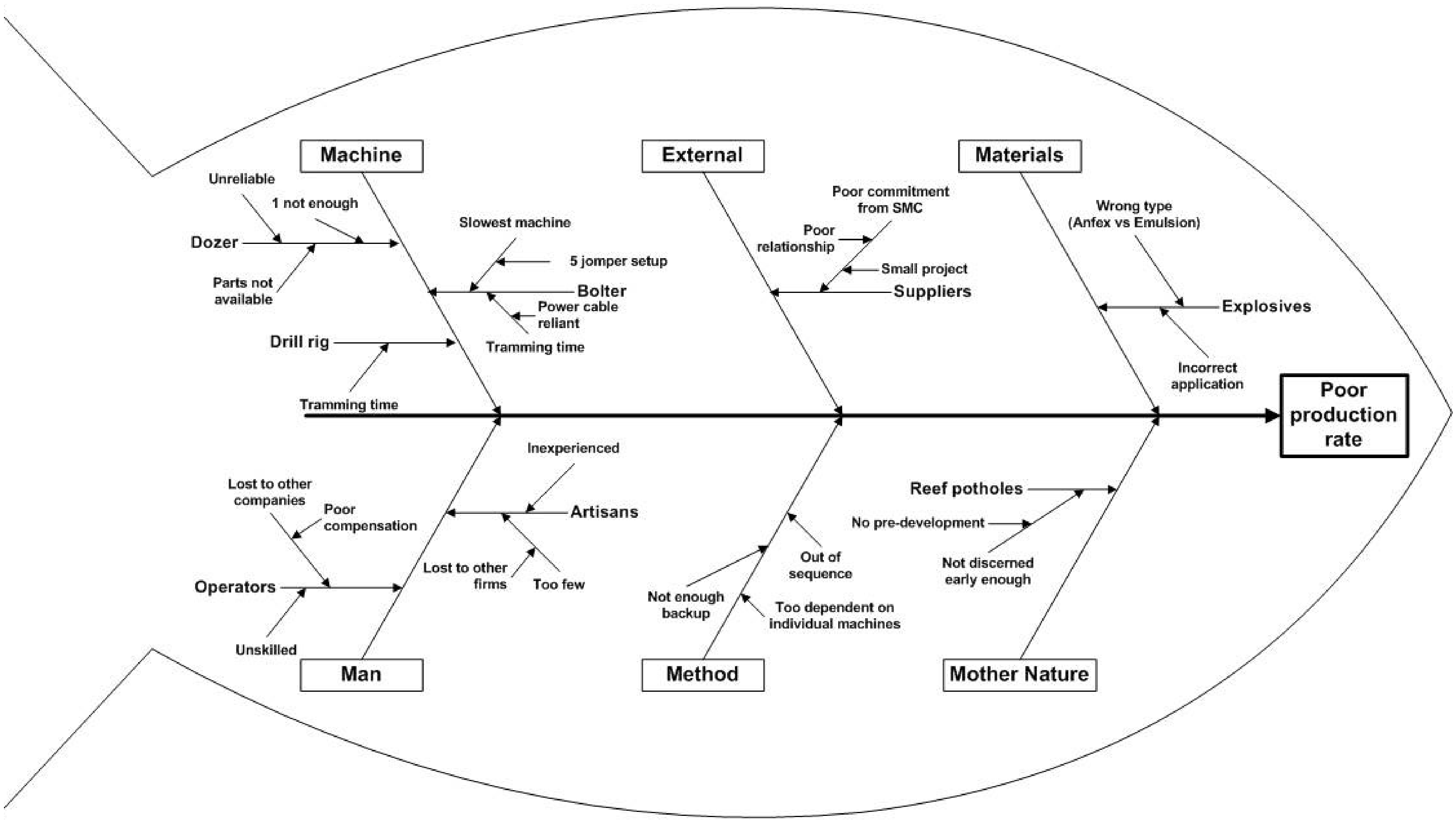
Figure 5.10 XLP section performance 2007



5.3 Ishikawa Diagram

An Ishikawa diagram (Figure 5.11) has been constructed to investigate the cause of the problems experienced in the XLP section. It gives a good overview of the problem and its contributing factors.

Figure 5.11 Ishikawa diagram



5.4 SWOT Analysis

5.4.1 Strengths

Probably the greatest strength of the XLP section is that it is much safer than conventional mining due to the operator being removed from the sharp end of the face. XLP mining also provides much less dilution and improved ore grades.

5.4.2 Weaknesses

With XLP mining being a new technology it is often quite complicated to manage (it) correctly. The ideal method to operate an XLP section is yet to be established with little or no past precedent available.

A definite weakness is the XLP section's dependency on the machines being in good working order at all times. If any of the machines experience a breakdown that lasts for more than one shift it has an extremely negative impact on productivity due to the mining cycle going off track.

5.4.3 Opportunities

These days mining industry is under increasing pressure to improve the safety of the mining environment. Mechanised mining is much safer than conventional mining. Therefore a lot of resources are currently being applied by mining industry to advance these new technologies. This in turn will definitely improve the performance of the XLP section.

5.4.4 Threats

Managers involved with the XLP section complain a lot about a lack of commitment from the supplier of the XLP equipment (Sandvik). Sandvik employs artisans who are responsible for servicing the machines. There are however not enough skilled artisans. Those that are currently employed do not have enough experience to be able to repair the machines quickly.

The XLP section has lost quite a number of their XLP machine operators who have left to work for other mining companies. However, this problem has recently been addressed by offering operators better reimbursement packages. The geology of the UG2 reef also provides a threat to the XLP section. Sometimes the reef forms potholes which cannot be mined.

5.5 Ergonomic assessment

An ergonomic risk assessment on operating XLP equipment was already performed by James et al. (2005). A summary of this study can be found in Chapter 2.5 of this document.

In this project the correlation between the ergonomic risks and the XLP section's performance have been evaluated.

I do not believe there is much correlation between the ergonomic risks and the XLP section's performance. Operator discomfort, especially during tramming of machines, should however be monitored at regular intervals to ensure that it doesn't affect productivity.

5.6 Assessment summary

Detailed modelling of the functions and processes of the business unit has helped to gain better insight into the workings of the system. The GAP analysis showed that the XLP section's monthly performance has to increase by approximately $800m^2$/month in order to achieve its targets. The Ishikawa diagram provided valuable insight into the problems experienced in the XLP section and their contributing factors. Assessing the strengths, weaknesses, opportunities and threats of the XLP section highlighted the internal and external factors which might have an influence on the performance.

Taking into account the results of the above-mentioned tools and techniques it becomes clear that the biggest problem within the system is the availability of the machines. If one of the machines experiences a break-down it sets back the mining cycle which in turn has a very negative effect on the performance.

6 ENVISIONING

This chapter highlights the desired objectives and future expectations of the XLP section.

The primary goal for the XLP section is to maximise the number of tons of ore mined while minimising cost and by placing a premium on safety.

Table 6-1 Waterval XLP section KPI's

Description	Target
m^2/month	2200
Tonnes to Concentrator/month (2200 x 1,41 x 3,79)	11 800
m^2/in stope employees	55
m^2/total employees	34
Stoping width (m)	120
Grade	2.94

The KPI's of the XLP section are used to gauge its performance.

As soon as the XLP section proves to be consistently successful in terms of the anticipated safety, productivity and cost benefits, it can be used as a model for implementation at other shafts operated by Anglo Platinum.

7 DESIGN

This chapter discusses the design strategy that was used to develop a solution for the machine non-availability problems experienced.

7.1 Static Model 1

A static model of the XLP process was developed in Microsoft Excel. The model imitates the mining cycle within Waterval's XLP section over a period of 22 working days (the average for 1 month). The following assumptions were made in this initial model:

- There are no machine breakdowns.
- Operators are always available.
- Every machine is booked for scheduled maintenance for one shift per week.
- One Axess dev rig can drill and blast one ASD in a single shift.

Table 7-1 Summarised results of Static Model 1

SUMMARY					
	ASD blasts	**Face blasts**	**ASD m^2**	**Face m^2**	**Total m^2**
XLP 4 East	60	30	480	1115	1595
XLP 5 East	60	30	480	1115	1595
XLP Section	**120**	**60**	**960**	**2230**	**3190**

The results of this initial static model indicate that it is possible to achieve a stoping rate in excess of **3100m²/month** under the ideal conditions assumed. The full results of Static Model 1 are available in Appendix C.

Figure 7.1 Static model - 5 day sample

			SECTION 4 EAST										SECTION 5 EAST									
		Panel No		1		2		3		4		5		1		2		3		4		5
		ASD No	1		2		3		4		5		1		2		3		4		5	
DAY	SHIFT	Blasts	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6
1	D			B	A-C		A-X		A-BD										A-C	C	A-X	X
1	A		A-BD	D		B	A-C		A-X		A-BD										A-C	C
1	N		A-X	X	A-BD	D		B	A-C		A-X		A-BD									
2	D		A-C	C	A-X	X	A-BD	D		B	A-C		A-X		A-BD							
2	A				A-C	C	A-X	X	A-BD	D		B	A-C		A-X		A-BD					
2	N						A-C	C	A-X	X	A-BD	D		B	A-C		A-X		A-BD			
3	D								A-C	C	A-X	X	A-BD	D		B	A-C		A-X		A-BD	
3	A										A-C	C	A-X	X	A-BD	D		B	A-C		A-X	
3	N		A-BD										A-C	C	A-X	X	A-BD	D		B	A-C	
4	D		A-X		A-BD										A-C	C	A-X	X	A-BD	D		B
4	A		A-C		A-X		A-BD										A-C	C	A-X	X	A-BD	D
4	N			B	A-C		A-X		A-BD										A-C	C	A-X	X
5	D		A-BD	D		B	A-C		A-X		A-BD										A-C	C
5	A		A-X	X	A-BD	D		B	A-C		A-X		A-BD									
5	N		A-C	C	A-X	X	A-BD	D		B	A-C		A-X		A-BD							

Activity	ID	Machine	No.
Panel roof bolting	B	XLP roof bolter	1
Panel drilling	D	XLP drill rig	1
Panel blasting	X		
Panel cleaning	C	XLP dozer	1
ASD roof bolting & drilling	A-BD	Axess dev rig	2
ASD blasting	A-X		
ASD cleaning	A-C	LHD	2

7.2 Static Model 2

The second model builds on the first one to take machine breakdowns and its effect on the mining cycle into account. This was done using the Static Model 1 as a platform and penalising the performance of the XLP section based on the availability of the machines. The method and assumptions are as follows:

- The availability of each machine for that month is entered as a percentage value.
- The blasting efficiency for that month is also entered as a percentage value. From this point onwards blasting efficiency is considered to be the "availability" of blasting.
- The amount of working time lost as a result of a machine's non-availability is determined.
- This lost time is translated into the number of shifts lost.
- Every shift that a machine loses sets the mining cycle back by one shift.
- If a single machine loses 10 or more shifts, the number of lost shifts are penalised further by 50%.
- For both the panels and the ASD's, the total number of lost shifts is then determined.
- When determining the number of blasts from the initial model, the lost shifts are then not counted. For example, if there are 8 shifts lost, the model only counts the number of blasts from Day 1's day-shift up to Day 20's afternoon-shift. Day 20's night-shift up to Day 22's night-shift couldn't be performed and is assumed to be lost.

Table 7-2 indicates how the number of shifts whose blasts are to be counted is calculated, based on the availability of each of the machines. The number of blasts in the first 29 shifts of the initial model was counted to calculate the panel advance. Likewise, the number of blasts in the first 43 shifts of the initial model was counted to calculate the ASD advance.

Table 7-2 Input table for Static Model 2

PANELS										
Machine	Total time	Availability	Lost time	Time/shift	Lost shifts	Penalty	Total lost			
Roofbolter	7920	71.80%	2233.44	360	7	0	7			
Drill rig	7920	68.00%	2534.4	360	8	0	8			
Dozer	7920	73.45%	2102.76	360	6	0	6			
Blasting	7920	76.19%	1885.752	180	11	6	18	Initial shifts	Shifts to count	
					32	6	38	66	28	
								Final Shift	10	D

ASD'S										
Machine	Total time	Availability	Lost time	Time/shift	Lost shifts	Penalty	Total lost			
Axess Dev	7920	68.82%	2469.456	360	7	0	7			
LHD	7920	70.48%	2337.984	360	7	0	7			
Blasting	7920	76.19%	1885.752	180	11	6	18	Initial shifts	Shifts to count	
					25	6	32	66	35	
								Final Shift	12	A

In this specific scenario the average machine availability and blasting efficiency for 2007 was entered as input into the model. Table 7-3 summarises the results obtained. Full results for this second model are available in Appendix C.

Table 7-3 Summarised results of Static Model 2

SUMMARY					
	ASD blasts	Face blasts	ASD m^2	Face m^2	Total m^2
XLP 4 East	32	14	256	520	776
XLP 5 East	31	11	248	409	657
XLP Section	**63**	**25**	**504**	**929**	**1433**

The accuracy of this model was tested with the monthly machine availability figures and the XLP performance for 2007. The model proved to be approximately 84.9% accurate in determining the monthly performance of the XLP section. The actual average performance of the XLP section for 2007 was 1397m²/month which is very close to the model's predicted **1433m²/month**.

7.3 Static Model 3 (Monte Carlo method)

The Monte Carlo method is often used to develop static models of systems with significant uncertainty in inputs. It uses randomly generated data and computer simulations to approximate solutions to complex problems.

The third model makes use of the Monte Carlo method to introduce variability into the inputs of the second model. A triangular distribution was used to generate random input data for the availability of the machines and blasting efficiency. A lower limit, mode (most likely value) and upper limit for each of the input figures is specified which is then used to determine the random value.

Table 7-4 shows the input table that was used for the Static Model 3 and indicates how the number of shifts to be counted was calculated.

Table 7-4 Input table for Static Model 3

PANELS												
		Availability										
Machine	Total time	Low	Likely	High	Value	Lost time	Time/shift	Lost shifts	Penalty	Total lost		
Roofbolter	7920	40%	70%	90%	83%	1325.124	360	4	0	4		
Drill rig	7920	50%	65%	85%	73%	2174.497	360	7	0	7		
Dozer	7920	30%	75%	90%	66%	2713.687	360	8	0	8		
Blasting	7920	70%	80%	90%	81%	1523.3	180	9	0	9	Initial shifts	Shifts to count
								28	0	28	66	38
											Final Shift	13 A

ASD'S												
		Availability										
Machine	Total time	Low	Likely	High	Value	Lost time	Time/shift	Lost shifts	Penalty	Total lost		
Axess Dev	7920	55%	65%	83%	81%	1507.539	360	5	0	5		
LHD	7920	35%	65%	90%	71%	2279.746	360	7	0	7		
Blasting	7920	70%	80%	90%	79%	1656.071	180	10	0	10	Initial shifts	Shifts to count
								22	0	22	66	44
											Final Shift	15 A

Fifty iterations were then performed using the fifty random machine availability combinations. The average performance of the model can then be used as an approximation for the XLP section's performance.

In this specific scenario the input values for the triangular distribution was based on the machine availability and blasting efficiency for 2007. The average performance achieved over the fifty iterations was **1487m²/month**. The full results for these iterations are available in Appendix C.

7.4 Static Model 4 (Monte Carlo method)

The fourth model builds on the third model and was used to determine the effect of adding a second XLP Dozer and Roofbolter to the existing machine fleet. Although there are already two Roofbolters in the fleet, the second one is currently only used for parts to service the other one.

There will be no changes in the stoping schedule. The second Dozer and Roofbolter will merely act as a backup for the first one. If the primary machine breaks down, the backup machine can immediately take its place without disturbing the mining cycle. The broken machine can then be repaired.

The other machines that do not have backups will always have right of way in the service centre due to the fact that they are now critical resources. This will improve their availability slightly and will be taken into account in this model by raising their triangular distributions by 5% from the third model's values.

Table 7-5 Input table for Static Model 4

PANELS														
		Availability												
Machine	Total time	Low	Likely	High	No. 1	No. 2	1 & 2	Lost time	Time/shift	Lost shifts	Penalty	Total lost		
Roofbolter	7920	40%	70%	90%	55%	43%	74%	2047.859	360	6	0	6		
Drill rig	7920	55%	75%	95%	79%			1656.049	360	5	0	5		
Dozer	7920	35%	75%	90%	68%	79%	93%	539.8657	360	2	0	2		
Blasting	7920	70%	80%	90%	77%			1821.459	180	11	6	18	Initial shifts	Shifts to count
										24	6	30	66	36
													Final Shift	12 N

ASD'S													
		Availability											
Machine	Total time	Low	Likely	High	Value		Lost time	Time/shift	Lost shifts	Penalty	Total lost		
Axess Dev	7920	65%	75%	87%	86%		1085.873	360	4	0	4		
LHD	7920	45%	75%	95%	70%		2350.411	360	7	0	7		
Blasting	7920	70%	80%	90%	76%		1937.878	180	11	0	11	Initial shifts	Shifts to count
									22	0	22	66	44
												Final Shift	15 A

Table 7-5 shows the input table for the fourth model. The additional Dozer and Roofbolter are only used during breakdowns and reduce the time loss associated with that type of machine.

Once again fifty iterations were performed with these fifty random machine availability combinations. The average performance achieved over these fifty calculations was **2191m²/month**. The full results for these iterations are available in Appendix C.

7.5 Static models – Summary

These static models were developed to simulate the effect of machine availability on the system performance. Table 7-1 provides a summary of the results obtained in the four models.

Table 0-1 Results Summary

Model No.	Description	Performance
1	Ideal Conditions (no breakdowns)	3100 m²/month
2	Simulation of 2007	1433 m²/month
3	Monte-Carlo input	1487 m²/month
4	Additional XLP Dozer & Roofbolter	2191 m²/month

The Monte-Carlo method was applied to bring variability into account. The static models showed that a backup XLP Dozer and Roofbolter need to be added to the fleet in order to meet the target monthly production rate.

8 RECOMMENDATIONS

This chapter gives recommendations to be implemented with the aim of optimising the performance of the XLP section. The recommendations are structured according to the problem areas identified in the Ishikawa Diagram (see Chapter 5.3).

8.1 Machine

In the assessment stage it became apparent that the availability of machines plays a critical role in mechanised mining. Machine breakdowns have a very negative impact on production performance and needs to be minimised wherever possible.

The static models in Chapter 7 provided evidence that an additional XLP Dozer and Roofbolter should be added to the existing fleet in order to reduce the effect of machine breakdowns on the system. A new Dozer will need to be purchased. However, there is already a second Roofbolter in the XLP section which is currently being stripped for parts to service the primary one. This one should be repaired and added to the fleet.

These additional machines should act as backups to the primary ones. If a primary machine breaks down the additional machine can immediately take its place while it is repaired. This will ensure that Dozer and Roofbolter breakdowns do not disturb the mining cycle.

The other machines without backups will have a higher priority in the service centre due to the fact that they are critical resources. This will improve their repair time and in turn also their availability.

8.2 Man

8.2.1 Operators

Salary structures and retention bonuses of the skilled XLP operators need to be reviewed at least every six months to ensure that they are not lost to rival mining companies.

8.2.2 Artisans

Artisans with XLP machine training is a critical resource that needs to be developed and appreciated accordingly. The XLP artisans should be divided into the three shifts according to their experience level to ensure that all the shifts have the same maintenance support quality.

8.3 External

8.3.1 Supplier relationships

The poor relationship with the machine supplier, Sandvik (SMC) has had a negative impact on the production performance because they are responsible for service and maintenance of the machines. Top management should meet with Sandvik to re-negotiate the contract so that it includes performance incentives. This should be filtered down the ranks to the lowest organisational levels and will in turn ensure better commitment from the supplier.

8.4 Method

8.4.1 Mining cycle

Strict discipline is required to prevent deviation from the agreed cycle of mining. Equipment operators and supervisors are to be instructed to adhere to the mining cycle as per approved schedule. This is imperative in order to prevent lengthy travel distances of electric driven XLP Drill Rigs where inter-panel movement distances must be restricted to adjacent panels wherever possible.

8.4.2 Maintenance

Planned weekly maintenance of the machines must be strictly observed by the production personnel. No deviations should be allowed because the equipment maintenance and reliability is a prerequisite for success in mechanised mining.

8.5 Materials

8.5.1 Explosives

There is a big debate in the mining environment over which type of explosive to use. Anfex was recently replaced by emulsion explosives due to safety reasons. Initial results within the XLP section have however showed that a lack of expert application of emulsion tends to result in poor face shape (smoothness of the rock wall) and blast reliability.

A comprehensive training session regarding the application of emulsion explosives should be held to ensure that the best possible blasting results are achieved. This should be compulsory for all shift bosses and miners who are responsible for applying the explosives.

8.6 Mother Nature

8.6.1 Reef potholes

Geological anomalies (e.g. where the reef suddenly veers away from its pathway) can have a very negative impact on production performance in that time and effort is wasted on rock that doesn't contain minerals. However, it can be discerned in advance by doing sufficient pre-development of the ASD's. This will allow the section overseer to modify the stoping plans to make provision for potholes.

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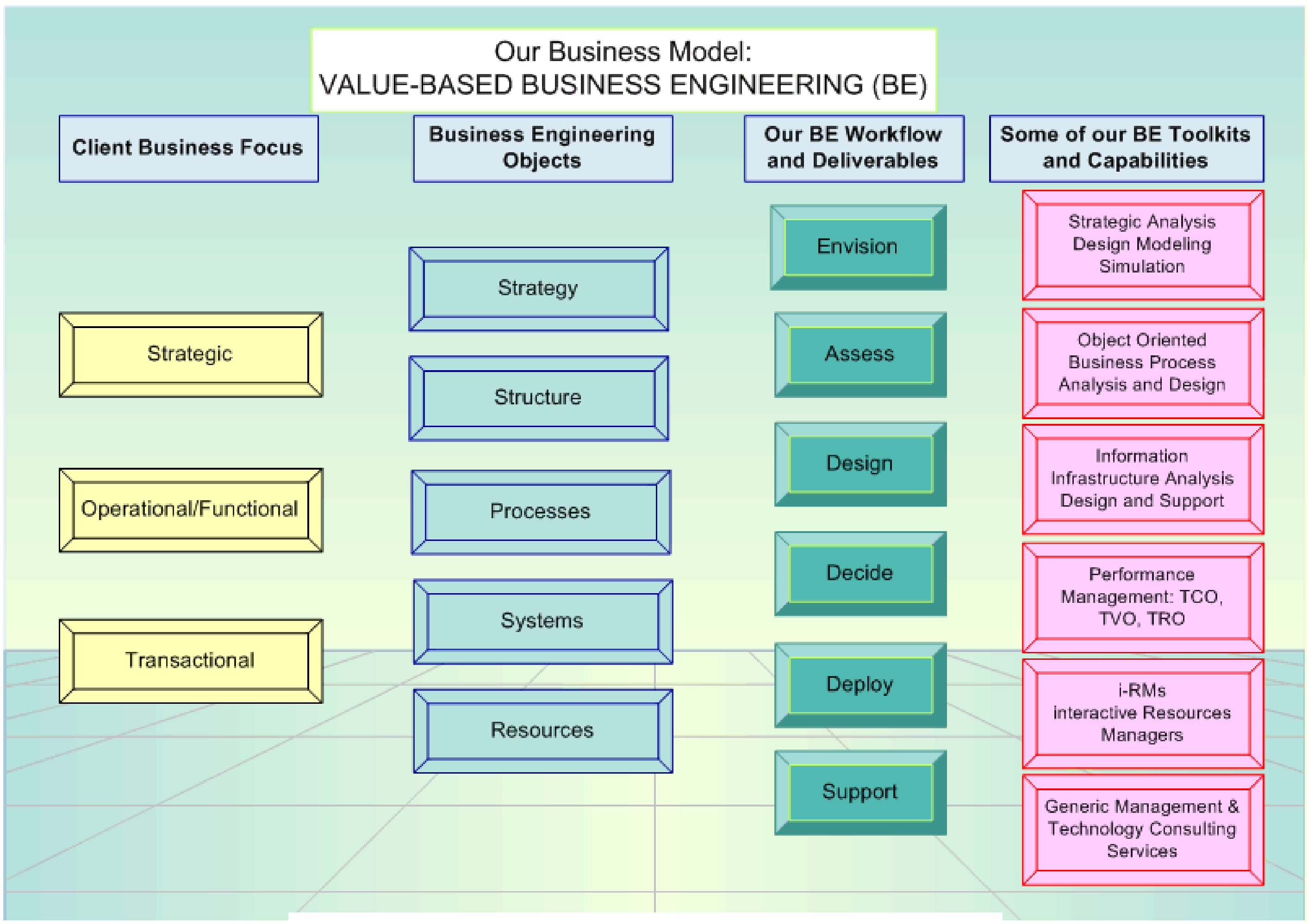
10 APPENDICES

Appendix A: Ceenex model



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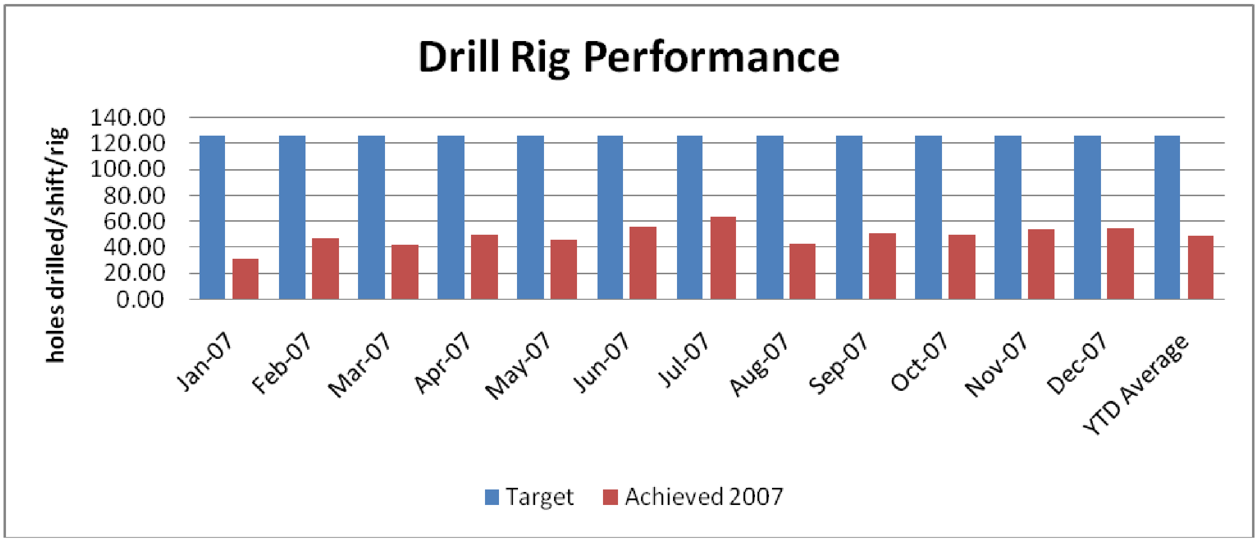
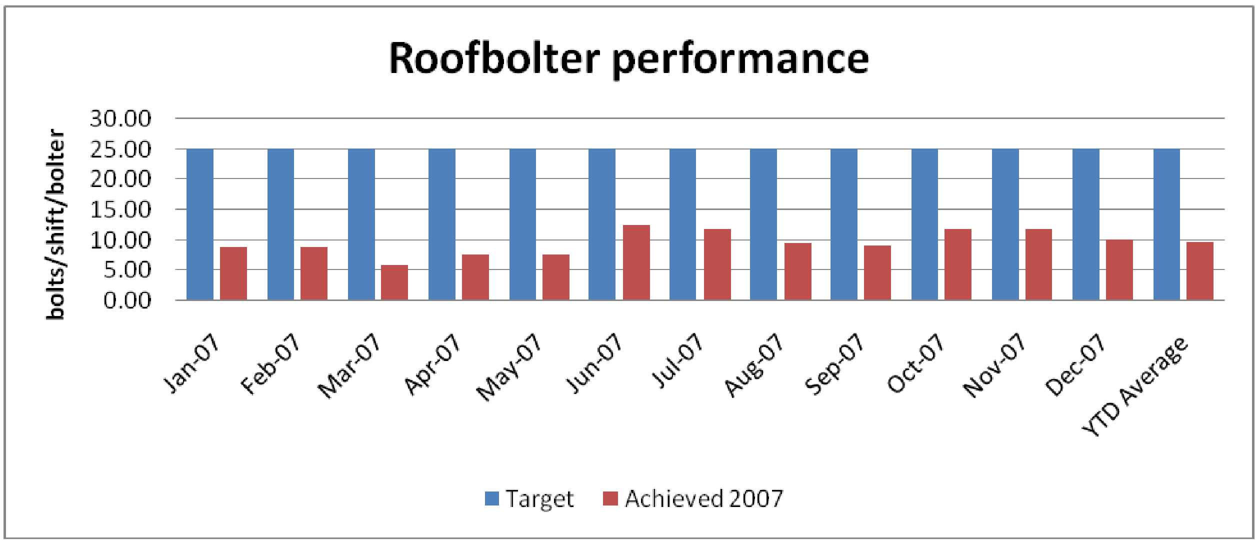
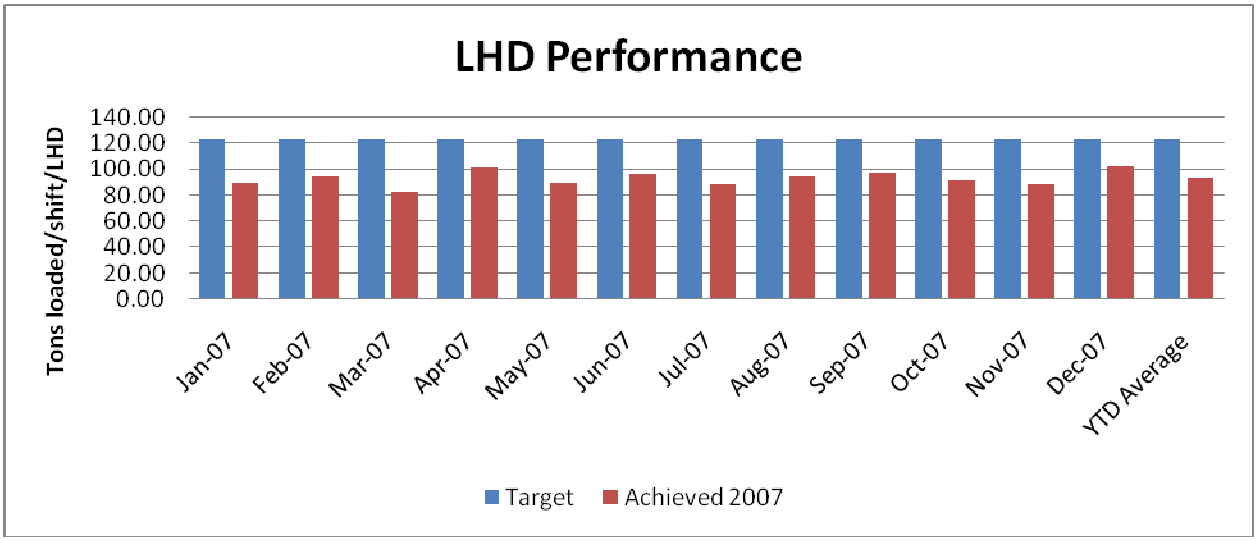
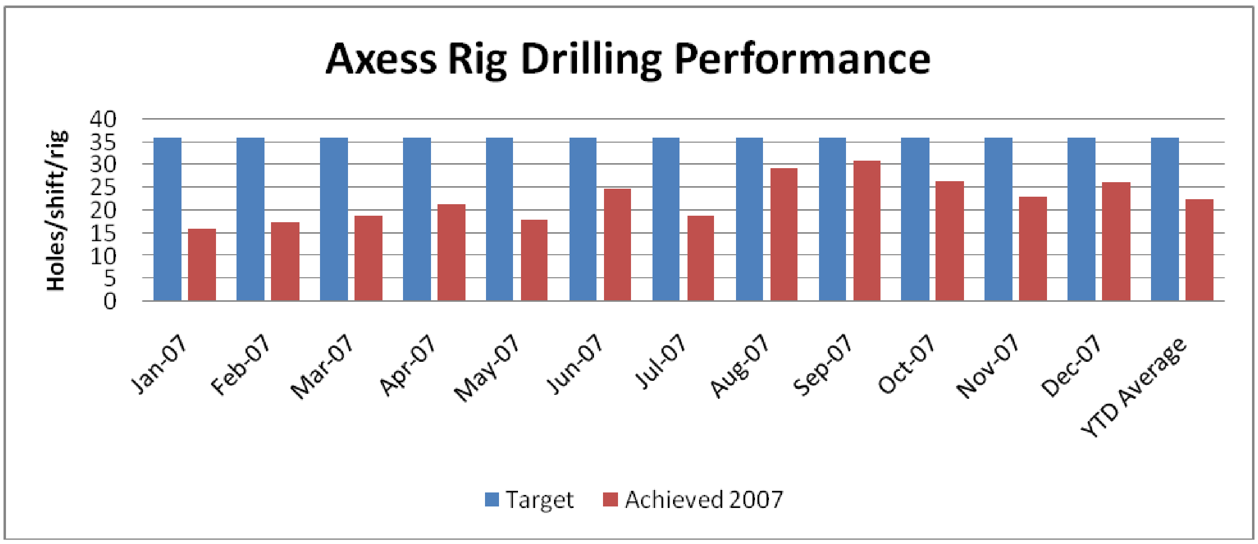
Appendix B: XLP Equipment Performance 2007



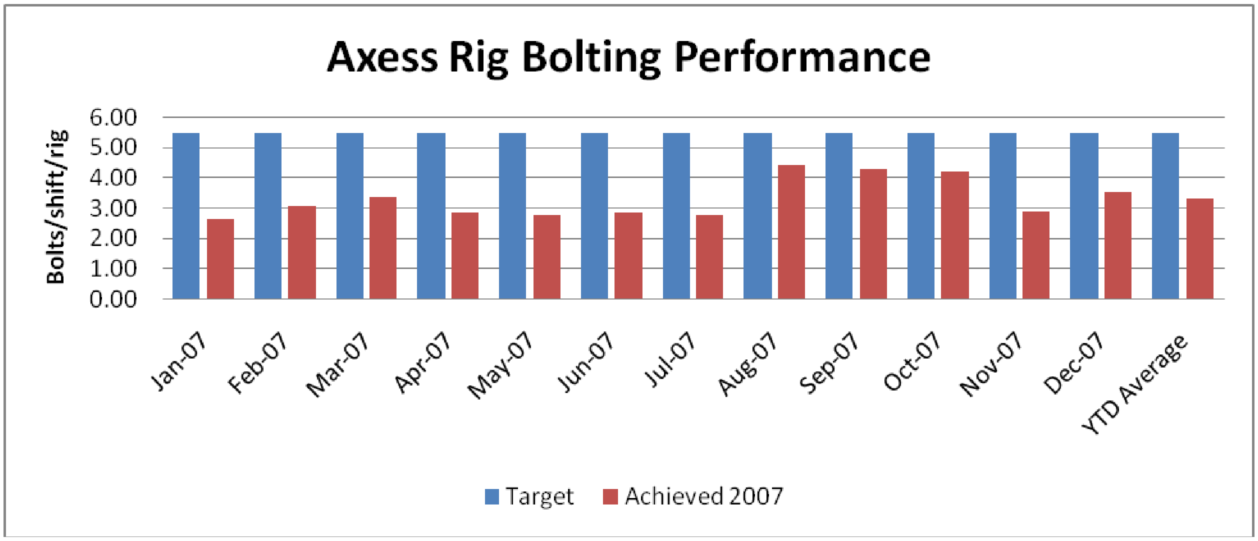




LHD Performance
Tons loaded/shift/LHD
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Jan-07
Feb-07
Mar-07
Apr-07
May-07
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07
Nov-07
Dec-07
YTD Average
Target
Achieved 2007



Axess Rig Drilling Performance
Holes/shift/rig
40
35
30
25
20
15
10
5
0
Jan-07
Feb-07
Mar-07
Apr-07
May-07
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07
Nov-07
Dec-07
YTD Average
Target
Achieved 2007



Axess Rig Bolting Performance
Bolts/shift/rig
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jan-07
Feb-07
Mar-07
Apr-07
May-07
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07
Nov-07
Dec-07
YTD Average
Target
Achieved 2007

Appendix C: Static models

Static Model 1 results

XLP 4 East									
PANEL No			**Room & Pillar**			**ASD`S**		**ASD`S M2**	**Total m²**
	No of Blasts	Advance per blast	Face Length	Face Advance	Face Sq Meters	Face Length	FACE ADV		
ASD 1	12	2.00			0	4	24	**96**	**96**
1	6	1.77	21	10.62	223			**0**	**223**
ASD 2	12	2.00			0	4	24	**96**	**96**
2	6	1.77	21	10.62	223			**0**	**223**
ASD 3	12	2.00			0	4	24	**96**	**96**
3	6	1.77	21	10.62	223			**0**	**223**
ASD 4	12	2.00			0	4	24	**96**	**96**
4	6	1.77	21	10.62	223			**0**	**223**
ASD 5	12	2.00			0	4	24	**96**	**96**
5	6	1.77	21	10.62	223			**0**	**223**
TOTALS	**90**	**1.89**	**105**	**53.1**	**1115**	**20**	**120**	**480**	**1595**

XLP 5 East									
PANEL No			**Room & Pillar**			**ASD`S**		**ASD`S M2**	**Total m²**
	No of Blasts	Advance per blast	Face Length	Face Advance	Face Sq Meters	Face Length	FACE ADV		
ASD 1	12	2.00			0	4	24	**96**	**96**
1	6	1.77	21	10.62	223			**0**	**223**
ASD 2	12	2.00			0	4	24	**96**	**96**
2	6	1.77	21	10.62	223			**0**	**223**
ASD 3	12	2.00			0	4	24	**96**	**96**
3	6	1.77	21	10.62	223			**0**	**223**
ASD 4	12	2.00			0	4	24	**96**	**96**
4	6	1.77	21	10.62	223			**0**	**223**
ASD 5	12	2.00			0	4	24	**96**	**96**
5	6	1.77	21	10.62	223			**0**	**223**
TOTALS	**90**	**1.89**	**105**	**53.1**	**1115**	**20**	**120**	**480**	**1595**

Static Model 2 results

XLP 4 East									
PANEL No			**Room & Pillar**			**ASD`S**		**ASD`S M2**	**Total m²**
	No of	Advance	Face	Face	Face	Face	FACE		
	Blasts	per blast	Length	Advance	Sq Meters	Length	ADV		
ASD 1	6	2.00			0	4	12	**48**	**48**
1	3	1.77	21	5.31	112			**0**	**112**
ASD 2	6	2.00			0	4	12	**48**	**48**
2	3	1.77	21	5.31	112			**0**	**112**
ASD 3	7	2.00			0	4	14	**56**	**56**
3	3	1.77	21	5.31	112			**0**	**112**
ASD 4	7	2.00			0	4	14	**56**	**56**
4	3	1.77	21	5.31	112			**0**	**112**
ASD 5	6	2.00			0	4	12	**48**	**48**
5	2	1.77	21	3.54	74			**0**	**74**
TOTALS	**46**	**1.89**	**105**	**24.8**	**520**	**20**	**64**	**256**	**776**

XLP 5 East									
PANEL No			**Room & Pillar**			**ASD`S**		**ASD`S M2**	**Total m²**
	No of	Advance	Face	Face	Face	Face	FACE		
	Blasts	per blast	Length	Advance	Sq Meters	Length	ADV		
ASD 1	6	2.00			0	4	12	**48**	**48**
1	2	1.77	21	3.54	74			**0**	**74**
ASD 2	6	2.00			0	4	12	**48**	**48**
2	2	1.77	21	3.54	74			**0**	**74**
ASD 3	6	2.00			0	4	12	**48**	**48**
3	2	1.77	21	3.54	74			**0**	**74**
ASD 4	6	2.00			0	4	12	**48**	**48**
4	2	1.77	21	3.54	74			**0**	**74**
ASD 5	7	2.00			0	4	14	**56**	**56**
5	3	1.77	21	5.31	112			**0**	**112**
TOTALS	**42**	**1.89**	**105**	**19.5**	**409**	**20**	**62**	**248**	**657**

Static Model 3 results

Iteration	Total m²
1	1354
2	1891
3	810
4	1481
5	1938
6	1681
7	1142
8	1405
9	1476
10	1529
11	1256
12	1776
13	1327
14	1530
15	1811
16	1497
17	1317
18	1883
19	1389
20	1795
21	1497
22	977
23	1612
24	1518
25	1612

Iteration	Total m²
26	1604
27	1492
28	1476
29	989
30	1741
31	1444
32	1760
33	1704
34	1439
35	1752
36	1537
37	1402
38	1235
39	1426
40	1556
41	871
42	1327
43	844
44	1808
45	1407
46	1476
47	1705
48	1463
49	1574
50	1832

Static Model 4 results

Iteration	Total m²
1	2164
2	2259
3	2206
4	1752
5	1941
6	2132
7	2015
8	1806
9	2013
10	1758
11	2401
12	2132
13	2108
14	2273
15	2180
16	2238
17	1811
18	2164
19	1965
20	2188
21	2350
22	2002
23	2074
24	2254
25	2039

Iteration	Total m²
26	2206
27	2222
28	2183
29	1946
30	1925
31	2148
32	2151
33	1935
34	1911
35	1978
36	2262
37	2304
38	2059
39	2018
40	2178
41	2267
42	2239
43	2262
44	2263
45	2161
46	2167
47	1808
48	1978
49	1975
50	2278

Appendix C: XLP Equipment Specifications

Technical Specification
6-910 S-C
2006-06-28

AXERA XLP

APPLICATION

The Axera XLP is an innovative extra low profile twin boom electro hydraulic jumbo designed to work in stopes as low as 1.1 m with minimum face width of 8 m.

The robust universal booms gives fast and precise hole position.

The powerful four-wheel-drive skid-steered carrier ensure great manœuverability in tight areas. To match the low headroom conditions, the operator can modify the Axera XLP overall height independently on each wheel.

High drilling performance is ensured by two powerful independant power packs, electric driven controls and roto-percussive rock drills. Both boom and feed are remote controlled and manœuvred from ground level. Automatic functions allow the operator to concentrate on safe, fast and accurate drilling.

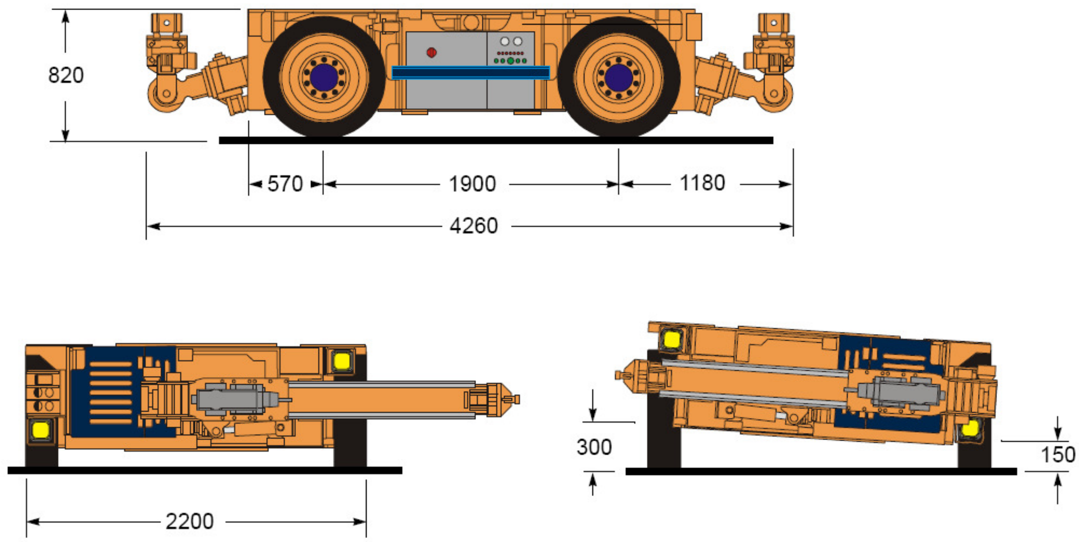
All actions are controlled by a lightweight radio remote control.

MAIN SPECIFICATIONS

Carrier		1 x CB XLP 2
Rock drill		2 x HLX1
Feed		2 x CRXS-F
Boom		2 x B 1.1 F
Powerpack		2 x 30 kW
Air compressor		1 x CT 2
Length		4 260 mm
Width		2 200 mm
Track width		1 985 mm
Height	carrier up	970 mm
	carrier low	820 mm
Weight		6 500 kg
Turning radius		4 500 mm
Tramming speed	low	0.6 km/h
	high	2.4 km/h
Gradeability, max		35 %
Noise level		< 98 dB(A)

AXERA XLP

GENERAL DIMENSIONS



All dimensions in mm

HLX1 ROCK DRILL

(Technical specification 04025-1)

Standard male shank	R 23
Weight	50 kg
Impact frequency	70 - 88 Hz
Percussion pressure	100 - 180 bar
Impact power	3.0 - 6.5 kW

CRXS-F FEED

(Technical specification 3-500S)

Feed type	Cylinder Rope Xstra Short - Face
Drill steel	H 22

	CRXS - F 6	CRXS - F 7
Total length (mm)	2230	2540
Drill steel length (mm)	1830	2135
Hole depth (mm)	1650	1950
Net weight (kg)	115	120
Feed force, max. (kN)	3.7	3.7

B 1.1 F BOOM

(Technical specification 4-150S)

Weight (with hoses)	450 kg
Boom lift	± 15°
Boom extension	550 mm
Feed roll-over	270°
Feed swing	± 20°
Divergence	± 15°
Feed extension	850 mm

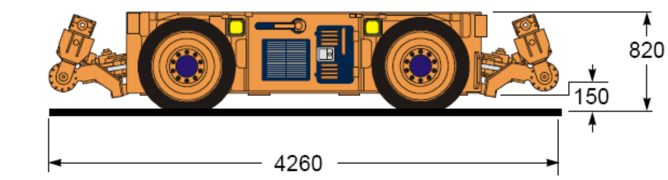
HYDRAULIC CONTROL SYSTEM

Type	Direct hydraulic Separate rotation
Anti-jamming system	Hydraulic, stepless
Hydraulic remote control	2 x Cable remote

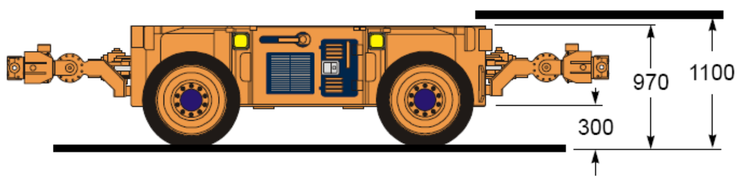
AXERA XLP

TRAMMING DIMENSIONS

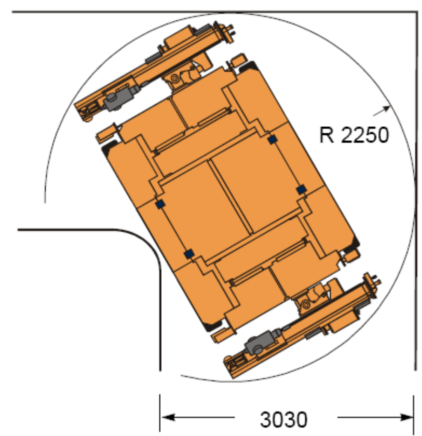
XLP LOW



XLP UP



TURNING RADIUS



All dimensions in mm

TC XLP 2 CARRIER

Electrical motor	2 x 30 kW *(also used for drilling)*
Automotive hydrostatic transmission	
- Two pumps	Variable displacement Axial piston, 0-45 cm³/rev
- Four wheel-motor	Axial piston
Rock drill rotation pump	Fixed displacement, gear
Tires	7.50 x 15 (segmented)
Steering	Skid-steering system
Brakes - Service	Hydrostatic transmission
- Emergency & parking	Spring applied, hydraulically released fail safe oil immersed multi disc brakes on each wheel
Remote control	Radio
Tramming alarm	Forward and reverse
Hydraulic tank	160 liter

AIR CIRCUIT

Compressor	C.T. 2, piston type
- Capacity	800 l/min. at 4 bar
Electric motor	5.5 kW (7.5 hp)
Cooler	Air / Oil
- Hydraulic motor	17 cm³/rev
Air tank capacity	1 x 8 liter

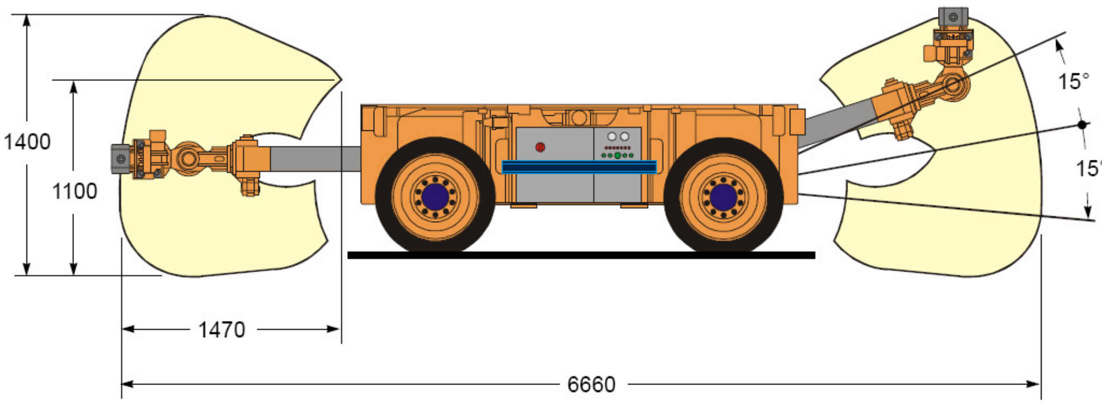
WATER CIRCUIT

Oil cooler	2 x OW 30, water-actuated counterflow
Cooling capacity	2 x 30 kW
Min water supply pressure	2 bar

ELECTRICAL SYSTEM

Total installed power	66 kW
High / Low voltage	Separate cabinets
Voltage	380 - 660 V
Phase sequence indicator	
Frequency	50 or 60 Hz
Starting method	Direct start
Thermal overload protection	
Lighting (24 V)	
- Orientable lights	8 x 70 W
- Working lights	2 x 35 W HID

COVERAGE AREA



All dimensions in mm

OPTIONAL EQUIPMENT

DRILLING SYSTEM

Both boom and feed radio controlled.

BRAKES

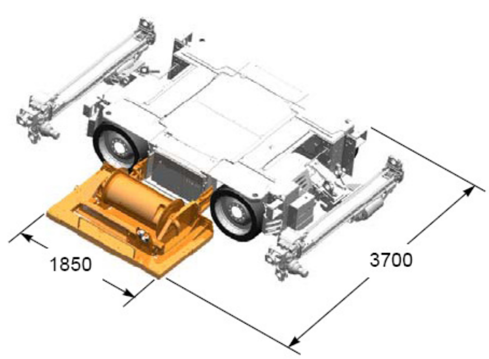
Hand pump for manual brake release.

CARRIER

Complete spare wheel.

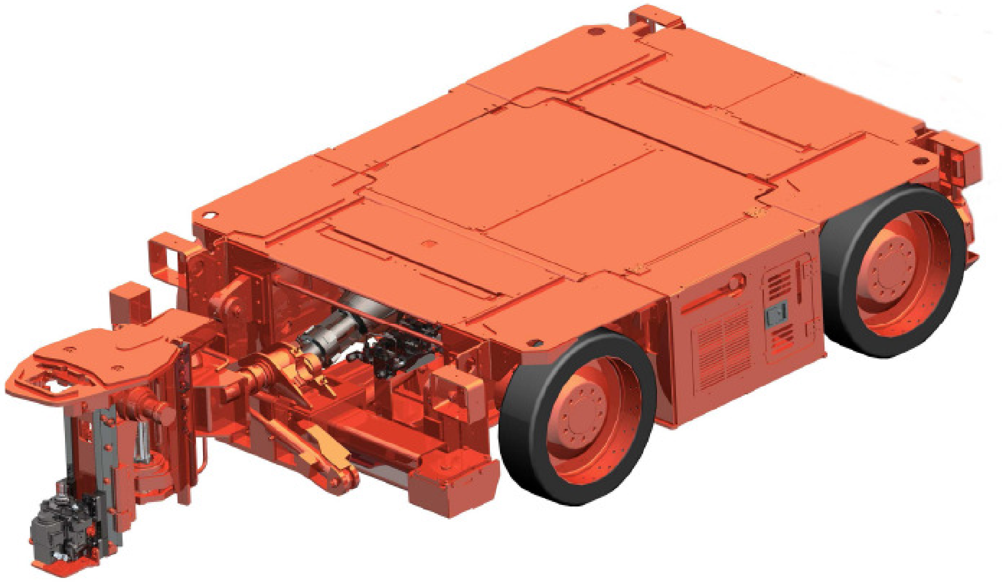
OTHER OPTIONAL EQUIPMENT

Fire suppression system ANSUL, 6 nozzles.
South African Specification XLP (SAS XLP) package.
XLP cable reel with spooling device.
Manuals other than French/English language.



Technical Specification
8-395 S-F
2007-06-01

Sandvik DS110L



APPLICATION

Sandvik DS110L is an innovative extra low profile electro hydraulic bolter designed to work in stopes as low as 1.1 m.

The robust boom gives fast and precise hole position.

The powerful four-wheel-drive skid-steered carrier ensures great manœuverability in tight areas. To match the low headroom conditions, the operator can modify the DS110L overall height independently on each wheel.

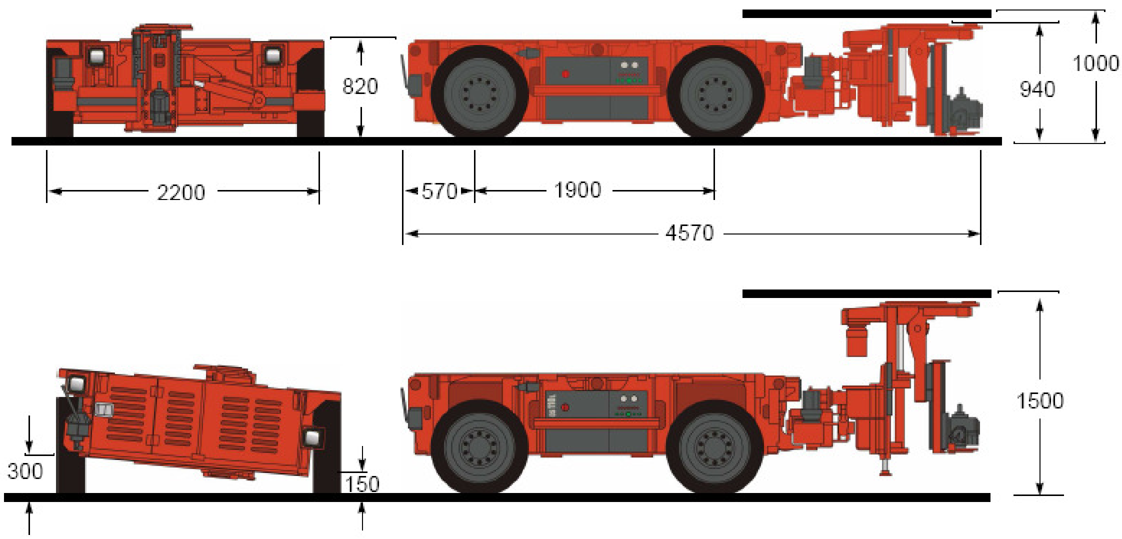
The high quality bolting performance is ensured thanks to the high frequency HSX rock drill. The one line bolting head makes it easy for the operator. An innovative indexing system allow to create space for bolt insertion. All actions are controlled by a lightweight radio remote control.

MAIN SPECIFICATIONS

Carrier		1 x CB XLP 1
Rock drill		1 x HSX
Bolting head		1 x BH-XLP
Boom		1 x B 1.1 B
Powerpack		2 x 30 kW
Air compressor		1 x CT 2
Length		4 570 mm
Width		2 200 mm
Track width		1 985 mm
Height	carrier up	970 mm
	carrier low	820 mm
Weight		6 200 kg
Turning radius		4 700 mm
Tramming speed	low	0.8 km/h
	high	2.4 km/h
Gradeability, max		35 %
Noise level		< 98 dB(A)

Sandvik DS110L

GENERAL DIMENSIONS



All dimensions in mm

HSX ROCK DRILL
(Technical specification 2-210 S)

Standard male shank	R 23
Weight	60 kg
Impact frequency	100 - 110 Hz
Percussion pressure	65 - 80 bar
Impact power	3 - 3.5 kW

BH-XLP BOLTING HEAD
(Technical specification 8-515 S)

Feed type		Semi-mechanized, chain feed
Drill steel		H 22
Overall length	Retracted	840 mm
	Extended	1 205 mm
Bolt length		from 1 200 to 2 000 mm

B 1.1 B BOOM
(Technical specification 8-415 S)

Weight (with hoses)	450 kg
Boom lift	± 15°
Slide table, max. spacing	1 100 mm
Boom rotation	105°
Bolting head swing index	3 x 40°
Bolting head extension	435 mm
Stinger extension	300 mm

HYDRAULIC CONTROL SYSTEM

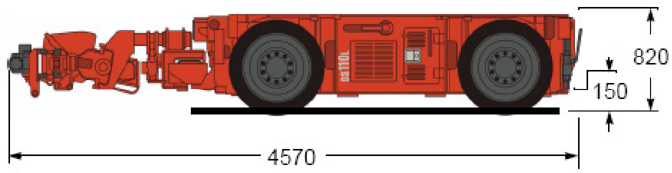
Type	Direct hydraulic
	Separate rotation
Anti-jamming system	Hydraulic, stepless
Remote control	Radio

Technical Specification
8-395 S-F
2007-06-01

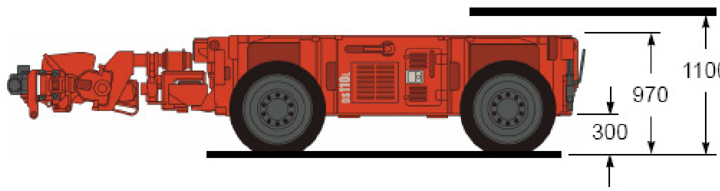
Sandvik DS110L

TRAMMING DIMENSIONS

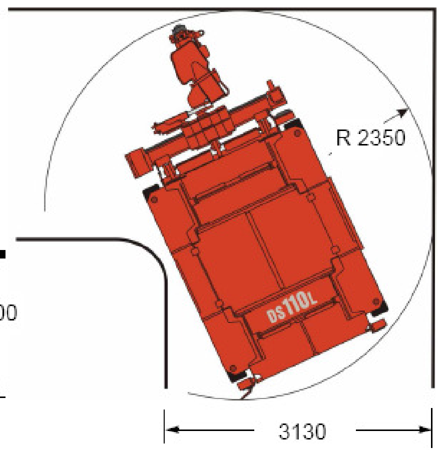
DS110L LOW



DS110L UP



TURNING RADIUS



All dimensions in mm

TC XLP 1 CARRIER

Electrical motor	2 x 30 kW *(also used for drilling)*
Automotive hydrostatic transmission	
- One pump	Variable displacement Axial piston, 0-45 cm³/rev
- Four wheel-motor	Axial piston
Rock drill rotation pump	Fixed displacement, gear
Tires	7.50 x 15 (segmented)
Steering	Skid-steering system
Brakes - Service	Hydrostatic transmission
- Emergency & parking	Spring applied, hydraulically released fail safe oil immersed multi disc brakes on each wheel
Remote control	Radio
Tramming alarm	Forward and reverse
Hydraulic tank	200 liter

AIR CIRCUIT

Compressor	C.T. 2, piston type
- Capacity	800 l/min. at 4 bar
Electric motor	5.5 kW (7.5 hp)
Cooler	Air / Oil
- Hydraulic motor	17 cm³/rev
Air tank capacity	2 x 8 liter

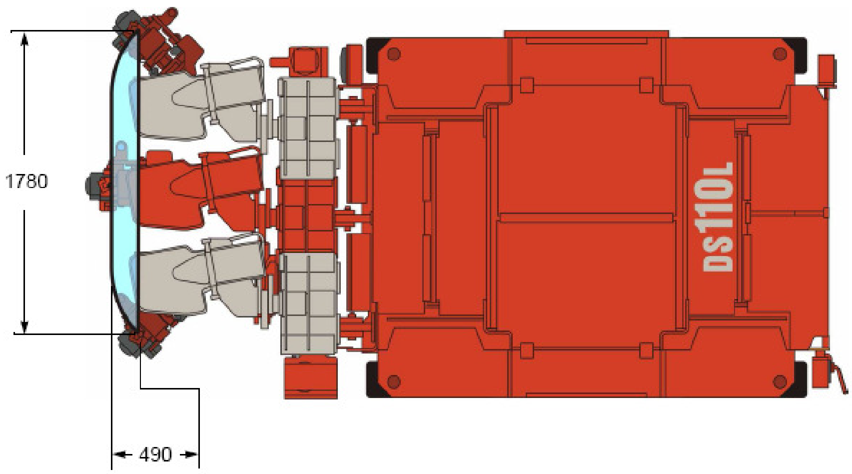
WATER CIRCUIT

Oil cooler	OW 30, water-actuated counterflow
- Cooling capacity	30 kW
Min water supply pressure	2 bar

ELECTRICAL SYSTEM

Total installed power	66 kW
High / Low voltage	Separate cabinets
Voltage switchgear	380 - 660 V
Frequency	50 or 60 Hz
Starting method	Direct start
Lighting	
- Direction adjustable lights (24 V)	8 x 70 W
Phase sequence indicator	
Thermal overload protection	

COVERAGE AREA



All dimensions in mm

OPTIONAL EQUIPMENT

BRAKES

Hand pump for manual brake release.

CARRIER

Complete spare wheel.

OTHER OPTIONAL EQUIPMENT

Fire suppression system ANSUL, 3 nozzles.
South African Specification XLP (SAS XLP) package.
Manuals other than French/English language.
XLP cable reel with spooling device (see below).