10 THE MINING OPERATIONAL MANAGEMENT MODEL

10.1 INTRODUCTION

The purpose of the mining operational management model was defined as:

"The operational management model needs to provide a first line supervisor with a proactive management tool that will assist him/her in quickly and easily adjusting the operations of the unit as well as to plan for the future in order to achieve the short and long term goals of the unit."

In the previous chapter the building blocks for the operational management model were chosen. From these building blocks the operational management model for a mining production unit is constructed. The model need to accomplish the purpose as stated above.

In the first part of this chapter the model is described. In the second part the roadmap to implement and institutionalise the model in a mining company is explained. In chapter 11 an illustration of the use of the model is provided.

10.2 OVERVIEW

For any production unit to succeed it must define what its purpose in the company is. This point of departure drives all further decision-making. This also applies to the mining operational management model. The production unit needs to define its vision and core values. Only then can the management of the unit be executed through the operational management model (from here-on referred to as the mining model). The mining model consists of two levels: a strategic and an operational level. On the strategic level a process focus exists, and continuous improvement of activities are driven. On the operational level the focus is on the day-to-day running of the unit. There is however a constant interchange of information between the two levels, and an integrated management approach is followed. The outline of the mining model is illustrated in figure 21.

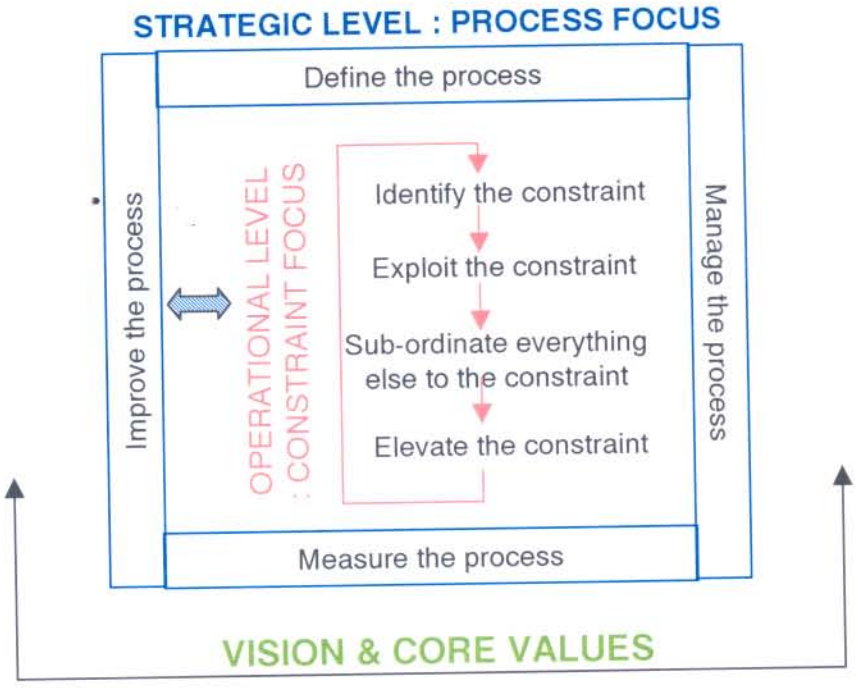

Figure 21: Overview of mining model

The different aspects of the model are discussed in the following paragraphs. To indicate how different elements are utilised as building blocks, the element number (referring to table 12, chapter 9, paragraph 9.3) is indicated in square brackets, i.e. *[element x].*

10.3 TEAM FOCUS

The first step for any production unit is to understand what its purpose in the company is. Therefore the team needs to develop their vision and core values. The following are guidelines on the attributes of a vision and mission for the team:

Vision

A vision must:

- be aligned with the company's vision
- refer to the quality of the product (coal)
- refer to the achievement of the throughput targets

Core values

The core values must as a minimum refer to the following:

- The company's core values
- Waste elimination being a passion *[element 3]*
- Constraints dictating all decisions *[element 6]*
- Decision making based on facts not emotions *[element 14]*
- The accountability and responsibility of all team members *[elements 7 and 8]*

10.4 STRATEGIC LEVEL

After the team has defined their vision and core values, the steps of the strategic cycle take effect. At this level the mining model focuses on the processes within the production unit, as well as the processes that the unit interface with. It provides an ordered sequence of events that addresses process definition, process management and finally process improvement *[element 2]*. Steps 1 and 2 are a yearly activity whereas steps 3 and 4 are activities that take place continuously. Step 4 integrates with the operational cycle, as improvement opportunities that arrive from the constraint management activities within the operational cycle utilise the same process improvement steps as described in step 4 of the strategic cycle.

Step 1 - Define the process

The first activity within step 1 is to ensure that the organisational structure of the unit is conducive to team work *[element 9]*. Organisational barriers (such as a split in reporting between engineering and production) may not exist. It is advisable that a team building exercise with the assistance of a facilitator is held. As the team composition changes this step needs to be repeated periodically.

The next activity is to define the activities of the production unit, as well as the interfaces with activities outside of the production unit *[element 2]*. Mapping the processes, and indicating the boundaries, achieves this.

After the mining process has been mapped accountabilities for every step in the process is determined. This ensures that every team member understands his or her specific role and responsibilities.

Step 2 – Manage the process

This step identifies the process management rules for the production unit. These rules need to be in place to ensure that decisions are taken based on facts, and according to the strategy of the mine *[element 14]*. As these rules are based on customer satisfaction the first action is to determine what the customer's requirements are. This can be achieved by answering the following questions:

- What are the required production targets?
- What is the production schedule? (When must what quantity be produced)
- What is the allowable cost expenditure for the unit to achieve the targets?
- What are the required quality targets?
- What is the planning for the unit in terms of mine layout for the next year?
- What major initiatives are planned for the mine for the coming year?

After the questions have been answered it is necessary to establish measures that quantify the performance of the production unit regarding the requirements of the customers with relation to quality, production and cost.

Quality

The measurements for quality are related to the quality of the coal sent to the client. These may include the following:

- Coal size - the size distribution of the coal produced
- Contamination – the percentage non-carbon material in the coal.
- Calorific value – the energy value of the coal

Production

The main production target for a production unit is that of tons of coal mined. This is defined per year, month, week, day and shift, and the targets depend on the mine production plan.

Supporting the tonnage target are production time targets, so called time buckets (grouping together similar actions and measuring the time used per period-mining term) that can be tracked on a "minutes per shift" basis. Some time bucket categories are:

- Cutting minutes
- Maintenance minutes
- Breakdown minutes
- Operational delay minutes
- Geographical delay minutes

Cost

The budget for the unit is determined based on the production target. The budget is developed according to the Theory of Constraints' definitions of inventory and local-operating-cost *[element 13]*.

Step 3 – Measure the process

In step 2 of the strategic cycle the items that must be measured (KPIs) were determined. These KPIs need to be measured regularly (daily for the production and quality KPIs, monthly for the cost KPIs), and any deviations acted upon immediately. The specific tools used to measure the KPIs are:

Quality

- Use control charts to track quality measurements *[element 11]*. Firstly determine the capability of the mining process to produce coal according to the quality requirements within the boundaries of the geological circumstances. This will enable the first line supervisor to act immediately when deviations against not only the target, but also the capability of the mining process, occur *[element 10]*. It is important that the first line supervisor is thoroughly trained in the basis statistical measurements, in order for him to understand the control charts and use the information from them. He must also be able to explain the control charts to his team. The quality control department will perform the analysis of the data. The

results of the analysis are provided to the first line supervisor, and he will plot it on the control chart in the unit.

- Where possible on-line analysers should be used to provide instant readings of the coal quality, but should still be backed up with the analysis from the laboratory.

The template for the control charts is shown in figure 22.

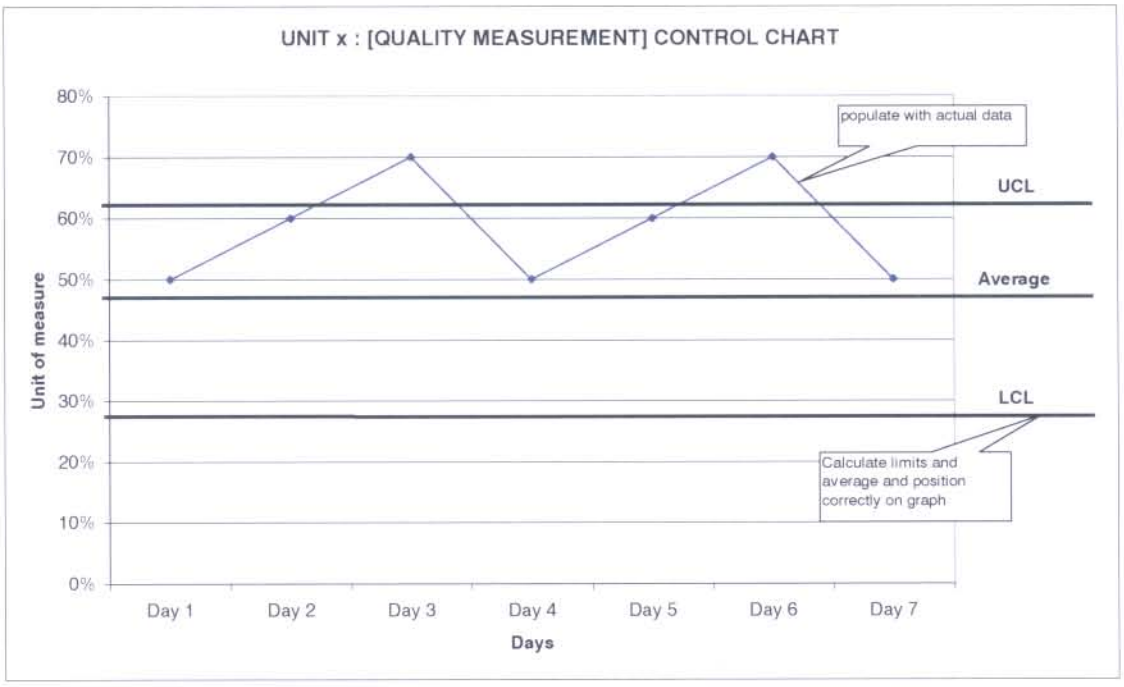

Figure 22: Template for quality control charts

Production

- To keep track of the tonnages line charts should be used, which the team can plot themselves to show the cumulative tons for the month, and year. The actual tons per shift produced are based on the scale readings (scales are installed on all section conveyor belts) and is provided daily to the first line supervisor. He then plots it on the graphs in the section. Refer to figure 23 for the template.
- Targets for the production time buckets should be determined for the production unit based on the tonnage that must be mined per shift. The ratio between the different categories of shift time can be pre-determined based on history. A scatter diagram per shift time category can be constructed, with on one axis the minutes and on the other the tonnages mined per shift *[element11]*. The time per bucket is determined

from the production report compiled during each shift. All non-production times are captured manually, and the cutting time of the continuous miner is captured via the hour meter on the continuous miner (also entered on the production report). These times are entered into the ERP (enterprise resource planning) system from where detailed reports can be extracted. The first line supervisor either pulls the information himself, or he receives it daily from his planner. He then plots it on the scatter diagrams in the section. Refer to figure 24 for the template.

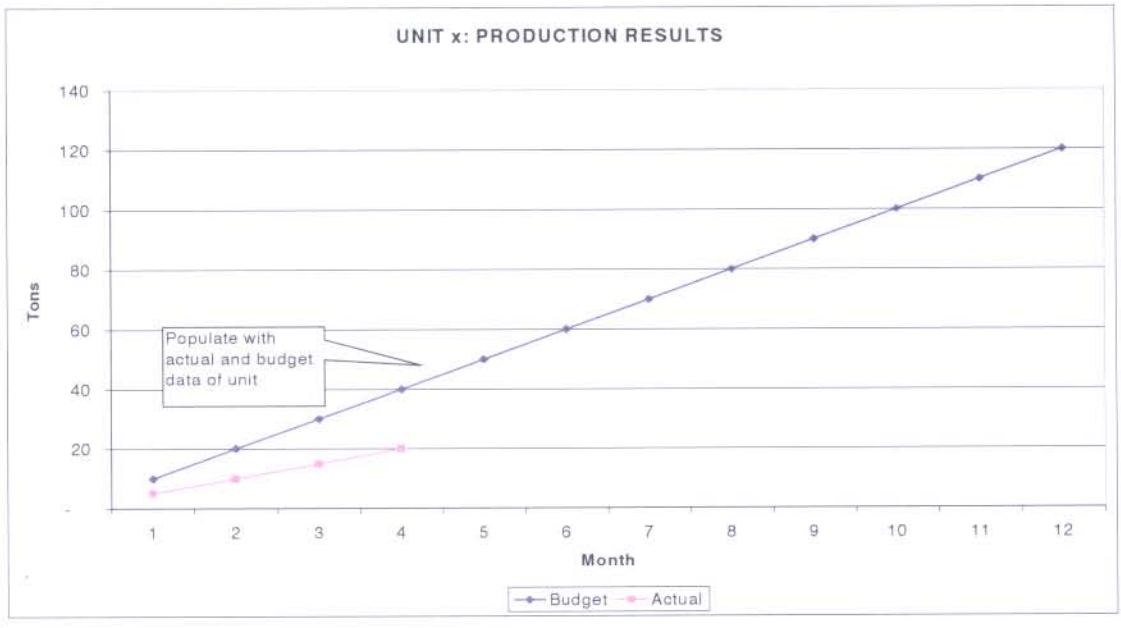

Figure 23: Cumulative tons template

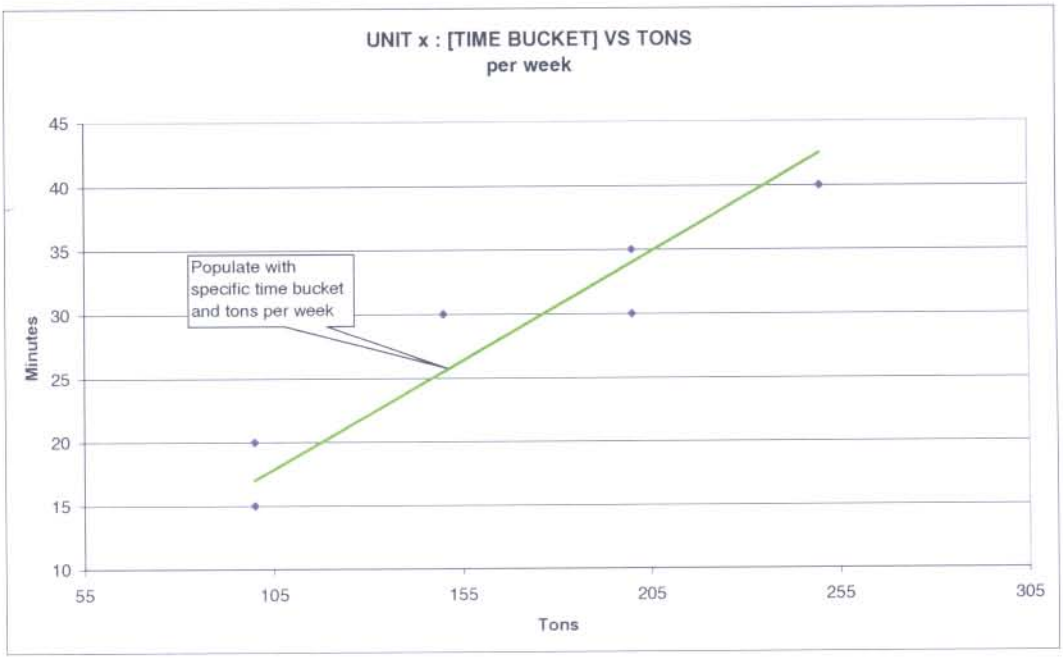

Figure 24: Tons versus time bucket template

Local-Operating-Cost and Inventory

- The cost expenditure needs to be broken down into main categories, i.e. overtime, maintenance, production material.
- These cost categories are measured on a weekly basis utilising a bar chart, plotting the actual against the budget *[element11].* The first line supervisor extracts this information from the ERP, or the financial department provides it to him. Refer to figure 25 for the template.
- The inventory figures for the unit are managed on a unit of issue basis. Each mining section has a small store where day-to-day consumables and spares are kept. It is important that the levels of inventory are kept as low as possible. To track this all the different items kept in inventory must be counted weekly, the incoming stock added and the resulting final stock levels calculated. This can be tracked manually in a book, or where a computer is available on a spreadsheet. The first line supervisor determines minimum and maximum stock levels for the section based on the consumption history, lead time for delivery and risk profile of the item. These levels are determined in consultation with the stock optimisation department utilising the relevant formula for the mine.

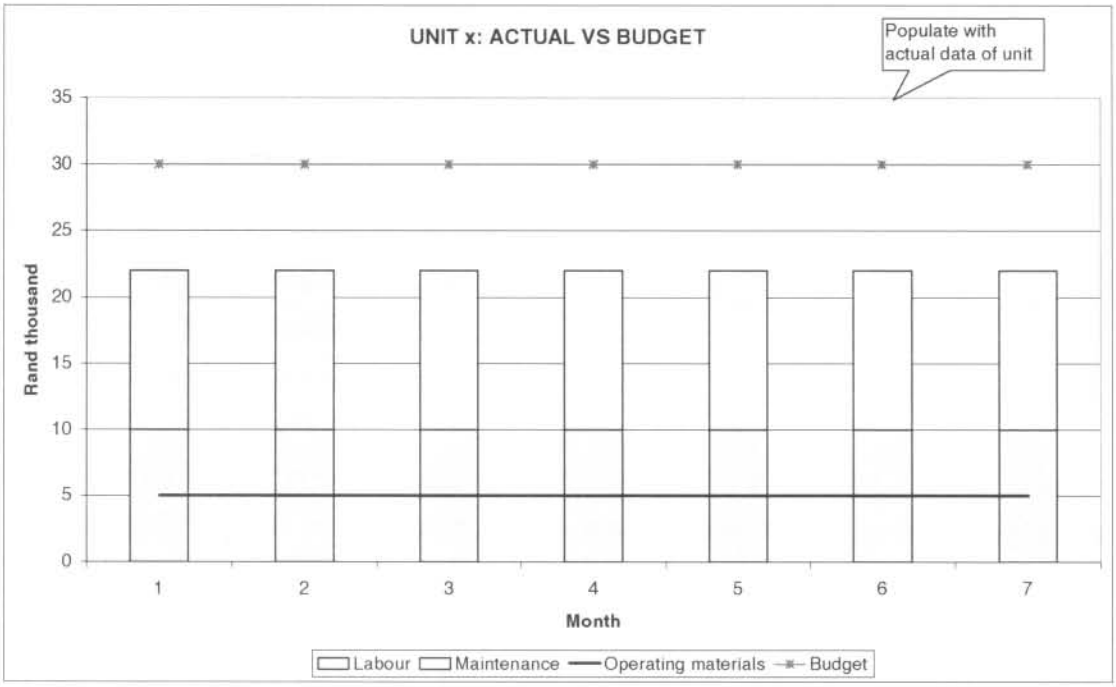

Figure 25: Actual versus budget template

Step 4 – Improve the process

The nature of the model implies that improvement opportunities will arise due to the measurement of the KPIs, as well as due to the constraint management activities. Therefore a constant interaction between the strategic and operational cycles takes place within this step. To address these improvement opportunities the following process must be followed: *[element 5]*

- Clearly define the deviation. To do this the following questions need to be answered:
  - When did the deviation occur?
  - Was it a once off, or did it occur more than once?
  - If frequently, is there a pattern in the occurrences?
  - Where did the deviation occur? What resources were involved?
  - What were the symptoms?
- Develop different possible reasons for the deviation. To do this various tools can be utilised:
  - Current Reality Tree *[element 4]*
  - Brainstorming, Fishbone Diagram, Pareto analysis *[element 11]*

- Each of these possible reasons are tested to determine if the occurrence of the reason would lead to the experienced symptoms as defined in step 1. From this analysis the core reason for the deviation will be identified.
- Develop a solution to prevent the deviation from occurring again. To be able to do this the following tools can be used:
    - Evaporating Cloud
    - Future Reality Tree
    - Brainstorming
    - Benchmarking
- An implementation plan for the solution needs to be developed. It is important that all interfaces with peripheral processes are analysed to ensure no negative effects due to the solution being implemented occur. For example a solution may require a section conveyor belt's speed to be increased, but where it feeds on the main conveyor belt the chute cannot handle the increased volume of coal. Depending on the complexity of the solution a full project plan may be needed. Before any project plan can be developed Prerequisite and Transition trees need to be constructed, to understand the impact of the solution fully and to determine all the interventions needed for the solution to be successfully implemented.

After the improvement plans have been developed, it must be implemented. It is the first line supervisor's responsibility to keep track of the progress of the improvement plans. This can be achieved by holding 2-weekly project meetings with the core team that is responsible for the implementation of the project.

It is important to close the loop of the strategic cycle by again revisiting step one to three whenever any major process change has taken place due to the process improvement process.

10.5 OPERATIONAL LEVEL

Through performing all the steps as per the strategic cycle the first line supervisor will have a clear understanding of the process and performance of the production unit. Continuous improvement activities take place that could alter the production capacity of the unit. It is therefore important that the day-to-day operations are managed taking into consideration

what volume and quality coal the unit can produce and comparing that to what is expected from the unit.

The first line supervisor will make use of the five focusing steps of constraint management to manage the operations of the unit on a day-to-day basis *[element 1 and 6]*. At any point in this cycle the process improvement steps (paragraph 10.4.4) can be utilised to assist with developing solutions to identify and manage the constraint.

Step 1 – identify the constraint

The ideal situation in the coal-mining environment would be for the constraint to be the continuous miner, as that is the first operation in the production chain. This is however not always the situation. The constraint can either be within the unit itself, or the demand for coal. Where the constraint is within the unit it will be the operation where the tons/hour that can be processed is equal to, or less than, the demand for coal.

To identify the constraint one or more of the following steps are taken:

- Analyse the production tempos of the equipment in the section and compare that with the demand rate.
- Analyse the downtime information to determine where the major waiting time occurs.
- Execute time studies in the section.
- Ask the team members which piece of equipment or part of the process is keeping them from achieving their target.
- Utilise simulation software to identify the constraint.

The constraint can be one of the following:

- The coal (feedstock): it may be very difficult to mine due to the geological conditions.
- The production (continuous miner, roofbolter etc) or auxiliary (switch gear, water pumps etc.) equipment.
- The conveyor system transporting the coal from the production unit.
- A management policy.
- The production plan – the demand may be too low – the unit has capacity to produce much more than it is required to.

Step 2 – exploit the constraint

After the constraint is identified, it must be utilised to the fullest. The golden rule is that every minute lost at the constraint is a minute lost to the system. Every ton of coal lost due to the constraint is a ton lost forever.

There are different options available to exploit the constraint. The following are guidelines.

- Reduce set-up times. This is applicable where a machine needs to be set-up after maintenance or where items need to be changed during on-line maintenance (such as changing picks and spray-water heads on the continuous miner, changing drill-bits on the roofbolter etc.) *[element 3]*
- Utilise the constraint as fully as possible– investigate hot-seat change over, doing maintenance in the off-shifts etc.
- Improve the availability of the constraint. Make sure that the maintenance strategy that is followed on the constraint is the right one. Analyse the downtimes on the constraint in-depth to determine what the major problem areas are. Involve the supplier extensively to increase the lifetime of the constraint.
- Make sure the quality of the coal being processed by the constraint is correct. If the constraint is used to process sandstone, scrap or low quality coal, the time lost will not be gained later.
- The quality of the product as it is processed must be controlled very rigidly from the beginning of the mining process. In the mining process coal that is too finely cut, or contains too much stone, cannot be reworked. It implies that the time the constraint was kept busy handling the coal, is wasted. It is therefore important that the quality of the coal must be maintained from the first time it is cut. For example, the continuous miner need to have roof-and-floor control systems in place (to prevent it from cutting roof and floor), the picks must be sharp to prevent fine coal generation etc.

Step 3 – subordinate everything else to the constraint

The production rate of the constraint dictates the production tempo of the whole unit. The drum-buffer-rope scheduling technique needs to be utilised to schedule the production rate of all the processes in the unit *[element 12]*.

If the continuous miner is the constraint the scheduling is easy as the rest of the equipment can only work as fast as the feedstock tempo. If downstream equipment is the constraint, then the continuous miner's cutting tempo, for instance, need to be adjusted accordingly. If the demand rate is the constraint the coal feeder tempo must be adjusted to the required rate. That will have the effect of controlling the production rate of the whole unit.

Step 4 – elevate the constraint

Only when the constraint is being used to full capacity, and the scheduling has been adapted to follow the tempo of the constraint, must any attempt be made to increase the capacity of the constraint. This can be achieved by:

- Having a standby piece of equipment available to use when the constraint is down, or to use concurrently with the constraint.
- In a mining section it may be difficult to add production equipment, but redesigning some features of the equipment, or using a different model can also increase capacity.
- It is very important that the right equipment is used for the different mining conditions. Exchanging equipment with other sections to ensure a right fit with the environment is an option.
- Changing mining methods and/or procedures.

Step 5 - re-evaluate the system

When changes are made in the section, it sets in place a whole new set of rules, with the possibility of a new constraint that has emerged. Inertia must not be allowed to set in, and the first line supervisor needs to start again at step 1 of the operational cycle, "identify the constraint". This must happen every time step 4 of the constraint management cycle has been completed.

10.6 IMPLEMENTATION

To implement the mining model the following aspects have to be taken into account:

- the implementation pre-requisites for Just-in-Time, Theory of Constraints and Total Quality Management as described in chapters 5-7
- the method of institutionalising it in the mining company.

As the building blocks of the mining model have their roots in the three operational management philosophies (JIT, TOC & TQM) all the prerequisites for implementation of these philosophies need to be taken into account. The following list is a summary of all the prerequisites.

- Management and employee commitment
- Organisational culture of sustained communication.
- Proper planning of the implementation project.
- Training and education of the employees in the new initiative.
- Proper change management.
- Supply of parts logistics changed.
- Operate at less than full capacity.
- Long-term emphasis.
- Prevent stagnation.

The approach to capture these prerequisites in the implementation of the model, is as follows:

- A project sponsor from the management group must be appointed. The role of the sponsor is to support and guide the production units in the process of implementing the mining model.
- A road show where the following three topics are discussed must be held:
    - Why do we need to change?
        - High expectations from the customers regarding quality, cost and throughput of coal

        - Highly skilled technical people exist but without the necessary operational management skills
        - Shareholders expect world class business results
    - What must we change to?
        - Production units run as business units, according to world class business principles
        - Ownership of these units lies with the unit members
        - Integration across functions
        - Continuous improvement culture
    - How will we get there?
        - Implementation of the mining operational management model
- The mining model is first implemented with three pilot units, and rolled out to three more after a six-month period.
- Formal classroom based training takes place before and during the implementation period. The training is broken down into different modules, of which the first line supervisor and deputy attends all, and the total team attends some. Refer to table 18 for the training module details. On the implementation plan (table 19) the training intervals are indicated. The training is scattered over the implementation period to increase the learning process, and decrease the production loss at any one time due to training.
- Facilitators from the continuous improvement department also partake in the training, and they are allocated to a unit for support and guidance during the first six months of implementation.
- Formal reviews by mine management take place during the implementation period according to the implementation schedule depicted in table 19.
- Every six months the mining model is introduced to 3 more units. For a small mine (4-5 production units) the implementation period will be one year, and for a large mine (8-10 production units) approximately two years. This process can be accelerated if the number of units introduced to the mining model per six-month period is increased. It all depends on the resources available to act as facilitators and trainers.

Table 18: Training modules detail

Nr.	Module title	Content	Participants
1	Change management	Change management principles Team building exercises Team roles	FLS, TM, F[2]
2	Mining model	Methodology of mining model Illustration of mining model	FLS, TM, F
3	Basic statistical techniques	Control charts Basic statistical measurements (st.dev etc)	FLS, F
4	Basic finances	Definitions of inventory, local-operating-expense Determining a budget and controlling it	FLS, F
5	Constraint management principles	Five focusing steps of constraint management DBR technique	FLS, TM, F
6	Waste management	Different types of waste Ideas on eliminating waste	FLS, TM, F
7	Process improvement process	Steps for process improvement Quality circles principles	FLS, F
8	Basic problem solving techniques	Brainstorming Pareto Fish bone diagram	FLS, F
9	Advanced problem solving techniques	Five trees (TOC) Evaporating cloud	FLS, F

[2] FLS = first line supervisor; TM = team members; F = facilitator

Table 19: Implementation plan for mining model

	MONTH 1					MONTH 2			
	Initial stage	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
MINING MODEL ACTIVITIES	Road show	Define team vision, core values	Step 2 of strategic cycle:	Populate graphs & tables with unit actual data	Identify constraint	Constraint management steps	Constraint management steps	Constraint management steps	Constraint management steps
		Define the process according to step 1 of strategic cycle	-determine customer requirements		Measure against targets	Measure against targets	Measure against targets	Measure against targets	Measure against targets
			-establish measurements				Identify improvement opportunities from measurements	Identify improvement opportunities from measurements	Identify improvement opportunities from measurements
								Process improvement steps	Process improvement steps
TOP MANAGEMENT SUPPORT ACTIVITIES									Mine manager visits unit; discusses measurements and improvement opportunites
TRAINING	Modules 1 & 2		Modules 3 & 4	Module 5		Module 6	Modules 7 & 8		

	MONTH 3	MONTH 4	MONTH 5	MONTH 6	MONTH 7	MONTH 8	MONTH 9	MONTH 10-11	MONTH 12
MINING MODEL ACTIVITIES	Constraint management steps	Constraint management steps	Constraint management steps	Constraint management steps	Constraint management steps	Constraint management steps	Constraint management steps	Constraint management steps	Constraint management steps
	Measure against targets	Measure against targets	Measure against targets	Measure against targets	Measure against targets	Measure against targets	Measure against targets	Measure against targets	Measure against targets
	Identify improvement opportunities from measurements	Identify improvement opportunities from measurements	Identify improvement opportunities from measurements	Identify improvement opportunities from measurements	Identify improvement opportunities from measurements	Identify improvement opportunities from measurements	Identify improvement opportunities from measurements	Identify improvement opportunities from measurements	Identify improvement opportunities from measurements
	Process improvement steps	Process improvement steps	Process improvement steps	Process improvement steps	Process improvement steps	Process improvement steps	Process improvement steps	Process improvement steps	Process improvement steps
TOP MANAGEMENT SUPPORT ACTIVITIES	Mine manager visits unit; discusses measurements and improvement opportunites	Mine manager visits unit; discusses measurements and improvement opportunites	Mine manager visits unit; discusses measurements and improvement opportunites	Presentation to Executive Group : targets and results, improvement initiatives			Mine manager visits unit; discusses measurements and improvement opportunites		Relook vision & values; process definitions; customer requirements; measurements
									Presentation to Executive Group : targets and results, improvement initiatives
NEXT ROLLOUT PLANNING ACTIVITIES		Mine management determines 3 new units			3 new units start their cycle (month 1, week 1)				
TRAINING	Module 9			3 new units receive training on Modules 1 & 2					

10.7 SUMMARY

Utilising the identified elements from the operational management philosophies Just-in-Time, Total Quality Management and Theory of Constraints a model for use in the mining production unit is constructed. The model is simplistic enough for the first line supervisor to utilise but powerful enough to assist him in achieving, and exceeding, his targets. All the necessary prerequisites for a successful implementation are captured in the implementation plan.