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MINERAL RESOURCE MANAGEMENT PRINCIPLES THAT NEED TO BE INCORPORATED IN ANGLOGOLD ASHANTI LTD

EAST AND WEST AFRICA REGION

by

WYNAND BENDER

A thesis submitted in partial fulfillment of the
requirements for the degree of

Master of Science in Engineering

University of Witwatersrand

2005

Approved by _____
Chairperson of Supervisory Committee

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_____

Program Authorized
to Offer Degree _____

Date _____

DECLARATION

I declare that this research report is my own work. It is being submitted for the Degree of Master in Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.

_____

(Signature of candidate)

_____day of_____(year)_____

University of Witwatersrand

Abstract

MINERAL RESOURCE MANAGEMENT PRINCIPLES THAT NEED TO BE INCORPORATED IN ANGLOGOLD ASHANTI LTD EAST AND WEST AFRICA REGION

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With the acquisition by AngloGold Ashanti Ltd of open pit mines in East and West Africa with possible addition of Greenfield and Brownfield operations, the emphasis of this research document was to improve the current open pit mines in this region. By identifying Mineral Resource Management (MRM) as a way to improve and manage operating practices, additional value and the accompanied risks have been identified. It was also realised that the current traditional, predominantly financial indicators are becoming increasingly inadequate, thus looking at alternative operating principles. Subsequent to this, proposals have been made to acquire the necessary production and cost change by integrating structure, strategy, systems, style, skills, staff and the defined goals as proposed in this document. Using a "process-based" approach integrating (best) operating practices, concepts such as: living out the company's strategic values; a learning organisation; better informed decision-making; people management; self-directed teams; continuous improvement; asset and capital management; integrated information systems; and an improved internal and external customer relationship be obtained.

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1. INTRODUCTION

The concept of MRM has been around for quite some time, but with varying degrees of success. In short, it can be defined as a business principle applied to all levels in the management chain. In its broadest sense, it is the translation of an ore body from a resource to an asset and then managing it as an asset. It then has a certain fiscal value, governed by legal structures, and undergoes depreciation. The value depends on the integration of very tangible technical and management skills with a business plan of objectives. If the business process is inadequately understood, it leads to:

- Inadequate competency development;
- Value chain integration problems;
- Non-compliance to protocols and standards in everyday practices;
- Persistent focus on the short term, destroying future value for the shareholder in the long term;
- Decreasing business knowledge in mechanistic processes and systems; and
- Underlying vision or theme that underpins development of successful assets development.

Mineral Resource Management exists out of various functions/elements that need to be addressed for complete and thorough understanding of the whole process. MRM is used to optimize the integration of all system components in such a way that the whole is greater than the sum of the individual components in reaching a common goal. Customer Relationship Management and Project Management Principles enhance this process to obtain an integrated resource planning and management approach in the extraction of the mineral reserves over different time horizons to benefit all customers over the value chain.

Mineral Resource Management is also a unique business concept developed to increase throughput and productivity by focusing on process alignment. It stratifies information systems, quality control, services, best practices, and also integrates tactics/strategic planning and management implementation.

This integration will release the desired growth as defined in the company goals over the mine operations in various degrees of effectiveness, but also quantifying and considering all risks along the value chain. Furthermore, the knowledge of the business process among personnel improves. Work is now goal orientated, resulting in increased efficiencies and productivity.

It must be realised that principles of MRM are in actual fact not rocket science. Alistair MacFarlane of the University of Witwatersrand has completed a vast quantity of work regarding this management form. This report expands on his work. The implementation process is more an institutionalizing of a different thinking process where change management is essential.

1.1 Background

AngloGold Ashanti Ltd corporate office is based in Johannesburg, South Africa, and is a global gold producer with 19 operations in eight countries, on four continents, and has extensive and focused exploration activities in 11 countries. AngloGold Ashanti Ltd (hereinafter referred to as “AngloGold”) Shares are listed and traded on the JSE Securities Exchange South Africa, the Australian Stock Exchange in the form of "CHESS" depositary interests, the London Stock Exchange and Euronext Paris, and are quoted on Euronext Brussels in the form of International Depositary Receipts. AngloGold ADSs are listed and traded on the New York Stock Exchange.

AngloGold's East and West African operations comprise five operations located in three African countries other than South Africa. They are: Morila, Sadiola Hill and Yatela within Mali in West Africa, Navachab Mine in Namibia on the south-western coast of Africa, and the Geita Mine in Tanzania.

Sadiola and Yatela Gold Mines are situated in western Mali respectively 80km and 60km south of the regional capital, Kayes, 20km apart from each other. Morila Gold Mine is in the southern part of Mali, 280km south east of the capital, Bamako. Geita Gold Mine is situated in north-eastern Tanzania, 60km south west of the regional capital, Mwanza, and in Namibia, 170km west-north-west of the capital Windhoek, is Navachab. See **Figure 1.2** for a geographical map of AngloGold operations within East and West Africa Region.



Figure 1.2: Geographical map of AngloGold operations

Herewith a brief description of each mine:

1.1.1 Sadiola Hill Gold Mine

The Sadiola deposit occurs within an inlier of greenschist facies metamorphosed Birimian rocks known as the Kenieba Window. The inlier is intersected by a series of north-south trending faults, the most prominent of which the Senegalo-Malian Shear (SMS) passes through Sadiola's lease area. The mineralisation occurs in the immediate vicinity of a parallel structure to the SMS.

The specific rocks which host the mineralization are argillaceous carbonates and greywackes which have been intensely weathered to a maximum depth of 200 meters. The Sadiola Hill deposit generally consists of two zones, an upper oxidized cap and an underlying sulphide zone.

Construction commenced at the Sadiola open-pit operations in 1994 and full production was achieved by June 1997, with 380 000 ounces of low cost gold being produced in the first year. The project cost was US$280 million. From 1996 until 2002, shallow, saprolite oxide ore from the Sadiola Hill pit was the primary ore source. Since 2002, the deeper saprolitic sulphide ore has been mined and in future, will progressively replace the depleting oxide reserves. The other joint venture partners are Toronto-listed IAMGOLD, the Malian government and the International Finance Corporation (IFC).

Mining takes place at the Sadiola Main, Blue Dam (FE-3) and Tabakoto (FE-4) pits, making use of a South African mining contractor, Moolman Brothers. Mining activities end in the first quarter of 2008 if the deep sulphides prove not to

be feasible. In the middle of 2004, an alliance partnership has been implemented as a method to decrease mining costs.

The plant is currently processing material at a rate of 5.3 Mtpa, in comparison to its design capacity of 4.0 Mtpa. The improvement in throughput has been achieved by streamlining processes, improving efficiencies and minor equipment changes.

1.1.2 Yatela Gold Mine

As part of the consolidation of Anglo American Corporation's gold mining interests, AngloGold acquired a 50 percent interest in Sadiola Exploration Limited, which company held the prospecting rights in the Sadiola region. Together with the Joint Partner, IAMGOLD, exploration was undertaken and a feasibility study conducted at the Yatela deposit site. The success of the feasibility study led to the formation of a company, Société d'Exploitation des Mines d'Or de Yatela S.A. In February 2000, AngloGold approved the capital expenditure of US$76 million for the mine's development along with two other joint-venture partners while AngloGold manages the operation.

Yatela mineralization occurs as a karst-related keel-shaped body in Birimian metacarbonates. The keel is centered on a fault which is the feeder for the original mesothermal mineralization, with an associated weak, mineralized diorite intrusion. The original mesothermal mineralisation has formed a residual layer along the flanks and in the bottom of the keel, which was subsequently filled up with Proterozoic sandstones. The ore dips almost vertically on the western limb and more gently towards the west on the eastern limb, with tight closure to the south.

The first gold was produced on May 9, 2001. The mine reached its design production capacity in the second part of 2001 and has subsequently surpassed expectations. In 2003, approval was granted to proceed with the development and mining of the Alamoutala deposit. Mining of the Alamoutala pit started in July 2003, 10 days ahead of schedule.

Yatela is benefiting from synergies and economies of scale obtained through utilisation of some of Sadiola's infrastructure. Processing is based on a 2.5 million tonne per year heap leach operation, at an 85% recovery rate, including a 3.0 million tonne per year heap leach pad and a carbon-in-solution circuit treatment facility. The loaded carbon is trucked to Sadiola, where treatment, on a toll basis, takes place.

Alamoutala will be mined out at the end of 2004 while Yatela will close down in 2006.

1.1.3 Morila Gold Mine

On July 3, 2000, AngloGold acquired a 40 percent interest in the Morila project in Mali, from Randgold Resources Limited. Under the joint venture agreement, AngloGold is the operator of the mine. AngloGold paid a purchase price of $132 million for its stake in the Morila Joint Venture, with US$72 million funded through AngloGold's own resources and the balance of US$60 million funded through debt, with a project finance provision of $36 million at acquisition. Randgold retains a 40% interest in the venture with the Malian government holding the remaining 20%.

Morila is a Birimian mesothermal sediment-hosted deposit. The mineralization model is still being developed, but indications are that mineralization is related to a compressive tectonic event. Original mineralization relationships are largely obscured by an intrusive event.

The process plant is a conventional CIL process with an up-front gravity section to extract the free gold. The plant has a rated throughput of 250,000 tonnes per month, which equates to 3.0 million tonnes per annum.

Attributable production at Morila is expected to decrease by 28 percent to 228,000 ounces for 2004, due to a 47 percent decline in recovered grade. Total cash costs should increase by 64 percent to US$177 per ounce due to the lower grade, increased mining contractor costs and the end of the exoneration period on import duties and taxes. At its peak, the Morila pit will have a surface area of approximately 666,000 m^2, a length of 1,190 m, a width of 820 m and a depth of approximately 196 m. Mining will end 2008

1.1.4 Geita Gold Mine

On December 15, 2000, AngloGold acquired a 50 percent interest in the Geita project in Tanzania from Ashanti Goldfields Company Limited. Under the joint venture agreement, the Geita Joint Venture is governed by a committee (the "Joint Venture Committee") which has equal representation from both partners. In the first quarter of 2004, AngloGold and Ashanti Goldfields Company merged, thereby reducing the management complexity.

A purchase price of US$205 million was paid for the Geita Joint Venture, with $35 million funded through AngloGold's own resources and the balance of $170 million funded through debt, with a project finance provision of $67 million

at acquisition. A French construction company, DTP Terrassement, has taken over mining operations over from AMS in 2002 after AMS has breached the contract.

Geita is an Archaean mesothermal mainly BIF-hosted deposit. Mineralization is located where auriferous fluids, which moved along shears, often on BIF-diorite contacts, reacted with the BIF. Some lower-grade mineralization can occur in the diorite as well (usually in association with BIF-hosted mineralization), and approximately 20 percent of the gold is hosted in the diorite.

The main pits being mined are Nyankanga, Lone Cone and Kukuluma pits, while satellite pits as far as 20km from the plant are being mined, using conventional open pit mining. The majority of mineralisation at Nyankanga is hosted in hard, competent basement rocks requiring drilling and blasting. This is overlain by soft, oxidised material. The mine has developed an environmental management system which earned them ISO 14001 certification.

The Geita plant uses conventional CIL technology, and has a design capacity of 4.0 Mtpa. There is the potential to expand to 7 Mtpa with little incremental capital.

During 2004, attributable production is expected to increase by 4 percent to 345,000 ounces. Total cash costs should increase by 9 percent to $199 per ounce, due to anticipated increases in mining contractor rates and plant maintenance requirements. Capital expenditure of $10 million, attributable to AngloGold, is planned in 2004.

1.1.5 Navachab Gold Mine

After having obtained an additional 30 percent interest in Navachab in 1999, AngloGold now holds a 100 percent interest in the Navachab open-pit gold mine near Karibib in Namibia, which has been in production since 1989.

The Navachab deposit is hosted by Damaran greenschist-amphibolite facies, calc-silicates, marbles and volcanoclastics. The rocks have been intruded by granites, pegmatites and quartz porphyry dykes, and have also been deformed into a series of alternating dome and basin structures. The mineralized zone forms a sheet-like body which plunges at an angle of approximately 25 degrees to the north-west. The mineralization is predominantly hosted in a sheeted vein set (60 percent) and a replacement skarn body (40 percent). The gold is very fine-grained and associated with pyrrhotite, pyrite, chalcopyrite, scheelite and sphalerite. Approximately 80 percent of the gold is free milling.

Navachab's processing plants include mills, carbon-in-pulp (CIP) and electro winning facilities and have a production capacity of 110,000 tpm.

A decision to proceed with a pushback towards the east to extend the life of mine by eight years to 2013 was taken by the AngloGold Board in July 2002 and this project is ongoing. Due to rising contractor costs, a decision was taken in 2003 to terminate the mining contract and proceed with owner mining. Capital expenditure of $17 million has been approved for this project and implementation will be during the first six months of 2004.

Summarised below in **Table 5.1** is AngloGold Ashanti Ltd's shared ownership at Sadiola Hill, Yatela and Morila Gold Mines while at Navachab and Geita AngloGold own 100%.

OWNERSHIP	SADIOLA	YATELA	MORILA	NAVACHAB	GEITA
AngloGold Ashanti Ltd	38%	40%	40%	100%	100%
Iamgold	38%	40%			
State of Mali	18%	20%	20%		
IFC	6%				
Randgold			40%		

Table 1.1.6.1: EWAR mines summary contribution to AngloGold

Greater emphasis will be made in unlocking the regions' values as defined in the beginning of this document. Using Mineral Resource Management Principles as a guideline, the region's mineral assets are optimally extracted with the minimum amount of risk, increase in profit, cutting cost and increase in discounted cash flow.

1.2 Values and behaviour

Successful implementation of Mineral Resource Management (MRM) requires simple integration with the current functional silo's assessing business opportunities, costs, technology needs, risks and impact on work teams, infrastructure and social environment. The proposed managerial methodology must furthermore be aligned with the vision of the company in order to enhance the required strategy. Simple actions can act as a vehicle, even if it means having a temporary duplication, creating a collaborated solution by evaluating possible options and identifying a preferred solution which will define the process, and

technical and operational requirements where appropriate (streamlining the process). It must be ensured that the preferred strategy will meet the defined needs.

AngloGold's current business strategy vision and values can therefore be summarised below in order to integrate it with simple actions.

MISSION

What we are here to do…

Our business is gold. We consistently seek to create value for everyone with a stake in our company, by finding and mining gold and by developing the market for our product.

VALUES

How we expect to get where we want to go…

- AngloGold consistently strives to generate competitive shareholder returns. We do this by replacing profitable gold reserves and by continuously improving the performance of our key resources – our people, our assets and our products. We conduct ourselves with honesty and integrity.
- We provide our employees with opportunity to develop their skills while sharing risks and rewards in workplaces that promote innovation, teamwork and freedom with accountability. We embrace cultural diversity.
- Every manager and employee takes responsibility for health and safety; and together strive to create workplaces which are free of occupational injury and illness.
- We strive to form partnership with host communities, sharing their environments, traditions and values. We want the communities to be better off for AngloGold's having been there. We are committed to working in an environmentally responsible way.

These values will guide the execution of East and West Africa Region Strategy that will enhance the AngloGold vision and mission. Africa Region's Goals are to the extent, but not properly defined. They are:

- Drive down cost and risk curve
- Organic growth
- Brown fields
- Green fields Sites
- Mergers and Acquisitions
- Gold Value Chain

The East and West Africa region is focusing on:

- Optimising current reserve exploitation; and
- Concentrating on exploration activities to produce new profitable ounces in or adjacent to existing operations.

Although optimization of reserve exploitation is one of the focus areas within the region, are there no clear tacticals identified. Like SA Underground Region that intensively make use of Mineral Resource Management principles, needs Africa Open Pit Region also find the means to acquire the required organic growth. Niches of expertises and technology areas exist but are scattered over the region. This needs to be communicated and integrated across the region to release the maximum value within the business unit's value chains.

EWAR key strategic issues are listed below:

Operational Excellence:

- Achieve budgeted earnings for the year;

- Counter the effects of strengthening exchange rate (Mali and Namibia) and increased fuel prices
- Medium to long term focus:
- Optimise operation plans to maximise Net Present Value (NPV)
- Ensure validity of geological models
- Improve mineral resource management
- Focus on projects identified for improving Return On Investment Capital (ROIC) through Shareholders Value Analysis (SVA)
- Extend the SVA process to Geita and Navachab
- Build in flexibility through stripped reserve and stockpiles
- Improve effectiveness of budget process
- Improving unit costs on all operations.

Organic Growth:

- Defining annual objectives and measurements for major projects
- Ensure there are no slippages on projects
- Limiting capital cost expenditure

Greenfields Exploration:

- Do a political, security and economical risk analysis for all the countries within Africa that we would want to do business in.
- Identify prospective gold targets for future business
- Persevere with the Democratic Republic of the Congo (DRC) initiatives
- Focus on Mali South exploration with objective to include in the 2004 Business Plan.

Brownfields Exploration:

- Focus on pit expansion exploration
- Focus on satellite orebody exploration
- Consider the economics of deep targets, i.e. open pitable versus underground criteria

For the short to medium term, the following was determined as the key focus areas:

i. Procurement and Logistics
    - Speed up the procurement process and optimal supply lines and routes to the operations

ii. Information Exchange
    - Excessiveness of information requirements
    - Separation of data and information needs and provision

iii. Legal
    - Contract design and management (with special focus on mining contracts)
    - Scope of management fees

iv. Manpower

- Comprehensive manpower planning for managerial staff at the operations to be in place;
- Localisation plans per operation with target dates to be formalised;
- Needs basis training and development plans for operational staff to be implemented;
- Capacity building programs for local employees and local shareholders;
- The formulation of competency based localization plans.

v. Role Clarity/Team Dynamics

- Nothing stated.

vi. IR Development in Mali

- Continue the development of internal relationships and networking capacity that will ensure good labor relations per country at each of the operations.
- National collective agreements
- Application of appropriate remuneration strategies for all operations.

vii. Information Systems

- WAN development in Mali
- Video conferencing
- Communication systems
- Common data platforms

viii. Sustainable Development

- Creation of a sustainable all inclusive structure and vehicle for the management of community development projects.
- The development of a sustainable and holistic health strategy that includes an occupational health program, malaria management program and AIDS management program.

Strategic planning is the essence of attempting to secure the operating environment of a business as well as giving substance to goal-directed functioning. In pursuit of these business goals, East and West Africa Region Business Units need to operate according to plan without harming employees. Therefore critical risk behaviours at each level in the organisation need to be defined. Furthermore, environmental impacts also need to be regularly assessed.

Using SWOT analysis, the current strengths, weaknesses, opportunities and threats of EWAR could be determined:

Strengths	
♦ World class ore bodies ♦ Good operating margins and cash ♦ Good operating relationships ♦ Sound operations ♦ Ability to work in Africa ♦ Africa based company	♦ Medical assistance ♦ US$ revenues ♦ Exploration ♦ Organic growth ♦ Strategic sourcing
Weaknesses	
♦ Industrial relations ♦ Cyanide management ♦ Environmental management ♦ Relationship key stakeholders ♦ JV structures ♦ Supply Infrastructure	♦ Heap leach experience ♦ Communication ♦ Safety performance ♦ Manpower management

Opportunities	
♦ IT ♦ Immature continent ♦ Operations efficiency ♦ Management localisation ♦ Grid power ♦ M&A ♦ Improvement mining contractors ♦ Owner mining ♦ Exploration	♦ Organic growth ♦ Strategic sourcing ♦ Short life of mines ♦ Diminishing local expenditure
Threats	
♦ Forced Localisation ♦ Labour relations ♦ Cyanide / environmental ♦ regulations ♦ Gold price ♦ Community expectations ♦ Social society expectations ♦ Logistics ♦ Infrastructure (supply)	♦ Country risk ♦ Lack local skills ♦ Malaria ♦ Aids ♦ Tax changes ♦ Concentration in Mali ♦ Short life of mines ♦ Diminishing local expenditure ♦ Escalating unit costs

Table 1.2.1: Current SWOT Analysis

The already defined Key Resource Indicators (KRI) for EWAR is:

Costs	$129/oz	*2002*
Gold Production	Level maintained through to 2004	
Organic Growth	Raise NPV – 10% of $493 million through improved resource modules	
Geita Plant Expansion	$10 million to achieve 7 million tons / annum	
Navachab	*Extend life to 2015*	

Table 1.2.2: Current KRI of EWAR

And the current Key Resource Area's (KRA) are:

Trust:

- Communicate openly
- Good reputation
- Constructive feedback
- Relied upon to perform your task
- Receptive to feedback

Professionalism & Ethics

- Confidentiality (Not withhold info)
- Competence
- Continuously set and maintain high standards
- Mentoring + coaching
- Timeous feedback
- Dependability
- Positive image
- Good leadership

Honesty and Integrity

- Give facts
- Provide objective information and opinion
- Truthful
- Transparency
- Fulfil promises

Reliability and dependability

- Fulfil commitments
- Meet deadlines
- Responsive
- Focus on issues
- Availability vs. Accessibility
- Accuracy
- Support
- Pursue agreed goals

A clear description of how well AngloGold wants to fulfil its role (as expressed in the vision), and how we are going to realise the vision (mission) has been clarified. From this mission, values, SWOT analysis, KRI's and KRA's are the "where to go", but it needs to be further enhanced. Specific Business Processes such as Mineral Resource Management, can therefore enhance the required goals and quantifiably state the what, how, who and when. This will also set a clear business direction.

Using MRM principles will implement further planning and controlling tools over the operational requirements. "Planning is critical for business governance, protection against vulnerabilities and for the exploitation or capitalisation of positive aspects related to the business" (Author unknown).

The development of the MRM principles are divided into two sections namely the Strategic Intent Document and the Action Management Document. The Strategic Intent for Mineral Resource Management can further be broken down into the

business goals, see Page 40, while the action management documentation applying activity driven standards according to the business, strategic and operational environments are shown in Page 54.

Activity driven standards are determined by physical conditions and can be used as production performance standards. These standards measure and evaluate planning, production, personnel and cost performance, creating a management and control environment. To achieve process focus, must the activity driven standards of the long term and production information be aligned.

The market structure in the particular commodity of interest, as well as the up or down phase of the commodity, will dictate the standards strategy for the supply of the commodity to market. Gold is typically in a competitive market. Competitive markets follow traditional economic principles where the balance between supply and demand dictates the price. This type of structure provides incentives for the producer to produce and supply a commodity as long as the price received covers the average variable cost. The net effect is that over capacity will result in exit of the high cost producers, and high prices will provide incentive for new capacity to be established, in either case, until demand and supply have reached equilibrium.

Factors that need to be considered either to enter or stay in the market are summarized as follows:

- The high technical cost of closure and reopening;
- The possibility of deferring some cost items to the future;
- Legislative issues regarding taxes, subsidies, labour, and other socio-political issues;
- Reduced profit incentives for governmental producer who may target employment of foreign exchange receipts;

- Downward trend in real prices and unavoidable escalating in costs such as wages, relate to increase in cut-off grades and decreasing payable reserves. Higher price conditions result in the future decrease margin where the supply is high but the demand is low;
- Depletion of quality deposits over time resulting in lower grades and higher risks that require ingenuity and sound management skills;
- Global competition steadily reduces costs, transparency and rapid reaction time by making use of integrated systems and the latest technology.

The purpose of this document is therefore to design and establish principles and Key Performance Indicator's over the whole value chain that will govern an effective and efficient mineral resource management process. It must determine the value determinants and describe how these can be optimized in order to bridge the gap between corporate and operational objectives.

1.3 Definitions

Mineral Resource Management: The definition of Mineral Resource Management is to integrate key mining functions from the resource to the market to create a seamless transaction to **maximise value** and **reduce risk, now and in the future.**

Resource knowledge areas**:** Different skills used within Mineral Resource Management to manage and control

S*takeholders*: Stakeholders can be identified according to availability and effective use of resources; political affiliations; public support; quality of strategy/organisation; dedication of members; and planning horizons / tasks complexity.

***Project Management*:** It is the combination of cross-functional human and nonhuman resources, overlays of multiple lines of authority, pulled together in a "temporary" organisation to achieve a specific purpose for a finite period of time. A well-executed program management is a leading factor in project successes. The primary focus is on results.

***Risk Management*:** Risk is the processes concerned with identifying, analysing and responding to uncertainty (throughout the project life-cycle). It includes maximising the results of positive events and minimising the consequences of adverse events. Risk, uncertainty and opportunity are closely related.

Transitional Management: Transitional management is the art and science of managing the conversion period from one organisational design to another. Transitional management necessitates an understanding of the new goals, objectives, roles, expectations, and fears that people consider.

Customer Relationship Management (CRM): Involves interaction between the customer and the rest of the project team. When the customer is external, it is also managing interaction between the customer and the performing organisation. The results of good CR are that both parties are enthusiastic about the relationship.

Total Quality Management: The nature of quality control procedures adopted must be highlighted, including whether acceptable levels of accuracy and precision have been established over the whole value chain.

Benchmarking: Benchmarking is a disciplined process that begins with a thorough search to identify best-practice organisations; continues with careful study of one's own practices and performances; progresses through systematic site visits and interviews; and concludes with an analysis of results, development of recommendations and implementations.

Creativity: the ability to take existing objects and combine them in different ways for new purposes.

Innovation: The capability of continuously creating new methodologies and implementing it successfully. It is a belief system of competitiveness / efficiency and an ability to leverage technology, systems and people in different ways to achieve results.

Business Process: An organized group of activities that work together to create a result of value to the customer.

System: A management approach that attempts to integrate and unify scientific information across many fields of knowledge towards achieving some common goal or objective. It can also be defined as the science of designing complex systems in their totality to ensure that the component subsystems making up the system are designed, fitted together, checked and operated in the most efficient way.

Re-engineering: Radical redesign of business processes of dramatic improvements.

Best Practices: It is those practices that have been shown to produce superior results; selected by a systematic process; and judged as exemplary, good, or successfully demonstrated.

***Mine line ore*:** This is the expected Run-of-Mine ore on which the stripping strategy is based.

Mine line stripping ratio: This is the ratio between the waste rock, which should be removed according to the strategy to expose the ore, and mine line ore.

Mine line ore losses: Mine line ore that is lost due to dilution with waste material and deposited with waste material on waste dumps.

Mining losses: This refers to any ore that is lost (measured against the ore based on the final geological information). This is a measure for resource utilization.

***Mining Recovery*:** That tonnages and grade on a block by block basis are expected to be realized in practice given at a certain cut-off grade and selectivity

in mining. This may be based on a classification of in-situ block grade estimates after making some allowance for dilution and ore loss, or on estimates of recovered fractions of the blocks that will be mined above a chosen cut-off grade.

***Minability*:** The estimate of tonnage and grade that will be recovered or is achievable through mining on a local block by block basis, but which is also contained within economic ultimate pit limits.

***Technology*:** Technology is all about knowledge (Know- why), People (Know-how), and Tools (Algorithms, Procedures, Rules and Processes).

2. OBJECTIVES

Value, integrity, and the minimum amount of risk are fundamental measurements to ensure that value is realized and optimised. Of significant importance, is to determine the linkage between the short and longer term, and that the value is manifested through the development of life of mine plans in order to maintain value, despite depletion. To integrate practices and/or principles, each core- and sub processes must be thoroughly understood. Resource Knowledge Area's (KPA's), Resource Knowledge Indicator's (KPI's) and customer needs must also be identified to obtain the best integrated performance.

By defining a framework for the rollout plan, the right mining practices and mineral resource estimate procedures can be implemented. It is all done to understand:

1) The impact of geological parameters and mining methods, and ore handling (contamination and fines control) on the beneficiation process to improve beneficiation and pro-active control in the mining environment;
2) To increase the product value by improving the in-situ information;

3) By improving recovery versus optimum quality, by determining critical ore morphology parameters to be managed during beneficiation.
4) By improving reconciliation between planned product and product quality and actual results through a holistic mineral resource accounting system.

Within the Framework, the required targets can be summarized into measurable and non-measurable and represents the company's economic viability and should be properly integrated with the correct mining procedures.

The quantifiable / measurable targets are therefore:

- Maximize revenue through the improvement of efficiency across the total production and supporting processes value chain. Implementation experiences showed an increase in revenue of between 2% to 20% and a decrease in unit cost of 5% to 15% per annum. Life of Mine can also be extended with 5% to 10%.
- Improve management and control, ensuring high utilisation of the ore body by integrating the mine planning and operational environments.
- Improved plant yield vs. grade optimisation.
- Utilization of low-grade ore, classified as discard.
- Extraction through improved control of grades and contamination.
- Enables better informed & defensible plans, budgets & schedules.
- Cutting out loss making activities and operations.
- Identify areas of risk and uncertainty that may limit or prevent achieving the objectives.
- Establish criteria for project prioritising and selection within MRM for achieving the strategy of the mine.

- Convey corporate Net Cash Flow objectives for the budget year to the operation.
- Establishing of clear audit trails and reconciliation.
- Continuous integration of value chain activities.
- Creating flexibility in the operation.
- Generate contractual procurement documents performance deliverables.
- Optimal understanding and utilization of ore reserves
- Improved ore utilization through:
    - Scheduling improvement based on material compatibility.
    - Choice and optimisation of mining horizon.

The targets are all about value and should be based on the cumulative cost up to the final function in the value chain, and not just only on the mining operations. Furthermore is it more appropriate to focus on actual costs of production rather than one of the parameters contributing to cost of production, thus breaking down the process cost into the different elements that make up that cost. See Figure 2.1 for an example of such a cost tree.

The minimum value of operation for the mine must be incorporated, but an assessment of accompanied risk must be done along with this return on investment. Communication is essential in this process. One of the non-measurable goals indicates the importance of communication between the role players that will improve culture awareness towards resource management.

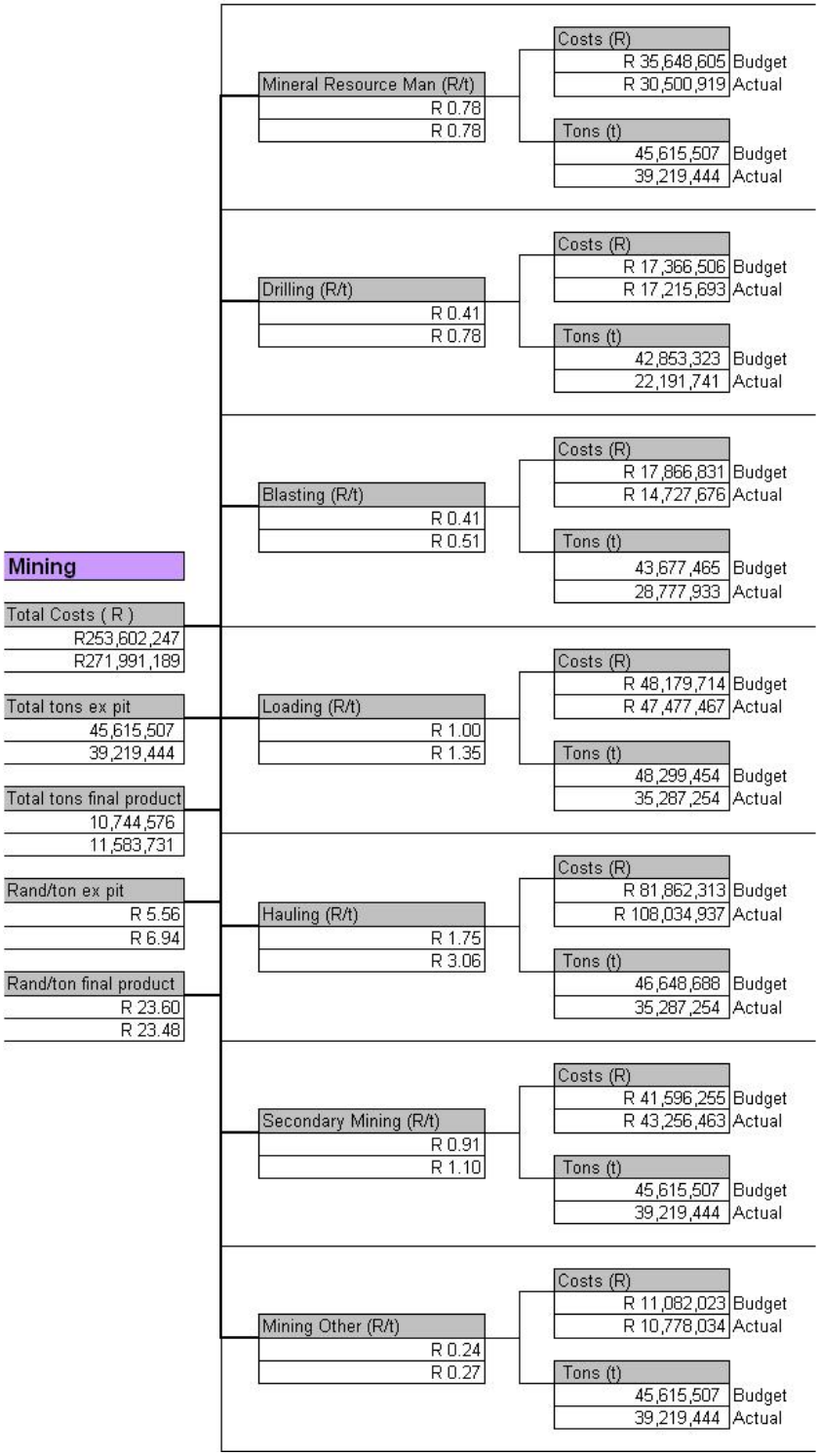


Figure 2.1: A cost tree example

Therefore, non-measurable targets involved proper and effective management of the hard actions. It included managing the culture and climate of the organisation to create and orientate positive behaviour. It required careful management through sensitive leadership.

The objectives therefore are:

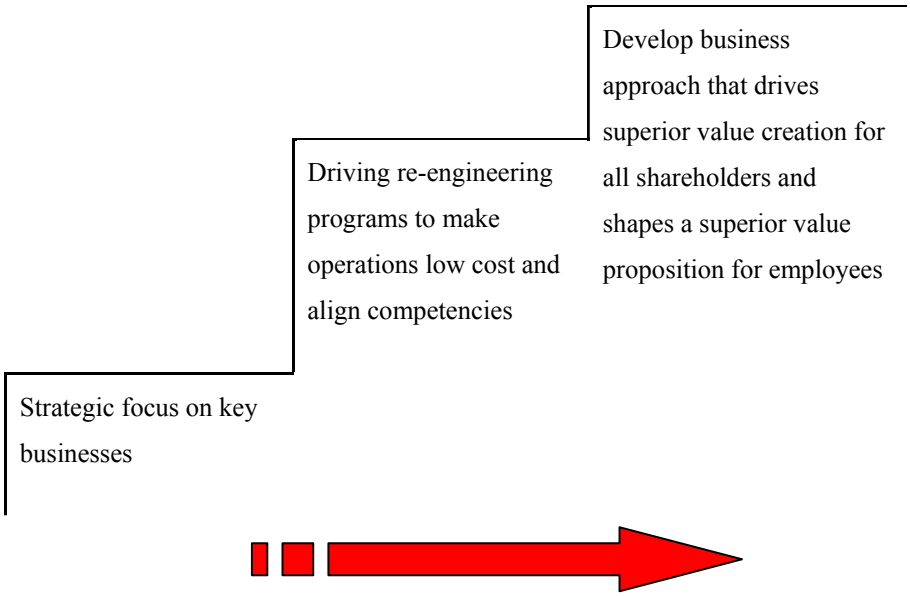
- Define and clarify objectives, strategy, policy and goals of the company.
- Necessitate and understand the new goals, objectives, roles, expectations, and fears of the people within the MRM-process.
- Determine objectives of the proposed mineral model for:
  - Target key technical activities;
  - Requirements of production feasibility studies.
- Making trade-offs between competing objectives and alternatives, in order to meet the stakeholder/client requirements.
- Decide on a resource accounting methodology model.
- Balance of short- and long-term objectives.
- Choose task and procedures on their ability to:
  - Have value for money;
  - To be flexible;
  - To be maintainable;
  - Must be of good quality.
- Achieve organisational (especially the technical functions) integration.
- Identifying conflicting goals and objectives.
- Establish a creative environment.
- Improve communication between role players.
- Establish a sound and fast decision making organisation.
- Apply innovative designs, technologies and methodologies to achieve improved performance.
- Align geology (in-situ reserves), mining (planning, scheduling and production), plant (product delivery and range) and market (specifications and volume).

- Formalize corporate experience and improve general communications.
- Improve understanding between disciplines and team spirit.
- Develop the ability of staff to assess risk in everyday tasks
- Encourage participation at all levels in the organization.
- Identifying and seizing market opportunities as they arise.
- Training and sensitising of MRM principles are planned and scheduled on a continuous basis for the whole organisation.
- Short- and long-term objectives are integrated to ensure balance is achieved now and in the future.
- Performance appraisals and personal contracts support the MRM principles.
- Knowledge sharing across functional boundaries is evident.
- Involvement and commitment from the highest level is evident (buy-in obtained)

Note that the more one moves to soft benchmarking factors, the greater the value that is created. Greater emphasis is therefore given to implement and develop best operating practices.

By quantifying these required targets, the production process definitions and business analysis will be addressed. This will provide valuable information regarding the current alignment of the business strategy, processes, technology and people. Proper benchmarking must constantly be carried out to ensure correct MRM Best Practices are sought after.

The result of the proposed desired outcome is as follows:



3. FRAMEWORK

Leading organisations established that there are 5 “must-do’s” that enable them to perform exceptionally well, namely:

1) Mission and aspirations – Define and relentlessly communicate a compelling mission & stretch aspirations;
2) Targets and goals – Translate aspirations into measurable, very aggressive targets and goals for the company;
3) Organisational approach - Define appropriate organisational units and break corporate goals down into measurable, aggressive performance targets for each unit;
4) Performance feedback – Establish processes to measure and publicly communicate performance;
5) Consequence management – Communicate and visibly execute consequences for over- / under-performance.

To be able to perform these "must-do's", there are 3 motivational levers and 3 coordination control levers that must be executed. These levers are:

Motivation Levers	Co-ordination and control levers
Incentives	People-incentive processes
Opportunities	Financial control and planning
Values & Beliefs	Operational control and planning

Table 3.1: Levers to perform well

Incentives are necessary to create value through suboptimal activities, but coordination of these measurable targets over the value chain of the MRM process need to be understood to leverage the desired output. This is about attracting, retaining and enhancing the commitment of the staff. In the Third World countries where AngloGold operates, staff must be made aware that the incentive scheme will lead to a respective production increase. But staff must also be made aware that incentives encourage value destruction than long term value creation. Focus is often driven for short term due to economic and business pressure, destroying future value for the shareholder.

The process control levers as defined above must be linked to individual performance and quality of leadership. The quality of leadership is directly related to the performance of an organization. 30% of variance in revenue and profit can be explained by differences in organisational culture / climate while 70% of variance can be explained by differences in leadership style. Apart from top level commitment and management employee trust, a special management style is required. The conventional management functions of Plan, Organize,

Lead and Control have to be replaced by management that develop, inspire, coach and teach.

A critical component of a business environment is the issue of competency and skill level. Competency-alignment is therefore needed to align the strategic organisational goals and objectives of the company, with the skills of the employees within the organisation. It involves the systematic study, analysis, and assessment of job functions, tasks, and skills required by an organisation, ensuring the best job fit for everyone. Skill gaps can be identified and if any remedy deficiencies exist, employee training, skill enhancement, redeployment, outplacement, or outsourcing can be used to decrease this gap.

An important outcome of competency alignment is the identification of current employees into new jobs or teams. True growth and vitality come from sensing new opportunities in the marketplace; building new competencies within the organisation; and leveraging the skills, talents, and adaptiveness of employees to achieve organisational aims.

In **Appendix A** is a quick lookup table with summarization of all the skills mentioned for the different kinds of managerial actions. The knowledge or skills competencies are for Strategic Competency, Business Acumen, Cross Boundary Management, Interpretation Competency, Team Work, Confidence building, General Managerial Competencies, Drive for Results and Continual Learning and Development.

4. OPERATIONAL STRATEGIES OF MINERAL RESOURCE MANAGEMENT PRINCIPLES

Initial investigations into the Mineral Resource Management environment revealed that the key success factor to any Mineral Resource Management solution is the ability to realise *collaborated* solutions that *incorporate functional specialisation* in an *integrated decision making* process. To achieve this, it requires integration across the value chain from exploration to marketing, as well as seamless information availability of all key management information to all relevant decision makers.

Mineral Resource Management is therefore an integrated approach to resource planning and management along the value chain. The value chain is a linked arrangement of interdependent business processes or value activities that is designed to generate linkage between business processes to optimize the total value process.

The new paradigm is to have a Resource Manager that is specifically tasked to ensure the optimization of the total value chain and that the production performance measurement is in place to support this. The Resource Manager should endeavour to ensure that the utilization of a particular mineral resource is economically optimized over the total value chain defining a Mineral Resource Management Strategy as indicated in **Tables 4.1.1; 4.2.1; 4.3.1; 4.4.1; 4.4.2 & 4.4.3** and discussed below:

4.1. Understand the resource

- Geographically and geologically;
- In terms of extractive metallurgy;

- Lithologically according to:
  - ore types;
  - rock type characteristics according to colour and texture;
  - defining discontinuities; and
  - Mineralogy: The mine must be scheduled to the compatibility of the lithological units with regard to the beneficiation process involved as well as, but not only, according to grade.

    A compatibility matrix must be created as defined by the different rock type lithological units with the highest value indicating perfect compatibility with the beneficiation plant.

    A compatibility matrix can therefore be used to:

    - Indicate to the scheduler in what order it should blend the different lithological units; and
    - The weighed average grade and recovery forecast to cater for the level of compatibility. The ideal would be to develop some relationship between the compatibility matrix and the fundamental mineralogical and physical properties of the different lithological units.
- Understand the physical metallurgical characteristics of the resource;
- Investigating ore blending - This is to collect and market sufficient information through exploration, mapping, analysing and physical testing to determine the ore characteristics, volume, grade, structure, lump/fine ratio, hardness, decrepitation, yield and beneficiation in order to satisfy mining exploitation and the processing plant.

BUSINESS GOAL UNITS	OPERATIONAL STRATEGY	FOCUS AREA	TARGETS OR OUTPUTS
1	**<u>Understand the resource:</u> Collect and market sufficient information through exploration, mapping, analysing and physical testing to determine the ore characteristics, volume, grade, structure, lump/fine ratio, hardness, decrepitation, yield and beneficiation in order to satisfy client needs and to create additional markets**	**Understand the resource geographical and geological**	Updated and verified geological models
			Updating of LOM statement
		Understand the resource in terms of extractive metallurgy	Beneficiation curves for each rock type & blends of rock types
			Predicted yield
		Understand the physical metallurgical characteristics of the resource	Known rock hardness and degradation of rock types
		Investigate ore blend	
		Stakeholder needs	Customer feedback system
			Value added to stakeholders

Table 4.1.1: Operational Strategy - Resourcing

4.2. Optimal exploitation of the mineral resource

By looking at the different functional mining departments, the mineral resource can be optimally exploited by:

- Effective exploration - Executing an exploration strategy or programme to optimize the mineral resource, and develop and follow a formal exploration strategy as defined in the strategic document. The geological and grade models must be continuously updated so that the most value to the mine planning can be added. This is normally stated annually by consultants in the resource statements and audits;
- The collection and processing of geological information – Geotechnically, a system must be developed to assess the risk of slope failure versus the financial benefit that will add the most value. Dewatering must be done in accordance with the LT mine plan;

- Mine design and scheduling;
    - Optimum pit design techniques must be evaluated to allow for maximum utilisation of the ore grade and mineral resource. By taking macro and micro economic conditions of the day into consideration, each unit of material in the blocked mine layout should be constantly evaluated. This is also called selective mining. By doing this, a material will ultimately be considered as ore or waste on a daily basis. Sets of interactive long term mine layouts for different long-term macro economic conditions should therefore be created.
    - Condition based and activity based costing should be a central part of the economic modulation of the economic viability of each part of ore, and not using average costs as traditionally done. The costs allocated to a material unit should be conditions and material based, and not averaged.
    - Constant testing on a mineralogical base, needs to be done in the plant. This is a valuable tool in helping to focus on the continuous improvement (CI) initiatives in the value chain and especially the interaction between the plant and the mine.
    - Risk matrix should also be used to indicate the risk profile of a specific mine plan. Many a mine plan, short- and long term, had different scenarios compared to each other without having a feel towards the risk profile of each mine plan. Mostly the mine plan with the highest NPV value is chosen, without making an informed risk profile of each scenario in consideration. The risk factors to be taken into consideration are:
        - Information risk;
            a. Accuracy level of information used;
            b. Geostatistic expertise;
            c. Applicability of models.

- Physical risk;
    a. Geotechnical conditions;
    b. Mining methods used;
    c. Beneficiation methods used;
    d. Mine layout risk;
    e. Geohydrological conditions;
    f. Plant design
- Production risk;
    a. Production rate;
    b. Equipment availability;
    c. Equipment utilization;
    d. Infrastructure;
    e. Material properties e.g. moisture content, fineness etc.
- Quality and recovery risk;
    a. Risk of contamination;
    b. Degree of homogeneity of the ore;
    c. Degree of control;
    d. Measuring capability with regard to time and total value chain tracing of the material.

- Resource exploitation - A pit development strategy (resource exploitation strategy) must be defined by determining sensitivities from:
    - Ore quality strategy;
    - Stripping strategy;
    - Selective mining strategy;
    - Waste rock dumping strategy;
    - Pit dewatering strategy;

- Surface structures;
- Adjoining properties; and
- Mining Equipment strategy (Asset Management Policy). Mining methods must be developed along with the equipment strategy for maximum utilisation of ore reserves, utilizing the best available technology and the lowest ore losses through the total value chain. Asset Risk Management must be also be done on a continuous basis.

- Grade control - Development of an efficient grade control system ensuring that the short term mining plans are followed within approved norms and the ore product grade values are produced within acceptable limits.

- Plant's physical capability – For the mine production scheduling, the influences on the mineralogical and physical properties of the plant on major components and sections must be taken into consideration. Typically short- and long term planning that leads to mine layout design and scheduling, would only indicate ROM and feed grade predictions. The plant performance predictions and what effect it has on the gold production, must be added in the short and long term mine planning schedule. A mine plan schedule will therefore be created over the total mineral resource value chain.

See **Table 4.2.1** for summary on the optimal exploitation of the mineral resource operational strategies.

BUSINESS GOAL UNITS	OPERATIONAL STRATEGY	FOCUS AREA	TARGETS OR OUTPUTS
2	**<u>The optimal exploitation of the mineral resource:</u> The optimal exploitation of the mineral resource by effective exploration, the collection and processing of geological information, mine design and scheduling, risk management, grade control, mining methods and the utilisation of the best available technology to continuously satisfy the plant demand in terms of ore quality and volume.**	**Exploration**	Optimize the mineral resource by executing the exploration strategy / programme
			Develop and follow the formal exploration strategy
		Geomodelling	Continuously update geological and grade models that add most value to mine planning exercises
		Geotechnical support	Develop system to assess the risk of slope failure versus the financial benefit that will add the most value
			Dewater pit in accordance with LT mine plan
			Decrease stripping ratio
		Pit Design	Evaluate methods for optimum pit design techniques by allowing for ore grade and the maximum utilisation of the mineral resource
		Resource Exploitation	Pit Development Strategy/Resource Exploitation Strategy. Determine sensitivities for the following:
			1. Ore quality strategy
			2. Stripping strategy
			3. Selective mining strategy
			4. Waste rock dumping strategy
			5. Pit dewatering strategy
			6. Surface structures
			7. Adjoining properties
			8. Mining equipment strategy
		Mining Operations	Develop mining methods and equipment strategy for the maximum utilisation of the ore reserve
		Grade Control	Develop an efficient grade control system ensuring that the short term plan is followed within approved norms and the ore product grade values are produced within acceptable limits

Table 4.2.1: Operational Strategy - Optimal exploitation of the mineral resource

4.3. Plant design and operation in terms of maximum resource utilisation by predicting the future plant performance:

- Basic mineralogical characteristics of the ore types such as:
  - Liberation factor (grain size and intergrowth);

- Maximum recovery potential – the value of this parameter taking the AU value in other minerals;
- Detrimental mineral influences – rock that has a negative influence on the grade and recovery of ore;
- Maximum mineral recovery – derived from the liberation factor taken as a linear relationship. The total orebody should be described mineralogically and physically as required for the required mining and beneficiation processes. The exploration description of an orebody should therefore take the proposed beneficiation and mining process into consideration.

- Optimum beneficiation - Developing and installing equipment according to the requirements set by the different deleterious effects of other minerals in the ore types as well as the ore type's characteristics, and to achieve the plant operating requirements to the desired set standards.
- Optimum product blending - Stack ore on product blending beds according to the correct batch size and blend ore types homogeneously on designated beds according to the physical properties of the host rock.

BUSINESS GOAL UNITS	OPERATIONAL STRATEGY	FOCUS AREA	TARGETS OR OUTPUTS
3	**<u>Plant design:</u> Plant design and operation in terms of maximum resource utilization**	**<u>SUFFICIENT LIBERATION:</u> Crush different ore types to the correct size**	Specific processes for specific ore types Crush to the correct size
		<u>OPTIMUM BENEFICIATION:</u> 1. Develop and install beneficiation equipment according to the requirements set by the different ore types 2. Operate plant according to set standards	
		<u>OPTIMUM PRODUCT BLENDING:</u> 1. Stack ore on product blending beds according to the correct batch size 2. Blend ore types homogeneously on designated beds	

Table 4.3.1: Operational strategy – Plant design

4.4. Full utilisation of existing systems and key principles

- Performance Management Systems - Skills gaps need to be determined in relation to job requirements. Diverse candidates must be identified, evaluated and contracted for fast tracking programs. Formal measurement or appraisal to sustain the performance of people, needs to be done to identify opportunities and continuous training needs. Remuneration anomalies need to be identified and rectified.

- Information Systems - Divisional practices and standards need to be evaluated and comply with best operating practices. It must integrate practices, standards and technical functions with the Information Management Enterprise System (IMES), and with each other.

- Communication - Communicate regional goals for staff involvement and commitment, whilst displaying a unified participative management approach.

- Establishment of monthly staff forum to incorporate all divisions;
- Identification of appropriate methods of communication, and implement it.

- Balance Short- and Long-term financial objectives. Corporate and Business Unit (BU) strategies need to be aligned while practising normal good management philosophies.

See **Tables 4.4.1, 4.4.2 & 4.4.3** below.

BUSINESS GOAL UNITS	OPERATIONAL STRATEGY	FOCUS AREA	TARGETS OR OUTPUTS	Measuring Criteria
4	**<u>Information utilisation</u> The information requirements to satisfy the support of the mining operations**	**Integration**	Information systems practices and standards need to be evaluated and integrated	
			Seamless integration through whole value chain	
			Interfaced with current IM Enterprise System	
		Auditable	Auditable documentation of team decisions	
		Measuring / Reporting	Definement of critical MRM indicators	
		Reconciliation System	One reconciliation system that is accepted by all parties	
		Communication	Communication of regional goals	
			Improve staff involvement and commitment	
			Establishment of a monthly staff forum	Dynamic information system through integrated homogenized IM system that is shared by all decision makers
			Real time communication and information sharing	Real time models
				Resource and reserve forecast
				Ore gains / losses trends
				Plant yields
				Relevant market trends
				Deviation in stripping ratio
				Constraint performances

Table 4.4.1: Operational Strategy – Information utilization

BUSINESS GOAL UNITS	OPERATIONAL STRATEGY	FOCUS AREA	TARGETS OR OUTPUTS	Measuring Criteria	
5	**<u>Balance short- and long term financial objectives</u> This is a linkage between strategic and operational planning, manifested by the translation of company goals into operational mining plans, which will realize the desired growth.**	**Alignment of Corporate & BU strategies**	Maximize LOM vs. Maximize value		
			Capital investment requirements		
			Growth Strategy vs. Containment strategy		
			Market development and Logistic impacts		
			Clear vision		
			Stability in operational processes	Incorporating MRM Principles	
				Proactive approach to create flexibility	
				Utilization / creating opportunities	
				Reduced risk	
		Supporting of long- and short term financial targets	Scenario planning	Stripping ratio's	
				Plant yield predictions	
				Reserve definition	
				Short term tactics against medium to long term impacts	
			Dynamic multiple sourcing	Asset Management	
				Blending resources	
				Stockpile management strategy exist	Adherence to
					Increase low grade utilization
					Multi-disciplinary team daily management
			Maintaining MRM targets	Quantity	
				Quality	
				Costs	
				Ore utilisation	
				Improved yield	
				Plant efficiency	
				Protocols & standards	Defined

					Implemented
					Agreed
					Comply to international norms
					Internal audits
			Due diligence		
		Financial Models	Linking of operational activities to bottom-line models	Scheduling simulation expressed to financial models	
			Financial standards and assumptions all signed-off		
		Risk Management	Leverage long term and short term risks		
			Production capabilities		
			Ore availability		
			Assumptions made		
			Unforeseen disasters or political risk		
		Asset Management	Technology	Maintenance planning	
				Control & management	
				Strategy	Autonomous Maintenance & TPM
					Efficient Mining
					Efficient Processing
					Shutdown & Turnaround
					Routine Work Measurement
					Information Technology
					Maintenance Tactics
					Materials Management
					Contractor Management
					Reability Analysis
			Capital	Scrubbing	
				Investment review	

Table 4.4.2: Operational Strategy – Balance short- and long term objectives

BUSINESS GOAL UNITS	OPERATIONAL STRATEGY	FOCUS AREA	TARGETS OR OUTPUTS	Measuring Criteria
6	**Performance Management**	**Skills definement**	Skill gaps need to be determined in relationship to job requirements	
		Measurement	Formal measurements as defined by the Business Units which ensures team driven goal attainment.	
		Performance Contracts	Performance contract includes MRM objectives and are shared across team members	
		Involvement and commitment	Proactively managed	
			Shared through the total value chain	
			Training and sensitizing is carried out	
			Objectives clearly defined and communicated	
		Communication forum	Exist and been used	
		Organizational attitude	Assessment	
			Team performance	Common goals
		Benchmarking		
		Reward & Recognition System		

Table 4.4.3: Operational Strategy – Performance Management

5. BEST OPERATING PRINCIPLES & MEASURING CRITERIAS OVER THE VALUE CHAIN

The methodology required to implement non-measurable MRM philosophies are over two levels, namely: the Integration/Collaboration level; and the Commitment and Creativity level. Tools for both these levels exist, as seen in paragraph 7.1: The culture required for success.

The integration/collaboration focuses on the linkage between strategic and operational planning, while ensuring integration of the individual functions with the company goals to realize operational mining plans, and the desired growth. Seamless information flow is required to ensure optimal decision making. The Toolkit level or Commitment and Creativity level, provides for the interactive "What-if" analyses that are measured against actual performances and activity driven norms and benchmarks.

Characteristics of MRM principles that therefore need to be considered are:

- Physical and mineralogical characteristics of the resource;
- Limitations and properties of the involved value adding processes;
- Market considerations;
- The economic environment predicted;
- Social and political requirements; and
- Environmental obligations.

In order to ascertain MRM perspective, it is necessary to look at best practice principles and Key Performance Measurement Criterias over the functional business processes as defined below.

5.1. Exploration

The task of the mining geologist is to analyze and interpret the geological structures and to find the key to the grade distribution within these. In this process, the experience of the geologist is often as important as the actual data available, inasmuch as it is supplemented by information that may be outside the data bank in terms of regional geology and general trends.

Best exploration practice principles can be defined as:

- Exploration strategy must be aligned with the LOM strategy;
- Comply with the SAMREC Code;
- One single database locking the following information:
  - Geological observations;
  - Geophysical survey results;
  - Geochemical survey results;
  - Bulk samples – size & method of treatment;
  - Metallurgical test results;
  - Groundwater;
  - Geotechnical & rock characteristics
  - Potential deleterious or contaminating substances.
- Seamless integration of data;
- Monitoring of sampling & analytical standards of exploration have been carried out;
- Extension of the LOM and measurement thereof;
- Increase reliability of resources and monitored against set targets;
- Compilation of a long term risk plan;

- Singular contract management of all drilling per Business Unit.
- Quality assurance of drilling; logging; sampling; and database management procedures have been done twice yearly.

Resource modelling must be done according to ore zones and grade variations in the geological file, but the latest paradigm is to model the orebody according to the different lithological characteristics in the targeted mineral resource. To address this paradigm, the various ore, waste and orebody characteristics are needed.

5.2. Production geology

Best operating production geology principles are:

- Increase in reliability of short and medium term reserves measurement and tracking thereof;
- Identification of geological structures;
- Seamless integration of data transfer between the long term and short term models;
- Integration of a real time production geology (short term) and grade control plan;
- Maintaining good communication with regard to grade control and short term planning;
- Monitoring of sampling & analytical standards of production holes have been carried out;
- Identifying selective mining opportunities;
- Mineralogy of the material must be related to processing and environmental requirements;

- Taking responsibility of plant effectiveness;
- Using performance appraisal indicators that supports MRM initiatives;
- Shift in focus from mine lines to in-situ ore body and ore gains;
- Medium to short term risk plans are carried out to indicate high-risk areas. Conditional simulation must be performed as well as in the medium mine planning side;
- Production geology must ensure optimal reserve utilisation by:
    - Pit inspections in liaison with Grade Control. Pit inspections play an important part in the daily operations in the pit. This comprises daily inspections of all blasted blocks to ensure optimum use of ore. The success of pit inspection centres on the ability to maximise geological gains, but more importantly, by minimising mining losses.
    - Carried out of pit mapping;
    - Agreement on load & dump instructions;
    - Pro-active indication of selective mining areas;
    - Allocation of areas of responsibilities between production geologists; and
    - Carrying out of reconciliation & risk management.

Actions are aimed at ensuring that value is added through growth in resources and reserves by the improvement in operational performance; optimisation of extraction and mining mix; essential mining- and geological recovery; less equipment needed to handle these tonnages; exploitation of opportunities such as enhancement of value and quality assurance; low grade ore utilization; and transparent resource reporting.

5.3. Geodata

Mineral resource evaluation forms a major component of any mineral resource interpretation and is normally performed by the Geology data capturing department. An activity primarily associated with resource evaluation is the interpolation of data and the estimation of resource tonnes and grade. By means of a tonnage / grade curve, the grade and tonnage distribution can be summarized within the mineral resource according to the measured, indicated and inferred reserve classifications. See **Figure 5.3.1** for the characterisation of resource / reserves levels.

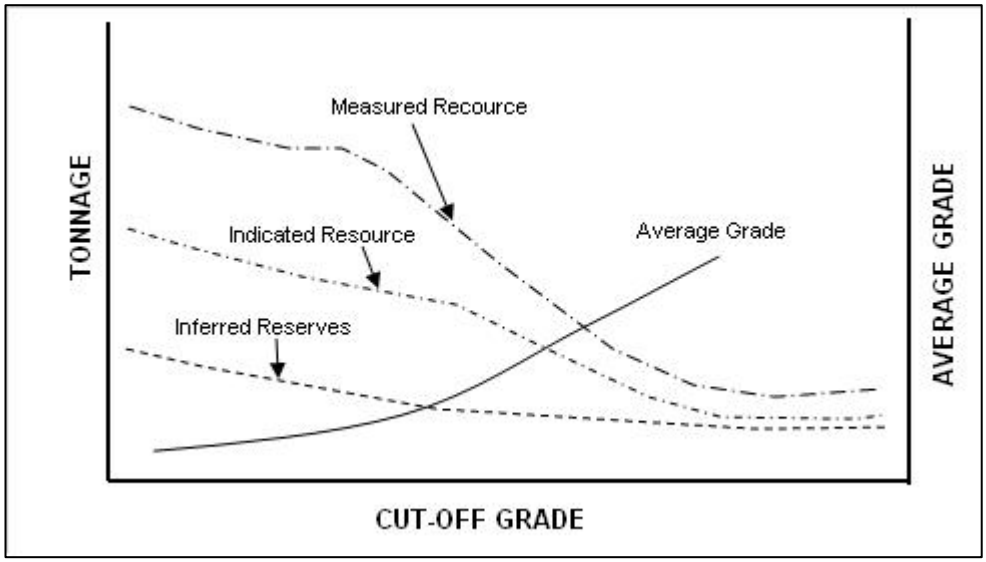


Figure 5.3.1: Characterisation of resource / reserve levels

An understanding of the grade- and tonnage distribution of the total resource is fundamental in the first step of composing a proper mine plan.

Along with statistical and geostatistical analysis, and the unique feature of the orebody, interpolation of the grade within the geological model can be done. The

level of grade estimate depends on the mathematical modelling procedure which includes choices between 2D and 3D interpretation; sectional techniques versus block modelling; the weighting applied and top grade cut applied (Snowden, 1996). Decisions made here directly affect the resource tonnages and grade.

5.4. Geotechnical engineering

Near surface exploration for the purpose of assessing soil and rock conditions are essential considerations in the design and construction of mine pits and waste dumps.

Soil has the characteristic that it simply fails. Such failures could lead to large settlements, and redistributing loads to other benches. The properties and behaviour of soil depend on a number of factors such as: grain size distribution, water content, mineral constituents, stress history and confining pressures.

In order to obtain sufficient soil properties, soil evaluation is needed that closely models field criteria. This enables sufficient extrapolation to the field conditions. Prior investigation of previous work in the vicinity and / or of geological maps can often provide an insight into anticipated problems at a particular location. Below is a more complete list of the usual criteria involved in site investigation for a mining operation:

- Vertical and horizontal variations in the strata at the site and the engineering properties of the soil or rock encountered;
- Ground water conditions and the influences of changes in these on the engineering properties of soil or rock encountered;
- Degree of stability of slopes on the site;
- Corrosion potential of soils and ground water;

- Possible signs of distress in existing structures on and around the site and where such indications were evident, an assessment of their cause and cures;
- Method of construction;
- Determination of soil behaviour when subjected to vibratory loading (etc. blasting);
- The possibility of soil liquefaction during seismic activity;
- Preliminary recommendations on the most appropriate foundation type or configuration for a particular structure;

Outcome or KPI's are:

- Analyse and design the optimal pit slope and communicate to all parties;
- Ownership of the implementation and maintenance of slope monitoring network;
- Development of a slope monitoring strategy. Deviation needs to be communicated;
- Develop a Risk management strategy and focus on optimisation. Formal communication must exist to advise exploration geology on needs, and pit production on critical cleanup areas. Optimization benefits with regard to slope design impact on the optimal ore utilization and / or recovery, must be communicated;
- Implement and monitor dewatering strategy that is aligned with long-term & medium-term mine plans. This must be based on the Geohydrological simulation model. Timing on the dewatering has an impact on the availability of the required ore qualities;
- Residue deposit design (Waste dumps & tailings dams) to be approved to ensure no ore sterilisation;

- Pit wall control (pre split, buffer drilling and pit wall scaling) management as included in mine planning. Using of specialized (approved) software packages can give design parameters to mine planning taking timing into account.
- Contributions to long-term & short-term risk plans.
- Input to production blasting fragmentation strategy;
- Management of an integrated database.

Maintaining a consistent assessment of confidence would require that the confidence of the slope design should match that of the mineral resource estimation between the different confidence levels. It is therefore proposed that for open pit designs, the confidence levels for slope designs should be categorised using the same fundamental approach as that adopted for resource / reserve definitions.

5.5. Grade control

In most of EWAR mines, grade control is essential to determine ore blending and mining practices. Advanced technological systems and teamwork helps to provide new solutions and insights into the varied grade problems, and also helps to re-define the mineable ore reserves. Due to structural complexity of the geology, ore content varies considerably throughout the orebody. This variability is an important factor in the prediction of ore grades in the geological model, and therefore also in mine planning, production scheduling, and grade control.

Grade control sections normally utilize information from a number of resources to control ore blending. Any weak link in this communication channel could therefore contribute to an ore loss. By comforming to ISO 9002 quality standards,

it prescribes the quality management systems needed to estimate qualities and tonnages for planned mining blocks. This ISO standard can be a valuable tool to reconcile information available for mine-planning scheduling and costing. Up-to-date information can lead to better risk analysis and decision making production control.

Composition of grade control is statistically normally done by inverse distances. Shortcomings of this method include:

1) The process of composition implies that quality prediction of the ore takes place across geological boundaries whilst geological homogeneous domains are prerequisite for grade prediction;
2) No clear confidence level can be stated for the predicted values.

Ordinary kriging overcomes these shortcomings by constructing a variogram model and anisotropy factors for each homogeneous area for every relevant element in each domain. This provides input parameters for the kriging process. Kriging therefore provides more accurate average values over several composite blocks than inverse-distance. In AngloGold Ashanti EWAR mines where most deposits are mined selectively, the optimal method of evaluation of individual blocks can be obtained by kriging. However, even if kriging is used, an error will remain in the estimation of the blasting blocks. Consequently, the tonnage mined and the corresponding average grade will differ from the tonnages and grades that would be mined if we knew the exact true grade distribution, but by increasing blasthole sampling to a point where the relative kriging error is reduced to 0.2, the estimated ore tonnage will be closer to the optimum.

The aim therefore remains one of continuous improvement in the ability to collect and analyze data quickly, to present the data in some friendly visual format, and

then to use it in the decision making process. Principles and Key Performance Indicators for Grade Control can thus be defined as:

- Grade Control must be an integral part of the Mineral Resource Management process. They must agree on the execution plan with the short term scheduling and production geology and agree on the definition of ROM with production geology in blasted blocks;
- Grade Control information must integrate seamlessly through the value chain, especially between real time production geology;
- Coordination with selective mining;
- Applying an approved stockpile building strategy that includes communication with the plant feed logistics;
- Pro-active grade control at the mining face;
- Relevant training to ensure evident Geological/Metallurgical background in the management of the grade control;
- Effective monitoring of plant performance by Grade Control;
- Intensive co-operation with production personnel in daily forums to ensure thru target alignment between geology/production/plant;
- Using of a simulation model for ore blending is reconciled regularly with the floor stocks. Recalibration of beneficiation factors (algorithms) must be done.

Reviewing existing information and applying scrubbing and re-evaluation techniques can improve the accuracy of the geological information.

5.6. Survey

Principles and Key Performance Indicator's of the Survey Function are as follows:

- Seamlessly survey information transfer through the total value chain;
- Real time floor stock and stockpile monitoring;
- Managing of only one reconciliation system for the MRM value chain - Reconciliation is an essential tool for any mine to improve the estimating procedures and to measure the variances between the planned and actual production. Regular reconciliation is necessary to evaluate the validity and accuracy of the geological model and mine planning by comparing the actual production i.e. volume, tonnages and grade achieved in a specific area or time with the planned production.

  In most mines the product or metal is separately accounted for in two primary operations, namely mining and processing. The mine will determine the metal content in the ore mined by the various estimates and measurements of volume, tonnages and grades. The processing plant, in turn, will determine the amount of metal received, the amount discharged to tailings and the discard dump as well as the amount recovered by measurement and analysis.

  It must be realised that ore losses occur and by using modern database information systems, reconciliation between long- or medium term plans and actual tonnages and grades can be estimated, but due to system insufficiencies and communication problems between the various mining support services, ore losses cannot be quantified.

  Using different operating systems and databases in the mentioned departments, communication and information flow lacks and limits a mass balance audit trail from the daily mining and plant production. In order to keep track of what has been mined and planned for, it is necessary to record the various parameters of the material from its in situ position in the blasting block, onto the different stockpiles, through the

crusher in the various stages of the beneficiation process, timely and accurately, to make changes in a constant process. Furthermore, this mass balance sheet must be integrated with the mine's reserve and resource statement for annual update and reconciliation.

Mine line (expected ROM ore) calculations must be done from the geological models by interpolating the mine out volumes determined by the surveyors. This is the basis of the forecasted tonnages and the mined out tonnages must by reconciled with these tonnages. As mentioned, the stockpile movement must be considered as well as the geological- and mining losses or gains.

Every tonnage is also expressed in percentages for easy fault or variance determination. Furthermore, the monthly, year-to-date and forecasted stripping ratios are very important for an open pit mine and these calculations can be determined from these flow sheets.

Part of the compliance and reporting rule for metal accounting is to prepare a checklist over the various stages of reporting in Resource Management. This must be compiled for complete ore flow management and cash flow analysis.

Survey is also responsible for:

- The co-ordination of Geographical Information System (GIS);
- Utilization of GPS Technology to improve accuracy and reduce time;
- For the demarcation of selective mining zones.
- Simulation model of blast induced rock movement and to predict mining zones after blasting.

5.7. Mine planning

Mine planning must be done to support the strategic direction of the company and must be communicated to all parties, especially to defining, managing and communicating the risk that goes along with the outcome of the plans. Furthermore, the function of the mine planning department is to constantly review the operational methods adopted and to adopt those methods and technologies which will see a further reduction in the cost of production.

Mine planning is concerned with physical exposure of ore in any given time at a specific grade and tonnages.

- Quality control & validation of geological models by means of an audit process;
- Carrying out of geo-statistical evaluation of ore bodies in homogeneous geological areas.
- Creating of chemical quality models based on established geological parameters. Biases need to be checked against real trends.
- Validation and re-calibration of chemical quality models, by means of correct geo-statistical models;
- Seamless integration of the models for Production Geology and Planning;
- Applying custodianship for management to ensure integrity of the database;
- Apply SAMREC standards in the preparation of the resource statement.

By identifying the inventory, spatial location of reserves and dumps, and quantifying operating and mining strategy, the following objectives as in a suggested ranking order should be obtained:

- Creation of an acceptable return for shareholders corresponding to the market sector and corporate philosophy;
- Creation of an acceptable operating cost to final product relative to world producers;
- Flexible requirements within plan e.g. upside potential to increase product volume by 15% within 6 months sustainable for 12 months; and
- Maximise NPV.

Mine planning must be risk based to plan for uncertainties. Experience has also shown that the improvement in communication and understanding of decision-making between management and mine planning engineering has added considerable growth for shareholder's value. Mine planning is currently being done in three stages, namely:

i. Life-of-Mine Statement : the building blocks for Strategic Thinking. The life-of-mine plan is therefore a definition of the inventory available which exploited and managed the maximum value to shareholders in accordance with corporate policies and philosophies;
ii. Business Plan : is the route map to the future; and
iii. Operation Plan : annual budget / forecast

The Reserve Statement is usually the only representation of the future in the LOM. It suffers from several draw-backs, namely: It already contains mining decisions (minimum mining thickness, dilution etc.); it contains no measure of value (grade and tonnages give only a poor measure of profitability); and the "National" reserve definitions often constrain the statement to a short term future by accepting only measured and indicated.

The Reserve Statement is also usually much too short for strategic thinking. Life-of-mine open pit represents the outline of the open-pit boundary faces with no further reserves to be recovered by open-pit mining. For this reason a cut-off criterion is proposed which is the cost of producing the finished product from the final increment.

Typical financial criteria are insensitive to the boundary limit location and it is important that every mining block should be investigated for profitability at these limits. Compared to the traditional cut-off grade approach to pit design, the essential difference lies in the emphasis on determining the mining costs, either to the ore process point or to the stockpile or waste location. The emphasis is therefore that the decision must be based on cost of production rather than profit, which is related to assumed price.

Deciding on an acceptable cut-off is a business decision. It reflects the optimism and the risk which the company is prepared to accept in investing in the particular ore reserve. Some guidelines and principles underlying such a decision can however be postulated as follows:

1) The tonnage vs cost relationship for the ore reserve can be a first indicator. Should the cost indicate an inflection point, this could be taken as a decision on cost limit since the risk increased in cost, is not matched with a corresponding increase in product.
2) Cost in relationship with other world producers. Reference to a world producer cost curve is therefore necessary. The relative position of the planned operation on the world producers cost curve is a function of corporate philosophy. This also represents the acceptable margin of risk compatible with the company's stated mission and philosophy.

3) The cut-off cost could be based on the breakeven equivalent underground operating cost. These cost comparisons are made on an operating cost basis only, ignoring capital.

Accurate cost modelling forms an essential part of mine planning, where different cost models apply to different planning phases. Many mining simulation packages are available which can produce a realistic schedule of production cost over a period and can reduce the amount of work involved and concentrate the effort and skill of the planning team to those issues to which they can contribute most i.e. improvement of the mine plan.

In the Business Plan, the targets and tactics are as follows:

- Financially / Productivity;
- Operational Effectiveness: continual adjustments of processes and procedures to make them more appropriate to conditions on mining difficulty;
- Flexibility: Ability to increase metal production / decrease cost for defined periods (amount of fully developed / exposed ore, amount of drilling ahead);
- Planning Category conversion: Material from inferred to indicated etc.
- Capital program: Ensure program schedules achieved.

Mine planning has a complexity in the measurement achieved and it is recommended that there must be focus on two categories, namely: Organisational Structures and Key Dimensions. Organisational Structures involved cultural and organisational structures, systems, people and management practices such as:

- Mine planning protocols and set standards with scheduled outputs, dates and responsibilities.
- Incorporation of risk analysis into planning by establishing management control on critical variables.
- Optimal stripping strategy in terms of volume, product qualities, and cash flow.
- Buffer stockpiles management
- Application of SAMREC and JSE standards.

Mine Planning is all about the span of control where constant improvements are investigated from a hierarchical level. Acquisitions, joint ventures, shut downs, internal development, divestments and restructuring are all methods to improve or gain a competitive advantage. Enabling strategies also refer to internal and external strategies. Internal strategies are all about:

- Training;
- Technology
- Incentives / rewards;
- Systems;
- Services; and
- Quality.

While external strategies look at:

- Customer satisfaction;
- Value;
- Pricing;
- Quality
- Reliability

Key dimensions or key principles can be defined as:

- Economic pit layouts that incorporate bench heights and equipment strategy;
- Design and selection of mining methods and equipment. This ensures continuous mine improvement, operational effectiveness and ore recovery;
- Real time management systems that are integrated with other value chain elements. Management Information Systems serve the report and make provision for measurement of information for the achievement of goals and strategies. It is all in "what gets measured, gets done".
- Financial performance;
- Interactive simulation within the scheduling environment;
- Multi disciplinary mine call factor team;
- Evaluation of alternative stripping scenarios;
- Effective use of technology / new innovations or products;
- Mapping of the mine planning process through all three stages namely:
    - LOM;
    - Long Term planning. The following important variables need to be evaluated according to throughput:
        - » Geological conditions, mining conditions and mining methods;
        - » Optimise contamination levels by effective utilization of low-grade areas as well as material compatibility (ROM) according to beneficiation properties. Furthermore the management of stockpiles and the buffer capacity between mining and beneficiation needed to ensure least outage;
        - » Smoothing of production cost and product yield;
        - » Choice of mining horizon;

- Short term planning. Questions that need to be considered are:
  - » Maintenance schedule of the process plant
    - Maintenance of the mining equipment within the shut down times;
    - Waste mining during the plant shut down period to decrease rehandling from the stockpiles;
    - Must look at the availability of the mobile cranes between the plant and the major mining equipment.
  - » Blasting
    - Is it necessary within a critical area?;
    - Are the tonnages needed? Can the blasting be postponed when more blocks are available to blast?;
    - Can blasting be postponed if equipment is broken down within the scheduled blasting area?

Long-term planning

In the long term environment where Whittle 4X are used, certain limitations have been found:

1. From an equipment capacity point of view, the schedule is not taken into account for pit room limitations.
2. The schedule only considers economics based on cost and income and results in high variations in ore quality from one year to the next.

To address these shortcomings, a South African firm, “Large Scale Linear Programming Solutions” created a linear programming (LP) package based on the scheduling system. This LP package was provided by Haverly Inc. & Dash and is

widely used in the mining industry. This package is capable of using multiple processors through a network, assisting in solving large LP matrices and cutting down on solution time. The aim of a linear programming model is to design a maximum profit, maximum net present value or a minimum cost plan.

For the LP scheduling, the Whittle optimised final pit limits are needed through the Whittle interface of the general mining package. The LP works on the principle that if a block is to be mined, it must mine all the blocks above it as used by the Lerchs Grossman algorithm in Whittle.

Weighted average ore qualities, mining and plant costs and ore and waste tonnages per block are accumulated in a separate list for each pit that can be mined independently. Equipment capacity constraints are provided by subdividing the total mine model into pits, each with minimum and maximum tonnages to be mined for the next scheduling period. The maximum tonnage is determined by the number of shovels that will fit into the pit, each requiring two blasting blocks with a preset face length. Although these standards may increase, it will require a lower utilization of equipment as a result of frequent blasting and a lot of time spent on waiting and travelling between blasts. The minimum tonnage per pit can be used in order to force the LP to mine out a specific pit prematurely, for example, during an investigation into the potential of backfilling of waste rock from adjacent pits. After each scheduling run, normally a one-year period during which the LP has found the optimum combination of blocks meeting the constraints, can the cost of mining and the final grade of ROM product be evaluated and compared using a short term auto scheduler package such as XPAC. (Source: L. Scheepers)

In **Figure 5.7.1** a typical a waste stripping curve can be seen which shows the following:

- The maximum stripping curve is the cumulative ore and waste mined if mining is done bench by bench from the top to the bottom.
- The minimum stripping curve is the cumulative ore and waste mined if mining is done according to the LP schedule without any exposed ore reserves and pre-stripping.
- The planned stripping curve is the cumulative ore and waste mined if mining is done according to the approved stripping strategy, ensuring the required ore exposure and future profitability of the mine without high risks.

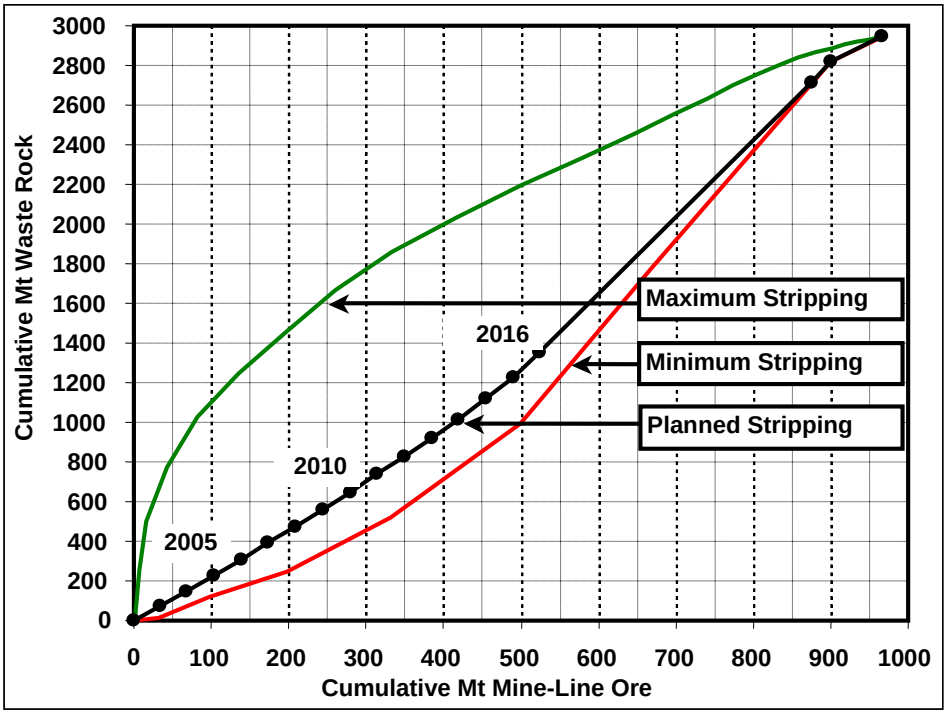


Figure 5.7.1: Minimum & Maximum Stripping Curves

The LP schedule therefore follows the same pattern in pit deployment as the Whittle schedule but looking additionally that low cost pits are usually mined at a lower rate and high cost pits mined sooner due to ore quality and pit room constraints. It indicates:

- Which blocks from

- which pits are to be
- blended in which proportions in
- which time periods and routed to
- the plant in order to meet mineral specifications so as to optimise cash flow, NPV or costs.

It generates the "how to get the optimal pit as generated by Whittle over time" scenarios. It further highlights the possibilities in terms of future ore quality trends and is a handy tool in order to evaluate and quantify different pit deployment strategies.

The LP model will only "mine" while the contribution of the total system remains positive. Each block is techno-economically evaluated in the full context of ALL CONSTRAINTS in the model, including an element of cross-subsidy, e.g. a given layer / bench of blocks may be unprofitable to mine, however, a block or layer / bench below it may be of sufficiently high grade to economically warrant the mining of the unprofitable layer / bench or block in order to reach and extract the high grade layer / bench or block. It should be clear that the model does not use conventional cut-off grade policies to decide whether to mine a block or not. It is far more complex than that, e.g. if mining costs increase with depth, the model will for example, cease mining at that layer where the contribution of the TOTAL system becomes zero or negative. (This in itself can be an indication to initiate underground mining).

Medium-term planning

On the medium-term planning there must be a rolling 18-month plan, where the main deliverable, is quantification of the operating cost. An optimized production schedule will have the least cost and the minimum risk that is obtainable. Final

product grade, cost of production, and “what-ifs” are furthermore important criteria that must be considered in the mining plan.

To be able to do this, it is now possible for the mine-planning engineer to know if the production process was effective and efficient. A prediction of the associated profit for each block or a combination of blocks can be made. A marginal mine block can therefore easily be identified and selectively mined so that profit can be made above the associated mining cost while mining dilution will be at minimum. Using this technique, a cost ranking exercise is completed. During scheduling, the combination of material from each pit or each shovel must be controlled in order to achieve the best blending scenario. The quality of the blend of material can be set according the geological and metallurgical specifications as required by mining or the beneficiation plant. See Mining Operations: Selective Mining.

Waste dump scheduling is crucial in mining planning, although less focussed, in comparison to the mine pit scheduling and layout. In open pit mining where normally high stripping ratio can be found, the mining cost is normally in the waste mining and therefore the waste dumps design and scheduling needs to be incorporated within medium-term planning.

By incorporating the haul road networking in the medium-term software packages, the best suited waste- and ore dumping position can be created. Animation and visualization is also helpful to easily simulate and communicate the mining operation’s actions and deficits. Risk on these deficits can then easily indicate future impacts.

Other Key Performance Indicators (KPI's) for mine planning are:

- Frequency and on time mining plans while progress has been achieved to improve value;
- All mining standards have been revised for complete mine plan understanding;
- Continuity of plan;
- Accuracy of grade, tonnages and cost has been predicted;
- Adherence to plan through the total value chain.
- Development of a real time planning process (dynamic life of mine)

Furthermore, the following parameters must be incorporated into the mine planning phase, especially in EWAR where the mining engineers on the mine site are responsible for implementation, maintenance and control of it:

- Rainfall precipitation;
- Block specific risk (Fragmentation, digging rate, rock types)
- Grade estimate risk, using conditional simulation;
- Dewatering risk area's;
- Equipment information (Replacement and rebuild schedule, allocation, optimal workable bench height etc.)

5.8. PLANT

The plant must be aligned with geology (in-situ reserves), mining (planning, scheduling and production), and the market (specifications and volume) by:

- Measure and reconcile the plant's performance, primarily to actual material received and not against budget and planned targets;

- Measure the mining activities primarily to deviation from the given mining plan and not against ROM targets;
- Lab quality assurance is in place with optimised analytical techniques and improved integration of information and sampling results.
- Measure the mining activities primarily to waste/ore relationship and not feed grade.
- Cost estimates that are linked to the beneficiation plant are :
    a. Power distribution
    b. Tailings storage
    c. Water supply
    d. General plant services
    e. Access roads
    f. Employees required
    g. Mill operating cost / ton
    h. Plant operating cost / ton for different material types
    i. Administration and General Services
- Plant effectiveness monitoring looking at:
    - Screen grading;
    - Density deviation;
    - Production rate;
    - Beneficiation and effectiveness;
    - Yield; and
    - Total metal balance (monthly basis).
- Modular plant maintenance ensuring minimum total shutdown is applied to reduce production downtime looking at Shutdown and Turnaround management.

Companies that started using this maintenance procedure received great benefits and it appears to be a catalyst in realigning the plant personnel and providing a focus on planned work. In terms of feedback received on the major focus areas has been on differentiating between the modular and single line equipment and maintaining the focus on the latter during the shut. Here also the establishment of maintenance plans has been a challenge to the implementation. Mini shutdowns procedures prove to be compliment it

5.9. Mining operations

5.9.1. Selective mining

Selective mining deals with the identification of recoverable ore outside the definition of profitably mineable ore, or the upgrading of low-grade ore by applying an appropriate mining method.

Each ore/waste block must be inspected on a daily basis to ensure that the material is transported to the correct destination. The main emphasis is to offer alternative solutions for material classified as ore, but which has been contaminated with waste. Another purpose of these routine inspections is to confirm the accuracy of the different classifications as loading progresses, and to advise on ore occurring outside an ore classification. Information gathered during the inspection may result in the mine line being shifted or areas reclassified for selective mining.

It is generally the current practice that the contaminated ore is blended in on an ad hoc basis at a slow rate, or left in the mine for long periods, or when it hampers progress, it is reclassified as waste and transported to the appropriate dump. In most cases it resulted in a mining loss of ore.

To counter this abuse of potentially valuable ore, special dumps must be created to stockpile this diluted but high quality material. The material must be stockpiled until it can be blended in, or the beneficiation process is enhanced by technologically more advanced methods.

During mining, some degree of selectivity is applied during mining. Blocks & panels whose estimated value exceeds a specific cut-off grade are proposed as ore blocks, while blocks estimated cut-off grade are treated as waste. The decision to classify a block as an ore or waste block is made on the basis of the detailed but incomplete information available at the time mining takes place.

Information that can be used to classify a marginal blasting block either as ore or waste, are channel samples from the exploration drill holes, or the assayed blastholes. Consequently, some blocks will be estimated as being below cut-off grade whose true grade exceeds the cut-off grade. They will be incorrectly treated as waste blocks. Other blocks will be estimated as being above cut-off grade whose true grade is below cut-off grade. They will be incorrectly treated as ore blocks. In **Figure 5.9.1.1** a scatter diagram shows a mining block represented by a horizontal block, estimated value Z*, and a vertical true value Z. Ideally, one would mine only the ore blocks with true value Z exceeding the cut-off grade, but in fact, blocks will be mined whose estimated value Z* exceeds the cut-off grade.

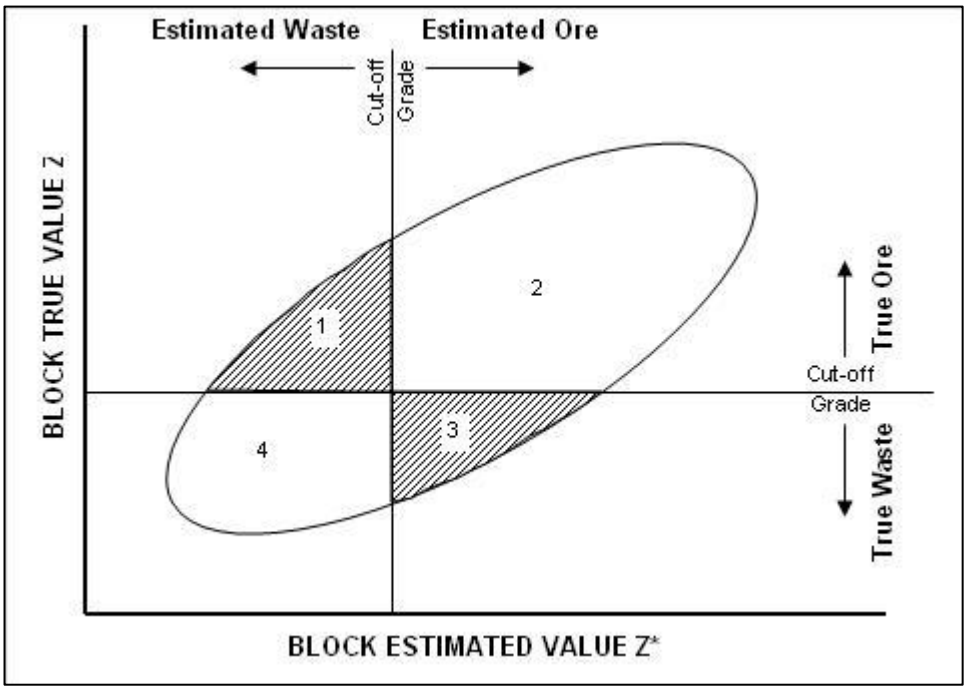


Figure 5.9.1.1: Error of estimation in selective mining

The scatter gram is divided in four sectors. The first sector contains ore blocks that will be treated as waste. The second sector contains ore blocks that will treated as ore. The third sector contains waste blocks that will be treated as ore. The fourth sector contains waste blocks that will be treated as waste. The number of blocks falling in the first and third sector should be minimized.

In a selective mining environment, two types of dilution should be taken into account, known as external and internal dilution. The external dilution is caused by limitations in the mining method while internal dilution reflects a weakness in the method of reserve estimation. Both should be minimized to allow the minimum amount of ore to be sent for treatment.

Factors that influence the selective mining process are identified as follows:

Process Variables (impacting on quality)		**Estimated Impact of Variable on Quality**		
		High	**Med.**	**Low**
1	Sampling accuracy Function of: - Lab accuracy - Sampling methods	**High**		
2	Accuracy of geological logging Product dependant on geologist's knowledge. Function of training and experience.	**High**		
3	In situ orebody complexity	**High**		
4	Accuracy of geological model Function of: - Ore definition - Model's structure - Geological interpretations - Geostatistic methods - Algorithms – Sink/Float tests	**High**		
5	Mining complexity/inaccuracies on blast blocks Function of: - Block orientation - Movement due to blasting - Mining method - Equipment size - Loading procedures	**High**		

Table 5.9.1: Variables impact on Quality

Other methods that should be considered in selective mining are:

i. Contamination control where homogenized material are sent to the plant to minimize plant cost and improve metallurgical recoveries and plant throughput.

ii. Utilization of low-grade ore through the life of mine must also be constantly investigated.

iii. A Blasting (fragmentation) optimisation program is in place with selective blasting of ore zones (where applicable.)

iv. There is strict adherence to the planning schedule and follow up procedures on deviations.

v. There is formal collaboration with Grade Control and Production Geology.

vi. Clear control on blast hole sampling is evident and continuous audits with reporting structures are in place that is focused on optimised ore utilisation.

vii. There is commitment to selective mining and procedures to ensure compliance.

viii. There is strict adherence to loading and hauling instructions.

A commitment to selective mining and procedures must be given to ensure compliance. The costs that should be considered during selective mining are:

i. Beneficiation costs – more dilution creates higher metallurgical cost due to higher tonnage throughput x treatment cost / ton.

ii. Incremental cost - the benefit if ore is mined somewhere else.

iii. Costs of selective mining – the cost to load or track doze ore or waste separately from waste or ore. Selective mining also has lower production rates which cause production delays.

iv. Mining cost – Cost difference between waste mining and ore mining considering further / nearer hauling.

5.9.2. Double Handling

As with all mining practices, ground rules should be applied to set standards. The main rule applicable for double handling stated that transportation of material to special stockpiles can only be allowed if the material impedes the expansion of the pit in that specific area. If the situation does not meet this criteria, the material is left at its location until such time that it hampers expansion or can be used for blending purposes. This rule limits double handling of the materials and limits the potential growth of the special stockpiles and unnecessary mixing of material.

5.9.3. Reconciliation

The relationship between mining and plant can be determined by the Mine Call Factor (MCF), namely the Plant Head Content divided by the Mine Head Content. See Principles and KPI's: Survey for detail discussion.

5.9.4. Information Technology Management

Technology enablers are a pre-requisite for the sustainable application of Mineral Resource Management. Benefits between the in-situ reserves and transactional areas of accounting, human resources, materials management and beneficiation can be aligned by related information technologies. Critical areas of focus are alignment of business systems with the operational planning; and the tracking and monitoring of production and commercial information.

Currently at EWAR, communication and information flows lack, thereby creating system inefficiencies. Most of the communication and information are via e-mail, which lead to complex data capturing and extensive lead-time before any sensible analysis and trends can be made. Problems experienced currently are:

1. No information flow integration between the mining sites and head office;
2. Wrong factors and budget figures were used due to more than one version being created while the latest reports weresent to different persons;
3. Inability of departmental analysts to do proper measurement / benchmarking and trend comparisons, due to not obtaining information within time. This leads to time constraints for proper trends and analysis.
4. Strategic contingencies such as:
    - Total metal balance sheet;
    - Bulk Mining Equation Spreadsheets;
    - Volume optimization;
    - 3 Year graphs for all CPI's;
    - Optimisation between mine centers have not been done.
5. Conflicting performance measurements.

A great deal of time and effort is spent on reporting weekly and monthly performances from each mine. Not only one person is involved in creating these reports but a series of activities that are connected to each other are needed from different persons. Each activity has an input which serves as the driver and each has an output which is usually the driver for the next step in the process. In the middle, you've got a series of numbers which specify how much or what percentage of people's time in this particular department is spent on each activity. The customer channel per product profitability can therefore be determined, adding a new dimension to the process.

The objectives of this process are:

i. Data integration;
ii. Eliminating duplicate administration procedures;
iii. Easy and up to date performance measurement of KPI's, KPA's and activity drivers;
iv. Effective benchmarking;
v. Performing business analysis on the performance measurement drivers;
vi. Understand and perform pro-active measurements to improve current performances;
vii. Automated reconciliation on all main procedures;
viii. Easily integrate and enhance regions' vision and key drivers;
ix. Information value gap analysis;
x. Cost reduction and profit improvements through lessons learnt;
xi. Flexibility to run alternative plans or schedules (looking at contingencies / opportunities); and
xii. Performing risk analysis.

Benefits that will be received other than mentioned above are:

i. Real time computerized reporting;
ii. Improvement of communication between departments;
iii. Inter-departmental database flow;
iv. Decision making monitoring to assist decision making;
v. Cross-checks over the whole information flow;
vi. Compilation of Management reports;
vii. Standardization of information flow;

viii. Theory-of-Constraints (TOC) for daily measurements;

- Can be used to solve problems of bottlenecks, scheduling, and inventory reduction;
- Investigation on throughput analysis that caused a shift from cost-based decision making to decision making based on continuous improvement of processes in which system throughput, system constraints, and statistically determined protective capacities at critical points are key elements; and
- General application to attack a variety of process problems within organizations. TOC logic is applied to identify what factors are limiting an organization from achieving its goals, developing a solution to the problem, and getting the individuals in the process to invent the requisite changes for themselves.

ix. Stockpile volumes and weighted average ore grades on these stockpiles;

x. Daily production reporting of non-productive time and equipment analyses coupled with standard reports;

xi. Lost production and reasons for exceeding or failing to reach the target rates;

xii. Software that can be expanded by the user;

xiii. Clearer picture of the entire process;

xiv. Improvement of decision making;

xv. Aid in adding value to the business

It is critical that supportive processes and IT-systems flow seamlessly between the different value chain elements identifying all key measurements. The trick here is to flow chart and identifies all the key measures which are usually the activity

drivers. When the basic flow has been identified and created, the ideal process line can be identified, bypassing all repetition and delay loops. All non-value-added activit key triggers can therefore be identified and eliminated. If one tends to enhance the IT-process without re-engineering the IT-flow, one tends to lock inefficiencies. There is an awful lot of activity that does not add value within the process flow, measuring and recording trivial and unimportant stuff, while high level duplication across departments also hamper the system.

It must be remembered that IT-systems and process is not a solution to business efficiencies, but a tool to get sound fundamental business processes. One main aspect of such a system is on-time information to relevant decision makers so that decisions on the short term can be optimised or proactive measurement can be taken to leverage production lows and reduce risks. Process improvement, benchmarking and profitability analysis can therefore easily perform that are entirely coherent with what is trying to be achieved.

Therefore, the details of such an IT-system must be derived after the process flow has been optimized and re-engineered. It must also be closely aligned to the regions business process, organisational structure and strategy. The following steps will help to achieve an effective performance management IT-system:

1) Identifying the performance measurements and key resource indicators that the new system will enable. [See **Addendum A** for KPI's that need to be benchmarked for the mining department.]
2) Mapping information flows - Information flow mapping identifies how data, information and knowledge are transferred to and from all relevant stakeholders, both inside and outside the working process. It identifies where the transfer adds little or no value, where information is provided in the correct format, whether timely or not and how information is transformed and how it is used. Information Flow Mapping will enable

significant improvement on quality and timeliness of important (or non-important) data and information. Duplication and redundant information flow can also be reduced. Furthermore it can improve customer relationships.

The following needs to be done to ensure effective information flow mapping:

i. Cross Functional Process Mapping. Depicts – through inputs and outputs – how works gets done and which functions in the organisation are involved in accomplishing a given task.

ii. Process Relationship Mapping. Shows – through inputs and outputs – how each process interacts with other processes.

iii. Functional Relationship Mapping. Provides a picture of key relationships, expressed as inputs or outputs, between its departments and its customers/suppliers

Information mapping must therefore commence to provide a thorough understanding of the information flow. Using the Mineral Resource Management value chain as a guideline, information mapping needs to be done from geology, grade control, mine engineering, up to and slightly beyond the plant throughput to estimate reconciliation between mining and processing. Information that therefore needs to be mapped is:

a) Where do the inputs come from and in what format?

b) What is done with the inputs?

c) When and how often?

d) In what media or format is it stored?

e) Format of the outputs and to whom?

f) Is the information being used by more than one person?

Detail design of the data, documentation, and functional system needs to be recorded to ensure that inefficiencies can be determined.

5.9.5. Performance Measurement

Performance measurement must relate to a specific Critical Performance Driver, matching employees' and managers' actions to the regions' strategy. This can either be to identify resource allocation where there are problem areas; or to communicate progress towards strategic objectives; or to evaluate managerial performances. Performance appraisals and personal contracts must also support these specific performance drivers.

5.9.6. Quality Management Process

The purpose of the Quality Management Process is to ensure that the final products are produced at 100% within customer specification at point of delivery. This entails focusing on:

- **Preventative Quality Management Processes**
  i.e. the control (through rigorous measurement) of production and distribution variables impacting on physical and chemical quality of the required throughput.

  e.g. ISO standards, Standard Work Practices according to design

- **Corrective Quality Management Processes**
  i.e. The work processes involved and activated when quality deviations occur

  e.g. On-mine grade control

- **Effective Information Gathering Infrastructure and Processes**
  i.e. Quality feedback loops

e.g. Laboratory outputs

- **Quality Management Philosophies**

  i.e. Supporting and contributing to stable on-mine operations optimizing use of available capacities.

5.9.7. Benchmarking

At East and West Africa Region Corporate Office, the objective is to have a balance between financial, social and environmental objectives. All three parts are interconnected. Intensive due diligence exercises are performed looking at quality assurance and control; standards and protocols; estimation and confidence levels; recognized techniques and models; reasonable levels of reputable external audits; recognition and application of best practices, and public disclosures and scrutiny.

However, since you can't manage something if you can't measure it, continuous audits and measurement are needed. This is where benchmarking, analysing of data and studying of best practices comes in. Benchmarking, trends and forecasting are necessary to be able to predict future risk and / or opportunities. In the Mining Department at Head Office, monthly meetings are held, discussing the following mining parameters for understanding trends, risks, future opportunities and/or limitations. These are:

1) For production control:
   - Volume mined;
   - Tonnage mined;
   - Grade mined;
   - Plant feed & grade;
   - Plant throughput & grade;

- High grade ore mined;
- Stripping ratio;
- Rehandling %;
- Volume blasted;
- Average density of material;
- Gold produced;
- Dewatering;
- Grade control;
- Gold produced.

2) Safety figures

- LTIFR;
- Accidents - small vehicles;
- Accidents - mining equipment;
- Value of accidents.

3) Production indicators;

- % Availability (all machinery except support equipment);
- % Utilisation (all machinery except support equipment);
- SMU hours (for all equipment);
- Penetration rate of drill machines (instantaneous Lm/hr);
- Production rate (BCM/hr);
- Powder factor (kg/BCM);
- % Redrilling (calculated from above);
- Truck factor;

- Diesel consumption for all equipment (L/BCM);
- Face length and exposed ore.

4) Cost

- Contractor's cost (US$/BCM);
- Total mining cost (US$/BCM);
- Total mine cost (US$/BCM);

Most of this information is already within the monthly management reports and does not need to be changed, while other information is susceptible for the needed analytical processes and evaluation. All information as mentioned is required on a monthly basis but also in YTD with the corresponding budget or revised budget. A rolling timeline covering a total of a 48 month period has been identified as beneficial in determining trends, risks or opportunities: 18 months history, 18 months forecast and 12 months for current financial performances.

Benchmarking is an important way of improving operational efficiency, but is not a tool for strategic decision-making. Everyone would want to occupy the point on the strategic landscape that the most successful competitor has staked out. Acknowledging this fact emphasises that benchmarking is not a once-off exercise and lean back to experience results. Benchmarking is an ongoing investigation and a learning experience that ensures that the best industry practices are uncovered, analyzed, adopted and implemented. The greatest benefit from benchmarking is from studying practices - the way the work is done rather than the results; and it requires participation of line personnel and management.

McKinsey & Company has identified 7 “generic” ground rules of world class management and analyzing operation effectiveness through benchmarking, the following must be sought:

GROUNDRULE	PRE-REQUISITE
• Culture	A strong sense of “ownership” with a willingness to take risks
• Portfolio view	Portfolio and asset driven targets with a split between expansion and maintaining production
• Strategy	Operations must be strategically aligned
• Ideas	Idea generation must be institutionalised and widespread with a pertinent value engineering mindset in place
• Consistency	Compliance and standardisation driven by systems, process and tools/methodologies
• Value creation	Rigorous, fact based financial evaluation of all projects with focus to maximise return on investments
• Delivery	All benefits tracked and audited using measurable KPI’s

Table 5.9.7.1: Ground rules for Operating Effectiveness

5.9.8. Technology

Using new technology in mine operations is a strategic necessity to improving safety and operational effectiveness. Implementing new technology can therefore link core products to competencies and skills; knowledge and abilities; and competitive processes and procedures. Most of the time, failure of technology implementation is not with the technology itself, but within the environment to which the technology is introduced. Implementation of technology seems easier when using process environments above the common functional departments.

Technology is dependent on people, process and the technology required. Where these overlap, successful implementation is normally achieved. With this finding,

ground rules have been created for successful technology implementation within the mining industry (A.S. Macfarlance, 2001). These can be defined as:

i. Technology to be introduced must be appropriate to the level of development of the work system;

ii. The technology to be introduced must have a clear objective which is identifiable in terms of bottom line benefit;

iii. The introduction of new technology must be part of a common vision shared by all;

iv. The work system into which the technology is to be introduced must be adequately engineered to ensure its success;

v. The workforce who will operate the new technology or work process must be involved every step of the way in its design and implementation;

vi. Off the shelf technology may not be mineworthy in certain conditions: time must be allowed to establish mine worthiness through redesign and retrofitting;

vii. Quantified benefits must be documented, and mechanisms for sharing experience must be developed.

An essential measurement within a company is to determine and understand the technological health of the company. A useful tool to measure this is by means of a technology balance sheet looking at the technology itself; the role of the technology for the company; the resources that are going to use it; the maturity of the project / technology; the organisational architecture; the team and engineering culture; the products it will be used on, and how it fits within the strategy of the mine. Insights can therefore be gained on:

- Overview of the business technological capabilities in an easy to understand graphical format;
- The current / future markets and products are mapped and also the technologies required to sustain them;

- Which technology is essential to the organisation;
- Level of maturity of these key technologies; and
- Which key technological areas need to be scanned in the external environment for groundbreaking innovations.

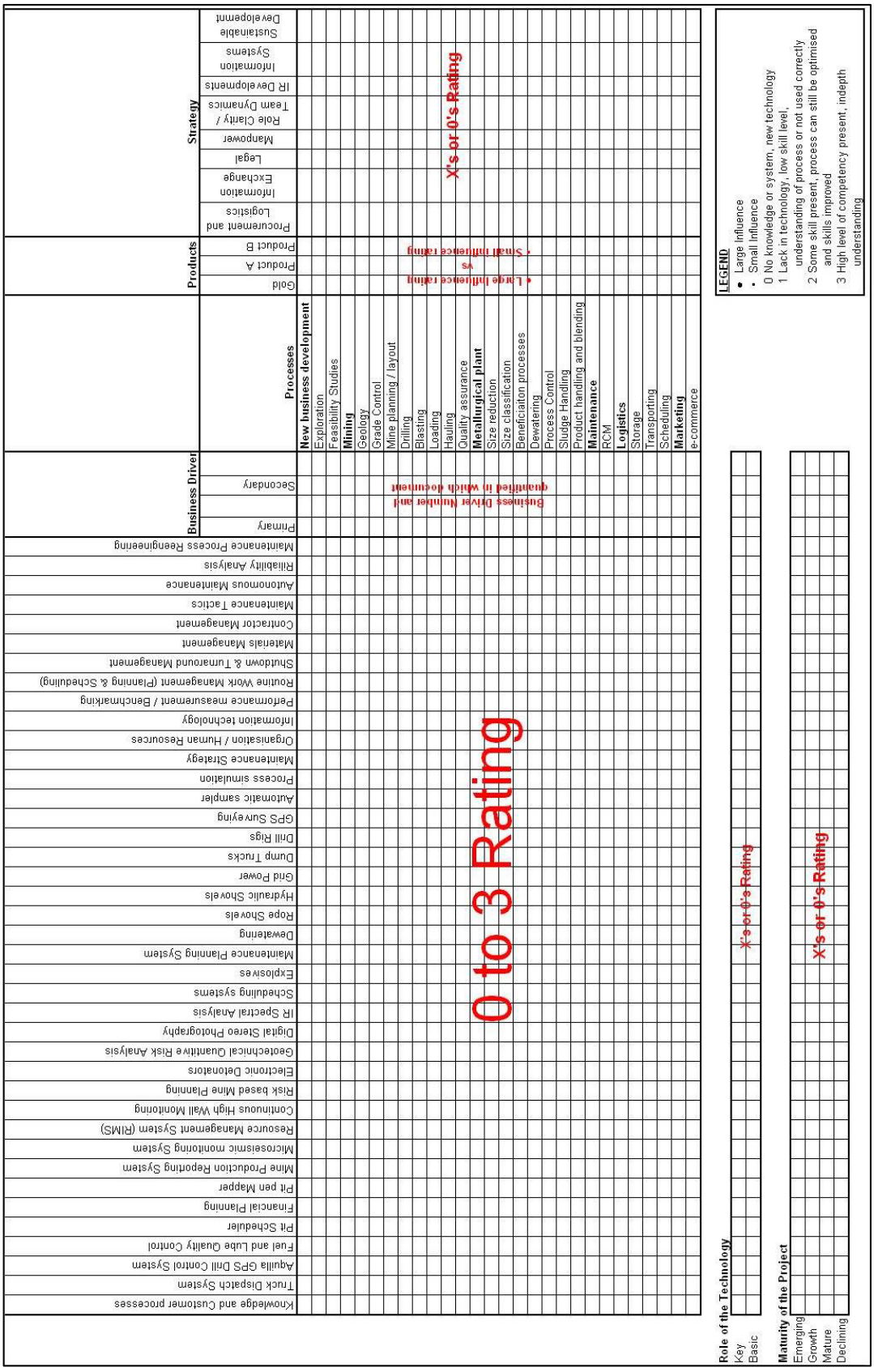


Table 5.9.8.1: Example of a Technological Balance sheet or Value Matrix

5.9.9. Risk Management

Companies who successfully measure and act on risk-adjusted returns are typically rewarded with:

i. Higher valuations from financial markets;

ii. Higher credit ratings; and

iii. Lower costs of capital.

Small changes in valuation or evaluation can translate into significant returns on investment.

By listing all resource risks; geographically, in business units or market segments, it would assist everyone in the organization in defining process behaviours and outcomes. At the same time, it would provide the necessary diagnostic risk tools to help process owners and specialists in the various functional departments to visualize and anticipate complex relationships for faster reaction time and better defining of current and future operations. Projects and operational functions are therefore more clearly defined and higher earnings could be obtained.

Risk Management is performed to quantify the potential frequency of lost information; to ensure the reliability of information and help with information overflow. Furthermore, risk management is used to determine the potential severity of loss; vividness of consequences; and potential publicity of information. In all it is a tool to manage risk and measure consequences.

The aim is to provide risk reporting so that decision makers can quickly react to changing market conditions, rapidly identify new strategic directions and uncover sources of potential problems before they materialize.

Using Mineral Resource Management will determine the risks over the value chain and by using Risk Management, these risks can be ranked, resulting in:

- Better informed & defensible plans, budgets & schedules;
- Increases the likelihood that the project will follow plan;
- Provides a rigorous assessment of contingencies;
- Reducing the likelihood that economical flawed projects will be accepted;
- Contributes to an informal database of project experience useful to corporate;
- Enables objective comparisons of alternatives;
- Identifies & allocates responsibility to the best risk owner;
- Formalizes corporate experience & improves general communication;
- Improves understanding between disciplines & team spirit;
- Helps to distinguish between good luck & good management;
- Develops the ability of staff to assess risk in everyday tasks;
- Focuses management attention on the real issues;
- Demonstrates a responsible approach to staff, community & environment;
- Allows justifiable economic risk talking from a position of understanding;
- Encourage participation at all levels in the organization.

Other best operating principles that have not been discussed but help to develop and implement best operating practices additionally to MRM are:

- Total Quality Management (TQM);
- Business Process Re-engineering (BPR);

- Optimum Production Techniques (OPT);
- Total Productive Maintenance (TPM);
- Asset Management;
- Project / Capital Management.

6. MANAGEMENT ACCEPTANCE

Commitment from management towards the concept is absolutely vital, and depends on cross-functional understanding and relationships in the workplace. Certain traditional functional departments and their heads definitely must change to achieve the greatest benefits. This includes:

- Change the way they measure and understand their performance and contribution to the value chain;
- People in the hierarchy would have to accept new responsibilities and loose old responsibilities;
- Third parties will have a large input into the management of the production functional departments.

Determine the outputs and responsibilities of the organisational structure, bearing in mind what needs to be accomplished, are fundamental, depending on:

- The size of the Business Unit;
- The type of mining business involved e.g. Owner mining or Contract Mining;
- The amount of production systems across the total value chain;
- The level of maturity of the organisation in terms of cross-functional support and integration;

- The length of the value chain under consideration as regards different major value adding processes involved;
- Total management support;
- Effective change management process;
- Change to performance measurement programme;
- Responsibilities of individual persons.

7. IMPLEMENTATION: THE WAY FORWARD

Implementation would include ensuring that all systems have been used optimally in the value chain and have been integrated with each other. Defining optimization possibilities; information flow requirements; analysing and evaluation campaign and measurement and reconciliation procedures necessary; refinement of necessary work procedures and organizational structures are all to support Mineral Resource Management actions.

The ultimate purpose of Mineral Resource Management is to create value and decrease risk. It starts with the identification of what needs to be done, followed by different states of design, on to operation and ends with the phase-out of the desired outcome. To implement the principals as identified in this document, system or value engineering is the underlying theory to use.

Value engineering process consists of multiple cycles until target is achieved over the total identified mineral resource management chain. This chain consists of five stages that need to be aligned, namely:



Figure 7.1: Re-engineering Process

Re-engineering is specifically developed to change systems, organisational structures and values, but also the processes that support it. One of these support processes is competency alignment which involves the systematic study, analysis, and assessment of job functions, tasks, and skills required by an organisation, ensuring the best job fits everyone. Competency alignment helps the reengineering process to perform on time, focusing on the right energy / task and creating internal and external customer satisfaction.

Although work teams are emphasized, the institutionalizing of MRM principles across the total value chain is necessary to ensure that the success of the principles does not function individually.

Together with reengineering, system engineering has been used to focus on evaluating and optimising each value chain process step. System engineering focuses on a three phase approach, namely business engineering, process engineering and detail engineering, as defined in **Figure 7.2**. After a potential business or working methodology is identified and initiated, business engineering, process engineering and then detail engineering approaches need to be taken to be evaluated and optimised. The economic or value evaluation forms the centre of all the processes and directs and governs the systems design towards value creation.

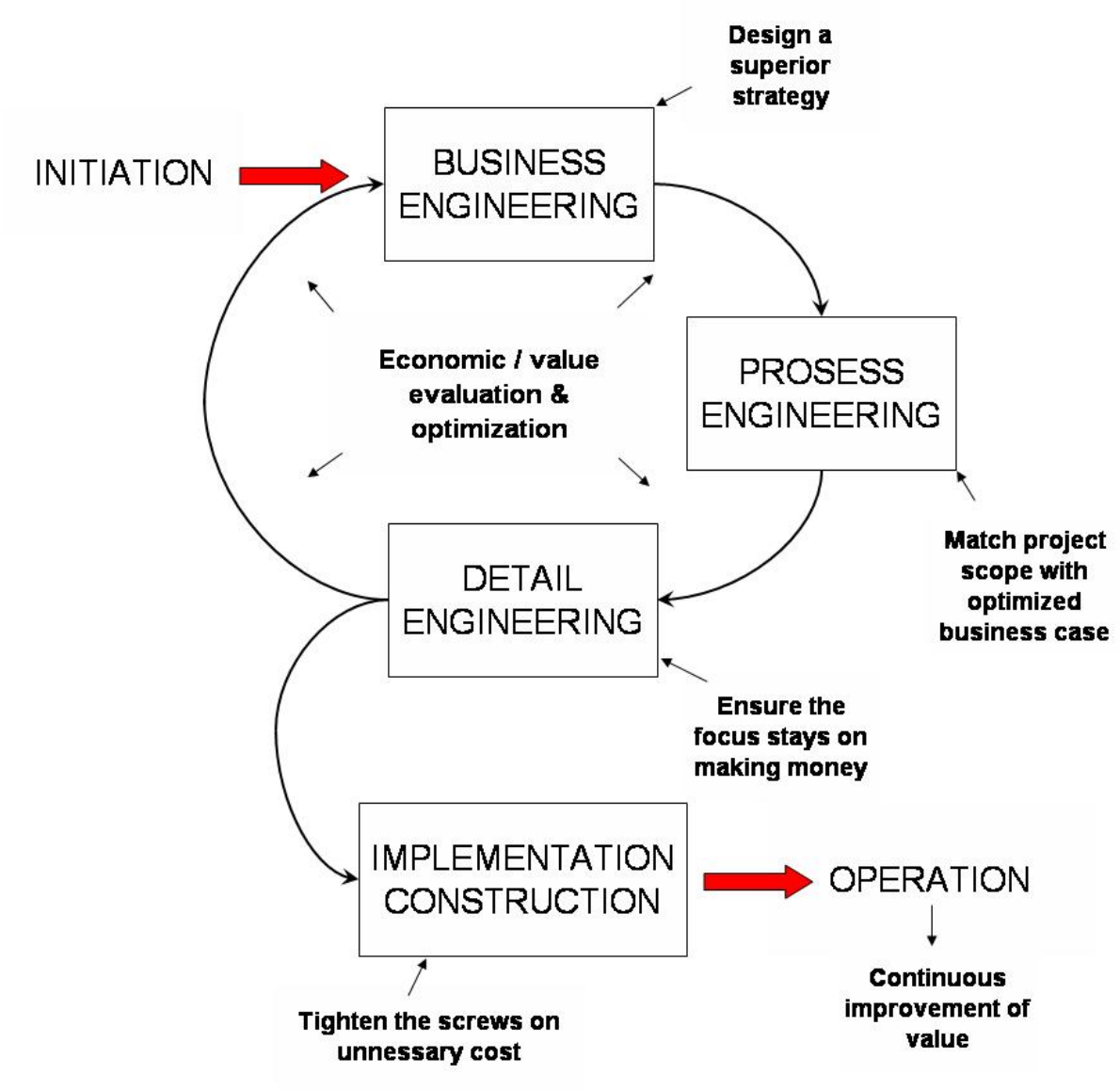


Figure 7.2: System engineering process

The fundamentals of value engineering are:

7.1) The culture required for success;

The success of the project depends on the team's ability and willingness to improve the project. Dr Jay Hall defines competence as a sustained capacity for meeting demands in a committed and creative way.

There is a proper sequence to attain competence, namely: Collaboration, Commitment and Creativity. If these dimensions are approach out of sequence, the competence process is disrupted and a less healthy climate and lower productivity results. See Jay Hall's competency process in **Figure 7.1.1.**

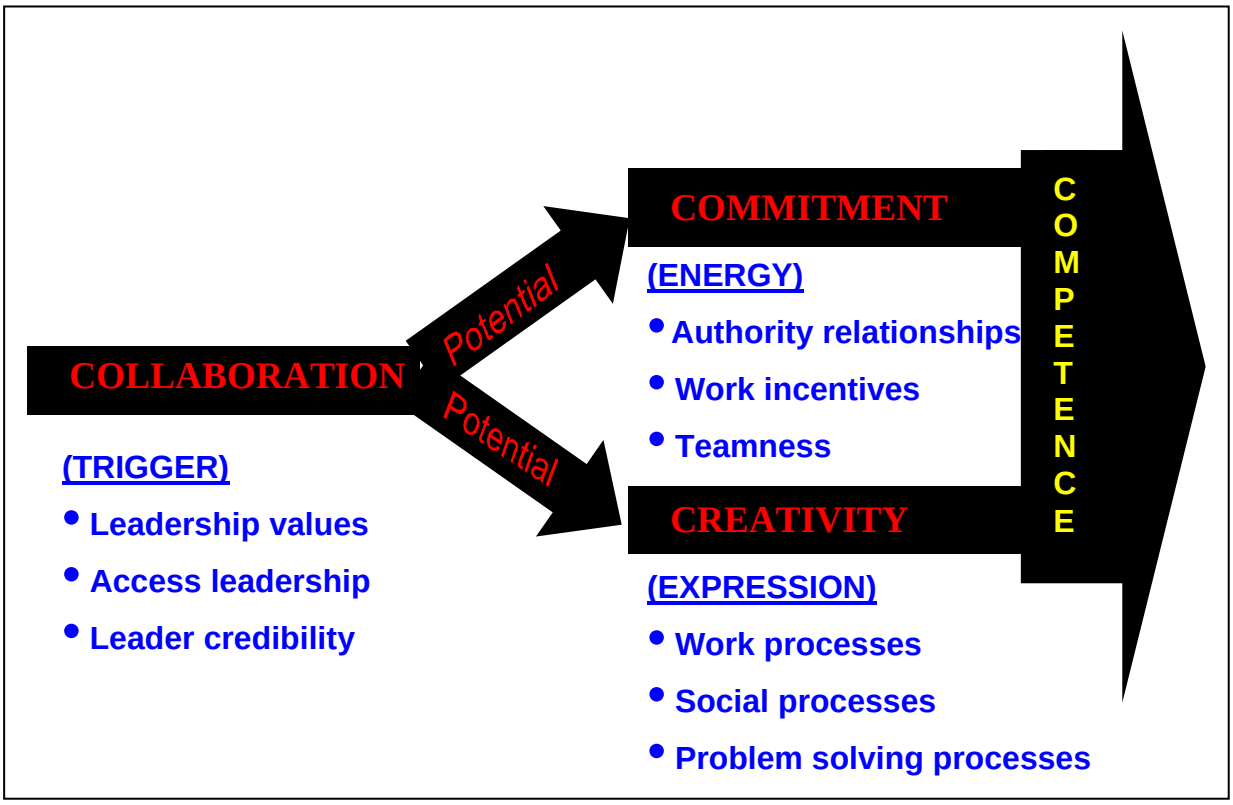


Figure 7.1.1: The Competence Process

A. Collaboration

The collaboration approach is a triggering mechanism. Collaboration sets in motion the potential for heightened commitment on the part of the people who collaborate and paves the way for creativity on the part of those who are committed.

Collaboration is a problem-solving activity, namely for task-decision making; job analysis; planning and forecasting; and allocating resources as well as responsibility. Furthermore, collaboration is sharing of power. It empowers, gets people personally involved in the task, and sees that supporting conditions exist for further performance implementation. The collective intelligence of an organisation is a contribution of all employees. (Source: J. Hall)

The Key Performance Area's of collaboration are defined below:

i. Management Values

- This reflects the basic managerial culture of the organisation;
- Affirms management concern for excellence;
- Gives evidence that management values the resources of it's personnel; and
- Acknowledge humanity of people.

ii. Supporting Management Structures

iii. Manageral credibility

iv. Team is working as one towards the focused goal

v. Willingness and belief in the ability to achieve the set targets among team members.

B. Commitment

Commitment is the psychological energy that powers and facilitates a creative interface between internal and external environments. Commitment has to do with power, the nature of the work itself, the incentives involved and with factors relevant to the work situation. This is also called willingness. To create this willingness, the following principles can be followed:

- Management must give permission to perform. They must be empowered. To empower people results in increased initiative, involvement, enthusiasm, innovation and speed, all in support of the company's mission. The word empowerment means to authorise, enable, and to permit. However, traditional leadership in a multi level organisational structure may be fearful of empowering their subordinates in anxiety that ideas and initiatives may undermine their authority and ultimately their position in the firm. It is a struggle but may be overcome by clear, ongoing communication and commitment from the top of the firm down.
    i. The process must be trusted;
    ii. Must be authentic and conscientious.

If authority, responsibility and accountability don't exist, the commitment to make work a success is limited. If commitment has been achieved, the following advantages will be obtained:

- More creative and innovative ideas will be created;
- Better decisions can be made due to increase in the communication between different departments;
- Individuals will obtain individual job satisfaction;
- Less conflict will exists;
- Group cohesiveness will distribute work related problems and ideas; and
- Employees will be more in contact with top-management.

The culture is to evaluate and test assumptions (don't assume, evaluate) rigorously and if a time limit exists, it is focused towards the improved goal.

Commitment equates to the energy that drives the competence process. The support conditions for Commitment are as follows:

i. Authority Relationships

The amount of impact that people feel or believe they may have on the decisions and policies that govern their work – the amount of power people have, and the freedom "to decide" and "handle problems" within the range of doing their jobs.

ii. Work incentives

The degree to which people feel the tasks to be done, performance rewards and activities are both relevant to organisational objectives and meaningful in terms of their personal goals. To be able to utilize these work ethics, EWAR region must change to performance management programmes for effective measurement of success and or possible opportunities / lessons learned in the region.

iii. Teamness

This is the extent to which people feel a sense of belonging to and identification with – mutual reliance upon and responsibility to – the organisational group in terms of both its objectives and its well-being.

C. Creativity

Creativity can be divided into divergent and convergent reasoning.

- *Divergent thinking* is the intellectual ability to think of many original, diverse, and elaborate ideas.
- *Convergent thinkin*g is the intellectual ability to logically evaluate critique and choose the best idea from a selection of ideas.

Both abilities are required for creative output. Divergent thinking is essential to the attitudes and in-depth understanding whereas convergent thinking is fundamental to the meaning of self-direction and teamwork. Playing a big part in creativity is the motive of the people. Without the motivation and opportunity to do so, it is unlikely that a person would complete an act. In addition, if a person does not have a passion for what he is doing, he will be doing what the rest of the crowd is doing. Employees will not have the courage to persist with their ideas and products and will be lacking guts.

To assist employees to become more creative, strategic focus is required from management by letting the employees understand the issues of global competition. Furthermore, management must share more information, educate employees of corporate goals; creating guiding structures and not controlling one's; support, and encourage involvement; communicate key success factors; customer requirements & cost drivers. There are many ways to promote individual creativity but it needs to be focused towards a common goal.

Competitive challenges also need to be understood and employee's roles as wealth creators. It's all about opportunity and expanding horizons. From knowing why things occur to superficial knowledge.

Creativity reflects the capacity of the competence process. The support conditions for Creativity are as follows:

i. Work processes

   The physical- and psychological structure of work within which people must do their jobs.

ii. Social processes

The prevailing system of social norms and priorities which define the nature of interpersonal transactions and workplace ambience.

iii. Problem Solving Processes

The values, priorities, and processes which govern the way organisational problems are addressed.

By moving over to processes that are normally complex and diverse, it can be streamlined for effective and efficient change or transition. With this, the organisational structure and its people within will be driven by the end results. This alignment will ensure key success drivers are continually searched for and communicated by integrated business and information technology systems. It will also create rapid informed and decision making process by making use of tools, metrics and formal investment and performance appraisals for up to date quality measurements.

Looking at **Figure 7.1.2**, MRM can be further broken down into four processes namely Customer Relationship Management; Production Process; Asset Management Process; and Continuous Improvement. Customer Relationship Management Process focuses on quality with full understanding of the internal and external customer's requirements; while the Production Process manages all mining and plant activities for tonnage throughput to the plant. Asset Management Process focuses on maintenance and Capital Management while Continuous Improvement Process speaks for itself. By changing a typical functional organisation to a matrix organisation, more focus will be attained on the product / process / project, which is supported by systems, company culture and behavioural patterns. It is an instrument to overcome the unavoidable functional fragmentation of modern corporations.

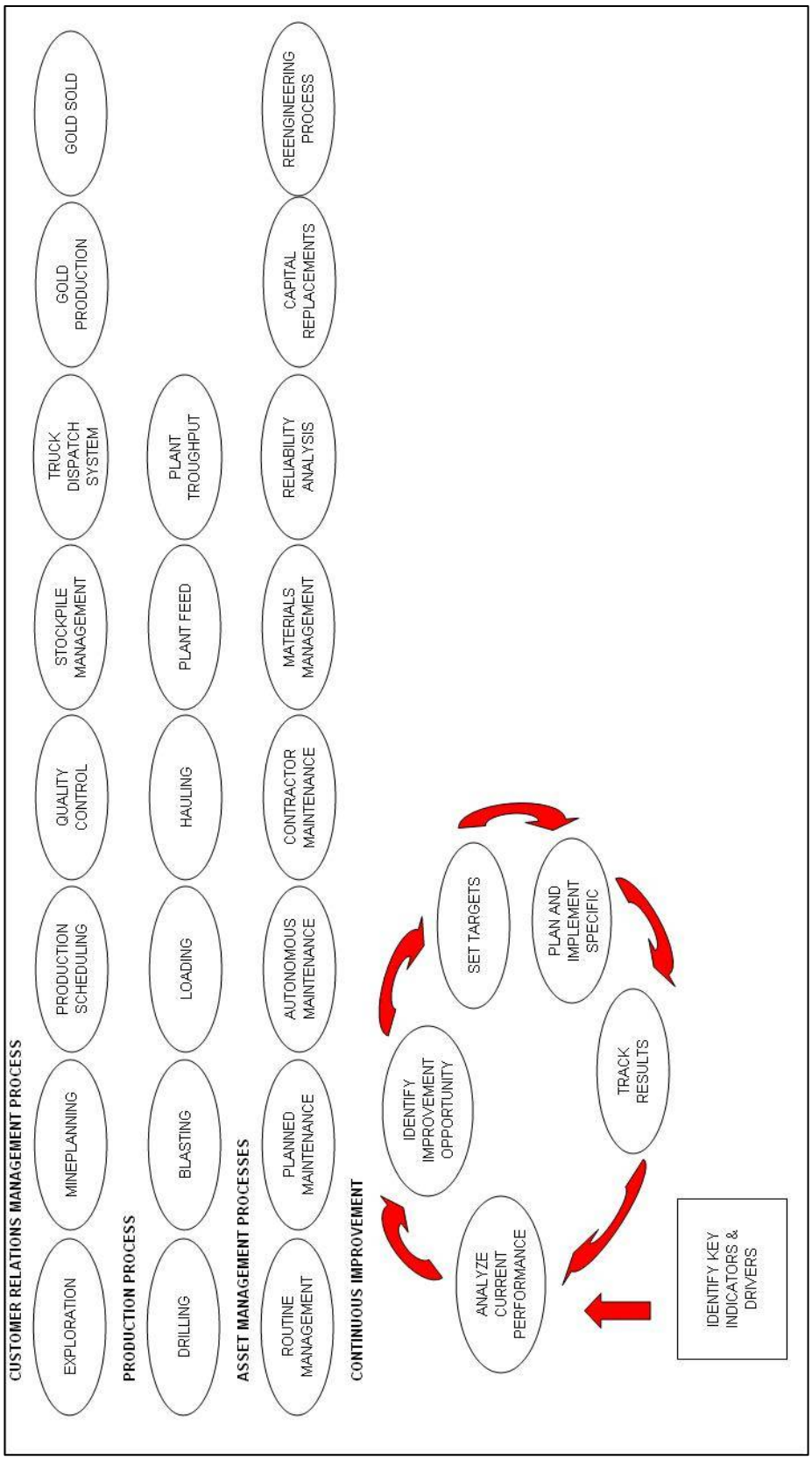


Figure 7.1.2: Processes that enhancing MRM

A process driven organisation can only be achieved by knocking down silos and creating a multidisciplinary vision. Once that is done, one can then apply the best processes that are executed by the best people, which are normally, in this case, specialists in their fields. It also becomes easier to implement technology. See paragraph MINING OPERATIONS: Technology.

Advantages of such an organisation are:

- Better conflict resolution;
- Process orientation;
- Concerned with the co-ordination of specialist knowledge;
- Outward directed (Surging after higher performance, Product delivery, Goal driven)
- Mature authority improving team work, responsibility and decision making;
- Flexibility in resource usage;
- Increase development;
- Allowing more creativity;
- Fostering a direct relationship with external and internal clients; and
- Rapid responses are possible.

In EWAR the functional hierarchy can still be attained within the Business Units, while more and better support can be given from corporate using process management. This will also overcome the problems as mentioned in paragraph MINING OPERATIONS: Information Technology.

7.2. The strategy that must be followed; and

Strategy is defined in terms of focus on value and the required target that needs to be achieved. The organisation focus must therefore be to optimize the company and all actions should be directed to contribute to this goal. This goal becomes not only the most important, but also the only goal.

Critical decisions concerning development of the strategy and alternatives with substantial difference in economics must be made. Changes in strategic direction have major influences on costs, risks, capacity, and profitability. Within mining these strategic direction it is influenced by the Resources / Reserves estimations that are made out off different management disciplines such as Geology, Metallurgy, Marketing, Geotechnical, Ore quality and Civil work. The fundamental economics are depth, waste:ore ratio, ore characteristics (type, grade, plant yield) and the selling price.

For each cost centre / activity, it is required to determine the amount of waste removal and/or pre waste stripping to be done, cast blasting or just earth shaking, contractor usage, mine design, mining layout, mining equipment and mine scheduling, as well as the mining size or mining rate. For whole mine evaluation, the complete operating & capital costs for the mine must be developed and tabulated - leading to the whole mine cash flow analysis.

Guidelines must then be prepared and summarized to allow field personnel to make day-to-day decisions based on economic criteria. Decisions that influence the economics are therefore complete, allowing that actual costs can be compared with planned costs and to quickly highlight anomalies. An example of such guidelines is by producing a haul profile lookup table for field personnel to enable

them to decide on the best cost effective haul road for a particular blasted block. (See **Table 7.2.1** for a look-up calculated capacity with varying haul distances.)

To create one's own strategy, the process is comprehensive and needs to incorporate corporate issues such as sustainability, technical planning and due diligence. This strategy runs through the whole company internally from the reserves, environment, revenue, health & safety, social, debt, costs, ethics, people and prices and externally to financial-; environmental- and social reporting. These three parts are interconnected – if an economic decision has been made, environmental and social consequences will be obtained and vice versa. Nowadays other management issues need to be considered and the strategy towards it.

Table 7.2.1: Calculated capacity

Cycle time	Tramming Distance	CALCULATED CAPACITY																				
38.1	6000	186,302	188,964	191,625	194,287	196,948	199,610	202,271	204,933	207,594	210,256	212,917	215,579	218,240	220,902	223,563	226,224	228,886	231,547	234,209	236,870	239,532
37.7	5900	188,337	191,028	193,718	196,409	199,099	201,790	204,480	207,171	209,862	212,552	215,243	217,933	220,624	223,314	226,005	228,695	231,386	234,076	236,767	239,457	242,148
37.3	5800	190,417	193,137	195,858	198,578	201,298	204,018	206,739	209,459	212,179	214,899	217,619	220,340	223,060	225,780	228,500	231,221	233,941	236,661	239,381	242,102	244,822
36.8	5700	192,543	195,294	198,044	200,795	203,546	206,296	209,047	211,798	214,548	217,299	220,049	222,800	225,551	228,301	231,052	233,803	236,553	239,304	242,054	244,805	247,556
36.4	5600	194,717	197,499	200,281	203,063	205,844	208,626	211,408	214,189	216,971	219,753	222,534	225,316	228,098	230,879	233,661	236,443	239,224	242,006	244,788	247,569	250,351
36.0	5500	196,941	199,755	202,568	205,382	208,195	211,009	213,822	216,635	219,449	222,262	225,076	227,889	230,703	233,516	236,330	239,143	241,957	244,770	247,583	250,397	253,210
35.6	5400	199,217	202,063	204,909	207,754	210,600	213,446	216,292	219,138	221,984	224,830	227,676	230,522	233,368	236,214	239,060	241,906	244,752	247,598	250,444	253,290	256,136
35.2	5300	201,545	204,424	207,304	210,183	213,062	215,941	218,820	221,700	224,579	227,458	230,337	233,216	236,096	238,975	241,854	244,733	247,613	250,492	253,371	256,250	259,129
34.8	5200	203,929	206,842	209,755	212,668	215,582	218,495	221,408	224,321	227,235	230,148	233,061	235,975	238,888	241,801	244,714	247,628	250,541	253,454	256,367	259,281	262,194
34.4	5100	206,369	209,317	212,265	215,214	218,162	221,110	224,058	227,006	229,954	232,902	235,850	238,799	241,747	244,695	247,643	250,591	253,539	256,487	259,436	262,384	265,332
34.0	5000	208,869	211,853	214,837	217,820	220,804	223,788	226,772	229,756	232,740	235,723	238,707	241,691	244,675	247,659	250,643	253,627	256,610	259,594	262,578	265,562	268,546
33.6	4900	211,430	214,450	217,471	220,491	223,512	226,532	229,552	232,573	235,593	238,614	241,634	244,655	247,675	250,695	253,716	256,736	259,757	262,777	265,798	268,818	271,838
33.1	4800	214,054	217,112	220,170	223,228	226,286	229,344	232,402	235,460	238,518	241,576	244,634	247,692	250,750	253,807	256,865	259,923	262,981	266,039	269,097	272,155	275,213
32.7	4700	216,745	219,841	222,938	226,034	229,130	232,227	235,323	238,420	241,516	244,612	247,709	250,805	253,901	256,998	260,094	263,190	266,287	269,383	272,479	275,576	278,672
32.3	4600	219,504	222,640	225,776	228,911	232,047	235,183	238,319	241,455	244,590	247,726	250,862	253,998	257,133	260,269	263,405	266,541	269,676	272,812	275,948	279,084	282,220
31.9	4500	222,334	225,511	228,687	231,863	235,039	238,215	241,392	244,568	247,744	250,920	254,096	257,273	260,449	263,625	266,801	269,977	273,154	276,330	279,506	282,682	285,858
31.5	4400	225,238	228,456	231,674	234,892	238,109	241,327	244,545	247,762	250,980	254,198	257,415	260,633	263,851	267,068	270,286	273,504	276,722	279,939	283,157	286,375	289,592
31.1	4300	228,219	231,480	234,740	238,000	241,261	244,521	247,781	251,041	254,302	257,562	260,822	264,083	267,343	270,603	273,863	277,124	280,384	283,644	286,904	290,165	293,425
30.7	4200	231,280	234,584	237,888	241,192	244,496	247,801	251,105	254,409	257,713	261,017	264,321	267,625	270,929	274,233	277,537	280,841	284,145	287,449	290,753	294,057	297,361
30.3	4100	234,425	237,774	241,123	244,471	247,820	251,169	254,518	257,867	261,216	264,565	267,914	271,263	274,612	277,961	281,310	284,659	288,007	291,356	294,705	298,054	301,403
29.9	4000	237,656	241,051	244,446	247,841	251,236	254,631	258,026	261,421	264,816	268,211	271,606	275,001	278,397	281,792	285,187	288,582	291,977	295,372	298,767	302,162	305,557
29.4	3900	240,977	244,419	247,862	251,304	254,747	258,189	261,632	265,074	268,517	271,959	275,402	278,845	282,287	285,730	289,172	292,615	296,057	299,500	302,942	306,385	309,827
29.0	3800	244,392	247,883	251,375	254,866	258,357	261,849	265,340	268,831	272,323	275,814	279,305	282,797	286,288	289,779	293,270	296,762	300,253	303,744	307,236	310,727	314,218
28.6	3700	247,906	251,447	254,989	258,530	262,072	265,613	269,155	272,696	276,238	279,779	283,321	286,862	290,404	293,945	297,487	301,028	304,570	308,111	311,653	315,194	318,736
28.2	3600	251,522	255,115	258,708	262,301	265,894	269,487	273,081	276,674	280,267	283,860	**287,453**	291,046	294,640	298,233	301,826	305,419	309,012	312,605	316,199	319,792	323,385
27.8	3500	255,245	258,891	262,537	266,184	269,830	273,476	277,123	280,769	284,416	288,062	291,708	295,355	299,001	302,647	306,294	309,940	313,586	317,233	320,879	324,525	328,172
27.4	3400	259,080	262,781	266,482	270,183	273,884	277,585	281,286	284,988	288,689	292,390	296,091	299,792	303,493	307,194	310,896	314,597	318,298	321,999	325,700	329,401	333,102
27.0	3300	263,032	266,789	270,547	274,304	278,062	281,820	285,577	289,335	293,092	296,850	300,608	304,365	308,123	311,880	315,638	319,396	323,153	326,911	330,668	334,426	338,183
26.6	3200	267,106	270,922	274,738	278,553	282,369	286,185	290,001	293,817	297,632	301,448	305,264	309,080	312,896	316,711	320,527	324,343	328,159	331,975	335,790	339,606	343,422
26.1	3100	271,309	275,184	279,060	282,936	286,812	290,688	294,564	298,439	302,315	306,191	310,067	313,943	317,819	321,694	325,570	329,446	333,322	337,198	341,074	344,949	348,825
25.7	3000	275,646	279,583	283,521	287,459	291,397	295,334	299,272	303,210	307,148	311,086	315,023	318,961	322,899	326,837	330,775	334,712	338,650	342,588	346,526	350,464	354,401
25.3	2900	280,123	284,125	288,127	292,129	296,130	300,132	304,134	308,136	312,137	316,139	320,141	324,143	328,145	332,146	336,148	340,150	344,152	348,153	352,155	356,157	360,159
24.9	2800	284,749	288,817	292,885	296,953	301,020	305,088	309,156	313,224	317,292	321,360	325,428	329,495	333,563	337,631	341,699	345,767	349,835	353,902	357,970	362,038	366,106
24.5	2700	289,530	293,666	297,802	301,939	306,075	310,211	314,347	318,483	322,619	326,756	330,892	335,028	339,164	343,300	347,436	351,572	355,709	359,845	363,981	368,117	372,253
24.1	2600	294,475	298,681	302,888	307,095	311,302	315,508	319,715	323,922	328,129	332,336	336,542	340,749	344,956	349,163	353,369	357,576	361,783	365,990	370,197	374,403	378,610
23.7	2500	299,591	303,871	308,150	312,430	316,710	320,990	325,270	329,550	333,830	338,110	342,389	346,669	350,949	355,229	359,509	363,789	368,069	372,349	376,628	380,908	385,188
23.3	2400	304,888	309,243	313,599	317,954	322,310	326,666	331,021	335,377	339,732	344,088	348,443	352,799	357,154	361,510	365,865	370,221	374,577	378,932	383,288	387,643	391,999
22.9	2300	310,376	314,810	319,244	323,677	328,111	332,545	336,979	341,413	345,847	350,281	354,715	359,149	363,583	368,017	372,451	376,885	381,319	385,753	390,187	394,620	399,054
22.4	2200	316,065	320,580	325,095	329,610	334,125	338,641	343,156	347,671	352,186	356,702	361,217	365,732	370,247	374,762	379,278	383,793	388,308	392,823	397,338	401,854	406,369
22.0	2100	321,966	326,566	331,165	335,765	340,364	344,964	349,563	354,163	358,762	363,362	367,961	372,561	377,160	381,760	386,359	390,959	395,558	400,158	404,757	409,357	413,956
21.6	2000	328,092	332,779	337,466	342,153	346,840	351,527	356,214	360,901	365,588	370,275	374,962	379,649	384,336	389,023	393,710	398,397	403,084	407,772	412,459	417,146	421,833
21.2	1900	334,456	339,234	344,012	348,789	353,567	358,345	363,123	367,901	372,679	377,457	382,235	387,013	391,791	396,569	401,347	406,125	410,903	415,681	420,459	425,236	430,014
20.8	1800	341,071	345,943	350,816	355,688	360,561	365,433	370,306	375,178	380,051	384,923	389,795	394,668	399,540	404,413	409,285	414,158	419,030	423,903	428,775	433,647	438,520
20.4	1700	347,953	352,924	357,895	362,866	367,836	372,807	377,778	382,749	387,719	392,690	397,661	402,632	407,602	412,573	417,544	422,515	427,486	432,456	437,427	442,398	447,369
20.0	1600	355,119	360,192	365,265	370,339	375,412	380,485	385,558	390,631	395,704	400,777	405,850	410,924	415,997	421,070	426,143	431,216	436,289	441,362	446,435	451,509	456,582
19.6	1500	362,586	367,766	372,946	378,126	383,305	388,485	393,665	398,845	404,025	409,205	414,384	419,564	424,744	429,924	435,104	440,283	445,463	450,643	455,823	461,003	466,182
Utilisation		70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90

Budgeted figures

Parameters

Speed loaded	25	km/h
Speed empty	35	km/h
Load time	4.5	min
Spot	1.3	min
Tip time	1.1	min
Wait crusher	1.6	min
Wait Shovel	3.6	min
Ore tonnes	110,000	tonnnes
Waste tonnes	240,000	tonnnes
No. trucks	44	
Average load	186	tonnes
Working hours	24	hour
Availibility	86	

These figures are only an approximation and only hold under the conditions set out in the table called "parameters"

To simulate the use of pantos and inclines, the average speed must be adjusted.

Once the strategy has been implemented, auditing and reporting needs to be done, asking questions such as:

(i) Is what was reported true?

(ii) Is it really happening as planned?

(iii) Are the systems in place?

(iv) Are the results being achieved?

(v) Are commitments achieved?

The focus areas for value improvement can be grouped according to Dr. Moll in the following groupings:

- Optimize functions (quality, speed and flexibility)
- Hunt out lazy capital
- Management of risk (and not killing it with capital)
- Minimize waste

It is required that a specific target must be aimed for. This target has to be stretched and be difficult to achieve. A target where the team knows beforehand how they are going to achieve would not result in the required frame of mind.

7.3. The structure required for value engineering.

Since the objective of value engineering is to optimize the value of a business, the dynamics of the factors contributing to this value have to be understood fully and clearly. Therefore analysis needs to be done to completely understand the business and to serve as a method to improve its value.

The basic process consists out of three basic steps preceded by an initiation phase where targets must be fixed. These three steps are:

- Getting the facts of analysis;

  Analysis is done with the clear focus of identifying improvement opportunities by identifying value destroying paradigms and by exposing non-optimised factors.

- Finding the best solution or design using fundamental principles such as interviews, analyses, benchmarking, what-if scenarios, and financial manipulation; and
- Identify and communicate the need and potential for change It is necessary to understand the fundamental aims of the project:

  i. Economically – Analysing the feasibility of the project by identify the financial parameters, the business drivers and list of assumptions with key risk areas;
  ii. Strategically – Develop strategies and ideas and ranking it;
  iii. Process a model to understand the work that needs to be done – Creating KPA's; decompose performance areas into processes and identify technical and commercial requirements for each process;
  iv. Reviewing the technical requirements of the project assigning technical task teams and review current work assessments; and
  v. Creating Work Breakdown Structure (WBS) to plan and align resources and time.

The outcome of the initiation phase is a recommendation that the improvement exercise should be focused on a specific process within the value chain. It is

important not to address the different aspects in detail, but rather to scope and assess all aspects within the limited time available.

The fundamental aims of the project must be the business actions that were defined that need to be changed. To understand the activities that need to be performed, the current reality (define overall project objectives), the future intent (define sub-objectives) and the movement from business strategy reality to intent (define goal decomposition) must be understood. The output is a detailed work breakdown structure (WBS) and schedules.

Value can possible be improved by finding different concepts of linking the market or functional department to the resources or upstream & downstream processes. Not just horizontal integration but also vertical integration needs to be done to add value to the overall processes. Here we look at business drivers such as:

- Volume;

  Perceptions of economy of scale, lack of available cash and ballpark-type statements by management are often the factors determining the design volume of a business;

- Quality;

  Quality always must be compared to the value been added. An optimum quality against value can be found where thereafter value is destroyed if quality is improved further.

- Flexibility;

  Flexibility could be used to compensate for a lack of business information or market focus. Once the cost of flexibility and the fundamental reasons behind flexibility are understood, value can be improved.

- Minimized expenditure;

  It is often possible to achieve the required outputs from a plant at a much reduced capital. By eliminating unnecessary equipment, not only capital but also a lot of maintenance and operating costs are eliminated. Lazy capital and capital fit for purpose are potential expenditures that must be eliminated. Three sources of lazy capital can be quickly identified namely:

  - Capacity balancing;
  - Provision for expansion; and
  - Phasing / learning curve.

- Risk; and

  A completely risk free plant would imply very high capital or operating costs. The relation between the cost of avoiding risk and the actual risk is not linear. Value can therefore be added by determining the right amount of risk to bear and by searching for alternative ways to improve the risk exposure.

- Waste.

  Waste is defined as any activity or process that is not contributing to the bottom line. Categories of waste to look for are:

  - Waste of over production;
  - Waste of waiting time;
  - Waste of transportation;
  - Processing water;
  - Inventory waste;
  - Waste of motion;
  - Waste from product or service defects;
  - Waste of time;

- Waste of human capabilities; and
- Administrative waste.

This research document is set as an input to identify the required activities that need to be achieved. Final agreed target settings must be done to ensure EWAR management are committed to it.

8. CONCLUSION

Never in history has business been such a globally competitive endeavour, and to stay in business, radical different practices and management principles are needed. There is a subtle shift in focus, away from continuous improvement towards a commitment to learning, better understanding, and faster decision-making by streamlining the process flow. Continuous Improvement is still prerequisite for throughput analysis focussing on small, step-by-step improvement on key performance areas. Align it with process engineering and proposed strategies, principles and measurements, can integration within all aspects of the organisation be obtained that will snowball a vast number of improvement opportunities that may be lost if the focus is only on keeping within specification, budget and time constraints.

The way forward?

Using fundamental analysis focussing on the Business level, Process level and Engineering level, can key performance areas be identified that have not yet been optimised. Integrating this with the vertical as well as the horizontal objectives, can optimization over the whole value chain be obtained. See Table 8.1 for the fundamental analysis done in EWAR. The outcome of this is a vast number of smaller improvement opportunities or action lists.

	Key Performance Area's		Objectives	Actions	Key Performance Indicators
BUSINESS LEVEL	STRATEGY	Mission, Vision & Values Strategy / Strategic Plan Strategic Control Business Plan Change & Transformation to support strategies	Maximize revenue Enables better informed & defensible plans, budgets & schedules Cutting out loss making activities & operations Manage risks Create flexibility in operation Define & clarify objectives & goals	Formulation of a strategic region plan and various LOM scenarios, by creating a business simulation program using Whittle Multi Mine or Pitstrat Defining a strategic scope model (Risk Matrix) from simulation program Activity driven, continuous improvement budget Improve on processes and not in departments Establsih a reward / recognition for employees by creating Kaizan teams Establsih a reward / regocnition function for middel management for continuous improvement projects Training / creating mentors Programs for foreman & managerail functions to improve teamness (e.g. teamlink) Careers plans with rotation of staff between business units Create / join a technology forum with other regions / sister companies Create a performance management integrated reporting database Have a storyline to communicate objectives, goals & expextations Create / establish a project capital management process in middle management Electronic filing system for all project completed	NPV IRR Employee satisfaction Customer satisfaction Lower operating cost with set targets Flexible plan Social responsibility Minimum Risk Set of designs / options that optimize the value of the resource Team performance / value added
	BUSINESS ACUMEN	Management & Business Information Business Decisions Business Opportunities Customer & Supplier Agreement	Maximize revenue Enables better informed & defensible plans, budgets & schedules Establish a clear audit trails Optimal understanding / utilization of ore reserves Understand current goals, objectives, roles, expextations Balance of short- and long-term objectives. Commitment & involvement of highest level Establish a reward & recognition system Give clear communication Using / establsih a business planning simulation model Know constraints of each business unit Ability to recognize & seize opportunities Set & control standards & protocols		
	CROSS BOUNDARY MANAGEMENT	Networks Contribution to projects & other teams	Improve flow of information and resources Establish project prioritising Trade-off between competing objectives and alternatives Technical integration Establsih a creative environment Improve communication Commitment & involvement of highest level Knowledge sharing Control resources		
	INTERPRETATION COMPETENCE	Relationship Decision making	Improve plant yield vs. grade optimization Improve ore extraction / utilization Establish project prioritising Optimal understanding / utilization of ore reserves Trade-off between competing objectives and alternatives Balance of short- and long-term objectives. Commitment & involvement of highest level Knowledge sharing Improve employees empowerment		
	TEAM WORK	High Performance Teams Values & Cultures	Enables better informed & defensible plans, budgets & schedules Understand new goals, objectives, roles, expextations Establsih a creative environment Commitment & involvement of highest level Use cross-functional teams in projects Have common goals Team reward recognition Establsih continuous improvement environment		
	CONFIDENCE BUILDING	Confident teams & individuals People development	Establsih a creative environment Commitment & involvement of highest level Culminating confidence levels on plans and achievements		
	MANAGERIAL	Policies, Procedures and guidelines Physical working environment Organisational structure Business process understanding Customer management Schedule, action plans and project plans Managerial control mechanism Communication management Sound IR practices Health & Safety	Improve management / control Enables better informed & defensible plans, budgets & schedules Manage risks Establish a clear audit trails Establish a clear reconciliation Create flexibility in operation Understand current/new goals, objectives, roles, expextations Balance of short- and long-term objectives. Establsih a creative environment Improve communication Knowledge sharing Recognition & application of best practices		
	DRIVE FOR RESULTS	Optimised Resources Sound business practices Performance management system in place Resolved problems Optimal business processes Rewards	Improve management / control Enables better informed & defensible plans, budgets & schedules Optimal understanding / utilization of ore reserves Understand current/new goals, objectives, roles, expextations Trade-off between competing objectives and alternatives Balance of short- and long-term objectives. Commitment & involvement of highest level		
	CONTINUAL LEARNING AND DEVELOPMENT	Competent Staff Development Feedback, guidance & advice Culture of learning Unit skills plan	Establsih a creative environment Commitment & involvement of highest level Knowledge sharing		

	Key Performance Area's		Objectives	Actions	Key Performance Indicators
PROCESS LEVEL	NEW BUSINESS DEVELOPMENT	Exploration Feasibility Studies	Utilization of low-grade ore Cutting out loss making activities & operations Optimal understanding / utilization of ore reserves Balance of short- and long-term objectives.	Defining MRM planning and operation standards & definitions Link production simulation program to the strategic objectives Create an evaluation & reconciliation system Create a LOM Stripping Curves for the whole region Optimize grade profile over LOM and Region Continuous improvement over the value chain (process) Creating Andon communication boards at shift change areas Create a complete 18 month forecast roling plan Risk Assessment build within production plan Interactive mine planning over production & asset management processes Focussing on continuous blending silutions identify gaps in information system/process to increase communication Focussing on technical processes integration Implement Asset / Maintenance Management processes over mining/plant/engineering	Comply with the SAMREC Code Map lithological characteristics of material Decrease double handling Mining Recovery Mining Dilution Cut-off grade Continuity of plan Short term adherence to plan Floor stock level Accuracy of AU content Cost deviations Accuracy of tonnages forecast Sufficient supply of loadable ore Proper inclusion of risk by adding additional blocks Single reconciliation Stable quarter plan Costing deviation on ore Costing deviation on waste Lower delay / standing times
	MINE FUNCTIONS	Geological modelling Production Geology Geotechnical Engineering Grade Control Mine planning / layout Drilling Blasting Loading Hauling Survey	Integrating planning and operations Improve plant yield vs. grade optimization Utilization of low-grade ore Improve ore extraction / utilization Enables better informed & defensible plans, budgets & schedules Manage operating & planning & geological risks Establish a clear reconciliation Integration of value chain activities Create flexibility in operation Optimal understanding / utilization of ore reserves Understand new goals, objectives, roles, expextations Balance of short- and long-term objectives. Technical integration Conitnuous target communication Drilling & blasting must be done timely Appropriation of programming assumptions within reserve estimates		
	METALLURGICAL PLANT	Size reduction Size classification Beneficiaiton processes Dewatering Process Control Sludge Handling Product handling and blending	Improve plant yield vs. grade optimization Utilization of low-grade ore Improve ore extraction / utilization Enables better informed & defensible plans, budgets & schedules Manage risks Establish a clear reconciliation Optimal understanding / utilization of ore reserves Understand new goals, objectives, roles, expextations Technical integration Conitnuous target communication		
	MAINTENANCE	Routine Maintenance Planned Maintenance Process-Redesign	Routine Work Maintenance Performance management indicators Production / Maintenance interface Capital Management Shutdown Agree on critical processes & make visible Standarised processes Enables better informed & defensible plans, budgets & schedules Manage risks Understand new goals, objectives, roles, expextations Balance of short- and long-term objectives. Technical integration Conitnuous target communication		
	PROCUREMENT / LOGISTICS	Storage Transporting Scheduling Materials Management	Enables better informed & defensible plans, budgets & schedules Manage risks Establish a clear audit trails Understand new goals, objectives, roles, expextations Conitnuous target communication		
	MARKETING	e-commerce	Enables better informed & defensible plans, budgets & schedules Manage risks Optimal understanding / utilization of ore reserves Balance of short- and long-term objectives. Conitnuous target communication		

ENGINEERING (DETAIL) LEVEL (PART 1 / 3)

Key Performance Area's	Objectives	Actions	Key Performance Indicators
Financial Management	Enables better informed & defensible plans, budgets & schedules Cutting out loss making activities & operations Manage financial risks Establish project prioritising Establish a clear audit trails Establish a clear reconciliation Understand current goals, objectives, roles, expextations Trade-off between competing objectives and alternatives Balance of short- and long-term objectives. Improve communication to all stakeholders / employees	Integrated computerize IT System and create interactive webbased reports for mining/plant/engineering/procurement Implement BME & BFE Installing a Technology Matrix Implement Selective Mining & decrease Double Handling (Implement RIEMS) Using low grade ore by direct blending (Using RIEMS) Implement Performance Contracts whereupon bonuses and annual salary increases are based Create a Mass- Balance sheet Investigate In-Pit Crushing and conveying Using Analytical tools to do benchmarking, forecasting and determine risk Implement conditional simulation within short term scheduling for risk (Monte Carlo, conditional simulation) Integration of people, processes and technology Quality control systems (IT) throughout value chain Develop integrated dynamic planning system which allow dynamic reporting Debottle neck operations looking at TOC & continuous improvement Communicate / Establish environmental objectives over total processes Scrubbing and optimization of current capital projects Identify high-impact cross functional projects over the whole region Cross department participation in production planning looking at the process Benchmark contractors against each other Create a full equipment life cycle asset management historic database 360 Performance Evalaution Create Career routes / development plans Specific contracts and standards to be measured against Look at Multi Skilling for operators Fast track and set goals for EE / localized candidates Get Business Engineering Department (Weswits) more involved in EWAR Creating a communication forum / general meeting in H/O Monitor compliance in short term planning (extraction rate, sequence, quality) Create a Waste Dumping Strategy Create process environement teams and reporting structures Implement social upliftment plans	Income Statement BME BFE Improve cost Accurate equipment need forecast for Plant & Mining Risk Mass-balance sheet Project lead times / cost. Capturing projects and benefits of projects Employee matriks Benchmarking between BU / Regions / Companies More mine planning plans Improve production Faster & accurate reports Active continuous improvement teams ISO standards & compliances Maximise life of mine Maximise equipment life vs economical operation cost
Asset Management Autonomous Maintenance & TPM Maintenance Tactics Reliability Analysis Contractor Management Materials Management Maintenance Strategy Routine Work Management (Planning & Scheduling) Shutdown & Turnaround Plant Management Performance Measurement / Benchmarking Information Technology Manangement Capital Management Project Management Tribiology	Manage risks in projects / capital requirements Establish project prioritising Establish a clear capital audit trail Technical integration between production / planning / asset mng. Establsih a creative project environment Improve communication between stakeholders / projects Define & clarify current objectives & goals for asset management Understand new goals, objectives, roles, expextations Measure & Analyze Benchmark Preventive Maintenance High utilization of condition-based technology Making use of vibration analysis; oil analysis; laser alignment; thermal imaging Weekly shutdown strategy Parts readily available - minimum lead time / mijnimum stock Accurate inventory data Every item has a article number Contractors should conform to Parent company safety and quality standards Contractor continuous performance reviews Clear contractor safety standards Train staff regarding current Best Practices on Shutdown Management Focus on full life cycle of the asset		
Information Technology Manangement	Integration of value chain activities Understand current goals, objectives, roles, expextations Technical integration utilizing a process environment Establsih a creative environment Improve communication Review definitions of standards Extensive / Effective use of information technology Streamline work processes Data is entered only once Creating interactive webbased reports		

ENGINEERING (DETAIL) LEVEL (PART 2 / 3)

Key Performance Area's	Objectives	Actions	Key Performance Indicators
Research & Development (Feasibility)	Utilization of low-grade ore Improve ore extraction / utilization Establish project prioritising Establish a clear project audit trail with a historical project database Create flexibility in operation Optimal understanding / utilization of ore reserves Understand current goals, objectives, roles, expextations Balance of short- and long-term objectives. Technical integration Establsih a creative environment Improve communication Improve operating cost		
Human Resource Manangement Labour management Performance Management Employee development Recruitement	Creating a incentive scheme according to individual & company performance Clear accountabilities to all employees Empowered individuals and teams Flexible use of workforce (operators), looking at multi-skilling Career development for management & specialist Manpower compliment according to needs Optimize individual development Attract & Retain high skills Rotation & placement according to succession planning Establsih a creative environment Development of emotional intelligence Performance Management System Performance Based Pay Open & Transparency Collaborating Technical integration Knowledge sharing Improve communication Liaison with South African universities and technikons.		
Risk Management	Manage risks Cutting out loss making activities & operations Create flexibility in operation Optimal understanding / utilization of ore reserves Trade-off between competing objectives and alternatives Understand current goals, objectives, roles, expextations Improve communication Quantified risk analysis Improve data quality		
Due diligence	Establish a clear audit trails Establish a clear reconciliation		
Legal compliance	Ensure compliance controls in short- & long term planning Ensure SOC compliance on reports Ensure contractor has legal compliance Ensure competent persons at each business unit Give compliances to Project Managers		
Audit	Establish a clear audit trails Establish a clear reconciliation Reasonable levels of reputable external audits Reserves / Resources are audited Risk / Uncertainties must a clear audit trail		
Sustainable development	Utilization of low-grade ore Improve ore extraction / utilization Enables better informed & defensible plans, budgets & schedules Understand current goals, objectives, roles, expextations Technical integration Knowledge sharing Promote rural economic development & social upliftment of communities affected by mining		
Environmental Risk	Improve ore extraction / utilization Manage / quantify risks Environmental risk must be clearly stated		

ENGINEERING (DETAIL) LEVEL (PART 3 / 3)

Key Performance Area's	Objectives	Actions	Key Performance Indicators
Technology Selection & Management	Utilization of low-grade ore Improve ore extraction / utilization Manage current risks Optimal understanding / utilization of ore reserves Define & clarify current / revised objectives & goals, roles, expextations Technical integration Establsih a creative environment Improve communication between BU on technology improvements Knowledge sharing		
Mineral Economics & Evaluation	Utilization of low-grade ore Cutting out loss making activities & operations Manage risks Establish project prioritising Optimal understanding / utilization of ore reserves Trade-off between competing objectives and alternatives Balance of short- and long-term objectives. Technical integration		
Planning & Optimization	Integrating planning and operations Improve plant yield vs. grade optimization Optimal understanding / utilization of ore reserves Improve ore extraction / utilization Enables better informed & defensible plans, budgets & schedules Manage risks throughout the planning cycle Establish project prioritising Integration of value chain activities Create flexibility in operation Understand current goals, objectives, roles, expextations Trade-off between competing objectives and alternatives Establsih a business simulation model Balance of short- and long-term objectives. Technical integration Improve communication over the value chain Conitnuous target communication Decrease Double Handling by improving continuous blending Improve selective mining in conjunction with blending		
Benchmarking	Cutting out loss making activities & operations Cost curve comparison and where every Business unit is laying on it. Ensure true data sourcing		
Total Quality Manangement	Understand new goals, objectives, roles, expextations Ensure controls are in place for quality mining plans Ensure quality on contractor performance - not chasing profit Ensure quality of communication to all parties Run of periodic checks / analysis on simulation models Quality organisation leadership that promote collaboration Use Project Management in procurement to ensure quality SOW Ensure quality policies, plans & manuals Reports must be standarized and quality ensured		
Performance Management	Improve management / control Enables better informed & defensible plans, budgets & schedules Technical integration Establsih a creative environment Projects must have fixed time, cost and performance Team participation must be included in performance appraisals Clear vision and shared goals must be within performance appraisals Have SMART performance indicators Align reward and regocnition system		
Reconciliation	Integrating detail planning and operations reconciliation Improve ore extraction / utilization Establish a clear single reconciliation system Variance analysis on production		
Continuous Improvement Target setting and tracking Faciliation Teams	Establish project prioritising Integration of value chain activities Trade-off between competing objectives and alternatives Balance of short- and long-term objectives. Technical integration Establsih a creative environment Improve communication Knowledge sharing Optimization of company value Establsih a project database Identify bottlenecks		

Key Performance Area's, objectives, actions and Key Performance Indicators have been identified that will cause a shift from cost-based decision making to decision making based on continuous improvement, a process in which system throughput, system constraints, and statistically determined protective capacities at critical points are key elements. The overall design is critical to sound implementation and must be best fit to organisational strategy.

This process gives us a high level picture of what ultimately are needed, and by defining a program of possible projects can the desired objectives be obtained – See Table 8.2. Fundamentally business goals and objectives must be supported by definable and documented measurement systems, and as identified one of EWAR earliest projects is to provide management- and reporting information that will serves as a driver for cost improvement and set the scene for a behavioural change.

Priority	#	Project identified
2A	1	Creating a business simulation program Set-up a risk matrix Link production simulation program to the strategic objectives Create a LOM Stripping Curves for the whole region Optimize grade profile over LOM and Region Create a complete 18 month forecast rolling plan Risk Assessment build within production plan Using Analytical tools to do benchmarking, forecasting and determine risk Specific contracts and standards to be measured against
1B	2	Implement Continuous Improvement over the total value chain Create teams at employees Create teams at middle management over processes Implement a reward / recognition system Benchmarking over value chain Have a storyline to communicate objectives, goals & expectations Integration of people, processes and technology De-bottle neck operations looking at TOC & continuous improvement
1C / 2B	3	Implement continuous improvement within Budget Risk Assessment build within production plan Create a complete 18 month forecast rolling plan Interactive mine planning over production & asset management processes Implement conditional simulation within short term scheduling for risk (Monte Carlo, conditional simulation) Communicate / Establish environmental objectives over total processes Cross department participation in production planning looking at the process Monitor compliance in short term planning (extraction rate, sequence, quality)
4	4	Promote a continuous improvement environment Identify mentors for engineers Improve foreman & managerial functions to improve teamness Look at Multi-Skilling for operators Creating a communication forum / general meeting in H/O
3	5	Setup career plans Implement Performance Contracts whereupon bonuses and annual salary increases are based 360 Performance Evaluation Create Career routes / development plans Fast track and set goals for EE / localized candidates
1A	6	Create a performance management integrated reporting database Defining MRM planning and operation standards & definitions Create an evaluation & reconciliation system Creating Andon communication boards at shift change areas Identify gaps in information system/process to increase communication Implement BME & BFE Using low grade ore by direct blending (Using RIEMS) Create a Mass- Balance sheet

	Using Analytical tools to do benchmarking, forecasting and determine risk Quality control systems (IT) throughout value chain Develop integrated dynamic planning system which allow dynamic reporting Specific contracts and standards to be measured against Implement Selective Mining & decrease Double Handling (Continuous blending solutions)
5	7 Setup project capital management process Electronic filing system for all project completed Process for choose project go ahead Focusing on technical processes integration Create / Join a technology forum Installing a Technology Matrix Scrubbing and optimization of current capital projects Identify high-impact cross functional projects over the whole region
	8 Ad-hoc Projects
6	Investigate In-Pit Crushing and conveying
7	Create a Waste Dumping Strategy
1D	9 Asset Management Create a full equipment life cycle asset management historic database Implement Asset / Maintenance Management processes over mining/plant/engineering

Table 8.2 : Program of possible projects

To implement the core production and management processes as defined above, two implementation phases are needed, while the third and forth phase are supporting these core processes. This will be done in a step phase manner over EWAR operations by focusing in the first phase on executive information, compilation of current Key Performance Indicator's (KPI's) and reports, as well as defining additional "quick win" indicators that can easily be integrated within the current reports. Streamlining of these indicators is a prerequisite to speed up the process, improving material movement and mass balance / metallurgical accounting. Quick wins can therefore receive while implementation costs will also be limited.

To implementing the executive reports such as the Basic Mining Equations (BME) and Basic Financial Equations (BFE), is historical information needed. It must be ensured that the source data is integrated and valuadated within the same platform over the entire region. Hence the standardisation of definitions and principles is a key component of the integrated solution.

The third phase will be to capture the commercial and asset management information within the information flow to enable proper scenario analysis, continuous improvement and risk based audits. Part of the process is to integrate the additional KPI's that have been identified, while business and financial models must also be accessed to ensure complete roll out of information flow. Once the data is captured and integrity is verified, can front-end portals be created, either for reporting or for business analysis, benchmarking and continuous improvement (Phase 4).

To determine the urgency and importance of each project, need the goals, the strategic basis of interest, the business benefit, the research & development investment needed, the implementation timing, toughest hurdles, and odds of success be tabled to align the projects into the total business plan. It must be realised local optimization (Corporate Office) does not guaranteed global optimization

APPENDIX A

Output / Knowledge areas	STRATEGIC COMPETENCY					BUSINESS ACUMEN				CROSS BOUNDARY MANAGEMENT		INTERPRETATION COMPETENCE	TEAM WORK	CONFIDENCE BUILDING	MANAGERIAL COMPETENCE						DRIVE FOR RESULTS						CONTINUAL LEARNING AND DEVELOPMENT			
	Mission, Vision & Values	Strategy / Strategic Plan	Strategic Control	Business Plan	Change & Transformation to support strategies	Management & Business Information	Business Decisions	Business Opportunities	Customer & Supplier Agreement	Networks	Contribution to projects & other teams	Relationship	Hig Performance Teams	Confident teams & individuals	Policies, Procedures and guidelines	Physical working environmnet	Organisational structure	Schedule, action plans and project plans	Managerial control mechanism	Sound IR practices	Optimised Resources	Sound business practices	Performance management system in place	Resolved problems	Optimal business processes	Rewards	Competent Staff	Development Feedback, guidance & advice	Culture of learning	Unit skills plan
Self management					X							X		X													X		X	
Change management					X					X				X													X		X	
People development					X							X		X			X			X	X		X			X	X	X	X	X
Organisational development	X	X			X		X	X	X	X	X		X	X			X			X	X	X	X	X	X	X		X	X	X
Business Understanding	X	X		X	X		X	X		X			X		X	X		X	X		X	X	X		X	X			X	
Strategic and Business planning	X	X	X	X		X		X															X			X				X
Relationship management	X	X				X		X	X	X		X		X						X							X		X	
Business process understanding		X		X		X	X		X	X	X				X	X	X	X			X		X		X					
Economic value creation / management		X		X				X													X		X		X					
Financial systems & statements				X		X		X															X							
Business information management			X			X				X					X	X							X					X		
Continuous Improvement								X								X			X		X				X				X	
Target setting and tracking		X	X															X	X		X		X		X					
Driving the business						X	X	X										X			X		X		X					
Customer management									X	X														X				X		
Performance management															X				X				X			X	X	X	X	X
Inspiring leadership styles	X				X							X	X	X														X	X	
People motivation	X				X							X		X			X						X			X		X	X	
Recognition and rewards	X				X							X	X	X	X								X			X	X			
High performance teamwork											X	X	X	X		X	X			X	X							X	X	X
Micro Skills										X	X	X	X	X														X		
Managing diversity	X				X							X	X	X						X	X								X	X
Problem solving									X				X	X		X		X		X				X						
Decision making						X	X	X	X				X	X				X		X				X		X					
Communication management	X	X	X	X	X															X										
Faciliation	X			X			X						X			X		X						X			X		X	
Business presentation	X			X																										
Conflict handling									X			X	X	X	X	X				X				X						
Feedback												X	X	X									X	X		X	X	X		
Mentoring																							X				X	X		X
Coaching															X								X			X	X	X		X
Negotiation / Deal making									X											X			X							
Planning		X		X			X						X		X			X			X	X								X
Organising			X								X		X	X			X	X			X						X			X
Managerial control						X											X	X				X	X							X
Project management																	X	X												
IR insights															X					X		X								
Persuasive (Buy-in) communication	X				X				X			X		X									X							
Learning skills					X					X	X																X		X	
Forecasting		X	X				X	X																						
Organisational structures																	X				X									
Information search	X	X	X	X	X	X	X	X																						
Critical thinking		X			X		X	X													X									
Business ethics							X																							
Health & Safety																X														
Values & Cultures	X	X	X		X							X	X																	
Operational management						X	X								X	X	X	X	X		X									

KNOWLEDGE & SKILL ELEMENTS (Left Column)

1. **Self management**
   - Self responsibility for learning, growth & self education
   - Self awareness / insight, e.g. influence of self-esteem, learning styles / brain functioning
   - Understanding the need for flexible career management in a changing workplace and the importance of enhancing individual potential, abilities and competence.
   - Ability to do self development planning (elements & process)
   - Identification & utilisation of sources to develop
   - Skills to balance work & life: Stress & time management
   - Understanding own role, to build self management capabilities of subordinates

2. **Change management**
   - Understanding the nature & drivers of change
   - Understanding the leader's role to support people in becoming more adaptable to change and the importance of global mindedness
   - Understanding change management principles & processes, e.g. to anticipate, initiate, manage & measure effective change and to ensure that change process is congruent to the organization's vision, mission & strategies
   - Insight into the local process of people's reaction to change, from resistance to full acceptance.
   - Ability to consider the full spectrum of change management dynamics when developing & implementing change plans.

3. **People development**
   - Shows insight into learning organizations theory & adult learning principles.
   - Understand the interrelationship between training & development, remuneration, employee utilisation and labour relations.
   - Understanding competency & output people development principles.
   - Understanding of the company's leadership development strategy & process (company's is one company and companies is several companies)
   - Ability to compile a unit skill plan.

4. **Values & Culture**
   - Understanding the nature / importance of organization, team values & culture
   - Interrelationship between vision, strategy, culture & values
   - Understanding current culture & values within the company (Conditions for : collaboration, commitment & creativity).

5. **Business understanding**
   - Company business environment understanding : external and market forces
   - Understanding how a Business works and what it takes to be successful
   - Understanding your own business
   - Understanding the business drivers
   - Role of technology
   - Principles of benchmarking

6. **Strategic & business planning**
   - Understanding the company's strategic & business planning process
   - Understanding the company's Business planning process : change
   - Developing Strategy & Business plans which are aligned within the bigger picture
   - Committing to courses of action to accomplish longrange goals / vision after developing alternatives based on logical assumptions, facts, constraints & values
   - Strategy implementation / control
   - Evaluating organizational effectiveness at different levels of work

7. **Relationship management skills**
   - Identifying opportunities and taking action to build strategic relationships between one's area and other areas, teams, departments, units or organizations to help achieve business goals
   - Ability to do stakeholder analysis
   - Networking skills
   - Sharing ideas across functional / divisional boundaries

8. **Business process understanding**
   - Understanding the value chain
   - Technical knowledge of own business process & products
   - Insight into business process optimization principles
   - Customer / Supplier management (service agreements)

9. **Economic value management**
   - Understanding value management philosophy / research
   - Cost & cash flow management
   - Calculating the value drivers
   - Insight into risk management principles

10. **Companies financial statements & systems**
    - Working knowledge of bookkeeping, budgeting & financial statements
    - Financial accounting principles
    - Interpreting financial statements

11. **Forecasting**
    - Understanding the importance of evaluating strategic position

- Identifying / monitoring indicators of directions to sustain a competitive advantage
- Insight into forecasting process & principles
- Scenario planning skills
- Skills to check forecasting for reasonableness

12. Business information management

- Setting up ongoing procedures to collect and review information needed to manage an organization or ongoing activities within an organisation.

13. Continuous Improvement

- Knowledge of company's continuous improvement system / process
- Ability to integrate best practices
- Ability to facilitate CI team target settings

14. Target setting & tracking

- Setting team measures and standards
- CI tracking skills

15. Driving the business

- Balanced Scorecard principles understanding
- Ability to identify & leverage business drivers
- Insight into productivity improvement principles
- Ability to apply theory of constraints principles
- Business driver manipulation skills

16. Customer management

- Integrated customer management (internal / external)
- Shows insight into elements that enhance customer satisfaction & trust
- Clarifying customer needs, expectations, rights & responsibilities
- Ability to involve & tap customer / supplier knowledge
- Customer satisfaction measurement

17. Performance management

- Company performance management system knowledge
- Performance measurement principles understanding
- Individual objectives and standard setting skills
- Measuring individual performance
- Addressing under-performers
- Applying the company's reward allocation principles to determine individual rewards

18. Inspiring leadership styles

- Insight into different leadership theories & styles
- Transformational – and Transactional leader behaviour
- Insight into pre-conditions to build trust
- Situational leadership styles understanding
- Strategic behaviour understanding (personality, politics, etc.)

19. People motivation

- Motivation theory (internal versus external, expectancy, etc.)
- Inspiring skills : Builds confidence in others; individual consideration; intellectual stimulation
- Knowledge of group/team motivation principles (influencing groups / members to co-operate willingly and productively to pursue set objectives)

20. Recognition & Rewards

- Insights into applicable people motivation principles/models
- Nature and types of recognition
- Ability to match & leverage reward / recognition to inspire specific individuals & groups
- Reward allocation skills

21. High performance teamwork & team building principles

- Understanding concepts / models of effective teamwork
- Insight into the process of establishing high performance teams, personalities etc.
- High performance team ???? measures
- Using appropriate methods and a flexible interpersonal style to help build a cohesive team
- Insight into team building techniques e.g. facilitation of team goal setting, role clarification, relationship building
- Contributes to solving problems through constructive feedback, ideas & suggestions

22. Micro skills

- Insight into various behavioural styles and the effectiveness thereof
- Effective utilisation of interactive skills by listening, information gathering, summarizing, reflecting, empathizing and involving others in discussions

23. Managing diversity

- Knowledge of diverse individuals / groups / cultures
- Insight into principles for creating a collaborative environment / relationship
- Ways of interacting and relating to others over a broad spectrum e.g. religion & customs
- Demonstrate values that reflect dignity, respect for others & fairness
- Ability to apply principles to tap diversity within teams
- Implement a diversity management plan

24. Problem solving

- Insight into right / left brain approaches
- Understanding PR problem analysis processes / principles
- Problem analysis techniques
- Group problem solving techniques
- Stakeholder involvement process understanding

25. Decision-making

- Understanding various forms of decision making (independent; consultative; consensual; delegation)
- Insight into decision making process (identifying criteria etc.)
- Importance of a holistic approach to decision-making
- Insight into decision making techniques (group / individual)
- Potential problem / risk analysis skills

26. Communication management

- Planning and managing communication understanding
- Understanding the levels of communication in organizations
- Understanding the formal & informal channels of information
- Insight into approaches to organizational communication
- Insight into communication planning principles
- Communication Campaigning skills
- Business writing skills: grammar, vocabulary and structure to achieve communication objectives of a specific target group

27. Influencing / persuasive skills

- Understanding persuasive communication principles & guidelines
- Understanding of the elements that enhance interpersonal impact
- Building & communicating a "Case for Change"
- Communication / selling / translating strategy, vision & values
- Determining & communicating team mission, measures and values

28. Facilitation

- Understanding facilitation process to improve & helps groups / individuals
- Facilitating team decision making & problem solving
- Facilitating of ideas / inputs to build team implementation & improvement plans
- Applying group facilitating techniques to increase productivity
- Applying problem solving techniques
- Ability to manage boundaries that have an impact on own work
- Ensuring that meetings serve business objectives while using appropriate interpersonal styles and methods and considering the needs and potential contributions of others

29. Business presentation

- Understanding pre-conditions to creating audience rapport
- Applying content & structuring principles
- Insight into positive & negative influence of non verbal behaviour
- Application of communication principles to reach communication objective
- Application of audio visual techniques
- Use of techniques to involve audience & get feedback

30. Conflict handling / management

- Insight into various conflict handling styles
- Assertiveness principle understanding
- Removing barriers to effective communication
- Applying effective interpersonal skills / styles to deal with conflict

31. Feedback

- Understanding the importance of feedback within learning organizations
- Pre-conditions to receiving & asking for feedback, for development purposes
- Applying, giving & receiving feedback – principles
- Handling difficult feedback situations

32. Mentoring

- Various levels of mentoring (micro / macro)
- Company's mentoring process: roles of mentor & protégé
- Pre conditions to build effective mentoring relationships

33. Coaching

- Providing timely guidance and feedback to help others to strengthen specific knowledge & skills needed to accomplish a task, solve problems or help others gain insight into business related issues
- Performance coaching & counselling skills
- Referring individuals to be coached / mentored

34. Deal making / negotiations

- Applying applicable negotiation approaches, techniques & practices
- Decision making process / principle understanding

35. Planning principles

- Insight into action planning and scheduling principles
- Ability to schedule and leverage resources to focus activities
- Insight into the function & use of procedures, policies, rules & values
- Ability to create buy-in to applicable procedures & policies
- Holistic time management techniques
- Establishing courses of action for self and others to ensure that work is completed efficiently

36. Organization principles

- Understanding the importance of balance between Organization & disorganization
- Insight into the relationship between organizing & people motivation
- Ability to create structure & simplify complex situations
- Personal organization effectiveness
- Allocating decision making responsibility / authority to enable or empower?? others to maximize the organization's and individuals effectiveness
- Ability to apply delegation principles

37. Organization structures

- Knowledge of various organizational structure types
- Insight into team based structures
- Ability to structure and facilitate role clarification within / between teams

38. Project Management principles

- Ability to identify & integrate different steps / phases in a project and manage them during total span of project
- Understanding the logistical process of a specific project and the resources needed
- Manage the steps & activities involved in the project
- To use the available resources and to control & co-ordinate activities logistically
- Integrate management of all resources & activities to ensure timeous and effective implementation
- Assessing the value added to?? a specific project

39. Managerial control

- Understanding of effective monitoring systems & processes
- Ensuring successful completion of assignments
- Ability to control work against set criteria and / or work procedures to achieve high levels of quality, productivity or service

40. IR insight

- Insight into legislation & basic employment conditions act
- Insight into the procedures to handle grievances
- Insight into the role of unions

41. Learning skills

- Applying, reading, learning & memory enhancement techniques
- Understanding various learning styles and importance of experiential & action learning

42. Information search

- Monitoring information to learn and detect trends
- Information processing & data reduction skills
- Utilizing technology (web-surfing)

43. Critical thinking

- Tendency to challenge assumptions behind ideas & actions
- Ability to imagine & explore options – beyond the obvious

44. Business Ethics

- Ability to distinguish between sound and unethical business practices
- Insight into the implications of unethical business practices
- Adhering to sound business ethics principles

45. Organizational development

- System theory: Shows insight into the cross-functional inter-relationship between different departments as smaller systems within bigger systems
- Understanding the inter-relationship / interdependence of culture, strategy, structure and other management processes in a complex, multi-level organization
- Understand the dynamics of organizational behaviour
- Insight into the assessment of organizational effectiveness & culture / climate

46. Operation management

- Insight into production process and operational managing issues (grade; quality; design criteria; waste; operational cost; equipment performance standards; breakdown maintenance programs; manpower needs & shift hours)
- Insight into condition of plant & equipment and implications thereof
- Implementing & managing maintenance strategies, replacement of equipment and consequent costs

47. Health & Safety

- Rescue & fire fighting aspects
- Integrated Environmental management

48. Values & Culture

- Adaptability
- Responsibility for own learning
- Global mindedness
- Sense of urgency
- Living core values / principles
- Acting as Role Model
- Customer focus
- Cost / quality / time / growth mindset
- Looking for people doing things right
- Open, continuous feedback approach
- Integrity / Honesty
- Customer / employee intimacy
- Personal effectiveness
- Doing the basics right
- Differences allowed / Diversity orientation
- Synergy mindset
- Confidence / optimism
- Respect / Interpersonal sensitivity

REFERENCES

1. Bell, C.G, and McNamara, J.E. The Technology Balance Sheet, EMR, 1993

2. Burger, H.J. Developing a Technology Strategy for Iron Ore Business Unit, Corporate Technology Metallurgical Processes at Iscor , January 2001.

3. Corporate Consultant for SRK Consulting, Strategic Mine Planning by Dr Chris Page – Normandy Group Mining Conference 22nd and 23rd April 1998, Perth

4. Diedericks, A.W, Fouche, P.A.P. and Badenhorst, S.N. A system approach in implementing Minerals Resource Management at a base metal mine (Rosh Pinah Zinc Corporation, Namibia), The journal of The South African Institute of Mining and Metallurgy, January/February 2003

5. Gasper, J.H and Adler, L. Conceptual and geometric design of steep slope contour mining, Mining Engineering, November 1991

6. Horney, N.F and Koonce, R. The Missing Piece in Reengineering, Training & Development, December 1995.

7. Knottenbelt, P.J. Engineers for the 21st Century – Mineral and metals industry, The Journal of the South African Institute of Mining and Metallurgy, March 2002

8. Kumba Resources Project Team. Process enterprise – Sishen Iron Ore Mine, Kumba Resources Ltd., 2003

9. Kumba Resources Physical Asset Management, Leadership Team, 28 February 2003.

10. Macfarlane, A.S. The implementation of new technology in Southern African mines: Pain or panacea, The journal of the South African Institute of Mining and Metallurgy, May / June 2001.

11. Macfarlane, A.S, Minnitt, R.C.A, and Viljoen, M.J. Education and Training for Mineral Resource Management, University of Witwatersrand, 2001

12. McCosker, B. Project delivery in the mining industry – options and trends, The Journal of the South African Institute of Mining and Metallurgy, October 2002

13. Moss, T.A. Geotechnical evaluation for the design and construction of mine projects, Mining Engineering, November 1992.

14. Morley, C, Snowden, V and Day, D. Financial impact of resource / reserve uncertainty, The journal of the South African Institute of Mining and Metallurgy, October – December 1999.

15. Penshick, D and Gilliland, K. The Missing Link - The Gap in the Mining Automation Hierarchy, The 6th International Symposium on Mine Mechanization & Automation,

16. Peterson, S.B. Developing an Asset Management Strategy, Strategic Asset Management Inc., 1999

17. Principles for Operational Excellence, Kumba Way MRM Project Team, August 2002

18. Rossi, M.E. Improving the estimates of recoverable reserves, Mining Engineering, January 1999

19. SAPR/3 Solutions. Mineral Resource Management – A definite description and discussion of the process of implementation and the application in the mining industry, Date unknown

20. Slater, M. Lessons learned in the execution of a major project, Ion Consultants, February 2002

21. Steffen, O.K.H. Planning of open pit mines on a risk basis, The Journal of the South African Institute of Mining and Metallurgy, March / April 1997.

22. Steynfaard, D.J, Louw, W.C, Kotze, J, Smith, J. and Havenga, B.H.J. New developments on mine planning and grade control at Sishen Iron Ore Mine - The Journal of the South Africa Institute of Mining and Metallurgy, January / February 2003

23. Strydom, C.F. An evaluation of the Self-directed work team concept as a means to improve overall performance on South African gold mines, The Journal of the South African Institute of Mining and Metallurgy, March 2002

24. Value engineering for improvement of capital projects, VM Services (Pty) Ltd., 1999

25. Van Daalen, F. Selektiewe Mynbou, 2002

26. Van Zyl, J.A.. Process Innovation Imperative, University of Witwatersrand, 2000.

27. Vorster, A. Planning for value in the mining value chain, The journal of the South African Institute of Mining and Metallurgy, March / April 2001

28. Zincliar, D and Zairi, M. Effective process management through performance measurement, Business Process Re-engineering & Management Journal, 1995