

# The use of Information Technology in the Mineral Resource Management environment

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The advancement in Information Technology has resulted in a change in workflow practice in our Mineral Resource Management (MRM) offices on the mines and at our corporate office. This paper discusses the AngloGold approach in defining an IT strategy for MRM, a brief overview of systems usage and benefits.

AngloGold has gone through a transformation phase and has positioned itself as a world-class, low cost producer. To support this objective, an initiative has been launched to provide the MRM division with an integrated MRM technical suite of systems with support of a Management Information System. Technical systems for a tabular orebody are not freely available and hence it took AngloGold almost seven years and a significant amount of capital to develop an integrated suite of technical systems.

AngloGold MRM IT adopted the typical Zachman framework (value chain) approach in the analysis process and formulated the final deliverable in terms of AngloGold's strategy.

Major benefits have been realized through the ability to change planning scenarios in a short period of time and hence be able to increase reserves and NPV. The development of MRIS, which will become the flagship in AngloGold's portfolio of systems is in phase two and this system will allow AngloGold to publish Resources and Reserves as per SAMREC and the JORC Code at will.

The availability of information at all levels of the operations has made making decisions easier and hence some specialized reports such as the Basic Mining Equation were developed from the Corporate Datawarehouse and from the MRM reporting database. Decision Support Systems (DSS) such as Business Objects and Oracle Express are now being used to assist in the process. The decision to use Business Objects to replace SAS reporting as the core reporting tool has resulted in the empowerment of the user and major cost saving as far as the use of consultants to set up standard reports.

## AngloGold's approach in defining an IT strategy for MRM

### Background

During 1995 the Anglo American Gold and Uranium division (now AngloGold) embarked on a feasibility study to evaluate the use of graphics in mine planning. Cadsolutions provided a graphical mine planning and ore reserve/geostats system to the mining fraternity, namely Cadmine. Elandsrand was the chosen site for the testing of the Cadmine graphics system. With the successful testing of the beta version of the Cadmine graphics system it became apparent that this system would be used on all the long-life shafts of AngloGold. However, Cadsolutions was a small company and the risk of failure was high. A new company (GMSI) comprising of the Infogold mining section and Cadsolution staff was formed. This new company would be the sole supplier of technical mining systems to AngloGold and would become the preferred supplier of mining systems to the mining industry. During this period the changes in the main frame and the drive to be Y2K compliant gave rise to a fresh look at technical systems in the Mine Survey and Mine Planning Departments. In May 1999 this company was sold to AST,

and the MRM technical systems were outsourced to GMSI.

Due to the partnership between AngloGold South Africa Region and GMSI, AngloGold requested GMSI to review the current situation with regard to the latest Information Technology (IT), business and information strategies and processes within the Mineral Resource Management (MRM) environment.

### AngloGold MRM vision and strategy

The aspiration of AngloGold MRM is to continually improve the reliability and risk profile of their resources and reserves by making use of appropriate IT solutions to facilitate feasible, realistic and achievable planning results.

The strategy of AngloGold MRM is to launch specific initiatives with upgrade options contingent on business performance to selectively enhance current systems and develop new applications to meet current business requirements, ensuring flexibility for future IT and business changes.

### The creation of an MRM IT strategy

The Information Strategy must address the strategic considerations surrounding the co-ordinated use of

Information Technology within AngloGold MRM to meet its business needs.

The strategy must provide recommendations on future action plans for hardware, data management, applications, enhance current systems selectively and develop new applications to meet current business requirements, ensuring flexibility for future IT and business changes.

The strategy is intended to arrive at a pragmatic plan of action which will allow AngloGold to invest wisely in Information Technology without continuous analysis. Furthermore, this strategy should define a migration route for AngloGold's MRM current systems to eventually eliminate longer-term legacy systems concerns.

### AngloGold business imperatives

AngloGold's business objectives are to:

- Increase margins at existing gold prices
- Extend future reserves and resources
- Expand gold markets
- Increase shareholder value to compete with other investment alternatives.

### Value Chain

The Value Chain concept states that it is possible to derive competitive advantage by arranging value adding activities in a sequential chain in order to satisfy the requirements of a business. Normally there are a large number of business processes that are active within a business. In order to constrain the investigation and documentation of the processes to the most pertinent to the business, a value chain has been generated as shown in Figure 1.

The Value Chain is a collection of quantifiable discipline specific actions that transform business process inputs into business process outputs. Business processes consist of operations that are achieved by utilizing the business process factors that establishes the trend of value accrual.

The sequential nature of the value chain establishes a single direction of traverse. Whilst it is possible to leave the value chain at every stage and suspend or delay subsequent transformations, or return to a previous value chain transformation, each transformation is a self-contained entity that does not allow movement against the direction of value accrual.

The establishment and use of the autonomous transformations creates a mechanism that allows for the grouping of related functions, disciplines and supporting infrastructures into self-contained and quantified 'building blocks'. These transformations are set out in Table I.

The business strategy drives the direction of the whole company. Systems, in turn, have to support the business strategy and by implication the company as a whole. This includes the vertical levels (strategic to operational management) as well as the horizontal levels (value chain and functional areas). This principle is illustrated in the diagram set out in Figure 3:

In support of the business initiative, the objective of the operational MRM architecture is to deliver an integrated software suite and supporting infrastructure that would allow for the planning, optimization and control of mining activities.

### Management framework

AngloGold in conjunction with GMSI opted for the Zachman Framework as a classification scheme to assist in the formulation of our MRM IT strategy. The use of the Zachman Framework as a classification scheme was first published in 1987. The information system architecture specific Zachman Framework is depicted in Figure 4. Enterprises across the spectrum have found that the use of the Framework has had a marked increase in the understanding and the subsequent implementation of cost-effective information systems.

'A Framework is a classification scheme that enables

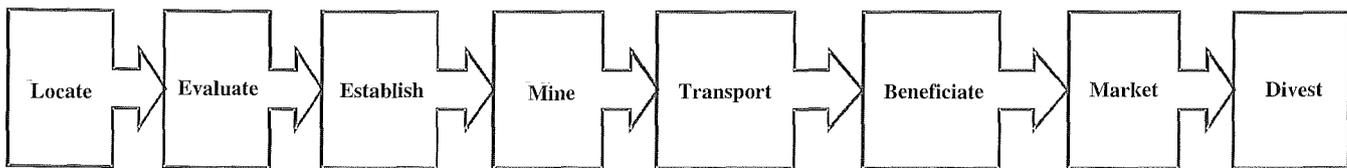


Figure 1. Mining Value Chain model depicting direction of value accrual

Table I  
Mining Value Chain transformations

Transformation	Definition	Input	Output
Locate Valuate	The determination of the presence of a deposit. The determination of the profitability of a project.	Suspected mineral resource deposit. Mineral resource estimate.	Mineral resource estimate. Bankable feasibility (Go—No-Go decision).
Establish	The execution of the mine plan.	Bankable feasibility (Go—No-Go decision).	Exposed mineral resource.
Mine Transport	The removal of mineral resources. The movement of classified broken rock from source to destination.	Exposed mineral resource. Contained and classified broken rock.	Contained and classified broken rock. Stockpiled tonnage at grade.
Beneficiate	The extraction of saleable products and the disposal of residue.	Stockpiled tonnage at grade.	Saleable products.
Market Divest	The maximization of profit. The curtailment of operations.	Saleable products. Revenue and profit.	Revenue and profit. New economic circumstances.

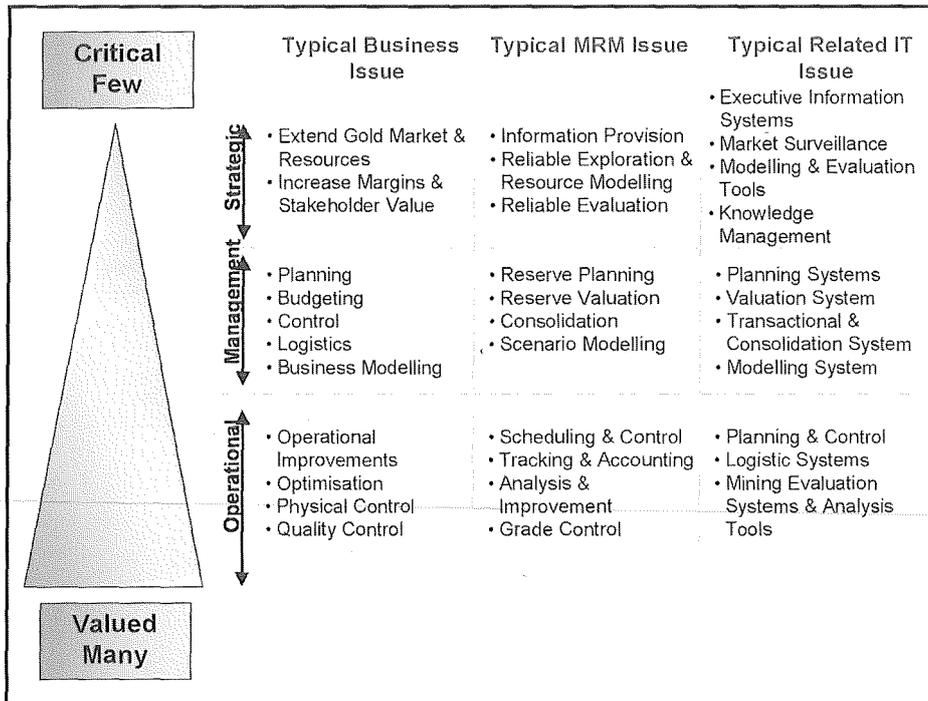


Figure 2. Typical business and IS related issues

	Data	Function	Network	People	Time	Motivation
Scope Model	List of things important to the business	List of processes the business performs	List of locations	List of organisational units	List of major business events	List of business goals & strategies
Enterprise Model	Semantic model	Business Process Model	Logistics Network	Organisational flow model	Master schedule	Business plan
Information System Model	Business Entity Model	BPR Model	Interface characteristics	Job flow model	Processing structure	Policies
	Logical Data Model	Software Specs	Hardware Specs	Human IF Architecture	State transition diagrams	Procedures
Technology Model	Physical Data Design	System Technology Model	Network Technology Model	Presentation Architecture	Control Structure	Rule Design
Components	Database Definition	Detailed Design and Programs	Physical Network Architecture	Security Architecture	Timing Definition/Operational Schedule	Rule Implementation
Functioning System	Physical Database and operational data	Physical Programs	Computer Network	Organisation	Triggers	Implemented business strategy

Figure 3. The Zachman Framework

focused concentration on selected aspects of a subject or object while retaining a sense of the contextual, or holistic perspective' (John Zachman).

#### Purpose

- Classification establishes order
- Simplify communication and understanding
- Clearly focus on independent variables for analytical purposes
- Maintain disciplined awareness of contextual relationships
- Preserve integrity

#### MRM the HUB of Information Sharing

The context diagram, Figure 5, depicts the interactions

crossing the MRM boundary. These external actors, which may be systems, departments or other entities, either provide services, facilities and information to the MRM environment or derive services, facilities and information from the MRM environment. It is important to be able to identify and envisage these interactions, and the spatial displacement between actors, as this has a direct bearing on the technology and application architectures that are required to support the MRM business functionality.

#### Supporting changing business requirements

To support the changing business environment, two factors need to be taken into consideration; namely, the demands on an IT system and the degree of business change.

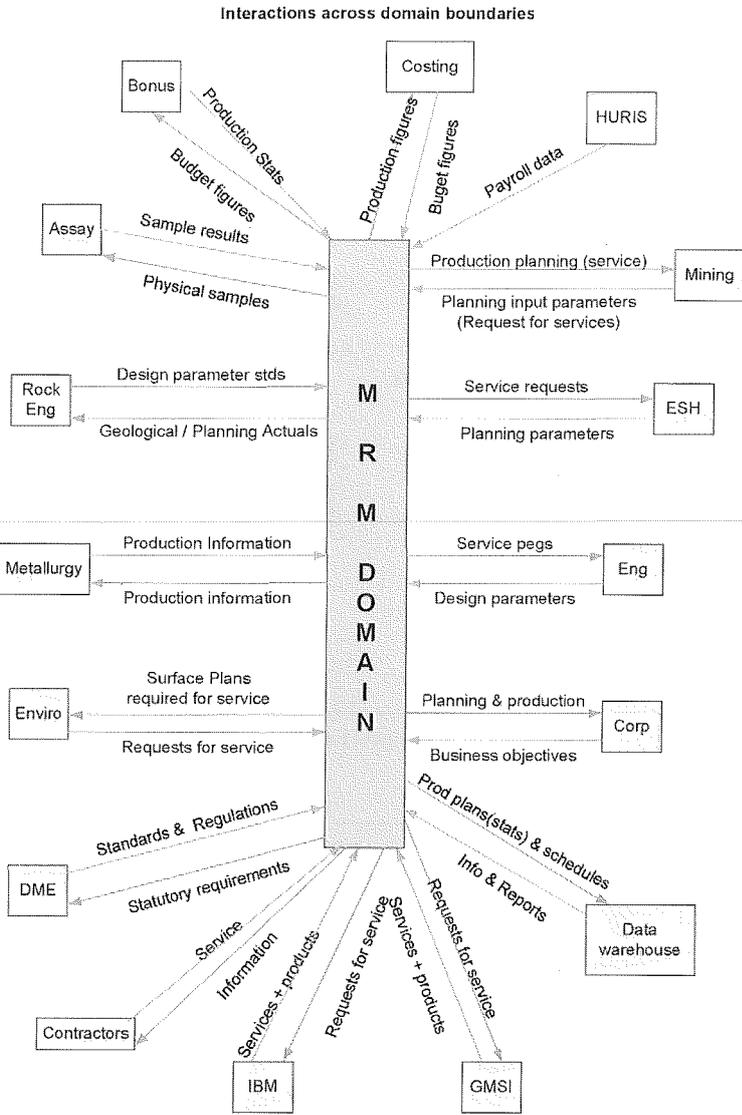


Figure 4. The MRM context diagram

### Supporting Changing Business Requirements

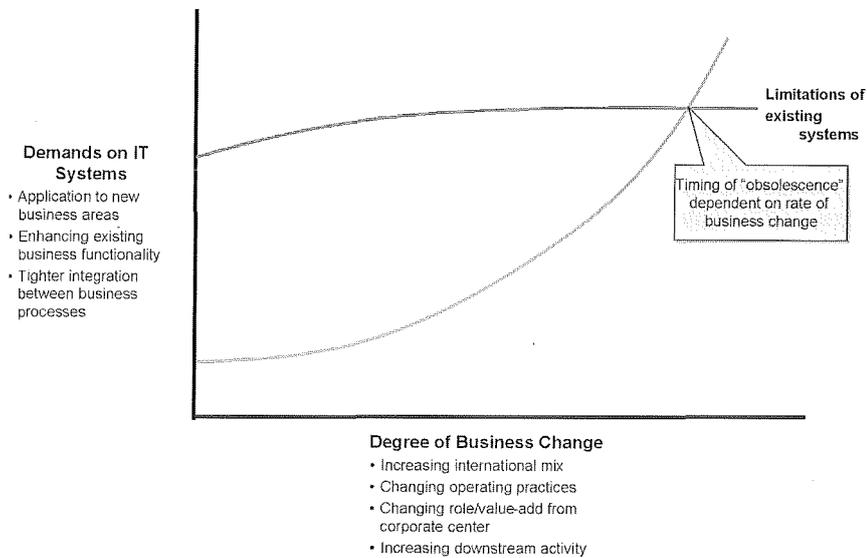


Figure 5. Supporting changing business requirements

When looking at the demands on an IT system one should take a closer look at:

- The application to new business areas
- Enhancing existing business functionality
- Tighter integration between business processes.

The degree of business change involves:

- Increasing international mix
- Changing operating practices
- Changing role/value add from corporate centre
- Increased downstream activity.

Taking the above-mentioned factors into consideration in relation to the limitations on existing systems, the timing of 'obsolescence' is dependent on the rate of business change.

### Interfacing/integration assessment

Current status of the interfacing/integration between the different modules of the GMSI suite of products (Figure 6).

It is evident from this Figure that there are a number of redundant interfaces and redundant data stores. It should again be emphasized that this situation is the result of technological advances and that it cannot be directly attributed to a lack of management or foresight. The important aspect is that there currently exists cost effective technology to address and solve this situation.

Another aspect that deserves attention is the inherent complexity of the systems that are deployed to support the MRM function. It should be obvious that the level of interaction requires a very clear understanding of the situation before any alterations are attempted. This calls for the establishment and maintenance of representative models at all levels of abstraction.

### Objective of the current development in terms of integration and data optimization of GMSI suite of products

In Figure 7, the shaded areas represent a common database for the different developments in the GMSI suite of products.

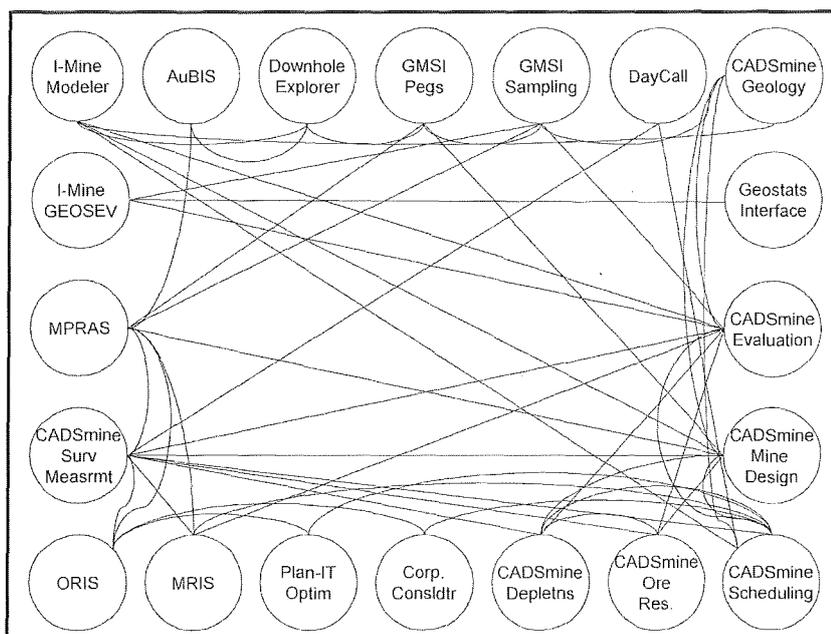


Figure 6. Current development of the GMSI suite of products

Figure 7 is also a depiction of the consolidation that could be obtained between these systems. The work in MRIS and CADSmine Version 4 are well advanced and should lead to the consolidation of the constituent systems as indicated above.

The Geomodel initiative could form the hub for the consolidation of the indicated systems whilst the use of the GMSI-MRM suite could yield the rest of the consolidation. The systems integration efforts could yield one consolidated database. This would lead to data level integration which is a requirement for consistent systems interaction.

### Analysis and reporting

The prime objective of the analysis and reporting is to provide timeous, relevant, accessible, flexible and usable information to all. This can be achieved by having a common store of data such as a Datawarehouse. However, without a proper front-end tool/decision support system (DSS) to extract and query the Datawarehouse we will be left data rich and information poor.

Such a front-end tool (DSS) should conform to the following five fundamental criteria:

- Integration of query, report and analysis
- Power
- Inter-operability and openness
- Deployability
- Ease of use.

The benefit in using proper analysis tools has many advantages. By making the data available to MRM from which they can carry out trend analysis from the source data has huge potential.

### AngloGold portfolio of application used in MRM

#### Buy or build?

Companies started to focus on core business during the 1990s by outsourcing non-core business and enhancing core

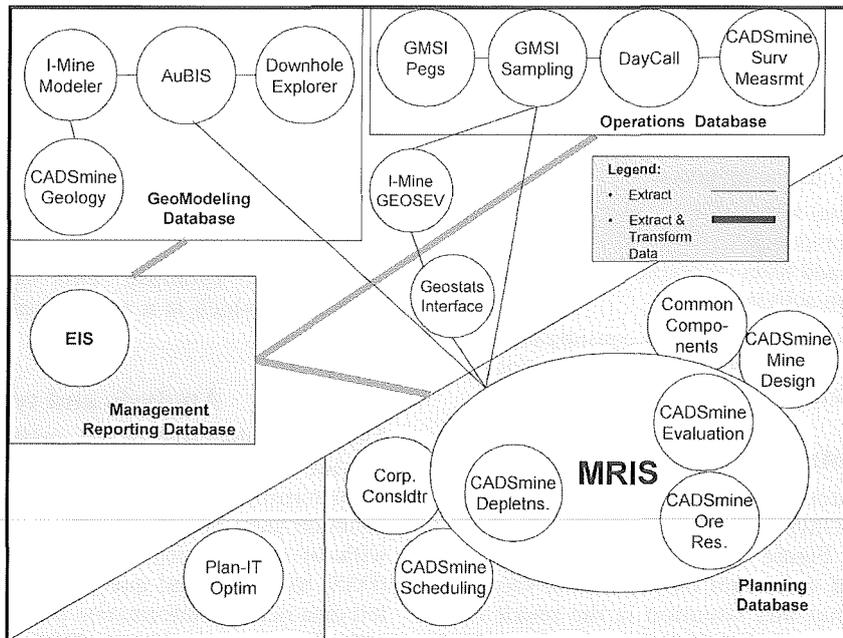


Figure 7. Envisioned objective of the current developments

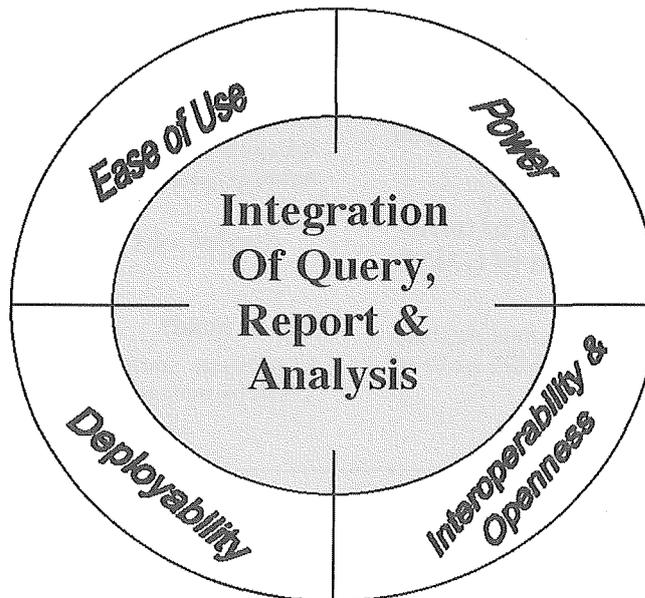


Figure 8. Decision support system

business. This approach implied that IT solutions should be bought rather than being developed in-house. This decision makes further sense by the fact that different IT companies spend 10-fold more on R&D to capture best practices.

The next questions companies are faced with are:

- To buy best of breed solutions and integrate them?
- To buy comprehensive integrated solutions and do limited integration?
- To buy services from preferred vendors who have well-established integration capabilities between them?

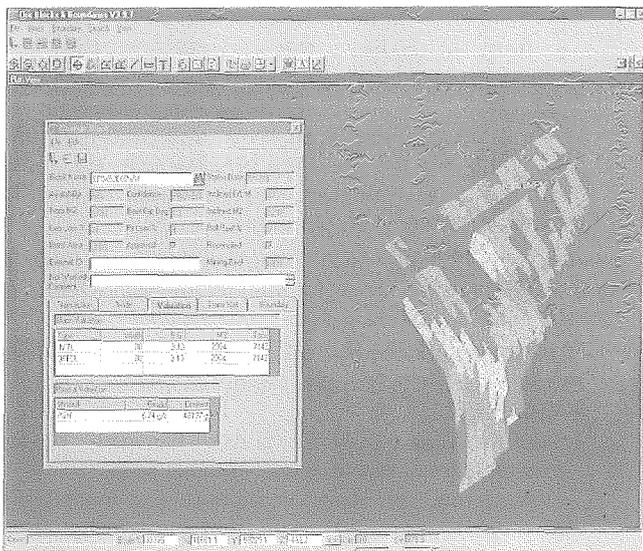
The relationship between GMSI and AngloGold is best described by the third option above. Pros and cons can be defined for each alternative. Each company should evaluate their business model every two to three years to assess if

the vendor strategy is aligned with their own business model.

Since the inception of GMSI and the establishment of MRM, AngloGold has spent R11.7 million over the past 4 years on research and development to establish an Information Technology solution. The two main applications developed are the Optimizer and MRIS systems. The Optimizer and MRIS applications will become the system flagships in the AngloGold portfolio of MRM systems, which will provide major benefits to the AngloGold MRM discipline.

#### MRM modules

- GMSI sampling—establish the mineral content



- Contract bonuses—calculate production bonus payments
- Ore flow—monitors ore flow from hoisting to plant and reconciles back to shaft
- Production analysis—compares actual production against planned production
- Redline planner—users do monthly pre-planning in real time
- Labour management—optimize resources available on a daily basis
- Daycall, daily production management control system to be used in the framework of a monthly plan.

### PlanIT-OPTIM

This integrated solution optimizes the business output by analysing the complex interaction of all the variables in a mining enterprise whilst simultaneously taking into consideration the parameters of economics and shareholder expectations.

### CADSMine

- Mine design—detailed mining layouts in 3D
- Mine scheduler—schedule depletion of ore reserve.

### Mineral Resource Inventory System (MRIS)

MRIS allows compliance with the South African Code for Reporting of Mineral Resources and Mineral Reserves (SAMREC code). This elegant solution of overlapping polygon sets makes good use of computational power now available to replace historical pencil and paper methods.

### GMSI Pegs

It is a comprehensive computerized surveying system designed for underground and open pit mining operations.

- Pegs Lite—non-graphical calculation module
- Pegs Pro—using MicroStation as platform, making extraction of data and production of graphical output extremely powerful.

### Imine suite

- Gev—Geological Evaluator, capture and analysis of sample data
- Strip—displays opencast, strip mining layouts in 3D graphical format
- Panel—displays coal long wall mining layouts
- Pillar—displays bord and pillar mining layouts
- Reserver—a generic system that can handle the evaluation and depletion of any renewable or non-renewable resource
- Geovse—a geostatistical tool for spatial analysis, interpolation and extrapolation of sample data values
- Modeller—surface modelling system that allows for the creation of models incorporating many layers.

### Benefits

Effectiveness based opportunities of up to R332 million could be realized by IT facilitating better management of the business.

- Capturing these opportunities requires system support in two areas:
  - Implementing mine planning tools to maximize long term resource value
  - Maximize corporate worth by rapidly finding best plans which satisfy R/kg and dividends in a dynamic cost/revenue environment

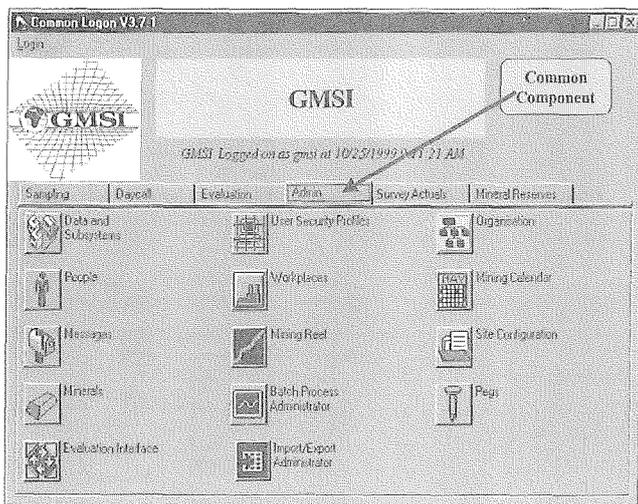
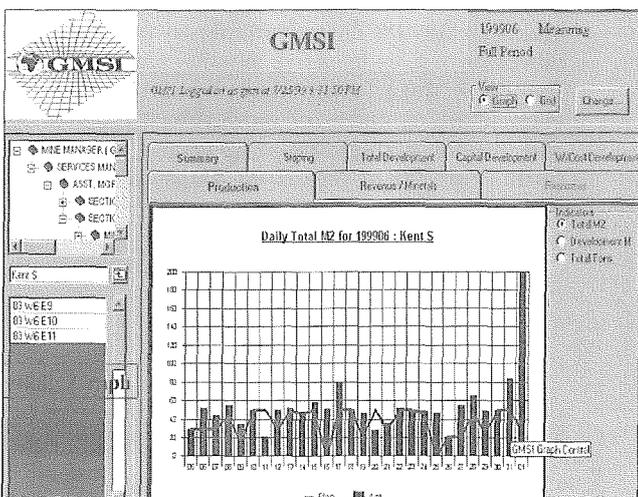


Figure 9. Three examples of the different MRM modules

- Survey measurement—coordinate data, stoping and development
- Evaluation—establish block values in terms of grade and channel width
- Ore reserves—update volume and content status in 3D
- Production actual—depletion of ore reserve

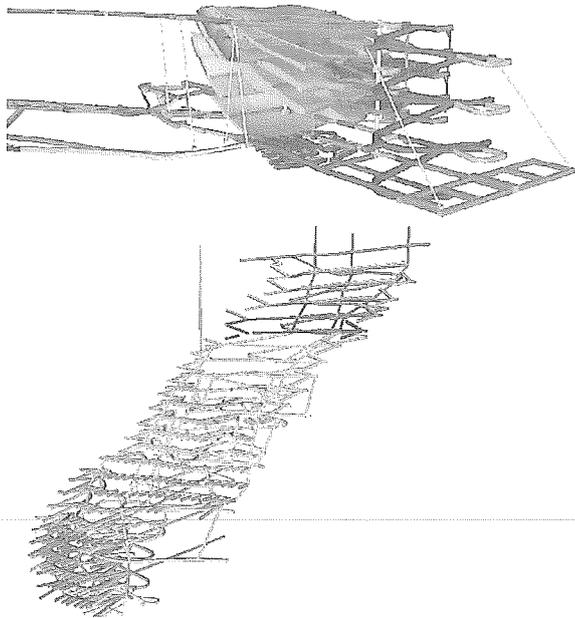


Figure 10. CadsMine underground graphics layout

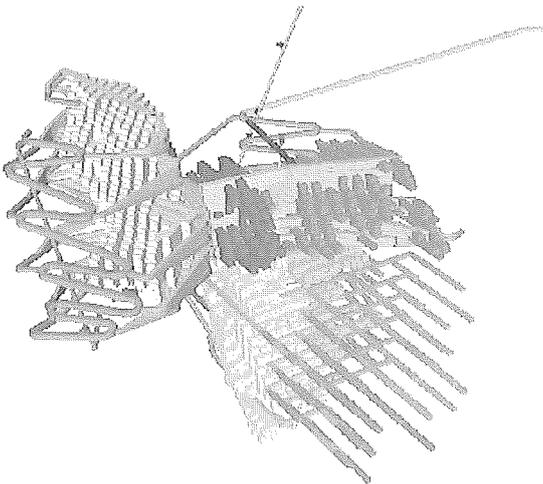


Figure 11. CadsMine mining development graphics layout

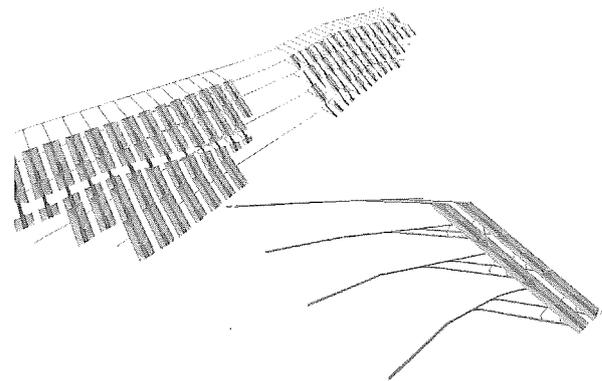


Figure 12. CadsMine underground tabular graphics layout

- Implementing Mineral Resource/Reserve Inventory System to facilitate the optimal targeting and extraction of mining areas having the best economic interest
- Eliminate duplication of work and establish new standards for the planning process (e.g. replacing mining block evaluation methods could save up to 1 man-year, per year, per mine).

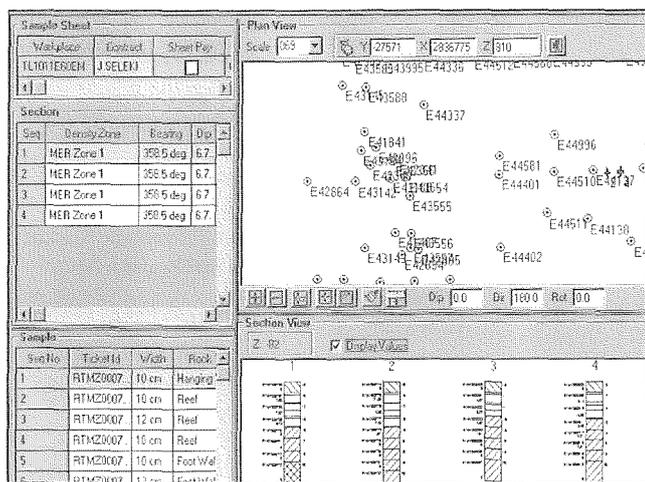
In addition, efficiency based opportunities could realize over R2 million in indirect opportunities for AngloGold.

- This saving would accrue to
  - Improved efficiency—Eliminate routine mundane tasks (e.g. electronic data capture).
  - Reduced risk
  - Standardization—essentially through better management of our peoples' valuable time.
  - Provide real time decision support (e.g. availability of ongoing updated geological knowledge from dispersed locations).
  - Enhance functionality and MRM productivity by making relevant data available to the necessary processes (e.g. updated live monthly planning).
  - Establish data level communication between programme modules for more robust applications and provide a single point of access for analysis tools (e.g. MRM reporting database, Business Objects).

Krig Block Size	Mineral	SAMREC	VAC	GTC
SAMREC	True Area	Value		
	(m2)	(cmg/t)		
	Inferred	137157.6	1829	
	Measured	19376.0	1577	
	<b>Grand Total</b>	<b>156533.6</b>		

Evaluation Result	
Evaluation Date	On the fly
Reef Krig Area (m2)	156533.6
Reef Actual Area (m2)	156533.5
Reef True Area (m2)	156533.6
Waste Krig Area (m2)	-0.0
Waste Actual Area (m2)	-0.0
Waste True Area (m2)	-0.0
Reef Tons (t)	435163.3
Waste Tons (t)	-0.0
Gully Waste Tons (t)	0.0
Slope Width (cm)	100.00
Value (cm.g/t)	1797
Mineral Content (Kg)	7821.73

Figure 13. MRIS Format

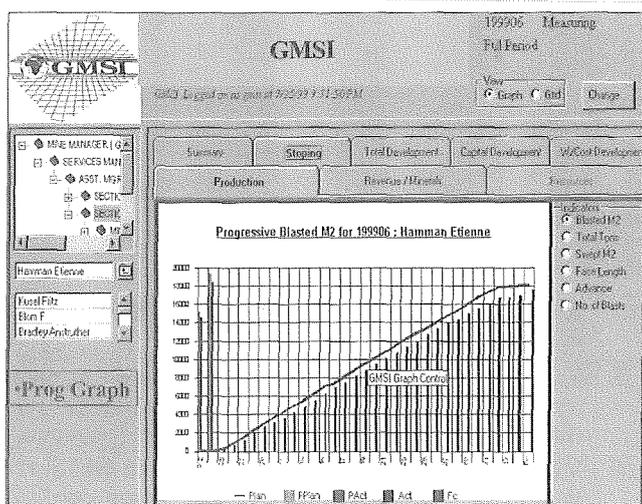


## IT architecture

The MRM discipline embarked on the formulation of its IT architecture using basic company IT strategy guidelines. The Zachman Framework was the agreed upon basis for the creation of the MRM architecture to align the MRM discipline with world-class best practice. The subsequent MRM IT architecture has been proven to be sound, and of such a standard that the company has used this document as a basis for the reformulation of its IT architecture.

## Vendor

The selection of the correct vendor is paramount to the success of the projects. It is essential that the vendor be closely aligned and has a full understanding of your business. Global Mining Solutions International (GMSI) was the preferred vendor as their core focus was on providing the mining industry with end-to-end IT solutions. These solutions include not only the development of new integrated systems but also the customization of shrink-wrapped offerings and interfaces into legacy systems. GMSI also have the full backing of the AST Group, which allow for a formidable access to necessary resources.



## Change management

To minimize the effects and resistance to change a philosophy of gaining high level buy-in is used. The heads of disciplines are involved in high-level interaction through their involvement in a MRM IT Steering Committee. Through this involvement management ensures that their users are properly aligned. A number of road shows and user group meetings that outline the numerous user benefits are subsequently held to reinforce the need to change.

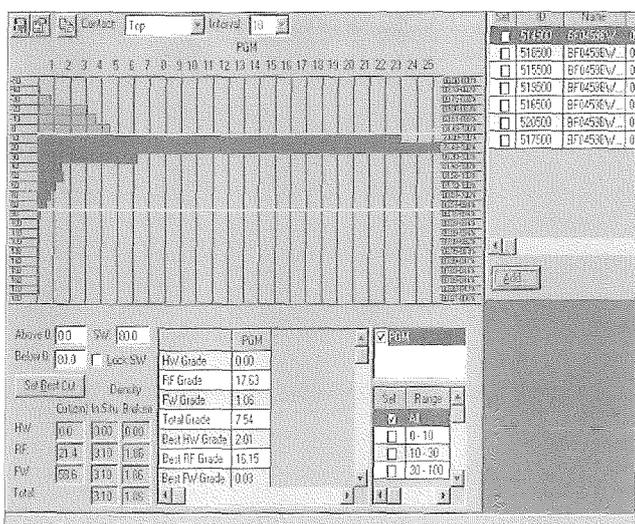


Figure 14. Three examples of the different GMSI Pegs

## Training

Comprehensive training is essential for a smooth transition from legacy system usage to the full utilization of the new systems. Provisional training takes place during system development through the dedicated allocation of company personnel to the project. These personnel are involved in the testing of the new systems and hence become 'super users' by the time that the system is implemented on site.

Comprehensive training, using the incumbent's own data, is delivered on site whilst the new systems are being implemented. Follow-up training is then offered at the company' training centre, which is then reinforced through user group meetings.

## Financial support

Comprehensive financial backing is paramount to the success of the project. This was achieved through the presentation of a sound IT architecture and a full benefits analysis. The company needs to have a full and comprehensive understanding of the magnitude of the project and that often additional out of scope functionality needs to be included before implementation.

## Conclusion

The success of an exercise of this magnitude relies on 5 key factors. Namely: an IT aArchitecture that conforms to the Company's IT strategy, an aligned vendor with the necessary backing, change management, a comprehensive training regime and lastly the financial backing.

## Acknowledgements

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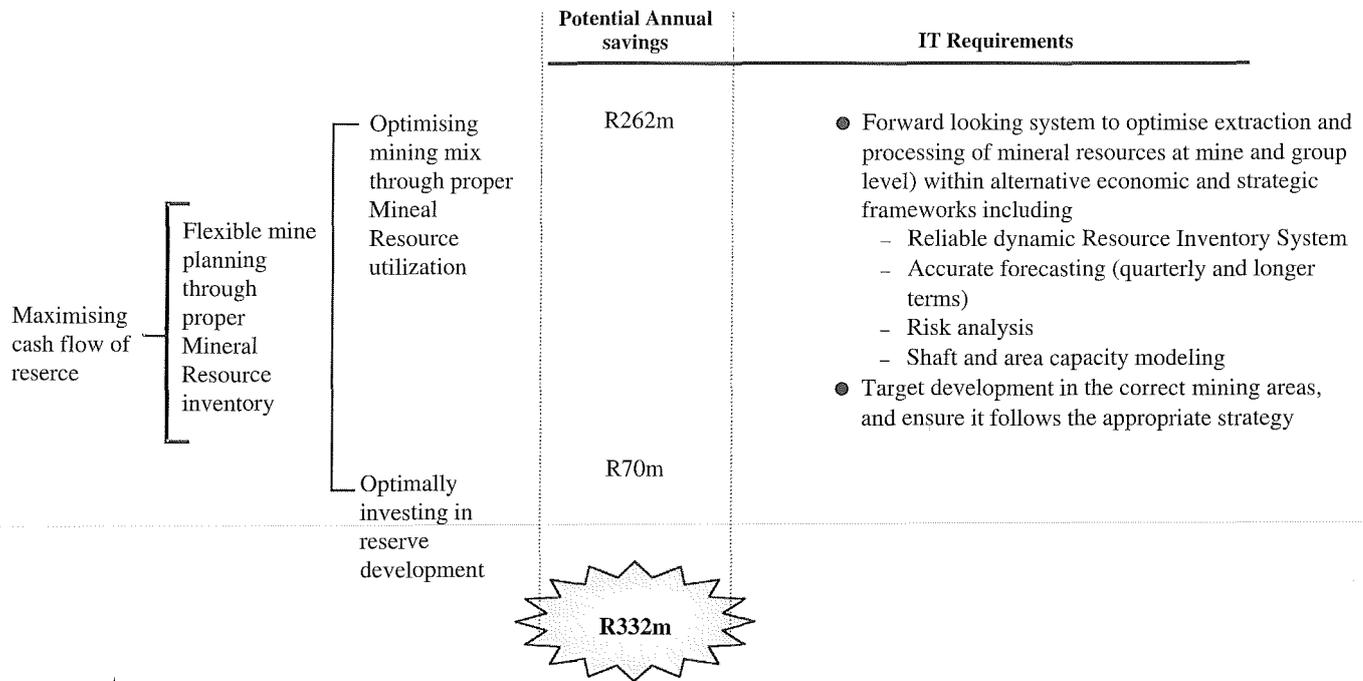


Figure 15. Potential benefits

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