# MINE OPERATIONAL PLANNING AS THE DRIVER FOR DETERMINING AND MANAGING ENERGY DEMAND

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## Abstract

Technologies and systems used in the management of energy consumption in the mining and metal processing industry are well understood and documented from the supply side of the business.
It is our contention that in many instances, through a more complete understanding of the demand side of the business, based on the detail of the operations plan, will provide greater lead time in terms of the design, implementation and utilisation of power supply infrastructure. Thus, optimal management of demand in a proactive manner, based on production requirements, will ensure both security of supply as well as continuity of operations.

This paper describes the technology and methodology that is being developed to enable the above statement to be achieved. We use a case study to demonstrate the ability of the tools and methodology and conclude by outlining the business benefits achievable as well as the future developments emanating from this initiative.

## Introduction

In this chapter, a brief background of the issue and the problem definition are described

### Background:

The global mining industry has become a tough, competitive environment for the South African (SA) industry since the first democratic election in 1994. Companies on this global stage do not only compete with other mining companies but with all other stocks seeking equity. The race is on to bringing mineable mineral resources to the market and to attract scarce capital. The issue reduces to one basic strategy: The company that is able to SAFELY produce at the cheapest $US/oz/lb/ton will attract investors (new capital) AND will maximize their mineable gold reserves (through lower unit cost of production). Currently, Rand volatility plus persistent strength exacerbates local economic conditions.

The global consultancy firm McKinsey has pointed out that whilst there is overall growth in commodities, conditions in the mining sector over the next five years will get more competitive and it is only through making radical changes in working practice and culture that companies will be able to thrive and, in some cases, survive. Increasing throughput with the same capital assets will be the key to driving productivity up and unit costs down. In addition, mining companies have to show they can perform in the stronger rand environment.

Mining companies implemented the first wave of efficiencies, mainly through job cuts, in the 1990's. Employees working harder are no longer the answer, so new ways of working have to be developed where the interaction of people, process and technology can be leveraged through the deployment of Information and Communication Technologies (ICT), as indicated in the following diagram:

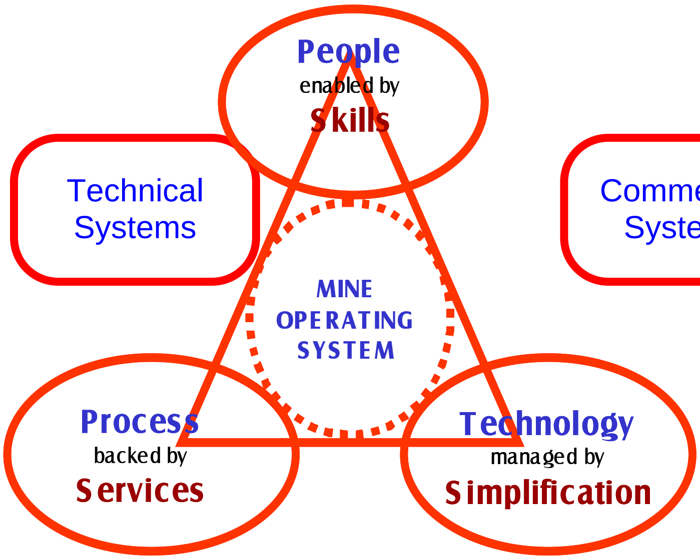



**Figure 1: Cost Effective Infrastructure Integrated with a Mine Operating System**

Figure 1 embodies the concept of convergence and also demonstrates a very strong synergy linkage between the commercial and technical systems and the infrastructure enabling them to be used by the people. Our experience in the industry has shown repeatedly that if there is not careful planning and management between the elements in this diagram, then the deployment of any one element is sub-optimal and both the capital cost and cost of ownership are inflated by up to 40% and require considerable effort to get under control.

This paper aims to set out the framework of how the Project Team has worked to put in place the means to deliver on effectiveness and efficiency in terms of the above diagram and what this means by demonstrating the practical application of the theory through referencing a real project for improving energy management on a large South African based gold mine.

Overview of the Project*:*

Energy supply and utilization has become a major consideration for all bulk users in the world, such as the mining and metals processing industries. This is not only based on the historical line item in the capital and operating costs of projects but has major impact on limited national resources as well as the environmental impact. In the past, bulk suppliers in South Africa have "forced" constraints on users to manage consumption via punitive tariffs and maximum demand charges. As can be expected this lead to a technology and methodology based on avoidance, primarily by looking at demand trends against historical patterns and "rapidly" turning off non critical demands.

This approach has obvious benefits and works well in many instances. However it has many operating short comings not least of which is switching off a supply with consequent loss in production. As we all know this leads to the management system being blamed and more often than not switched off and placed on the "to-be-investigated" pile until the next round of energy audits.

As part of a broader initiative to exploit various areas of technology convergence as explained in the introduction, this paper presents a fresh look at the problem and links it to our technology imbedded in a new product called MineServ. The simple principal is based on the observation of how the mining value chain operates. Basically, this involves marrying a mining plan; the what, when and how much to mine from a known reserve to the engineering (equipment) required to achieve the plan. Now, as this activity is well defined, it should be a simple procedure to accurately predict the energy demand for achieving the production.

If the demand pattern is well defined then the control mechanism becomes one based on feed forward rather than the classical feedback approach. The feedback element is thus responsible for small corrective action only. In addition, real-time of monitoring of load flow creates detailed insight into actual activities.

Further, the energy suppliers have indicated a desire to "negotiate" tariffs based on well managed and predicted demands. This method of dynamic "short term" demand management allows a move away from the classical worst case planning basis. The improved accuracy and referential nature of the estimate allows the estimate to be used as the monitoring reference.

By way of reference, for an engineering service such as compressed air on a large mining operation in South Africa, with distributed points of supply, the energy costs in any given month can range from 11 to 80 cents/KW Hour for the entire month. As the new tariffs are applicable to the notifiable points of supply (POS) the control and utilization of available machinery becomes a key bottom line decision.

Our proposal and study indicates that by using improved predictive tools the planning and scheduling would result in significant cost savings.

A typical example of the impact can be seen by the following indicative figures:

Assume Approximately:

- 1000 kg of compressed air is required to break 1 ton of rock
- R5,00 as the total cost to produce 1000kg of compressed air
- Thus, compressed air operating costs will be R5 to break 1 ton of rock. and
- As Electrical energy constitutes approximately 90% of the operating costs it would therefore be R4.50 per ton broken.

A reasonably sized shaft would break, say 150 000 tonnes per month, resulting in an energy bill of R 675 000,00 under normal Maximum Demand (MD) tariff conditions. Real world observation and experience of measured conditions demonstrate that this figure could more than double in a metering period (month), hence adding a significant amount to working cost.

Problem Statement (For Mining Industry):

All bulk energy suppliers desire to “smooth” the power draw from the distribution network. The supplier has to have sufficient running (rotating) capacity to meet any instantaneous peak demand. As for any electrical machine, the generation equipment protection devices trip instantaneously when capacity is exceeded. Even though there is an element of inertia in the grid connecting many supply points, the domino effect of loosing the entire network is always a possibility, as experienced in North America in recent times.

This often means that there is spare capacity which implies idle saleable capacity, capital and wastage due to poor efficiency of machines operating below design levels. In order to improve the situation the suppliers generally place a penalty on peak demand by the consumer.

The bulk consumer thus has conflicting objectives in that they are required to give long term forecast of expected peak demand but satisfy short term domestic demand variations. But for planning purposes, the supplier can at least ensure his capacity to supply and contract accordingly. The problem arises for the consumer in that his incentive is to set the maximum demand at as low a figure as possible, due to the base tariff formulation, yet the stick is a huge penalty when the target is exceeded due to short term operational needs. The method of measuring is the total energy consumed over a fixed metering period, varying between 30 minutes to 1 hour for various jurisdictions. For billing purposes it is assumed that the supply exceeded peak for the entire billing period - generally one month. These peaks, if large, result in charges running into millions of dollars in a calendar period for a large consumer such a mining operation.

Due to these factors most organizations have energy engineers who manage, coordinate and plan power consumption in order to void the application of financial penalties.

## The Solution

In this chapter, the requirement in terms of application will be discussed

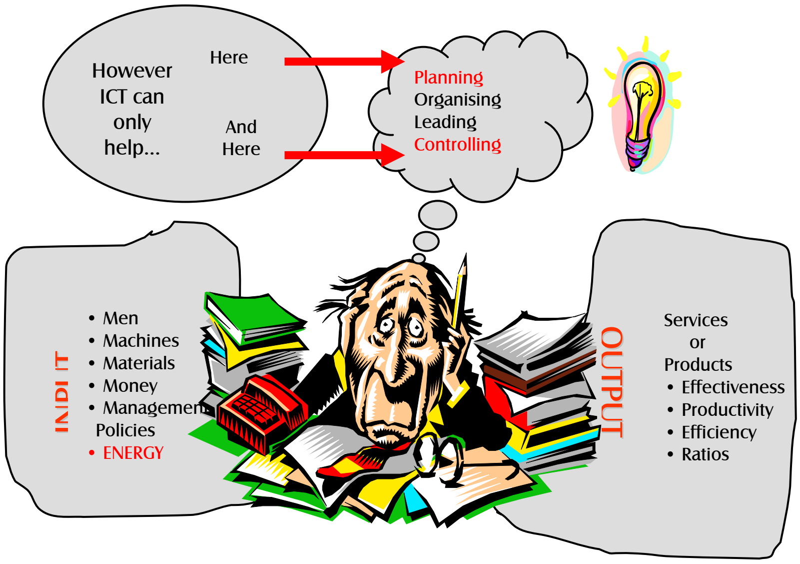
### Observations

In the past, the SA Mining industry has been an early adopter of Information Technologies. However, this has largely been driven by the fact that the organisations were large, centralised (in comparative terms to international operations) and employed large numbers of people. This meant ICT was mainly able to add value only by processing high volumes of transactions. Many companies also built proprietary systems to meet their unique business requirements.

Today, ICT has matured and companies are realising they must incorporate ICT into their business model at an operational level in order to maintain a competitive edge in the global economy. It is also a fact that some industries are more aggressive in adopting the ICT environment than others (banking/insurance versus mining).

However, because of unstable commodity prices and increasing production cost and subsequent shareholder demands for improved Return On Investment, there has been a focus on reducing production cost to improve mining companies' position on the cost curve. It is only obvious that the big ticket items come under the spotlight first and energy falls in to this category.

Over the last ten years there has been a reawakening in the industry about the potential
of ICT to improve a company's bottom line returns and, as the graphic to the right illustrates, it can play a role in supporting management activities. Business is now taking ownership and responsibility for the deployment of digital technologies. A common trend in the mining related ICT industry is a move from commercial business function ICT spending to value chain or mining technical systems ICT spending. So, how does this apply to energy management?




The Traditional Approach to Energy Management

Outside of the manual activity of planning consumption based on production forecasts many organizations have installed automatic control systems.

These systems are based on synchronizing a measuring device with the metering period at the point of supply. The system obviously has a set point being the contracted peak for the station. As the energy is consumed during the measuring period (Figure 2 yellow line) a vector predicting outcome by the end of the period is generated (Set Point), once this trend indicates that the peak will be exceeded an avoidance alarm is generated and an avoidance strategy is initiated. This may well be thought of as the target worm (as in one day cricket) but staying under the run rate. The idea being that the sooner in to the measuring period you react ("innings"), the more flexibility there is to take evasive action. Figure 2 illustrates the trend where the demand exceeds Set Point to an extent where the target is expected to be exceeded, a major load is switched off (Action), the situation recovers and the machine is started again.

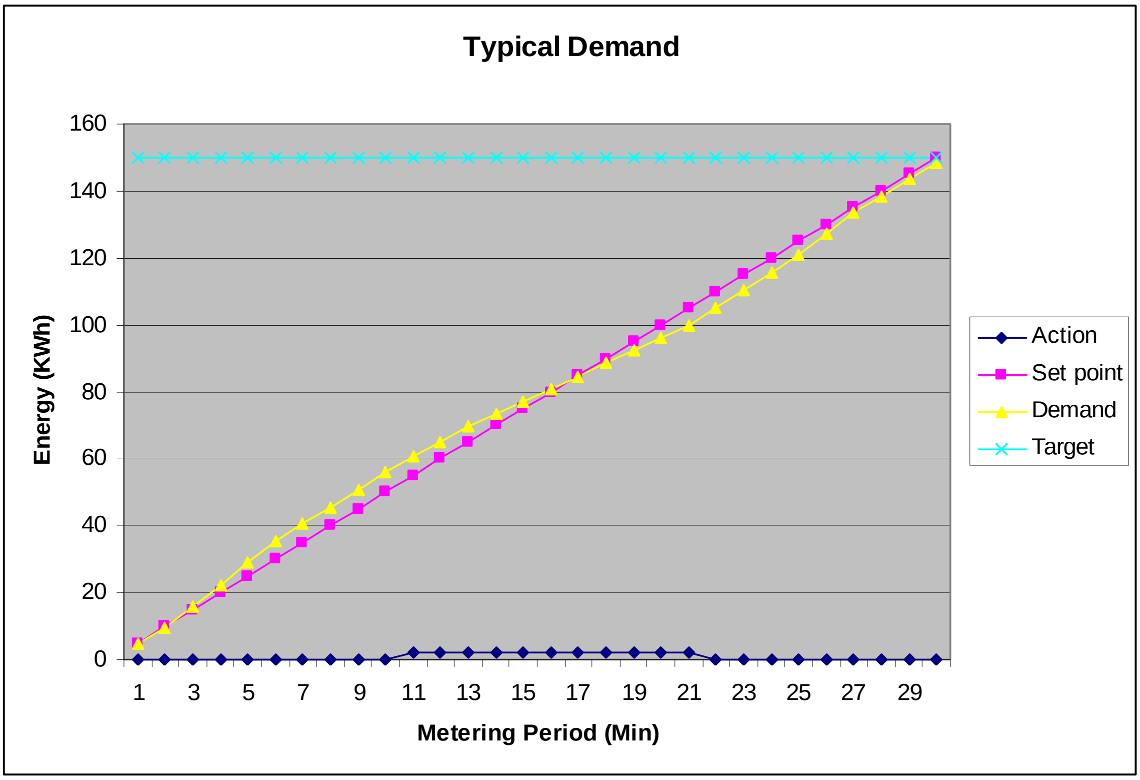



**Figure 2: Semi automated energy management of actual against target**

Most strategies are based on identifying and ranking non-critical loads in order and magnitude of the demand. The system can then automatically and sequentially shut these loads down in an attempt to avoid exceeding the peak.

In practice these systems vary from totally automated, automatic alarming systems with manual intervention to manual observation. The nature of the problem is that the problem only occurs over a few hours in the day yet the charges apply for the entire month.

It is obvious that this systems is fraught with potential problems from gross aggravation, equipment malfunction to production losses. Any organization applying such systems will attest to the organizational difficulty associated with implementation, not least of which is when the system is "said to be responsible" for lost production.

## The Alternative Approach

Based on the MineServ application a realistic short, medium and long term prediction (simulation) tool set has been generated.

MineServ is based on a methodology which takes the plan (3D mine layout) and the associated production planning and scheduling activity and builds a nodal network. On to this network is then mapped the engineering services required to meet these scheduled production requirements. It should be noted that in modern mines this includes knowing "who is going where to do what using identifiable equipment". As human beings are the triggers for power utilization, the ability to predict power demand becomes deterministic rather than requiring random averaging techniques.

One component of MineServ is a Simulation Engine which predicts the actual performance of the networked systems. In the mining context the system generates a theoretical demand pattern matched to the production plan. This allows two aspects of energy management to come into play:

### Impact of planning changes on demand

A major short coming in the conventional energy management procedures and work flows is that the Energy management Engineer is generally faced with a plan and told to ensure we do not "hit" maximum demand. The MineServ approach is to map this impact assessment and analysis directly into the planning work flow; this would be no different to mapping reserves, commodity prices, and labour costs etc into the planning (MRM) methodology so well accepted in modern practice.

### Monitoring of deviation from expectations

As can be envisaged if one has an accurate prediction of the demand profiles one has a powerful tool against which to compare actual measurements. As electrical usage is one of the simplest process variables to measure accurately and inexpensively the approach provides many additional advantages.

Given the original problem statement, a major advantage is that because the problem normally only occurs at fixed times of the day production planning can take this into account; a task almost impossible to contemplate if done manually. As MineServ automatically generates the demand profiles based on the scheduled short, medium and long term production plan, measurement and monitoring is then carried out within a proactive framework and corrective action is taken in the context of identifiable causes or a deviation from approved plan.

Implementation and Results

In this chapter, the implementation of the pilot system and actual measured results will be presented

Methodology

In order to be able to understand the benefits of simulating energy demand based on the "real time" production planning requires a brief examination of the IT based tools available to achieve the underlying concepts. The application, unlike other engineering simulation tools, takes advantage of its ability to directly interact with the mine planning and design applications used on the mine.

The process/work flow implemented at the project site is indicated in Figure 3 and MineServ is able to function in one of two ways. It can:

- directly map the mine design elements against engineering infrastructure parameters and then quickly generate the engineering service/utilities requirement against the mine planning, or
- a user can reference any mine design and manually create a 3D engineering infrastructure against that planning.

Once the engineering networks are created the system has the ability to edit, modify, delete and add any aspects of the network. Once the analysis is complete the results can be displayed in a true 3D CAD environment depicting the mine workings and planning.

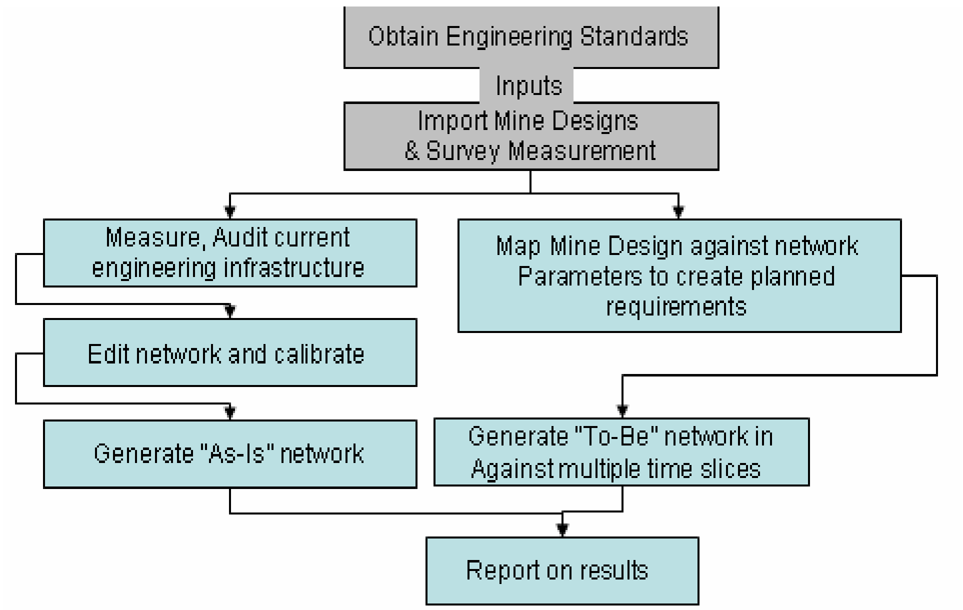



**Figure 3: Simplified process flow of Mining and Engineering integration**

Engineering planners and especially Energy Engineers are able to quickly determine the implications of changes to the production plan in both the short, medium and long term. What is also important to understand is that within these time frames the solution is also able to be used to determine the engineering consequences of a change in planning, mining method, or any of the engineering sub-systems/components as part of a feasibility study, a right sizing exercise or even to monitor plant in real time.

In the context of energy management, because the MineServ application is able to represent a full asset base (fixed and mobile plant) and can be connected in real time to the electrical supply network, a full load flow model is automatically generated.

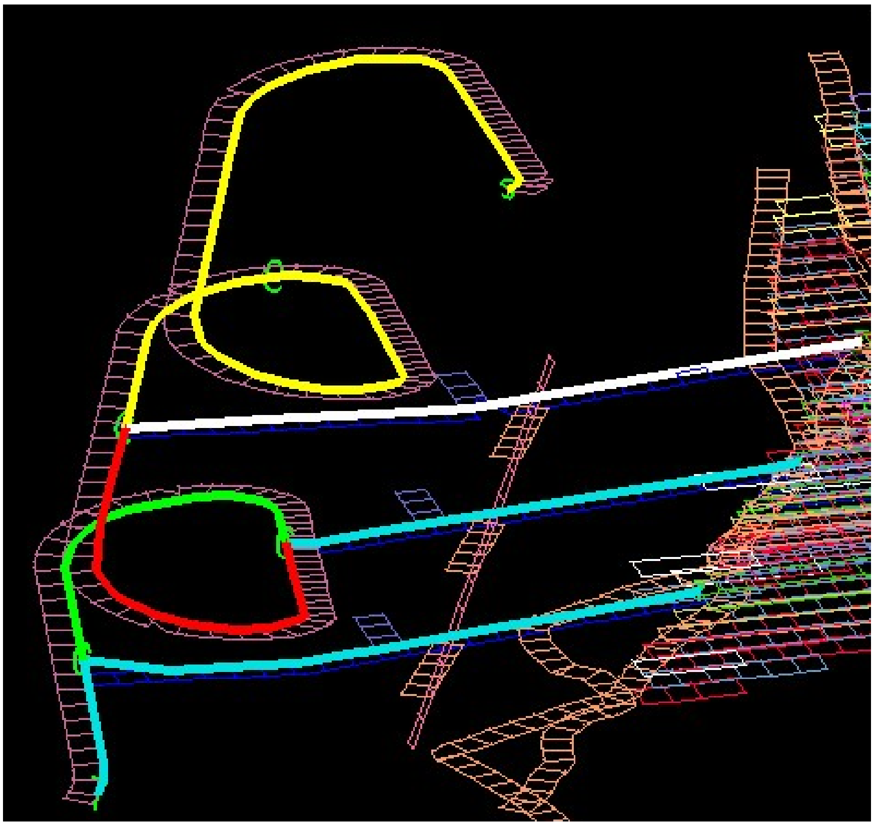


Figure 4: Example of mine design and utilities infrastructure

Electrical reticulation system

Imported 3D Mine design and

Demand node in network

[illegible]he mine plan as depicted in Figure 4 is used as the base to creates the de[illegible] [illegible]odes, which are the where, when and how, equipment is switched on an o[illegible] [illegible] [illegible]nd move rock. The simulation engine contains all of the mathemati[illegible] algorithms [illegible]alculate dynamic and static energy demand driven by k[illegible]wn (measured) demand characteristics of the production equipment, from surface fans to underground battery chargers. An accurate demand profile is thus generated throughout the electrical network. In doing this and by measuring key demand points in the network in real time to calibrate the model [illegible]viation monitoring tool is generated. Should the classical peak [illegible]eopardy then the network model in its operating state can be used to [illegible]rmine and predict the optimal evasive strategy. Moving away f[illegible] [illegible]ardwired" sacrificial loads to "best for the current circumst[illegible]ce" methodology.

## Main Problems

As with many new concepts the main difficulties revolve around the people aspects more than the technologies. At present, the energy management tool set is best used in a project or consulting mode. The ability to implement fully is constrained for the following reasons:

- Lack of underground infrastructure to automatically measure and calibrate the model to reflect reality
- Engineering planners reluctant to change current work practice
- Availability of resources to collect "as-is" data at start up
- Management capacity in terms of using new information in an operational context
- Due to the newness of the technology not enough sites are currently running with the tools to be able to adequately pressure test the algorithms and identify the optimal way of building the new work processes.

## Lessons Learnt

A great benefit from a Theory Of Constrains (TOC) perspective is that from the production schedule, a series of discrete time slices can be generated against the engineering infrastructure which can highlight any under or over supply of energy services due to:-

- Increases or deceasing production profiles
- Changes in mining methods
- Budget periods
- Implementation or decommissioning of engineering infrastructure
- Cost tariffs on bulk supply of services
- Equipment down time

MineServ is enabled to be used in the following modes:

- Projects - Feasibility and Pre-Feasibility studies
- Simulations - What If's and consequence (scenario) analysis
- Run Mode – Operations planning & maintenance

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Synergies (or convergences) resulting from the integration in to the mine plan system offers the ability to perform a number of key business functions, for example MineServ can be used to:

- Simulate the planned outputs of a compressed air system and the draw down requirements of the compressed air in 3D space at any point in time.

- The tool can be used to calibrate the actual performance of the engineering services infrastructure. This make a "design for life" strategy much more realistic.

- If the measured figure is out from the simulated model, then either the model needs further calibration or undetected leaks or pressure points are in the system.

- The tool can also provide a Bill Of Materials input for the detailed procurement plan for the operation again at any specific point in time.

- An easy to use interactive CAD analysis application that can be used by any department to visualise the mining operation and determine the consequences of decisions well ahead of spending real money.

Further Improvements

- A major initiative is to make the system work for the production managers rather than be seen as an evil "could happen" system. As the system has a detailed view of the instantaneous load flow the ability to predict deviations from plan in real time, ensures corrective action which assists production (fewer lost blasts) and not only attempts to reduced energy costs

**Figure 5: MineServ information flow to Functional/Departmental disciplines**

As has been mentioned earlier, from an ICT perspective, the ability to use this tool in a truly dynamic manner, for the integration of business practice and to extract the real synergies from convergence strategies, has not been investigated. Figure 5, above endeavours to depict the impact the technology can have on the technical/engineering disciplines list to the left.

Conclusions

In this chapter, the conclusions of this project are summarised. However, due to the timing of this presentation, the final results of the project will only be presented at the conference.

Conclusions

Whilst the final financial outcome of the energy management project are yet to be published, enough is now known of the tools and their application to engineering utilities and infrastructure planning to be able to make statement of a broader nature than only energy management.

Against the background of driving down unit cost and identified points of convergence between the ICT, Mining and Engineering worlds, is seen the opportunity for the integration of the mining supply chain for visibility and synergy across all areas of physical operations; in the mine from mine planning, through to blasting, digging and hauling to ore processing and mineral sales. This initiative can unlock the opportunity for an organisation to build an integrated value chain system, capable of planning, monitoring and controlling the entire mining process, keeping track of product pipeline and making operational changes optimised in the context of the whole mining company - at all levels - and not just part of it.

This unlock is best enabled through building service delivery cutting across traditional lines of thinking so multi-skilled professionals are able to ensure the business function is delivering across ALL levels of business and ICT architecture.

Additional Benefits

Many ICT applications areas have remained divided and in functional silos at most mine sites, as well as in the minds of most people in the mining industry. Only recently have mine management demanded more accurate and timely information about the cost of the mining process and the effect of decisions on mining outcomes. This - linked with the availability of new technologies such as GPS, RF data transmission, GSM, VoIP and a host of programming, internet and browser options for all applications – has made it both necessary and feasible to integrate the two previously separate worlds of technical and commercial mining systems.

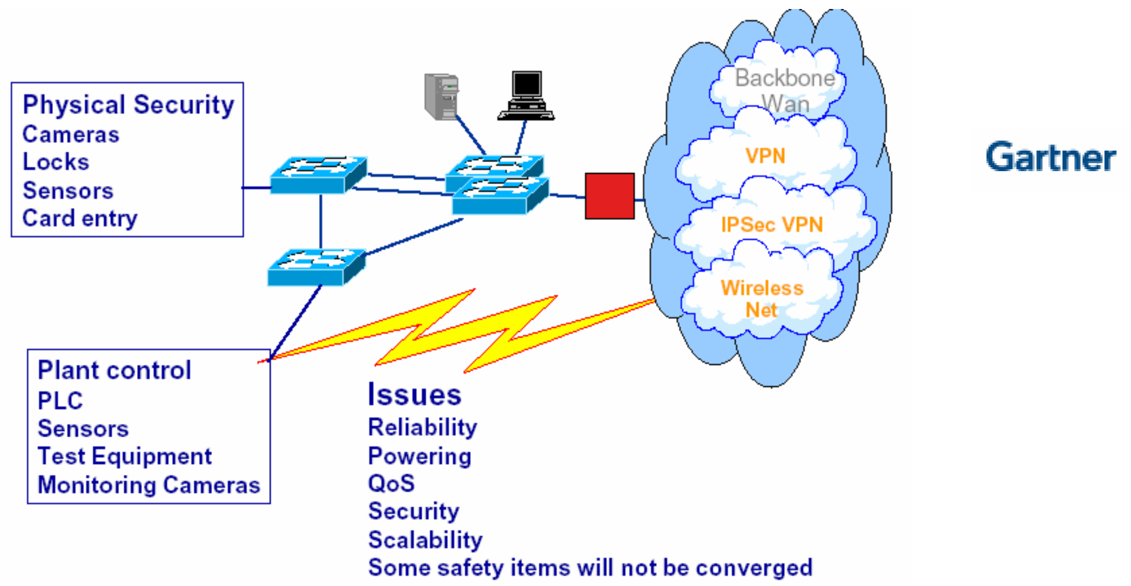
The project team referred to in this paper has built a successful and credible model (Diagram above) of how ICT can improve processes and business performance between the Mineral Resource Management Domain and Engineering Energy Management. A great opportunity exists to leverage the investment in the MRM space and roll out the model to the functional domains of engineering, metallurgy, human resources, etc.

Thus, the holy grail of true convergence is maximized between:

- Application, business systems and technical architectures (Simplification)
- Analogue and digital (voice and data) (Efficiency)
- Technicians, DBA's and IT engineers (Labour Efficiency)
- Engineering PLC & SCADA to MES, MIS and EIS (One version of the truth)

This scenario means that for operational planning, control, implementation and measurement, the ICT infrastructure and systems are for the first time part of how the mining company works as a process rather than in functional silos.

Extending the IM budgets (or the Engineering budget) from pure IT and IS to include the manufacturing control and automation side adds a complete new dimension. Many sources would indicate that the PLC's and control systems are an integral part of assets and machinery and thus make it difficult to split out any specific cost elements. However, the cost of automation of a plant has been found to range from 15% to 25% of cost of capital of the specific plant depending on the level of automation and the management approach to information and control. The diagram to the right is an example of machine-to-machine convergence in an area of Engineering to ICT convergence.



## Closing Remarks

By aligning the production planning process closer to the engineering energy management technical services, a more comprehensive operational plan is generated. By understanding in detail the workplace demand profiles, the predictive tool is now able to improve the operations ability to control its energy management and react accordingly and timeously. The application of ICT systems integration, TOC and innovative thinking to an old problem has resulted in the creation of a tool set that can be shown to assist in the reduction of the energy bill on a mining operation

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