Confidential

Applying Modelling and Simulation Technology to Add Value in the Mine Planning Environment

This document discusses the challenges and objectives of different planning types, associated in the mining environment, from operational mine planning through to capital and strategic business planning. The paper also highlights the application of simulation, modelling and reporting technologies [and methodologies] to the different planning functions, in order to create a single integrated planning environment.

The views and examples expressed here are all gleaned from the collective experience in mining of our senior team members. Not all of these examples will apply to any single mining business, the universal lesson howevers are we believe relevant throughout the industry.

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Several factors combine to make business and operational planning in the mining industry uniquely challenging.

> Firstly, mining involves the exploitation, and continuous 'wasting' of a finite resource base in order to create economic value. As a result, significant capital is required at regular intervals throughout the life of a mine, not only to grow the output of an operation, or to increase production efficiencies, but simply to maintain a certain volume profile. *(Often referred to as capacity replacement capital)*
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> Secondly, although geotechnical assessment technology continues to advance, there still remains uncertainty with regard to the mining risk due to factors such as, grade, geological faults or hydrology. This makes it very difficult to accurately predict production output or cost with finite certainty. *(By contrast when planning a manufacturing plant for example, the speed and efficiency of equipment is known with absolute certainty therefore output can be accurately projected).*
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> Thirdly, opportunities for mining producers to differentiate their products are relatively limited. In most cases prices are determined by external supply and demand driven forces, making the prediction of revenue also difficult. Although prices follow a cyclical pattern, over the long term, they tend [for most commodities] to reflect a decreasing profile, placing pressure on margins. *(This would not hold true for diamond mining)*
>
> Finally, as most mines age and therefore grow in physical scale, operational costs will trend upwards over time, again placing growing pressure on margins. This is typically alleviated by the commissioning of efficiency related projects which require significant capital with long term payback periods. *(Therefore in attempting to increase operational efficiency capital efficiency becomes the area of trade-off)*

The net result being that, because of the need for regular large capital 'bets' [with long pay back periods], and because of the unpredictability of both operational conditions and market forces, the requirement for a sophisticated planning and analytical capability is especially crucial in the mining environment.

This paper discusses some specific challenges associated with business planning in this industry, and highlights an integrated approach to business, capital and operational planning using advanced simulation and modeling technologies and methodologies.

The Problem of 'Fragmented' Planning?

The inherent technical nature of the mining industry, along with the quantum, complexity and frequency of large projects, mean that the mining world is, as a general rule, highly experienced at quantifying the risk and return of capital projects. However, these capital investment decisions are often assessed as stand alone cases. The dynamics of the mining business *(perhaps more than most industries)* are impacted by and in return impact on, an interdependent set of complex sub-systems. Simply stated, there are very few decisions that will not have a direct impact on other parts of the overall business system.

In other words, the risk and viability of each capital project is often justified not in total isolation, but without sufficient consideration of other aspects of the operation.

For example, a new capital project (e.g. increasing plant capacity) will often have a direct impact on the way operations should ideally be scheduled. Unless the mining plan is modified, full value will not be yielded from a capital project. This theme is explained in more detail later, where examples illustrating the conflict between capital planning and operational planning are discussed.

Despite the fact that in reality a mine is one large complex system, the planning function does not reflect this and is typically fragmented along several dimensions*****. For example –

> ***With regard to scale and time horizon*** – operations plans (e.g. production schedules) are usually short to medium term and are performed by mine personnel on a continuous basis, whereas large capital projects are the realm of specialist project teams and are conducted more sporadically. Often the teams responsible for these different planning arenas are not fully aware of important detail with regard to each others planning activities.
>
> ***With regard to functional scope*** – Whilst there is a degree of co-operation between engineers and accountants, they do not always operate as a single team. Often, the more operational and short term the planning focus, the more technical the orientation at the expense of in depth consideration of issues relating to commercial risk. Evidence of this is seen in the deployment of sophisticated graphical mine planning software where the costing functionality is firstly limited, and secondly rarely used to its full potential. Business planning and budgeting are one realm and are derived from that production plan as opposed to being a unified process.

The negative impact of fragmented planning manifests in several ways, for example - the elusive quest for <u>'one version of the truth'</u> persists; and subjective perspectives prevail. It is also not uncommon to find different project justifications being ranked when different assumptions (e.g. currency exchange rates, or production efficiencies) are used, thereby making such assessments flawed. *(Simply put it is not comparing apples with apples).* Equally as dangerous is the acceptance of projects that make sound economic sense when seen as stand alone initiatives, where in reality they have not considered the full impact on the entire business process. *(Again the operational planning vs. capital planning example discussed below provides a good example).*

The mining environment is especially prone to the dangers of fragmented planning because of its inherent technical detail and complexity, combined with the high degree of operational and market uncertainty.

(One tangible, albeit humorous, example of this is, are the tongue-in-cheek remarks made by and about engineering and accounting professionals - *"accountants don't understand anything about mining and shouldn't have a say, mining is very difficult to understand"* or in retort *"engineers don't realize that a mine is a business like any other business".)*

Note * - *The fragmented nature of the planning function has been evident with all the mining clients that we have had experience with, but we acknowledge that this may not be the case with all mines.*

Why is Fragmented Planning so Common?

There are good reasons why such fragmentation in planning occurs, for example –

> ***The need for autonomy and accountability*** – it makes sense for business units to control the operational aspects of their business.
>
> ***The required skills and experiences*** – the scope of different planning initiatives will require that different skill and experience sets are used for different planning arenas. The larger more complex projects generally require a greater understanding of financial risk and the macro economics forces shaping the industry, whereas tacit knowledge is required for operations planning.
>
> ***The need to balance differing objectives*** – Perhaps the most difficult aspect of planning in the mining environment are the 'legitimate' differences that exist between different parties. A Business Unit perspective would naturally motivate to configure its area of focus as optimally as possible, whereas the Head Office perspective would want to balance the configuration of the entire group. Nowhere is this better illustrated than in the debates that ensue with regard to the allocation of a finite capital pool.

Hence for these and other reasons, it is not always practical or desirable for a single team to be solely responsible for all planning that occurs within a mining group. This does not however preclude the desirability to have different teams working on different planning arenas, <u>but with a common perspective, and a common understanding of both technical and commercial detail</u>. This is where technology plays an important integrating role. But technology alone is not a panacea.

Mining is complex and planning will involve understanding firstly the complexity inherent within each planning realm and secondly the interaction between these realms.

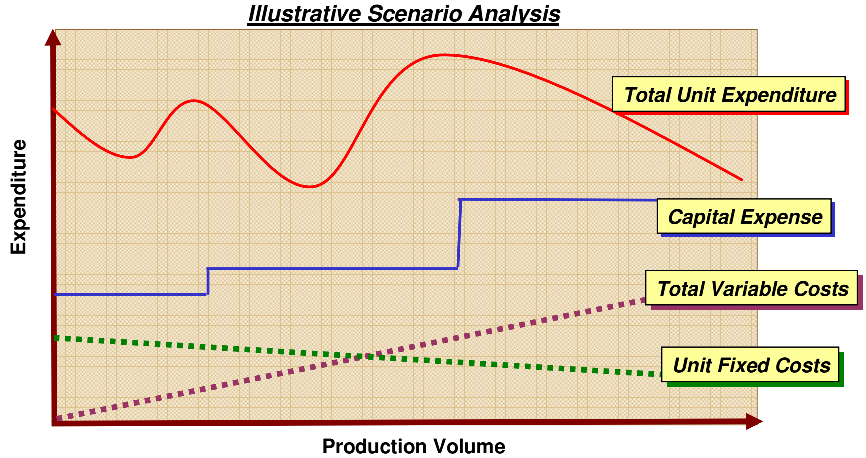
The following description of the three planning 'worlds' may be an oversimplification, but for the purposes of this paper will illustrate the different levels of complexity that must be catered for by any credible planning technology. These planning realms are - operational planning, capital planning and strategic planning.

Operations Planning – Activities here include, extraction planning, production scheduling, shift scheduling etc. This level of planning is usually the responsibility of a full time mine planning function, and informs and is informed by the business plan. An example of the focus of this level would be a thorough understanding of how different expenditures (capital, fixed and variable) behave under different production volume scenarios, as illustrated below –

Understanding How Expenditure Behaves with Different Volumes

Total unit expenditure is determined by the non linear relationship between capital costs, fixed costs and variable costs all of which vary under different volume scenarios.

Illustrative Scenario Analysis



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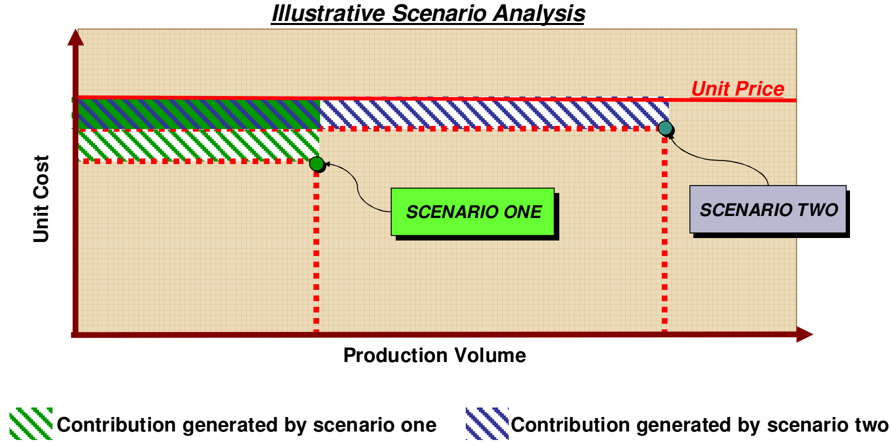
Whilst the dynamics impacting the behavior of costs are in themselves complex, defining objectives of an operational plan is no less difficult to determine, for example – At the most strategic level the task is simple: maximize shareholder value. But how does one practically translate this into the planning environment. Does one plan to maximize tonnage? to minimize unit cost? or to maximize operational efficiency? The difference between reduced unit cost (an absolute metric) and operational efficiency (a relative measure) is described in the diagram below -

Defining Operating Efficiency

Although scenario one below indicates a lower unit cost, scenario two with its higher unit cost, will yield greater contribution.

Illustrative Scenario Analysis



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In the first scenario the unit cost is obviously lowest but the operational efficiency or 'bang for the buck' is better in scenario two. The choice as to which scenario is preferred cannot be determined without understanding the impact on capital efficient and ultimately group strategy.

Capital planning – Whilst operational planning focuses on optimizing the mine within a given configuration (e.g. maximum capacity output). Capital planning is concerned with optimizing that configuration. Activities here include planning individual projects, through to scheduling a portfolio of different capital projects.

Capital projects can be grouped into different classes according to their objectives for example - those that replace declining volumes, those that increase the output potential of the mine, those that increase efficiencies and those that have no direct volume benefit but improve safety etc. As with operational planning here too the most desired objectives of capital planning are not easy to agree.

> For example when simulating the scheduling of projects to maximize the NPV of the mine, to maximize the capital efficiency of the mine *(capital efficiency being the same relative metric as operational efficiency)*, and finally maximize the ROI, we found that three very different schedules emerged. Furthermore under different operational assumptions each schedule changed again. Selection of the most appropriate schedule could only be determined by understanding the operational planning environment, as well as the strategic planning realm.

Strategic planning – This is obviously the most macro, long term and externally focused planning arena. Activities here involve apart from strategic decisions with regards capital planning, which makes up a substantial portion, an understanding of the relationship between different supply / demand equilibria and commodity price, as well as the dynamics that govern competitor and customer behavior. Specific analysis would be to research and generate industry cost curves. The strategic planning realm provides the context for all other planning; it is arguably the least tangible and most difficult arena to quantify.

The business planning function is therefore designed as an overarching process to integrate the three planning realms described above.

Capital Planning vs. Operational Planning an Inherent Conflict?

Logic would dictate that a portfolio of projects scheduled to maximize volume will in turn also improve operational efficiency. In theory this may be the case, but often simply because capital and operational planning are often not fully integrated, instances exist where capital planning and operational planning conflict with each other.

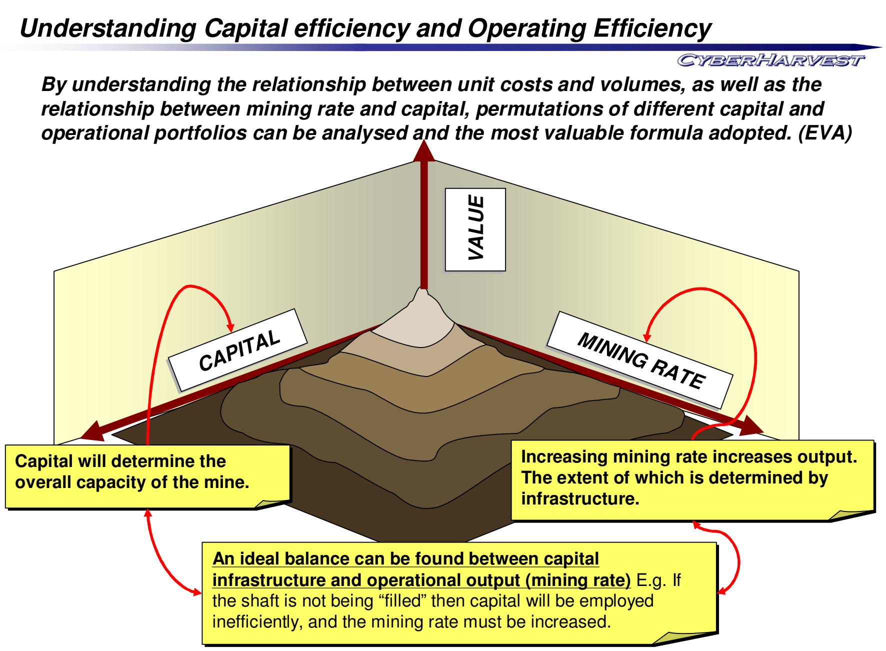
> For example - a capital investment to increase capacity would obviously improve the total volume potential of a mine. But volume is also affected by the mining rate. Cases exist where capital has been deployed to increase volume in circumstances where a change in the existing mining rate would have presented a lower cost alternative. Moreover, the introduction of capital has actually 'dis-incented' production management from attaining greater efficiencies.
>
> Our experience in the hard rock deep mining environment revealed that if all production units (in this case half levels) were to increase their efficiency by one or two percent, not only would there have been the operational cost benefits, but an even greater benefit would have been realized as the large capital projects to maintain volume would not have been required.
>
> The optimal solution is never clear cut and a delicate balance is always required after considering the risk. If too little capital is deployed, then growth is constrained and risk increased. Paradoxically, too much capital can on the other hand introduce the possibility of operational inefficiency as capital affords operational mangers excessive flexibility.

The cause of poor capital efficiency in this case resulted because the excessive capital employed resulted in the opening up of 'surplus' panels with the result that operations were subsequently 'spoilt for choice', and, instead of 'sweating' the panels that are already accessible managers now choose to mine the 'cherries'. (The result is an abundance of uneconomic 'white areas' on the mine plan). Ironically, because of opportunity to cherry pick the cost per ton may look good, but the return on the expansion capital dismal. In an environment of supernormal profits and insufficiently detailed reporting systems, this is not easily noticed.

A similar scenario existed in the opencast mining environment where the argument revolved around whether to run expensive equipment into the ground by performing the minimal levels of maintenance, thereby necessitating more frequent replacement; or alternatively gaining more life out of the equipment by regularly overhauling sub-assemblies. The advocates of each approach had sound data to prove their divergent points, and intense operational vs. capital cost debates ensued. Upon detailed analysis we found both to be right in their respective areas, but for very different reasons. The determinates behind the optimal decision were - the grade of the commodity being mined, which determined the minimal economic mining rate, which in turn informed the two different shift systems. Further explanation was found in the slight variances in equipment type being used, as determined by the geology.

The insight gained in this case was that these decisions are complex and there are no universal rules. As a direct result of the complexity associated with such decision, without a detailed frame of reference, a volatile environment for futile argument is created.

The relationship between capital (which determines configuration and capacity) and operations (in this example mining rate) is illustrated below, where at a certain capacity (capital investment) there is a mining rate that will yield maximum value* –



**** assuming of course that maximum value is the objective one is striving for?***

Because of the dynamic interplay between operations and capital efficiency, operations planning and capital planning should be integrated around an agreed objective function. Capital projects should not be justified on a stand alone basis. Planning criteria and logic should be well understood by all operations management before mining discipline can be expected.

The amount of 'greyness' and uncertainty that surrounds the mining world should no longer be necessary with the technology that exists today.

More Science and Less Art, but not all Science!

No matter how detailed the scope of planning, within all three planning realms (operations, capital and strategic) there will always be a degree of judgment required, specifically with regard to the objective function. For example - should a plan aim to increase efficiencies, increase volumes, increase profitability, reduce risk? All of these outcomes are desirable under different conditions. A sound planning system must therefore accurately quantify the outcome of any simulated change, under different assumed condition, but ultimately executive judgment will determine both what sound assumptions are, and what the objective function should be.

Given the uncertainties associated with mining and market risk coupled with the complexity of the overall mining system, the task of quantifying different scenarios is onerous. The ability of a planning system to do this effectively is determined by its depth and breadth. Depth refers to the granularity of detail and analytical functionality, and breadth to the extent that the relationships between variables of different sub-systems are captured by algorithms embedded in the technology.

The term optimization implies trade-off. In other words by increasing an input variable (e.g. capex), an output variable (e.g. profitability) will increase to a peak and then begin to decrease. All of the linear and non-linear and direct and indirect relationships between variables that comprise a system need to be captured in sufficient detail before a planning system is deemed valid. But here too there is a trade-off, too much detail and the technology becomes cumbersome to use, and even more dangerous and difficult to understand and trust. Too little and its outputs not credible.

The planning system will not make decisions, it can only assist executives in deciding, and, it is for this reason that a robust planning process is typically heuristic. Decision support technology hones the art of decision making and reduces the need for luck.

A Blueprint for the Ideal Planning System?

The most important prerequisite for the building of any successful decision support or planning platform is to understand in detail the business issues. In other words – what are the economics of the business? What are the important drivers of value? What decisions will the system be used to support? What data, analysis and insight is required? Who will use it? Who will use the outputs of the system? How often? To do what?

Our approach is to understand both the operational detail, as well as the strategic issues and then to link these two worlds. This often means that operational metrics (e.g.-volumes and productivity efficiencies) are incorporated along with financial metrics. Ultimately the system would be able to quantify the financial consequences of any change in operations, configuration or the macro business environment.

From all that has been discussed in the paper so far, the ideal planning system would have the following criteria and features -

Able to model complex future scenarios – robust planning systems should comprise advanced modeling applications not reporting or simple forecasting tools.

Able to capture linear and non-linear relationships – to incorporate a mine wide perspective and reflect the reality of interdependent dynamics and sub-systems that make up the overall mine system.

Flexible - to cater for the easy quantification of scenarios by changing assumptions or simulated actions.

Auditable – so that both counter intuitive results, as well as the reasons behind the difference in quantum between two different scenarios can be easily understood.

Able to store the results of different scenarios – to facilitate later comparison in the iterative process.

Be consistent – to facilitate one version of the truth, have consistent data sets, definitions and business rules.

Intuitive and simple to use – the challenge in planning must be in interpreting the analysis and conceiving optimal scenarios, not using the technology.

Have diverse interfaces – many different people will use it.

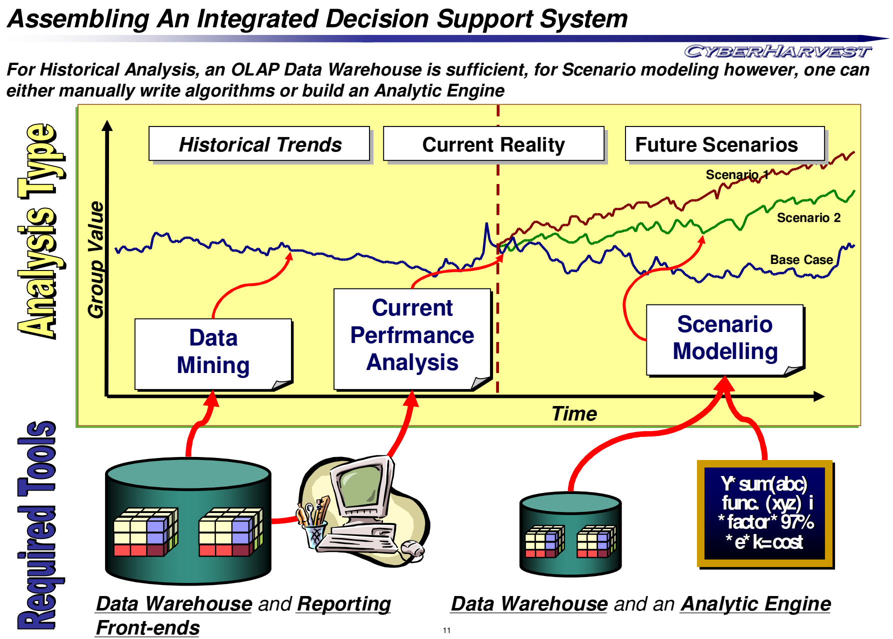
Be integrated into existing transaction systems – thereby creating a live planning environment that is automatically updated on a daily basis. In other words be integrated into the live reporting interface – the ultimate 'digital cockpit'.

Be able to produce for every scenario that is run – a life of mine plan, a business plan, a cash flow forecast, a future income statement as well as a detailed 12 month rolling budget.

Our Technology Suite

In order to build such a system with the functionality described immediately above, our planning system comprises a hybrid of different platforms and technologies, that incorporate – data warehouses, OLAP cubes, extract transform and load [ETL] middle ware, analytic engines, neural networks, simulation tools and reporting front-ends.

We combine all of the above to create a library of analytical and planning components. These components are integrated, and customized to suite each client's environment. All components can be described as belonging to one of three classes of decision support technology, namely - Accelerated time based simulators, modeling tools and reporting tools. The first two are common in that they create future data, the latter class deals only with historic data. They are all integrated as indicated below –



All three of these technologies are applicable to all of the different planning realms (operations, capital and strategic).

Modelling tools – comprise technology that captures complex interrelationships to calculate and quantify the resultant output of a scenario. (E.g. financial or production metrics). Modelling technology forms the core of any business planning system. Unlike disparate spreadsheet models that typically fulfill this role, our planning tools are integrated into a uniform data set and provide robust and consistent output. Modelling technology is used iteratively where by changing assumptions and operating parameters, different scenarios are tested. (See appendix 1) Incorporated in this genre is probability orientated modeling such as Monte Carlo simulations

Simulation tools are an advanced form of modelling technology, and differ from modelling tools in that they are more dynamic, and comprise preprogrammed intelligence. Examples at an operational level include plant or process simulators (e.g. G2) which we configure to suite the strategic realm by building industry wide simulators (see appendix 2).

Finally ***reporting technology*** – 'One gets what one measures', and one must be able to measure what you plan! Our objective therefore when integrating the planning environment into the reporting platforms is to ensure that planning and reporting metrics whether financial or production are fully comparable. For example, if the outputs of a planning system include items as varied as unit cost per specific geographical area, as well as group value, that the reporting platform will measure these exact metrics. Integrating planning and reporting systems, involves setting up common data marts and business rules.

Although these should ideally be fully integrated, not all genres exist in all client environments. The following table summarises some uses of the different decision support technologies –

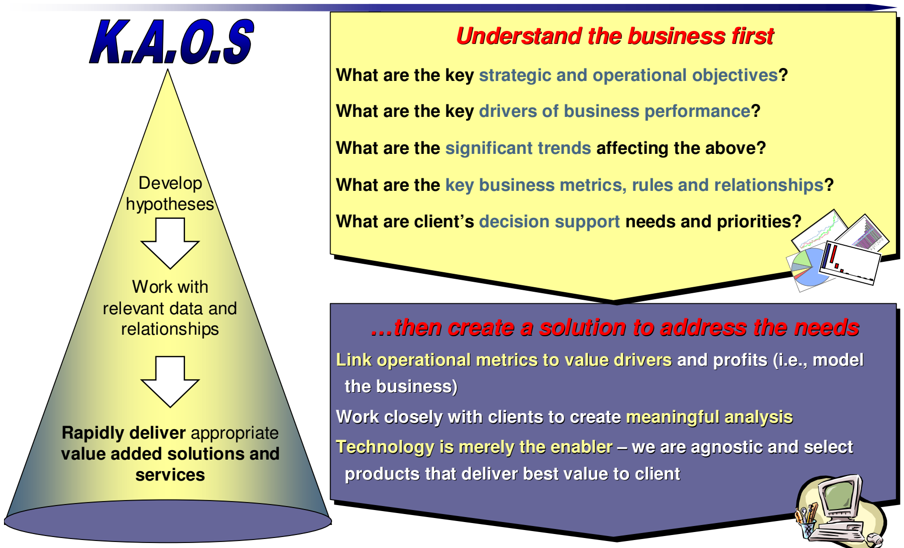
TYPE	SELECTED ILLUSTRATIVE USES
Accelerated Time Simulators	**Decision evaluation - Option and scenario modelling** • Time based simulation - Industry supply-demand equilibria - Process and plant simulation • Life-of-Mine performance and economics simulation - Entity valuations, scalable from half- level to corporate
Modelling tools	**Automated / assisted Decision Optimisation** • Business planning (1-3 years) • Probability sensitivity modelling – Monte Carlo • Capital planning – e.g. based on physical operations simulations and resultant economic implications • Logistics simulation and planning • *Flexible* short-term budgeting and operations planning • Shift rostering / resource scheduling • Activity Based Costing • Initiative-based budgeting
Reporting tools	**Performance tracking** • Best practice - performance tracking and knowledge building (Key metric management) • Key Initiative results tracking (i.e., integrate performance management and monitoring of cross-mine initiatives into operational plans of unit managers) • Performance forensics and analysis (i.e., interactive and adhoc tools to analyse specific issues) • Results tracking and report distribution (i.e., static and repetitive reports) • Employee performance tracking and balanced score-carding

The Technology is in Fact a Secondary Consideration

The above statement is obviously provocative and seemingly contradictory to the theme of this paper. But it does epitomise our mindset when building a decision support platform. Of course technology is important, but without being preceded by a sound understanding of the business issues, it is dangerous. This is evidenced by cases where sound technology is implemented but not used, or used to a limited degree. Technology should not be the focus, rather the business objective.

The guiding maxim we apply in any implementation is KAOS, knowledge ahead of systems. This means that the business drivers, the personalities, the planning processes, the required analysis, the use of that analysis etc. all need to be understood before building the technology. All of our implementations begin with a thorough analytical / consulting phase in order inform the most effective solution.

A Conceptual Summary of our approach



"Technology is pointless unless it supports client decision making and, ultimately, wealth creation"

Of course there are many complex factors that would determine the selection of the ideal technology, such as scalability, compatibility with existing technologies, cost etc.

We are agnostic to technology and have a competence in installing with most business intelligence tools. The advance of enterprise software is such that like computer hardware fifteen years ago, software is becoming a commodity. Today packages are becoming easier to configure and implement. It is the business understanding and analytical expertise that will determine the value derived from a system.

A Simplification of Our Approach

A typical engagement with us comprises three distinct phases -

The specification phase – this involves extensive financial performance analysis, data mining, interviewing of relevant decision makers, mapping of decision processes etc. This phase ends with three deliverables.

- A wealth of analytical insight about the clients business;
- An operational training model [OTM] which is simply a 'mock-up' of the final system. The OTM is built as a stand alone planning tool using simple technologies such as spread-sheets or OLAP data cubes;
- A detailed functional specification and a project timeline.

The development phase – comprises the building and integration of the tool. The length of this period depends greatly on the required functionality and scope, but 3 months is an average time.

The support phase – this includes not only user training on how to operate the technology but more importantly workshops to develop financial analysis and scenario optimization skills.
Most of the planning activities, described in this document are not new, and exist within large organisations. They however reside in a multitude of one-off Excel models. The solutions discussed here will replace all these isolated 'pockets of insight' with a single uniform platform that is configured to allow different layers in the organisation to make better decisions faster.

Appendices

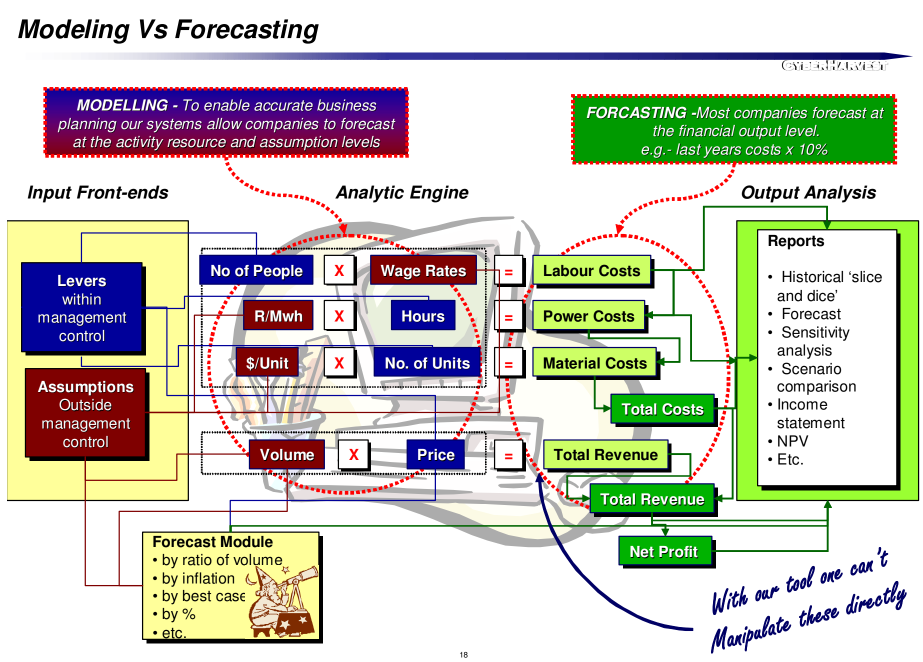
Appendix 1

The Challenge of Modelling

Planning systems must have a scenario modelling capability, this is different to forecasting. Forecasting is a very high level way of gaining a perspective on the future. Forecasting can take various forms –

- Projection – an extrapolation of future trends
- Prediction – based on explicit theoretical assumptions
- Conjecture – based on subjective assumptions

Modelling is an entirely different order of magnitude in terms of analytical rigour, and in terms of detail. Modelling involves an understanding of the causal relationships between different variables. The difference between the two is illustrated below -



Modelling is therefore the exercise of mapping the relationships of different input variables to outcomes. Models are therefore simply a manifestation of knowledge which forms a basis for simulation analysis. Simulations will quantify the resultant outcome of a scenario. Scenarios are tested by changing different variables to quantify the aggregated impact on outputs. In this regard models are used to predict future events, and /or to understand the sensitivity of an output to a change in any input.

An input variable would be the supply of a commodity,
An outcome would be price.

Relationships would be a statement of price at any given supply demand balance.
A scenario would be for example an assumed increase demand by 30% together with an assumed increase supply by 10% to test price.

What is clear from this example is that the input variables themselves (e.g. supply) are in fact outputs that are determined by other input variables such as the economics of producers.
Based on this, the possibility of very quickly 'chasing ones tail' becomes a very likely reality when attempting to model complex industry dynamics.

In our experience there are three main areas where the predictive validity of a model is often compromised.

- Firstly, **inaccurate data** - where the relationships between variables are inaccurately mapped; (e.g. the relationship between variable cost and volume). As a general rule relationships should be mapped at the most granular and direct level possible, and should always be based on historical fact.

- Secondly, **unrealistic assumptions** - where the assumptions used to create a scenario are impractical; (e.g. supply will increase tenfold within three years)

- Thirdly, **incomplete knowledge** where dynamics captured by the model do not represent all of the dynamics that exist in the real world. (E.g. the main driver of demand may be the fuel price which may not be considered in the model, however, fuel price is in turn determined by Middle East politics etc.)

In order to overcome these challenges, modelling analysis typically tends to rely on an iterative process where counterintuitive outputs will enable the modeller to question results and either change, both the inputs and the relationships, or map more knowledge in order to derive a more intuitively acceptable output. Although this may seem to be the case, iterative modelling is not always a self defeating endeavour in that it could afford the modeller opportunity to better understand the dynamics of the system being modelled. In this regard the value of a model is not only to yield an accurate prediction, and yield more accurate decisions, but also fosters learning.

Dynamic Simulation

Systems within Systems
As introduced earlier, we view an overall mine system as comprising many interrelated sub-systems each of which are in turn made up by several cause effect relationships that exist between 'objects' which aggregate to form each sub-system. A sub-system would therefore be the dynamics that drive the economics of a piece of equipment.

An object in this case is defined as any entity that impacts on, and in turn is impacted by, a change in any system variable. For example, a piece of equipment, would be regarded as an object and would be impacted on by factors such as geotechnics.

The key benefit of this type of dynamic simulation is to be able to quantify the risk associated with different decisions and assumptions.

Building Intelligent Objects
Object based modelling focuses on capturing both the outputs and more importantly the behaviours of each individual object.

Outputs would be volume.

Behaviours are the responses that an object would exhibit under any given circumstance. The behaviours of each object would also be captured in the form of a 'behaviour rule'.

A behaviour rule in this case could be the conditions that impact the performance of a piece of equipment. (*Behaviour rules would be determined by proven historical facts*).

Importantly, with this approach the behaviour of each object can be programmed to reflect lead and lag dynamics.

An object therefore allows for pre-defined logic to be programmed at a granular level and in so doing provides objects with a measure of independent intelligence in responding to simulated industry events. This allows for the decisions of different players to be modelled.

Accelerated Time Simulations
Given that the important behaviours of all the major objects have been coded, the modeller would have a tool that is 'loaded' with a multitude of 'intelligent' output responses to key stimuli. Therefore, when an event is 'triggered' it would result in a sequential and sometimes simultaneous series of 'responses' from each object which will be reflected in their outputs. This will in turn impact other objects that make up the system and so on. In this way years of industry dynamics can be simulated in minutes.

> **For example** – When simulating industry dynamics, a trigger could be a change in the production profile of a commodity producer *(incidentally we assume that knowledge about production profiles is more certain that the anticipated response of different market segments).* Such a change would have an impact on the supply / demand balance which would in turn trigger a rapid series of responses from each

market segment (or object) which will in turn have an effect on prices as well as the economics of the industry suppliers and so on.

Object based modelling simply makes explicit the multitude of implicit assumptions that govern any static modelling exercise. However, unlike static Excel modelling this would be dynamic in that simulations will unfold over a specified time period, (typically minutes) giving the user opportunity to understand dynamics as they unfold rather than just the end result. Although all the programmed behaviour rules are predetermined by the modeller, running each simulation will reveal the complex interrelationships of these behaviour rules over time, in this way counter intuitive results can be better understood.

Using the Model

The process of gaining insight will still require running iterative scenarios, but unlike static modelling, the variable that would be altered for each iteration will be the assumed behaviour, thereby deriving a greater appreciation of the sensitivity of price to different influences.

Another approach that is often used to gain the same insight involves simulating an industry by engaging in a participative business game where delegates (typically executives) are given information about industry dynamics and are then required to respond accordingly. Their responses are then entered to a static model. Results are analysed after each round of decisions along with a qualitative diagnosis of why different decisions were made. This technology will enable one person to perform exactly this type of analysis in a few hours as opposed to over several days.

About the Technology Platform

We propose building the model using a platform called G2. G2 is a simulation technology that has originated from a US military sponsored R&D program which has subsequently been commercialised in its present form. *(Relevant trivia – G2 is currently being used by NASA to plan space shuttle flights by simulating different scenarios).*
Closer to home G2 has been ubiquitously applied across the mining and manufacturing industries as a production plant optimisation tool. Its ability to capture a vast array of variables in the manner described above make it ideal for thermodynamic and other detailed and voluminous modelling. We are not aware of its application as an 'industry simulator' in South Africa, but it has been used as such in the US. We have applied G2 in the telecommunications industry where we were tasked with modelling the dynamics of an entire network in order to predict future faults. The predictive accuracy in this case has been over 87%. (Admittedly the degree of relationship mapping is more defined in this arena).

The steps to build the concept prototype would be as follows –

1. ***Identify the Objects*** – This will largely be determined by understanding the components that make up the overall industry, as well as the data that exists.

2. ***Establish the Behaviour Rules*** – This step represents the most significant portion of the exercise, and would involve data mining to reveal relevant historical trends and to establish behaviour rules. For example what has been the demonstrated behaviour of different consumers and producers to a change in price? Ideally every behaviour rule must be underpinned by sound economic logic and/or proven historical behaviour.

3. ***Populate the Objects*** – After the behaviour rules have been established, the process of populating the model is relatively simply, depending on the complexity, an object would take approximately one day to both populate and document.

4. ***Run Different Scenarios and Analyse Results*** – This is the exciting part of the process. We will in a day be able to run several simulations and after interpretation of the results change behaviour rules in an iterative process.

5. ***Revisit the Behaviour Rules*** – A benefit of the technology is that behaviour rules can easily be changed in the future as more insight is revealed.