# Implementation of an Economic Model at Gold Fields Limited

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**ABSTRACT**

Cyest Corporation was contracted by Gold Fields Limited in 2003 to assist in the development of a prototype Economic Optimization Model (EOM) using Microsoft Excel™. The rationale for the exercise was to develop a strategic planning tool to improve decision making. The success of this initiative resulted in Gold Fields commissioning a prototype 'Mini EOM' for all the South African operations to test economic viability and optimise the NPV of the life of mine reserve plans and projects. The 'Mini EOM' is a leaner version of the "big brother" EOM and uses the same costing and financial methodologies to generate the shaft and mine financial metrics from hard coded shaft production schedules. The 'Mini EOM' has allowed the quick generation of economics for a life of mine schedule allowing more time to optimise and test different production scenarios. Gold Fields have now commissioned Cyest Corporation to develop this into a robust enterprise wide economic model.

This paper discusses briefly the rationale behind the 'Mini EOM' philosophy, how it has been implemented at Gold Fields and the way forward to achieving a robust enterprise wide solution that integrates into all existing transactional and planning systems.

## 1. INTRODUCTION

Gold Fields Limited have partnered with Cyest Corporation over the past 3 years in the development of prototype Economic Optimisation Models (EOMs) to enhance their strategic and operational planning processes. It was deemed necessary to develop the EOMs in Microsoft Excel™, being a low cost rapid development platform suitable for prototyping. The prototype tools incorporate functionality that is able to quantify the causal relationships between operational metrics and their economic outcomes. The EOMs were also developed to acknowledge the breaching of production and other technical constraints that allow the user to be able to do 'what if' scenarios and test the economic viability and credibility of different production schedules.

The original EOM incorporated a complex production module that modelled the grade tonnage curve per geozone and is covered in a paper presented at AUSIMM in November 2004 by Ballington, Bondi, Hudson, Lane and Symanowitz entitled *"A Practical Application of an Economic Optimisation Model in an Underground Mining Environment"*. This specific paper deals with a 'Mini EOM' that was developed which excludes the production module complexity and is used to calculate the entire financial economics and labour complement for a given production schedule. This allows the operations to very quickly generate all the economics for a life of mine schedule. In this way different production scenarios that have been generated in CADSmine™ can be very quickly compared in terms of costs, labour complement, revenue, profit per period and overall valuation.

This prototype 'Mini EOM' has been integrated into the strategic planning process over the past year and the proven value resulted in Gold Fields commissioning Cyest Corporation to develop a robust enterprise wide EOM solution that integrates into all existing transactional and mine planning systems. This project is now in development stage using a proprietary modelling engine that Cyest have developed over the past year.

## 2. THE PROTYPE 'MINI' EOM

### 2.1 The Need for a 'Mini EOM'

The term 'Mini EOM' was coined as it does not include the complex production module that was included in the original EOM that also allowed production scheduling to be done. The production module required a significant amount of additional logic and programming, hence the model far more complex and difficult to use. The production module also required significant effort and time to set up the data for the predetermined planning polygons. It included grade tonnage curves by geozone, paylimit calculations, resource to reserve conversion and detailed constraint logic relating to ventilation, refrigeration requirements, compressed air, tramming and hoisting. The EOM was intended as a strategic planning tool that allowed different production strategies to be tested and compared as a guide for the detailed mine planning that is done in CADSmine™.

The 'Mini EOM' was developed out of a need to be able to generate economics for a given life of mine production schedule derived from the mine planning systems (i.e. Gold Fields uses CADSMine™ and Mine 2-4D™ at its South African operations). The concept is that the production schedule drives preset cost drivers which in turn generate operating costs through relationships that are derived from historical data correlation and known relationships between costs and production. The cost drivers for each activity and the labour complement are setup according to a known (historical or budgeted) production schedule for both production and non production related items. The economic viability of each operating shaft can then be tested on a year by year basis for the given production schedules. In addition, 'what if' scenarios can be tested where the schedule is adjusted on certain shafts and other shafts shut down to see the impact on costs, life of mine and value. The adjustment of the schedule is limited to increasing or decreasing production per area, without adjusting paylimits, as the grade tonnage curves have not been modelled in the 'mini EOM' This revised schedule would guide the detailed mine planning in CADSmine™ and the resulting CADSmine™ schedule would again be run through the 'Mini EOM' for the economics to be calculated.

The Gold Fields strategic planning processes now incorporate the prototype EOM model.

## 2.2 The Practical Application of the 'Mini EOM'

Traditionally once a production schedule for the life of mine has been completed it would be passed onto the Human Resource and Finance departments so that a labour complement and financial budget can be derived for that given schedule. In some instances these financial numbers are high level ratios that have been calculated for the detailed operational plan and applied to the life of mine production schedule to derive these labour and financial numbers.

The 'Mini EOM' models the causal relationships between operational metrics and their economic outcomes at a detailed level to derive the economics for the given schedule. These relationships can be defined as a combination of known relationships that exist, historical based cost metrics and/or first principle costing methods.

In its simplest form the 'Mini EOM' combines all the individual Microsoft Excel™ models and spreadsheets that exist on the computers of the Finance, Human Resources, and Technical Service departments which are used to derive the budget. In addition technology now allows far more complex relationships that mimic the realistic behaviour of costs over the life of mine. An example is the behaviour of fixed costs during a ramp up in production or during the tail of the mine life. The same rules apply to labour, where labour designations not linked to production may vary over the life of mine.

The 'Mini EOM' models the complete mining operation with multiple shaft complexes. In this way the dynamics of shaft closures can be modelled where direct

mining costs related to that shaft are removed, or care and maintenance costs for the shaft remain only and the impact of overhead fixed costs on the remaining shafts can be assessed.

In summary the prototype 'Mini EOM' includes the following functionality:

a. Configurable direct cost module where cost drivers and relationships can be changed per individual cost line item.
b. Configurable allocated cost module where each overhead cost line item can be allocated using a variety of production drivers.
c. Configurable labour module where labour categories can be adjusted and drivers per category adjusted (note that due to size limitations of Microsoft Excel™ the labour module does not model labour down to designation. This will be accommodated with the future enterprise EOM solution).
d. A hardcode capex module for known capital projects and a percentage of working cost rule for ongoing capital expenditure at each operating shaft.
e. Efficiency adjustment for both labour efficiency and costs.
f. Production adjustment where production can be increased or decreased per year with final reserve being mined remaining the same (no paylimit calculation in 'Mini EOM'). This 'what if' capability is used to guide detailed mine planning.
g. Shaft to plant mapping.
h. Rules based surface waste rock dump scheduling (highest grade first, nearest dump first etc) to utilise all spare plant capacity.
i. Ability to close shafts and see impact in operation.
j. Standard summary template reports for costs, labour complement and financials.

The 'Mini EOM' is currently being used for the following:

a. To optimise and test economic viability of the annual life of mine reserve declaration.
b. Project valuations (Mine NPV with or without project).
c. Costing and valuations of different production strategies.
d. Costs and labour calculation for life of mine production schedules.
e. Shaft impairment values.
f. Shaft paylimit calculations using average life cycle costs.
g. Financial statements per operation.
h. Tax calculation at operation level.

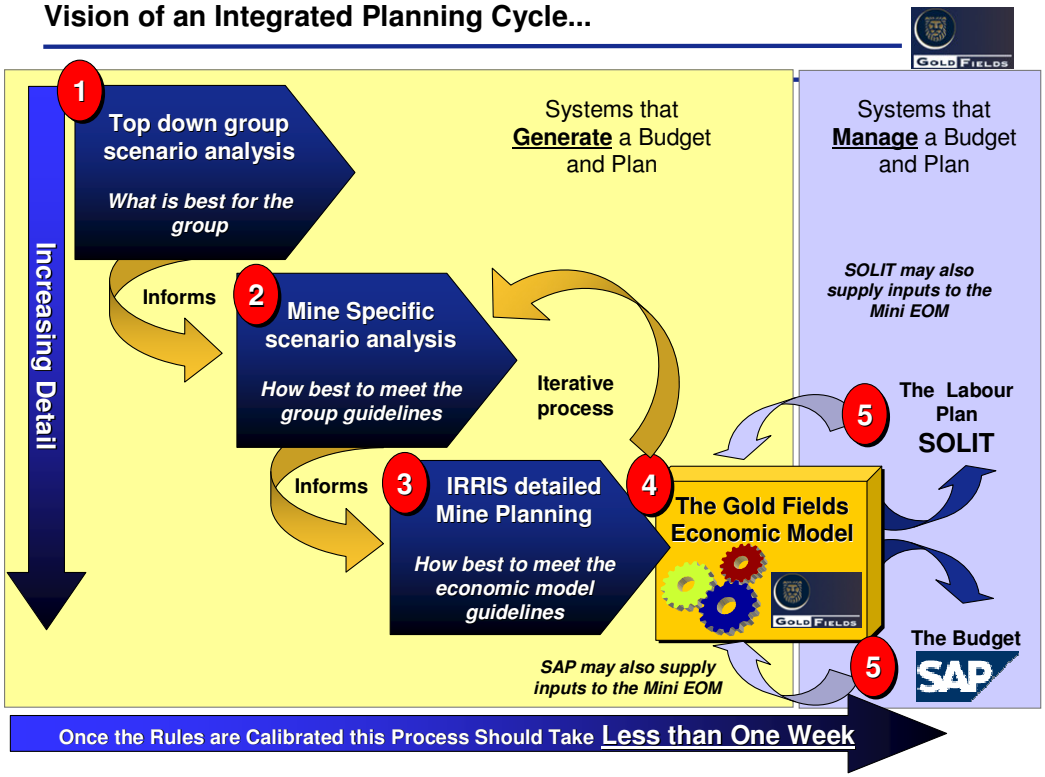
## 3. A ROBUST ENTERPRISE WIDE EOM SOLUTION

### 3.1 The EOM Positioning

Due to the value that has been proven over the past year from using the 'Mini EOM' for strategic planning, Gold Fields have commissioned the development of a robust enterprise wide EOM solution that is integrated into the existing transactional and mine planning systems.

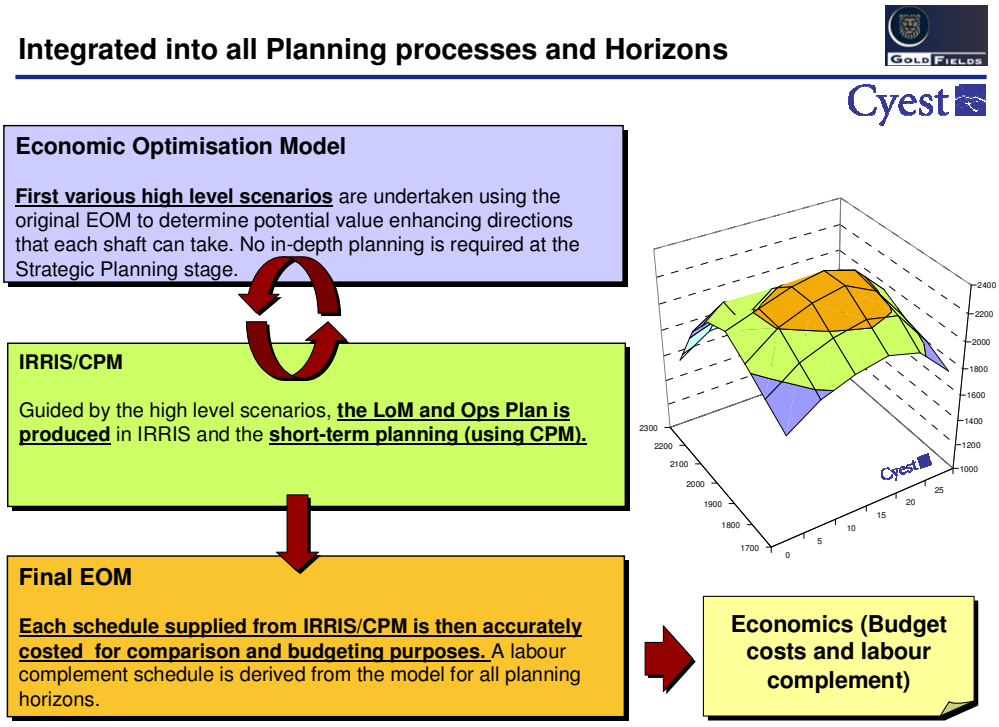
The prototype 'Mini EOM' has proven that financial and labour budget numbers can be calculated from a rules based model for the life of mine strategic plan. Therefore the final EOM solution will be positioned to generate the economics for the life mine plan as before and in addition also generating them for the two year operational plan. This will be achieved by increasing the level of detail within the costing module and using a detailed labour module which models labour down to individual designations.

It is envisaged that once the EOM has been implemented a pilot project will commence to investigate using the EOM solution to generate the detailed short-term monthly costing and labour calculations. This will result in a six month rolling budget forecast which integrates into the strategy for a rolling production schedule from CADSmine™. The labour and cost budget will integrate back into SAP™ as the budget against which actuals are measured on a monthly basis.



## 3.2 Integrated into all Planning Horizons

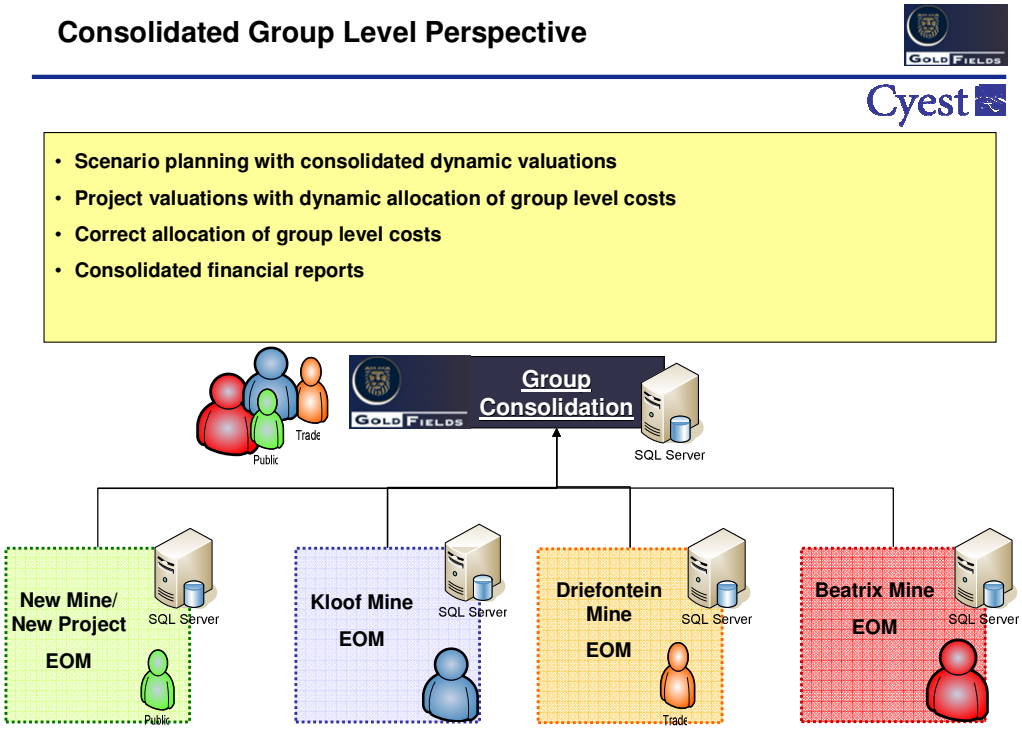
The final solution will calculate the labour and cost budgets for the life of mine strategic plan, the two year operational plan and the short-term monthly plan. This will mean that a single set of rules and relationships will be used for all three planning horizons, resulting in one 'version of the truth' and true integration of short, medium and long term planning.




## 3.3 Consolidated Group Perspective

The EOM solution will include a group consolidation module. This will allow consolidation of individual operational plans into a single group perspective. Scenarios can then be run at the group level as follows:

- Stress testing of overall group against changes in external global assumptions (gold price, exchange rate, inflation).
- Incremental project valuations with true incremental allocations of overhead costs.
- Impact on group of shaft closure decisions and reallocation of overhead costs.
- Group financial statements.




## 3.4 The System Context and Interfaces

Cyest Corporation has developed a proprietary modelling engine that will allow detailed modelling of the operations to any level of detail. The configuration of this model can be done by a business analyst and therefore bridges the gap between IT code and the business rules within the model.

Once implemented the EOM solution will be integrated into the Gold Fields existing transactional and mine planning systems as follows:

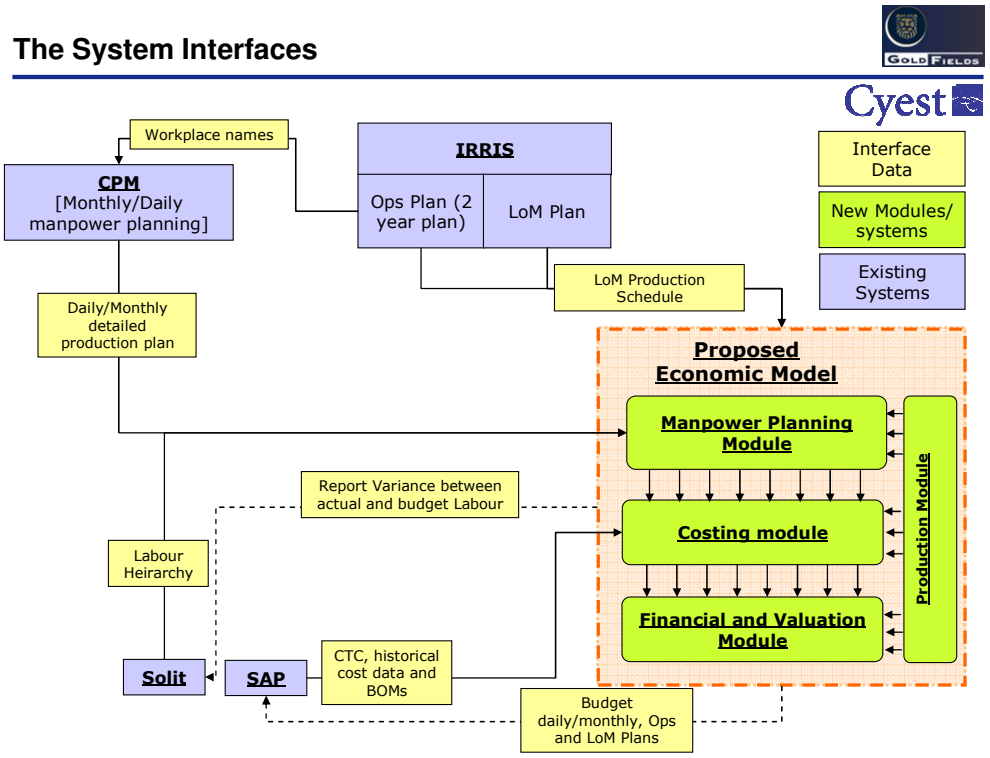
SAP – historical costs data will be extracted so that historical data relationships between costs and production can be derived. In addition standard budget Bills of Materials for standard activities will also be extracted. The budget generated in the EOM for a given production schedule will be exported back to SAP™ as the locked budget.

SOLIT – this is the Human Resources system for Gold Fields. The EOM will extract labour designations and hierarchies to be used to calculate the full labour complement for a given mine schedule. This budget labour complement will be exported back to SOLIT for comparison with actuals and variance reporting.

IRRIS – this is Gold Fields integrated mine planning environment that includes CADSmine™ and Datamine™. Production data will be extracted for both historical production, so that cost relationships can be derived, and for the life of mine and two

year operational plan production schedules, so that the labour and budget numbers for the production schedules derived.

CPM – this is the system that is used for the detailed short-term monthly production planning. Production planning data will be extracted so that labour and cost budget numbers can be calculated for the given schedule.




## 3.5 The Underlying Technology

The workings of the modelling engine are best explained by describing how it will be deployed in the Gold Fields context.

From a generic modelling standpoint an entire enterprise can be expressed in terms of the following interrelated objects –

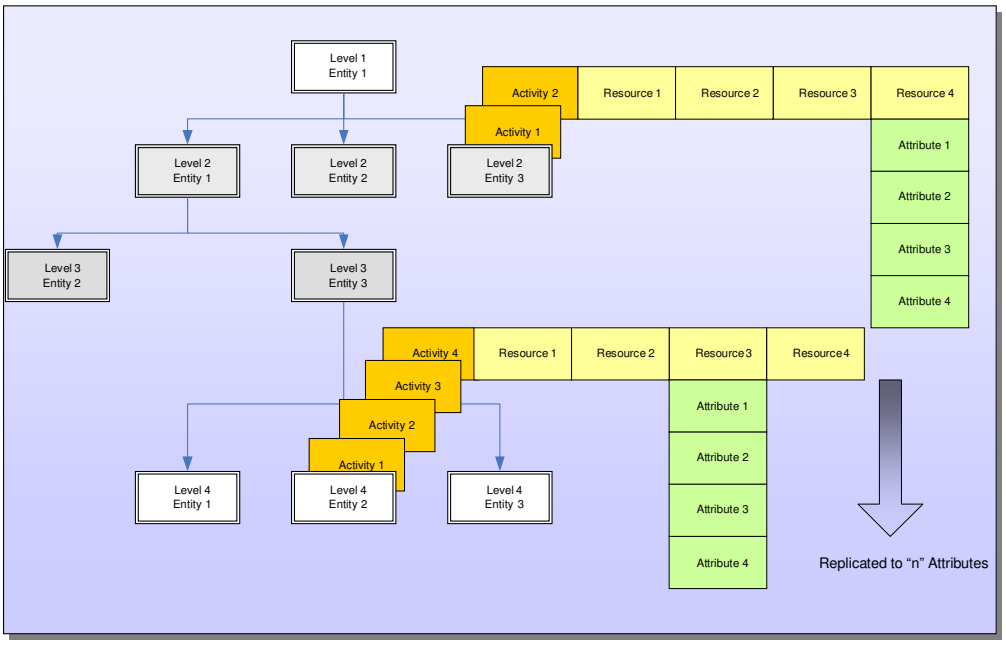
1. Production Entities e.g. Shaft complexes, individual shafts, levels within a shaft, the production sections within each half level where a single production team is deployed, and finally the geological blocks or geozones that make up a production entity. At Gold Fields this has been termed a workplace in SAP™.

2. Each production entity will then be characterised by the activities that occur in that area (e.g. drilling, blasting, tramming, hoisting,)

3. Resources are then assigned to each activity type (e.g. Labour, water, power, drill type, drill steel, and ventilation are examples of assigned resources to the drilling activity). At Gold Fields this has been termed a network in SAP™.

4. Finally attributes are assigned to each resource (e.g. Salary per labour category and efficiencies per experience level are attached. to the labour resource –For the resource "power" the attributes would be consumption rates, maintenance costs and operating costs).

***Generic Object Modeling – A Typical Mine Structure***




Please note that for the mining industry specifically, the modelling object engine has been configured to represent shafts, activities, resources and attributes. However for manufacturing it would be configured to reflect factories, production lines, products, markets etc. For retail the model could comprise branches, regions, promotions and competitors. And for financial services it would possibly reflect customers, financial products, and risk profiles.

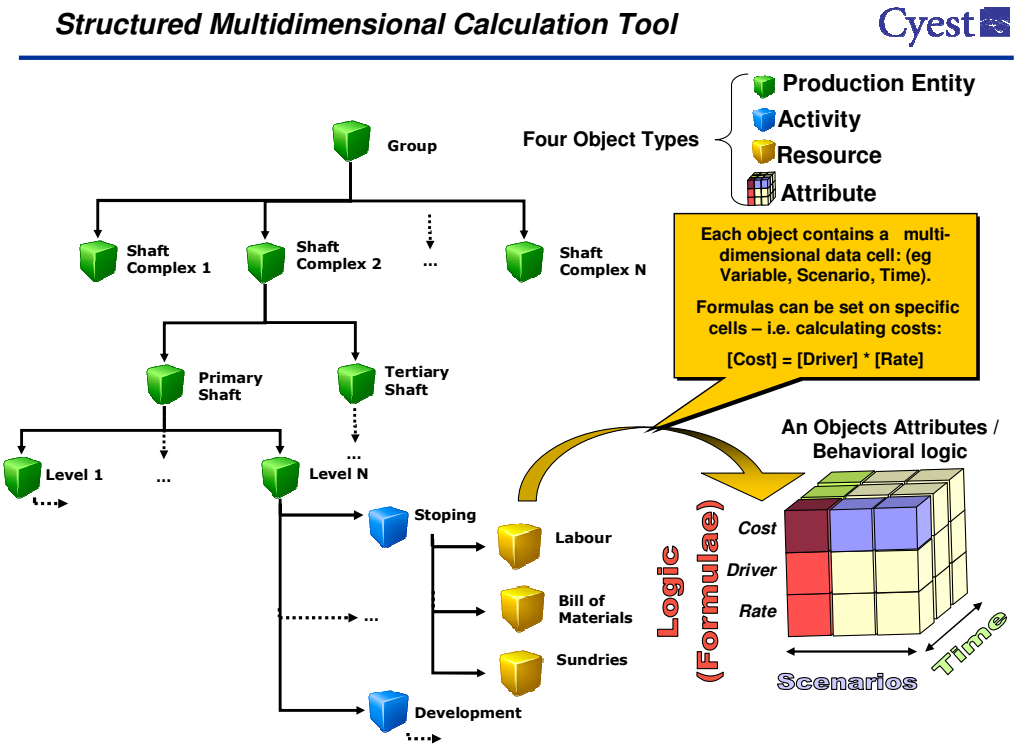
The real power of the software is not its ability to simply create entities, activities, resources and attributes, but rather its ability to interrelate all of these production entities, activities, resources and attributes to each other. This will for example allow for the following detail to be calculated.

> An attribute such as operating cost for the resource "power" will vary according to what activity (e.g. drilling) is consuming the power and also in

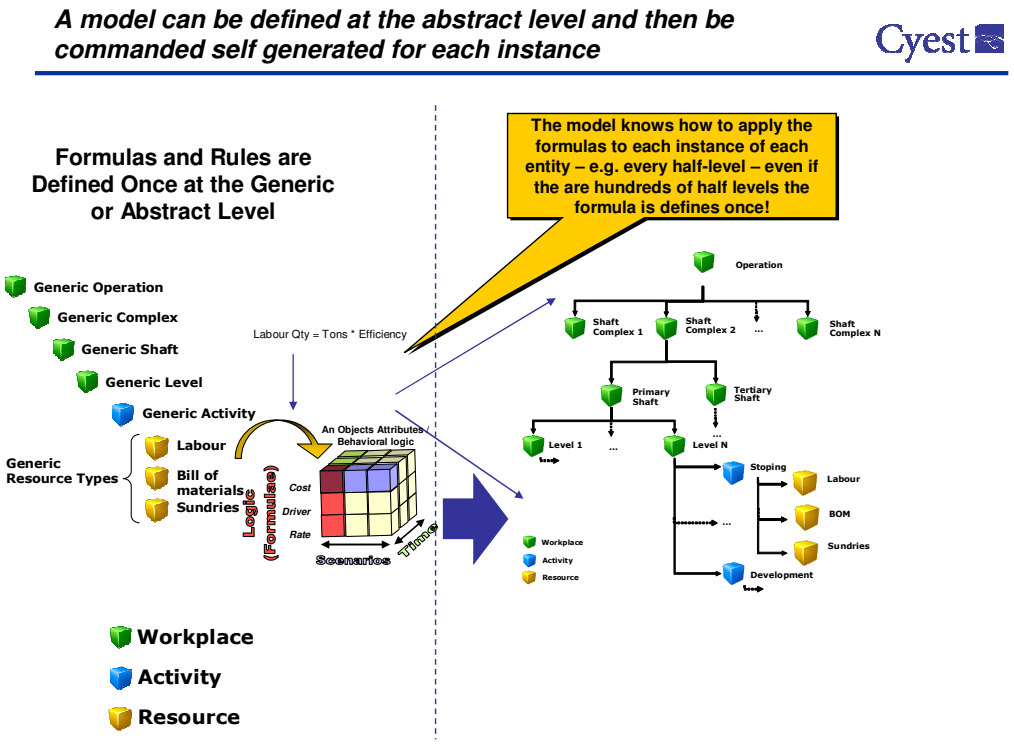
what production entity that activity is operating (for example - different levels will exist in different rock types and the density of each rock type will impact both drill efficiency and power draw).

Similarly, the economics of a production entity will be determined by the activities that occur in that entity (e.g. a different mining method comprising different activities can be tested in the same production entity to compare differences). The output and cost of each activity will be affected by the resources deployed (e.g. what would be the cost and productivity for the drilling activity if two different drill types were used, or two different teams, each with different experience levels, or a combination of different drills and teams).

Moreover the relationship between entities can be made to vary over time. For example – the efficiency of a team can be made to increase over years as presumably the team becomes more proficient. Similarly the efficiency of a piece of equipment can be made to worsen over time due to wear and tear. The rate of wear and tear over time can be made to vary according to the rock type in any given production area.



The tool will allow for a single generic 'palette' of objects to be established which would have been specifically configured for Gold Fields and which can then be used to easily create any number of different configurations of the enterprise on the scenario 'canvas'. In this way a generic model exists that can be configured for any of the Gold Fields operations, irrespective of the number of shaft complexes, shafts, sections or levels. .




Unlike desktop tools, this platform is integrated into existing enterprise systems to create a living dashboard. The resultant models are also fully auditable and Sarbanes-Oxley compliant. Most importantly the modelling capability of the platform exceeds that of spreadsheet tools, and at the same time, presents an intuitive and easy to use interface.

## 4. CONCLUSION

The prototype Microsoft Excel™ based EOM models have been used very successfully at the Gold Fields South African operations over the past three years to assist operations with maximising value through optimising of volume and paylimit, testing and quantifying the impact of different production strategies and more recently to generate financial and labour numbers for the life of mine strat planning.

The proven value of these models has resulted in Gold Fields commissioning the development of a robust enterprise wide solution that integrates into all existing transactional and mine planning systems.

Initially this EOM solution will generate all the labour and cost budget numbers for the life of mine and two year operational plan with the final intention being that this will also generate the short-term monthly budget that will be exported into SAP™ as the budget against which to monitor performance. This will culminate in a rolling forecasting system where a six month rolling production plan will be costed.

Gold Fields will continue developing their mine planning and budgeting systems and processes to enhance the integrity of mine planning and budgeting in order to achieve quicker and better decision making. This will result in a dynamic planning environment that can adjust quickly to a changing gold price and external macro assumptions to derive greatest value for the stakeholders.

## ACKNOWLEDGEMENTS

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