

What is Enterprise Optimisation?

Enterprise optimisation solves the production schedule challenges of mining and processing operations with multiple pits, mining faces and underground mines, multiple metal or mineral products, stockpiling and blending opportunities, and alternative processing options.

The combination of these features creates significant long term planning and analytical problems and opportunities that often exceed the capabilities of commercially available mining optimisation software.

Simultaneous optimisation aims to address all steps in the value chain and all assets in the enterprise portfolio together, and does this while also considering all time periods of the planned operation. This is a crucial additional complexity differentiating mining from other businesses. An ore body is a depleting resource; when we decide what to mine and process in one period, we constrain the available options for all future periods.

Figure 1 below illustrates the point. There is little or nothing that any enterprise can do to improve the resource in the ground or the international market for the products, but all the other steps illustrated in the figure can potentially be optimised.

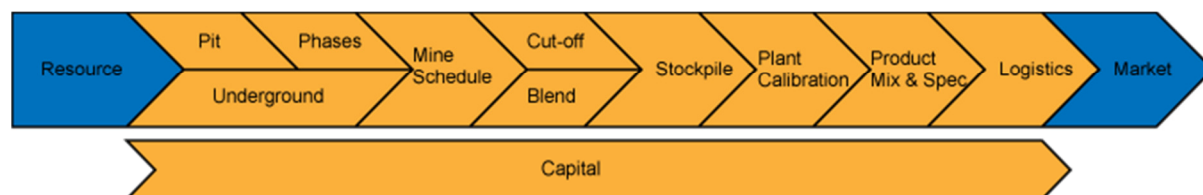


Figure 1: The Generic Mining Enterprise Value Chain

Enterprise optimisation concentrates on optimising the NPV of businesses. NPV is the sum of discounted cash flows, normally calculated or forecast annually. It reflects the time value of money and is considered to be a metric for planning and measuring the performance of any business that will be understood and appreciated by executive management, shareholders and other investors, and all stakeholders.

Philosophically, many mining businesses struggle to identify clear and consistent objectives. For example, maximising metal production, maximising life of mine, minimising costs, maximising resource recovery from the ground, maximising metal recovery from ore mined, and maximising utilisation of equipment are all often cited as being key objectives for operations. However, it is difficult to rank these against each other, and some of them conflict. Enterprise optimisation therefore focuses on a single objective, to **maximise the economic value of the business**.

Application of Optimisation Principles to the Case Studies

The case studies selected for this article provided diverse optimisation challenges in several links of the production value chain. They are used here to illustrate the flexible nature of the mechanisms and techniques applied.

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In all cases, the names of the operation, the parent mining company and the location have been withheld intentionally. Unfortunately since the analyses in each case identified operational strategies which could affect the valuation of the operation and all of the parent companies are publicly owned this is subject to confidentiality agreements.

Case Study 1

Nickel & Platinum Mine

This work was carried out with the author's participation for a large producer of nickel and platinum and related mainly to one specific operating mine. This mine operates seven open pits all within approximately fifteen kilometres of each other and which feed two concentrator plants. Open pit mining is carried out using conventional blasting, load and haul methods and ore and waste are both transported out of the pits using large dump trucks. The ore is crushed and can then be transported and fed to either of the two milling and flotation plants. The flotation concentrate containing PGM and base metals is transported to one of a number of possible smelters for further processing.

The main objectives set for this Enterprise Optimisation study were:

- to facilitate deferral or minimisation of capital expenditure for the next 3 to 5 years
- to evaluate the merits of several alternative operating strategies. These included variable versus capped mining rate, strategic stockpiling of low grade ore, deferral of waste stripping where possible but with smaller short term pit phases to access higher grade ore earlier, consideration of several concentrator upgrade or expansion strategies. Short term operational constraints were provided by the owner's team to inform the investigation and ensure that the objectives were not unrealistic or unachievable.
- to determine the optimal mining rate matching the current concentrator capacity
- to establish the optimum dynamic mining and concentrator processing rates matching current smelter and refinery capacity constraints
- to establish the optimal production rate taking into account the latest ore resource data and applying current cost estimates for possible mine, concentrator and downstream process plant expansions. The downstream plants receive material from other operations and only have a certain amount of capacity available to process concentrate from this operation. This had to be taken into account in the optimisation.

Results

- After approximately three months of activity, a typical waterfall graph was prepared, the format of which is shown in Figure 2 below and was used as a basis to determine the direction of the scenarios.

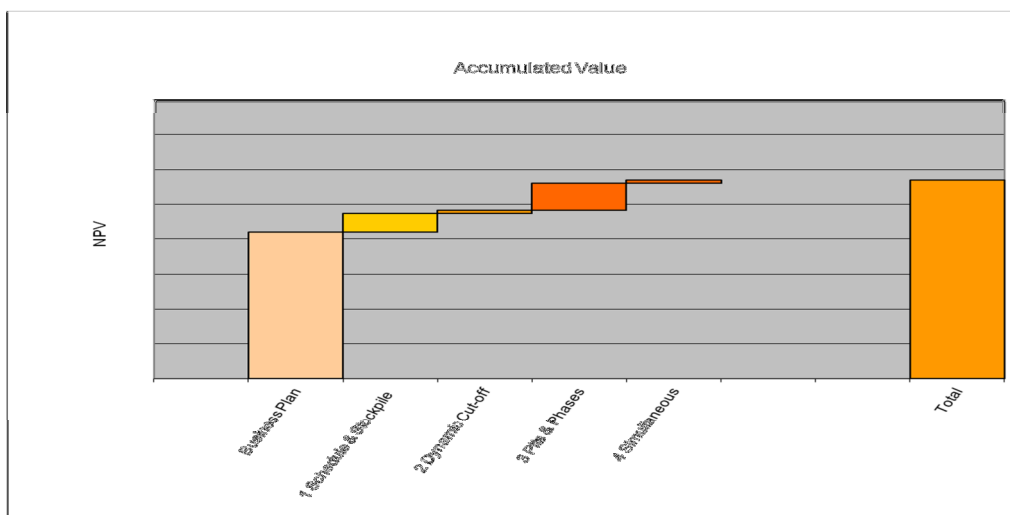


Figure 2: Typical Waterfall Graph Showing the Effect of the Mining Mechanisms

Scenario Planning Including Possible Expansions

The final phase of work on this study utilised a modified resource block model and investigated the likely impact of possible expansion of concentrator, smelter and refinery processing facilities on the mining operation. The following NPV cash flow comparison where the blue line represents the base case and the red line the optimised case gives an understanding of the impact Enterprise Optimisation has on generating significantly more early cash flows. Figure 3

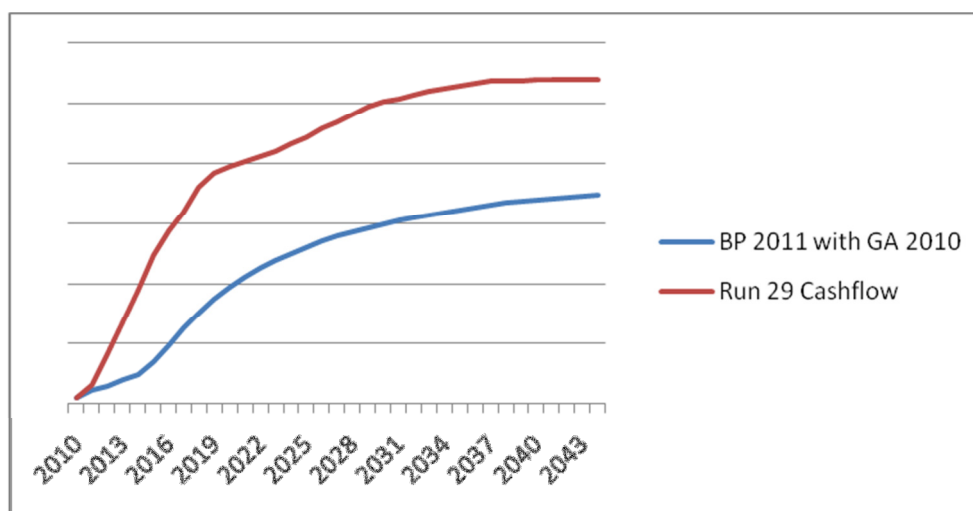


Figure 3: Case Study 1 – Typical Discounted Cash flow Comparison

Case Study 2

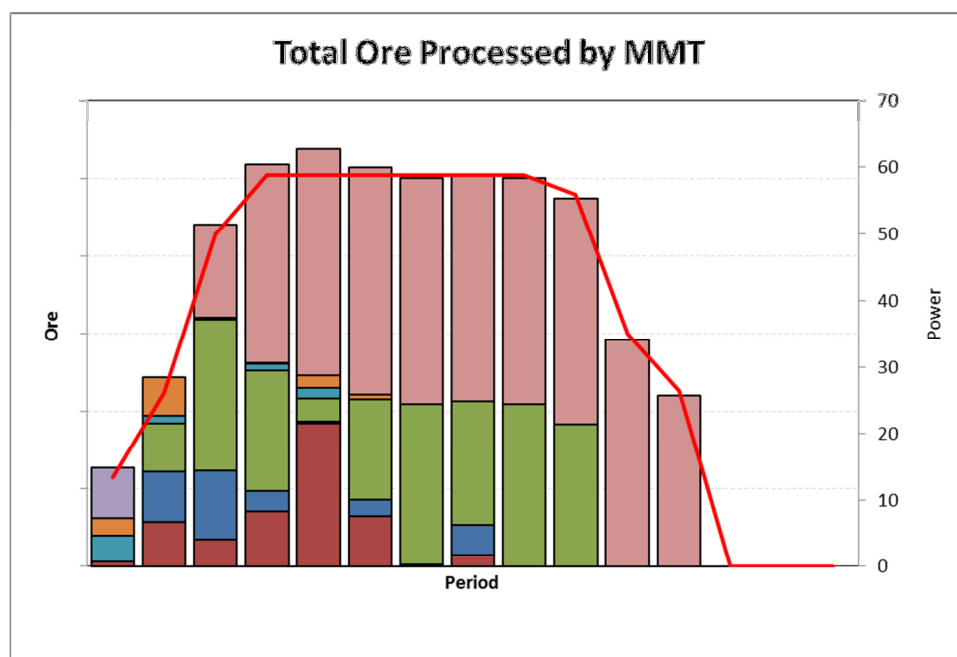
Open Pit Gold Mine with Mill

An open pit gold mine in a remote location was assessed. This operation was power limited. The owners had good information on power usage in the existing operation and they had bond work index data by rocktype. Using this data a power-constrained model was developed and calibrated to the existing operation. This contributed significantly to an NPV improvement of 24%.

The effect of this constraint can be seen in *Figure 4 Open Pit Gold Power-constrained Model*, where the optimizer is able to process more material in the early periods due to the material's lower power consumption. As indicated in *Figure 5 Open Pit Gold Power-constrained model cut-off grade* was another good source of value as the mine had a favorable grade-tonnage curve and also had the ability to stockpile material for later processing. This figure also indicates how closely related variable cut-off grade and stockpiling are. Stockpiling has a greater impact when the cutoff grade is allowed to change.

The cash flow improvement can be seen in *Figure 6 Open Pit Gold Power-constrained model Cash Flow Comparison*.

Figure 4 Open Pit Gold Power-constrained Model



For this study, stockpiling had little effect until a fully-variable cut-off grade was used. The combined effect of cut-off grade and stockpiling added over 6% to the NPV for this project. Pit and phase design utilizing the power-constrained data added nearly 16% additional NPV. This is indicated in the waterfall graph in *Figure 5 Open Pit Gold Power-constrained model*. The effect of these levers on cashflow can be seen in *Figure 6 Open Pit Gold Power-constrained model Cash Flow Comparison*.

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Figure 5 Open Pit Gold Power-constrained model Value Contributions

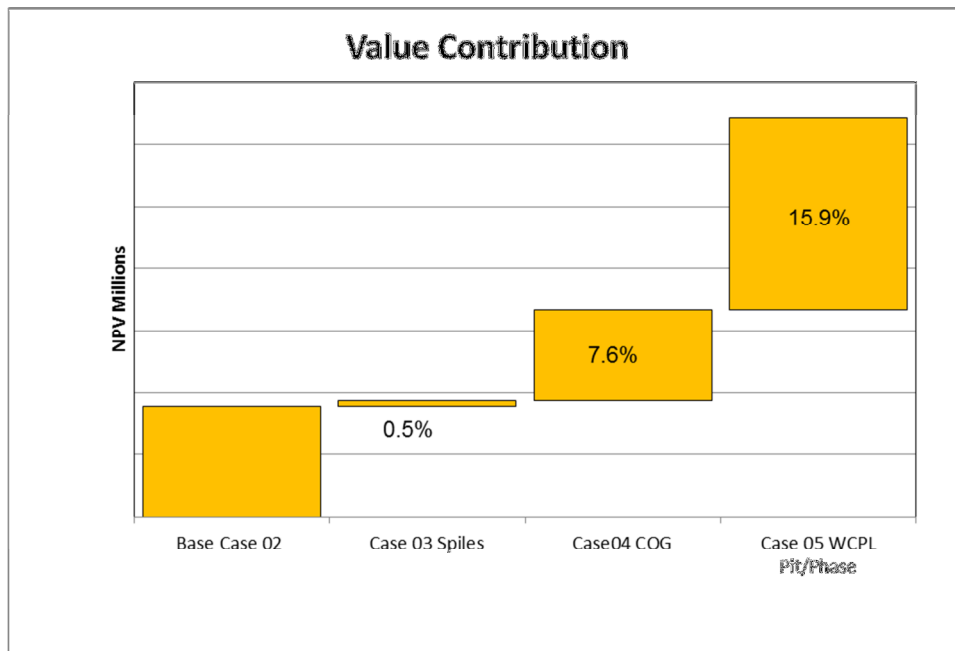
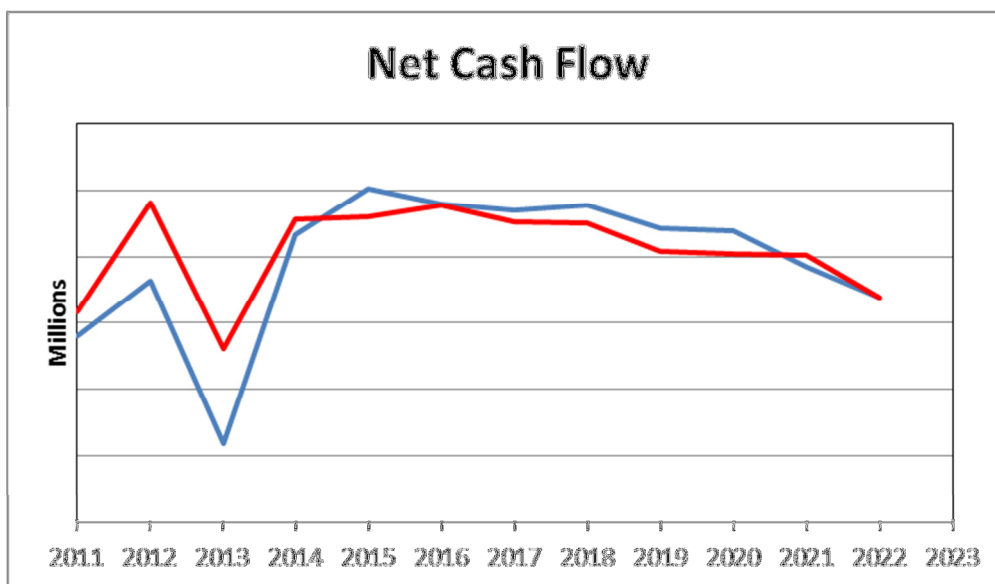


Figure 6 Open Pit Gold Power-constrained model Cash Flow Comparison



Suggested Further reading or viewing

Available at <http://whittleconsulting.com.au/publications.html>

1. **Miners should focus more on cash flow, advises Gerald Whittle, Whittle Consulting** - interview at Mines & Money London, December 2012
2. Case Studies of Simultaneous Mining & Mineral Processing Optimization Applied to Platinum & Nickel Operations
Steve Burks, The Southern African Institute of Mining and Metallurgy Platinum Conference - September 2012
3. Misguided Objectives That Destroy Value
The Orebody Modelling & Strategic Mine Planning Conference - March 2009