Cyest Analytics focuses on economic modelling and optimisation solutions for the mining industry. The offerings consist of modelling software solutions and specialized consulting. Cyest has developed a multidimensional modelling solution called **Carbon** that forms the platform for all the economic and enterprise modelling and optimisation solutions.

The OPEX department forms part of Cyest Analytics and focuses on using the economic modelling solutions created to accurately calculate and derive operational expenditure (OPEX). Over the past five years, the department has focused on applying an activity based costing methodology to their derivation of OPEX in the mining industry but is now starting to apply it into other industries where the same challenges regarding operational cost expenditure estimation exist.

OPEX IN MINING

Historically, capital project teams put in a great deal of effort developing the mine design, production schedule and associated infrastructure capital. The same rigor was not however applied to estimating the necessary expenditure to run the operation and often a shaft level estimate, proxy shaft, or current actuals were used – without a full understanding of the impact of different infrastructure configurations, mining method, depth and distance from shaft and mining efficiencies. Cyest's OPEX department has filled this gap and has gained extensive domain knowledge of OPEX modelling.

Cyest Analytics has developed a solution called ***Carbon$_{Economic}$*** which is an operational modelling and valuation solution used to derive the labour complement and costs per activity for the complete mine. In addition, the OPEX department has developed First Principle Costing Models (FPC) – used to derive detailed costs from first principles, taking into account for example machine moves, cycles times, breakdowns etc.

Based on the past five years of involvement in OPEX modeling on capital projects for multiple clients in platinum, gold, coal and diamonds, the department has developed a database of historical costs benchmarks for particular activities for different mining methods. This information where relevant, first principle costing and in some instances actual achievements by activity are used to model and derive expected OPEX for a life of mine.

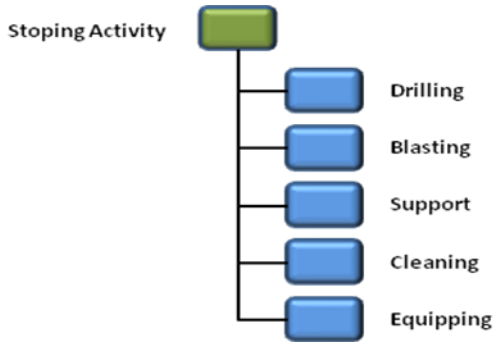
The solution allows for a mine schedule to be imported and rapidly costed allowing for rapid comparison of alternative production strategies, schedules and options.

The risk associated with OPEX cost variation is now also being modeled where the underlying variables impacting costs each have a variability and confidence level allowing for an aggregated confidence level and variability to be calculated for the final OPEX estimates.

ACTIVITY BASED COSTING

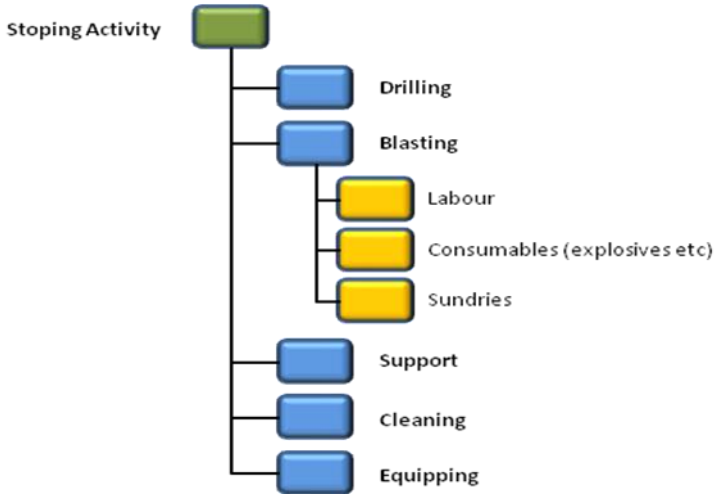
An activity based costing methodology relies on an in-depth understanding of the operation/ business core processes and activities and calculates the resource inputs/costs associated with each activity. Each activity in turn can comprise sub activities which in turn comprise cost resources.

For example: in the mining context, stoping can be regarded as an activity with five sub-activities namely drilling, blasting, support, cleaning and equipping.



Each sub activity is analysed to determine its individual cost resources, cost drivers and cost nature (fixed or variable).

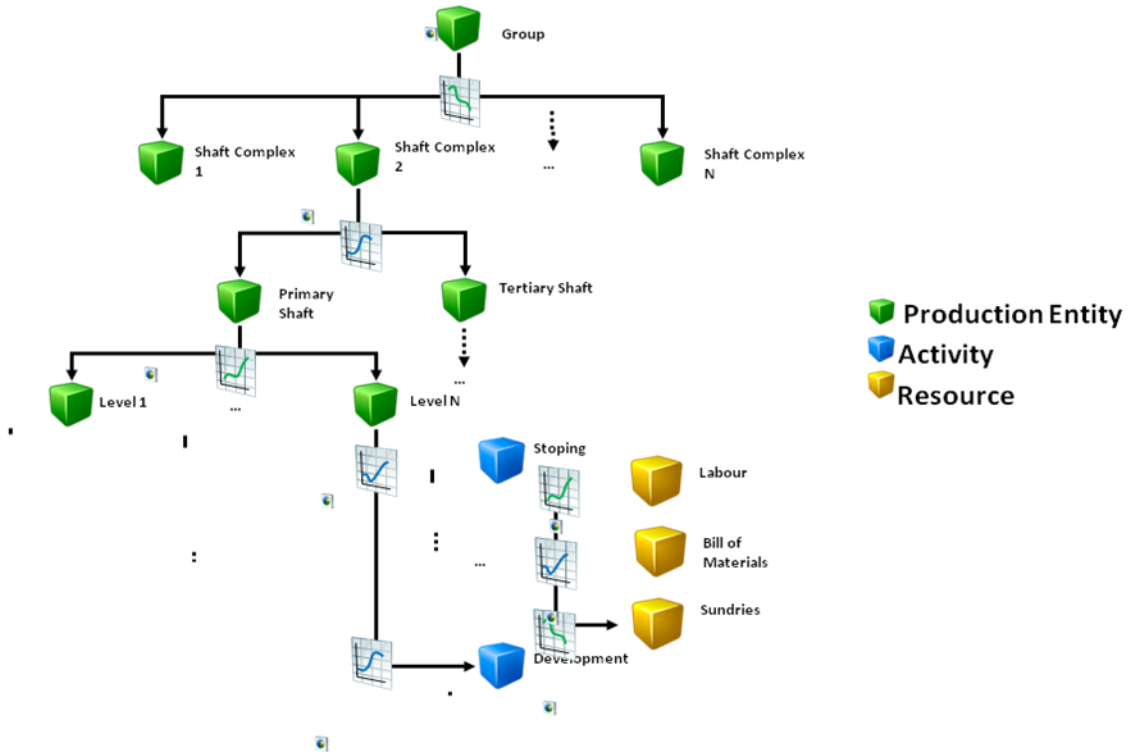
For example: the blasting sub-activity incurs costs from explosives, and explosive accessories consumables, labour required to conduct the activity and sundry costs associated with labour. The cost drivers of these cost resources are related to the blasting pattern, consumptions rates and labour cost and team efficiencies.



For each sub-activity, fixed and variable costs are either derived from historical cost achievements, first principle and / or zero based cost models. These costs are included in an activity based costing model that incorporates all activities, sub-activities and cost resources and is driven by the relevant cost drivers as identified in the analysis portion of the study.

All labour requirements are determined using first principles. For each sub-activity, labour teams are compiled representing the various job types. For each unique job type, labour rules are applied that govern how that job type changes either as a function of infrastructure, additional business process, other labour or based on efficiency.

An aggregation of all cost resources, sub-activities and activities across the configured business yields the resultant activity based OPEX cost.



The ***Carbon**Economic* solution developed is an activity based costing tool that enables the application of this methodology across industries and business processes. The solution has been developed to capture capital and working costs as well as any global parameters that may influence the determination of NPV's and cashflows. This will enable not only the determination of working cost budgets, but also capital budgets, cash flows and value of the scenario being modeled.

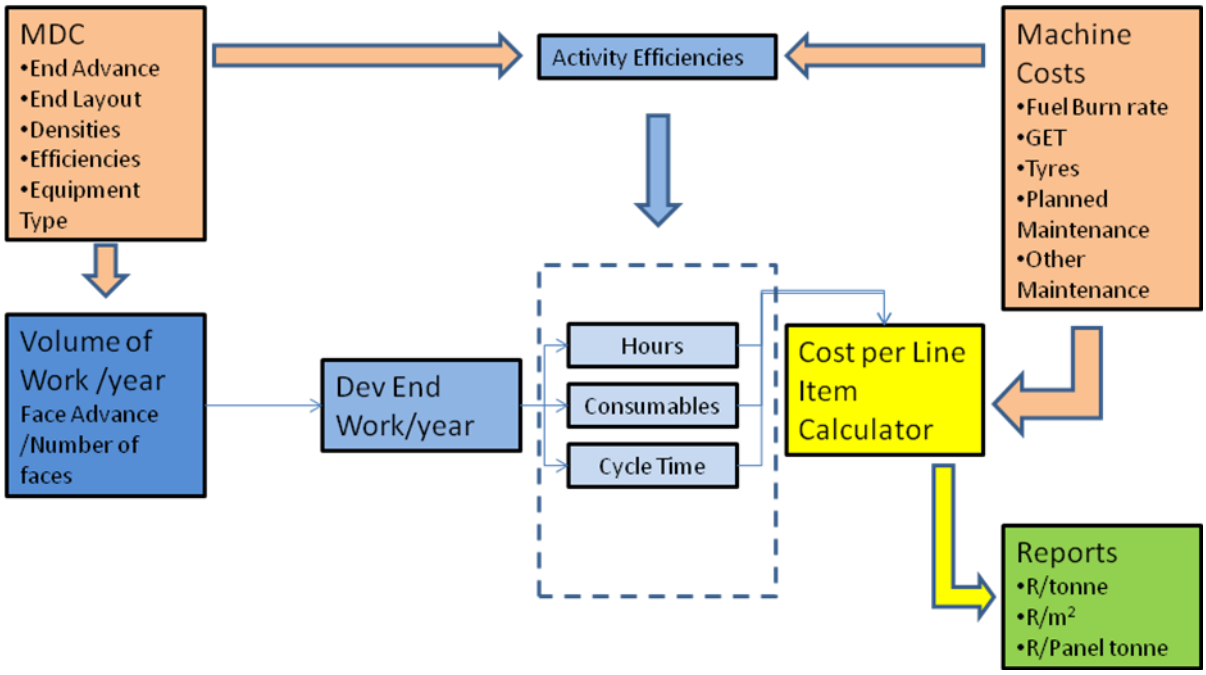
FIRST PRINCIPLE COSTING

As new technologies, mine designs and mining methods are developed, these influence the activities and business processes being conducted in the operation. Thus, to obtain a credible view of costs, this new technology or process may need to be costed from its most primary cost drivers from first principles, as no historical benchmarks are available.

One such example is the first principle costing model developed for mechanized mining. The introduction of low profile, extra low profile, ultra low profile mechanised machinery and hybrid mining methods have given project teams more options to evaluate. The OPEX department has reacted to this need by extensively understanding the sub-activities of this method of mining and the constraints imposed. As a result, Cyest Analytics have developed a first principle costing model for mechanized mining.

The model considers inputs such as fuel burn rates, maintenance philosophies, tyres, mine layout and dimensions, machine efficiencies and a full equipment list – items that are used to determine the hours of operation for each machine and hence, each sub-activity. The operating hours are then costed in line with either supplier quoted rates and agreed on costs with the client. Using the cycle

times planned, the total costs per sub-activity is determined and included into the activity based costing model.



Following the success of the first principle costing model for mechanised mining, the OPEX department has also invested in the development of a first principle cost calculator for engineering – with a focus on the derivation of maintenance costs of major engineering equipment. This is especially valuable in calculating the operating costs of a shaft or decline system taking statutory regulations around inspections into account.

The philosophy behind the modelling of maintenance costs is to establish the number of maintenance tasks that need to take place in a specific period, and multiply this number by the cost per task. This is done for a specific task, for stores, spares, sundries and contractor costs, for that task. This approach is consistent for planned, predictive and breakdown maintenance. The main difference in the determination of these costs is the establishment of the frequency of the maintenance tasks.

As described above, the difference in the planned, predictive and breakdown maintenance is in the actual determination of the frequency that each activity takes place. In the model, this is uniquely determined for every discrete maintenance task.

For the planned maintenance task, the time between repairs is used as a driver input that is in effect when the unit or component is active. In predictive maintenance, there is a mean time to repair based on a driver parameter (operational time, tonnage etc). The breakdown maintenance task takes place on a mean time to repair basis, based on a hazard function, as described above. In the establishing the hazard functions a number of key assumptions were necessary:

The input parameters necessary to approximate the hazard function, as illustrated in figure 3, are as follows:

- K_1 - the hazard rate at the constant failure phase of the lifecycle
- K_2 - the hazard rate at the very end of the lifecycle
- T_1 - the time to the end of the constant failure rate
- T_2 - the time of the end of life of the lifecycle
- T_r - the replacement time of the component or unit

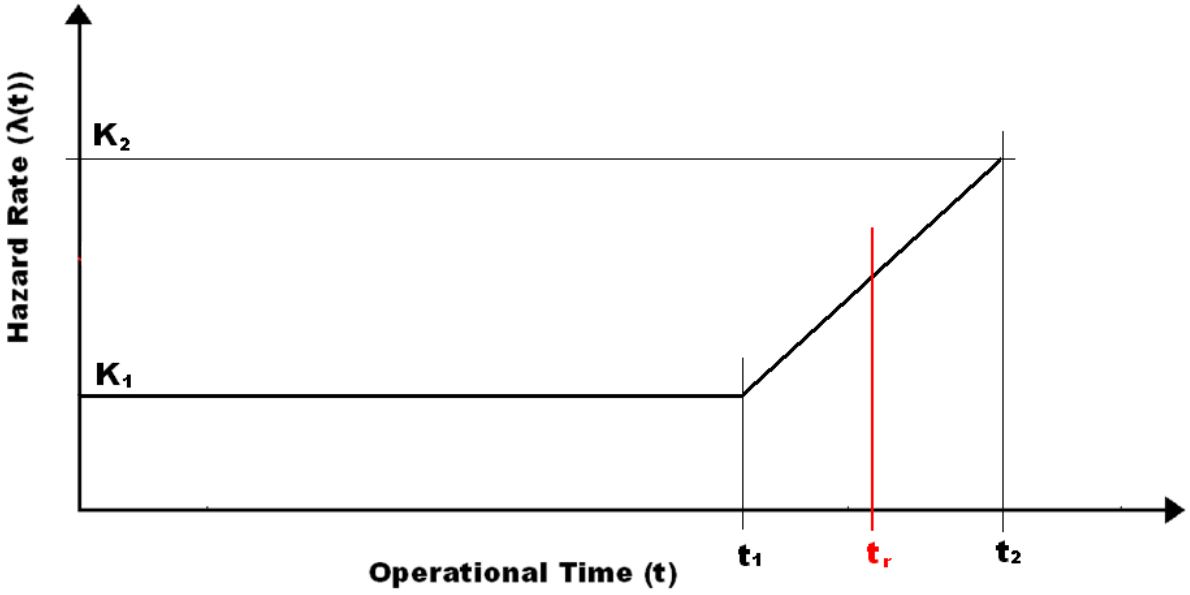


Figure 3: Hazard function format used in the model

With the establishment of task frequencies for the different types of maintenance, the calculated costs of the different types of maintenance per unit are a function of:

- The design parameters,
- The frequency at which tasks need to be completed in a period,
- The cost of the tasks,
- And the tasks themselves.

ZERO BASED COSTING

Zero Based Costing refers to the determination of costs using an existing bill of materials and historical utilisations. This approach is typically used when a sub-activity follows similar specifications as historical sub-activities but has a slight change, rendering the historical costs not applicable. In this instance, a database consisting of detailed consumable line items complete with unit prices and historical usage is used and reconfigured to match the revised requirements.

For example: Suppose a mining operation currently employs a conventional mining method using emulsion explosives. The project team is investigating a conventional mining method using anfex explosives.

Historical costs will be used for all mining activities similar to the current operation and in the case of the explosives, these costs will be determined using the zero based costing database. All consumables required for blasting (explosives and explosive accessories) will be determined using historical line item utilisation configured in line with the revised blasting and drilling patterns to obtain an applicable explosive cost. This cost will be added to the applicable historical costs to obtain a revised cost per sub-activity which in turn is used as input cost rate into the activity based costing model.

Through our five years of experience in this field, the OPEX department has obtained a mining consumable database that reflects most mining practices employed across the industry coupled with supplier quotes and costs. This database contains embedded logic to determine explosives, support cleaning and drilling costs.

OPEX MODELLING METHODOLOGY

The OPEX methodology employed focuses primarily on full absorption activity based costing (where cost inputs are sourced from historical cost achievements, supplier's quotes, first principles or zero based models). Depending on the type of study in which we are involved, costs span consumable line items that comprise the respective bill of materials or higher level aggregated costs for studies that require lower levels of confidence (such as concept or pre-feasibility studies).

The structure of the activity based costing model aligns with either the existing or planned cost tracking systems (ERP System) at the business to ensure accurate cost tracking after Cyest's involvement in the study. This will also ensure that our clients can credibly benchmark results at any level of the model.

In most instances of our involvement, the OPEX department conducts extensive benchmarking of all results derived and has recently offered the service of stochastic modelling on specific cost levers to accurately determine contingencies.

OTHER INDUSTRY APPLICATIONS

Although the services offered by the OPEX department have been predominantly in the mining industry, the nature of activity based costing is not industry specific. The methodologies described in the text above can be applied to any industry.

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