RPMGLOBAL

Making Better haulage decisions through Discrete Event Simulation

Mine haulage is often the one of the highest cost components of the mining process. In the current climate, pressure is on mining companies to move more material with the same or less equipment forcing them to look closely at latent capacity in the current fleet. Large mines are becoming increasingly complex as they push to move large volumes of material to maximise the value of their mine assets.

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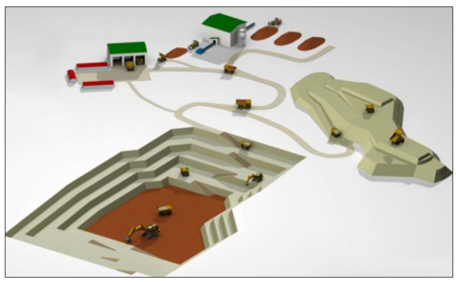
The mine haulage process in, and of itself, is a relatively simple one. A truck drives to a source location, gets loaded, and then it drives to a destination and gets unloaded. Most models used to calculate trucking requirements at mine sites model this process.

This traditional approach is appropriate in many mine planning situations, such as estimation of fleet for a life of mine plan. However it is not suitable for analysing some of the more complex problems presented at modern mines.

Modern mines have complex mine haulage systems made up of multiple loading units and trucks that are often different sizes to move different types of material from multiple sources to multiple destinations. Another challenge to the modeller, is that haulage systems are dynamic, with a number of variables constantly changing, including:

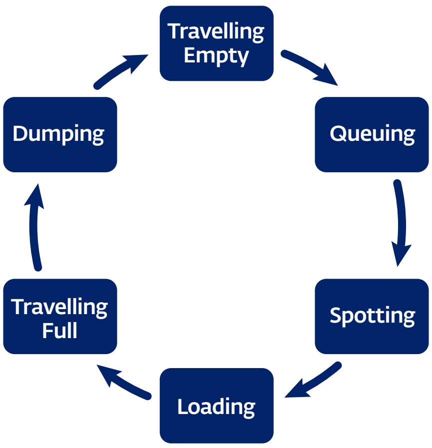
- the haulage network itself;
- throughput targets;
- road conditions;
- equipment availability; and
- interaction between trucks and other infrastructure.



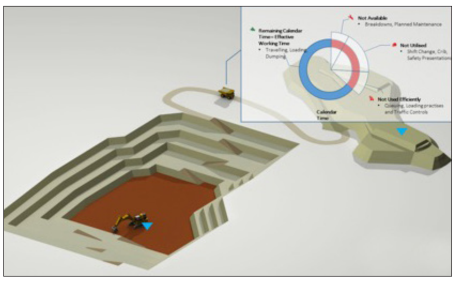
Traditional Fleet Estimation Techniques

Traditional fleet estimation techniques simplify the complex mine haulage system into a number of independent haulage routes. For each haulage route, calculations will be completed for truck travel time, dumping and loading time. Normally a traditional model will consist of:

- A loading unit loading a single material type from a source to a single destination;
- A single truck type and
- A cycle time across the haul road between the source and the destination.



There is an acknowledgment that there the trucks and loading units are not always working. There will be time when trucks are not available because it requires maintenance, and there will be times when a truck is available and it is not utilised because the operator is having lunch. Allowance for these times when the equipment is not working is made through the use of factors that effectively remove time from the calendar. Other factors that reduce the efficiency of the mine haulage system like interactions between the equipment, queuing and traffic controls is accounted for through further reductions in time available for the trucks to operate.



These factors are derived in many different ways across the mining industry. Some will attempt to create a time usage model based on time in motion studies. Others will use accepted industry standards, or factors based on past experience. Sometimes these factors are derived using information from a Fleet Management System (FMS).

Fleet Management Systems are used at many large sites to help manage the mine haulage system. One of the key features of a FMS is the ability to allocate trucks to loaders units to both meet production targets and maximise the utilisation of equipment. Fleet management systems also are able to collect a lot of data about how the haulage system is performing (tonnes moved, utilisation and availability). Additionally they collect high level statistics about fleet performance, as a lot of detailed information is collected about the way the fleet operates. It is not unusual for equipment to be fitted with GPS instruments, collecting precise location and speed information. Information about how the equipment is being used 24/7 is also collected detailing maintenance and process delays.

Detailed information from FMS are rarely used to model future fleet requirements. One of the reasons for this is that it does not fit into the simple haulage models described above. All of the details are aggregated into a few factors that are applied to the whole fleet equally.

Modelling Mine Haulage using Discrete Event Simulation

Discrete-event simulation (DES) is a modelling technique that is widely used to model complex systems. One of the major advantages of discrete event simulation models, is that they can be built to reflect the way that complex systems actually operate, including the variability, interactions and dependencies that occur in these systems.

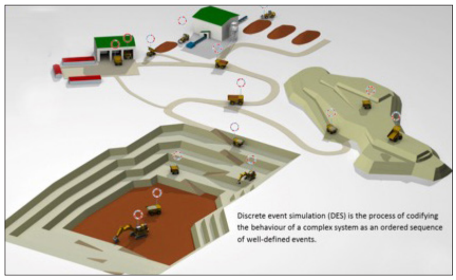
Some advantages of discrete event simulation over other methods of modelling are that they are:

- **Stochastic:** some variables are random;
- **Dynamic:** the models evolve over time; and
- **Discrete-Event:** changes occur at discrete points in time.

Discrete event simulation models can be used to analyse problems that cannot be modelled using traditional fleet estimation techniques. Some examples of the types of problems suitable for modelling using discrete event simulation include, but are not limited to:

- Management of queuing at stockpiles and crushers;
- The impact on production due to one lane roads;
- The placement of passing bays in underground operations; and
- The production benefit of ore passes versus direct loading in underground operations.

Examples of challenges that have been analysed using discrete event simulation are discussed later in this paper.

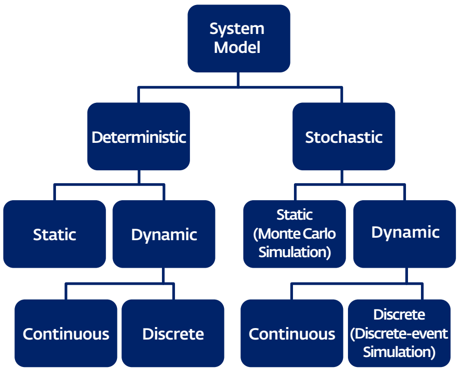


Discrete event simulation is not new to the mining industry, however its use has been limited to large mining companies and consulting groups with specialist modelling skills. The reason for this is that software that is used to create discrete event simulation models are not designed to be used by mining companies. They are designed as a toolbox of functionality that can be applied to many industries including:

- Manufacturing;
- Banking;
- Container terminals;
- Health Care; and
- Traffic management.

Mining is different from other industries. It is dynamic and equipment characteristics are not simple to model as estimating the travel time for various trucks across a network of roads is a challenging problem that is difficult to solve. Mining professionals that understand the problems associated with mine haulage and some of the approaches that should be investigated to mitigate the problems are not normally able to set up complex scripts to run simulation models.

Discrete event simulation models look at the problem of mine haulage in a different way from the traditional approach. Utilisation for example is an output from the simulation rather than an input. Instead of applying a utilisation factor, the events that stop equipment from being utilised are modelled as individual events (lunch time, shift change, refuelling and queuing) independently for each piece of equipment in the model.



Each of these events can be modelled using either fixed times or randomly generated times. Examples of random (stochastic) variables that effect modelling of fleet management are:

- **Delays:** Breakdowns, refuelling, crew communication, meal breaks, shift change.
- **Load Time:** The time to load a truck will vary depending on the type of material that is being loaded and the skill of the operator.
- **Travel Time:** The time to travel from point A to point B may be effected by the operator, the weight of the load in the truck, the weather, lighting or road conditions.

The time taken to complete each of the tasks that it is assigned during the modelling process can be influenced by settings in the model used to add variability (delays) and interaction with other objects that are being modelled (queuing may take longer if the loader breaks down or if there are too many trucks).

How Discrete Event Simulation helped our customers Examples of Decisions Made Using Simulation

SCENARIO 1

CHALLENGE

As one of the largest gold producers in the world, our client experienced challenges in estimating how productivity levels would be impacted by changes in the geometry of their underground mining operation. From an operational perspective, the changing geometry meant an increase depth of the production sources and a corresponding decrease in ore pass capacity. Due to the potential adverse effect this could have had on productivity levels, our client needed to confirm that the operational strategies identified would mitigate the associated risks with changes in geometry.

As a result, several questions and concerns were raised:

- With a decrease in surge capacity, how often would ore passes run empty?
- As mining progressed down to the haulage level, what would the impact on production be of loading the trucks directly from draw points?

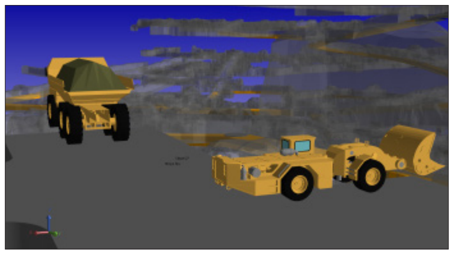
As mining continued to progress, there was an increasing need for a sustainable simulation solution. Prior to engaging RPM, there was no clear ROI on money spent on an existing system that was difficult to use, slow to update and didn't have 3D simulation capabilities.

SOLUTION

As a result, our client was able to better understand the impact of equipment and infrastructure changes and ROI before implementing the changes on-site.

RPM was engaged to implement HAULSIM, enabling our client to develop several Discrete Event Simulation models based on real data from their mine. With this, an overarching, calibrated (Base Line) model of the current operation was developed to illustrate the impact the planned changes. Scenarios covered using this Base Line model included:

- What would be the effect of adding another truck to the system?
- What would be the effect of adding another bogger to the system?
- Would the construction of a new passing bay to relieve congestion?



Each scenario was modelled on top of the base simulation to show the effects on total system productivity as the mine developed over a 3 year period. Along with this, quantifiable data was used to simulate the most cost effective strategy to improve equipment interactions and reduce overall truck travel time. Consequently, the site could effectively plan with full understanding of the outcome.

SCENARIO 2

CHALLENGE

Based in Chile, our client was having problems understanding the true cost of congestion throughout the operation. Congestion bottlenecks were not hard to find. A number of projects were already identified. Projects included realignment of intersections and changes to ramp geometry. The difficult part was assessing the benefits of the changes to accurately justify and prioritise expenditure.

SOLUTION

The design of an intersection at our client's mine was modified to dramatically reduce the distance driven by equipment, increasing overall production by 5% and reducing congestion by 9.5%.

Using HAULSIM, our client could model the impact of congestion at critical areas in their mining circuits. Comparisons between the calibrated Discrete Event Simulation model and the models with the improvements indicated the impact of those changes on the bottom line. Specifically, our client inputted the following targeted data from their mine to generate realistic simulations on each improvement initiative to validate assumptions:

- Transportation routes
- Mine movement (planned or actual)
- Mining equipment
- Mine Plan
- Time and event description model
- Speed profiles and restrictions
- Traffic rules
- Light equipment interference
- Mine infrastructure.

SCENARIO 3

CHALLENGE

In response to low commodity prices and difficult mining conditions, our client used HAULSIM to validate productivity estimates. Productivity was the key driver to the success or failure of the project. Prior to implementing HAULSIM, calculating productivity was difficult due to the interactions between equipment that were expected to occur in the pit.

SOLUTION

HAULSIM helped to identify the best approach to mining by understanding the key operational risks before moving into the next phase of the project.

HAULSIM provided a solution that was powerful, easy to learn, and simple to use. The 3D user interface ensured that the model setup was realistic. Within a matter of weeks, following implementation, our client was using HAULSIM to accurately validate productivity assumptions in their current operations as well as carry out risk management by simulating "what if" scenarios of their future mining operations.

Our client inputted data from their mine to calibrate HAULSIM's simulation activities, producing a model that provided a detailed view of the dynamic system components working together across the mine and the impact the proposed changes would have on productivity.

Using Discrete Event Simulation to simulate additional multiple scenarios, our client was also able to quickly explore and analyse different mining configurations.

SCENARIO 4

CHALLENGE

In the 'age of productivity', mining companies are exponentially increasing cost-saving strategies with an emphasis on ROI. As part of their own operational improvement charter, our client needed to identify ways to dramatically reduce operating expenditure across selected operations.

SOLUTION

Overall, our client reduced operating expenditure by 15%, exceeding mine KPI's. Our client found their winning formula though the use of HAULSIM.

Using HAULSIM, our client was able to input their mine plan and short-term operating strategy data and run a series of "what if" simulated scenarios which allowed them to:

1. Investigate bottlenecks in the operation to put together an improvement priority project to reduce operating expenditure in the following areas:
   a. On-bench scenarios – vary dig rates, loading, and queuing strategies;
   b. On-ramp scenarios – electric versus mechanical drive trucks, retard gear strategies (lower gear to save tyre life or higher gear for improved performance with faster cycle time); and
   c. Ex-pit intersections – traffic rules with general overtaking, park-up bays and optimisation of truck bays, refuelling strategies and general pit execution.
2. Identification of congestion limits comparing their Life of Mine Plan, HAULSIM simulation results, and the results of an optimised scenario. In doing so, our client was able to identify that using 5 – 6 diggers to feed a principal ramp increased optimum productivity levels.

Conclusion

Although mine haulage is one of the highest costs areas our mine haulage modelling techniques have lagged behind techniques commonly used in other industries. The simple haulage models that are appropriate for estimate fleet requirements are not appropriate for modelling complex mining operations. Significant decisions are being made about complex systems using either simple models that are not representative of reality based on minimal information.

Uncertainty has long been accepted and integrated into our simple haulage models with the application of assumptions based on 'best practice', 'industry knowledge' or 'past history'.

Technology now provides the tools and data mining engineers require to make informed decisions about the complex mining operations that they manage. DES not only validates ll of these assumptions, it provides mining operations with a tool that can significantly impact the bottom line positively. Mine haulage no longer needs to be a significant cost. It can be an area of efficiency which increases productivity, reduces cost, and adds value to the bottom line.

We can do so much better using DES to validate assumptions and no longer need to accept uncertainty in mine haulage.

To learn more about how HAULSIM and DES can add value to your mining operation, contact RPMGlobal.

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