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DISCRETE EVENT HAULAGE SIMULATION

MAKING BETTER DECISIONS WITH REDUCED UNCERTAINY

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It is widely understood that mine haulage is one of the highest cost components within the mining process. The current economic climate presents heightened pressure to maximise the value of current haulage systems and drive down costs; doing more, with less. It is also important to ensure that production is not compromised as a result of any cost saving initiatives.

Operations are not only becoming increasingly complex as mines become deeper and larger, but with the current slump in commodity prices, they are under great pressure to move more dirt with the same or less equipment. These conditions (complex operations and cost pressures) are forcing mining companies to look closely at latent capacity in the current fleet.

Traditionally, modelling and analysing mine haulage has been done using simple models. These models usually consist of a single loading unit and a fleet of trucks moving material from one location to another. The current mining environment is much more complex, made up of multiple loading units and trucks that are different sizes that move material from multiple sources to multiple destinations. At most modern mining operations, simple models have limited application.

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Discrete-event simulation is a modelling technique that is widely used to model complex systems. This article will explore the concept of discrete-event simulation and its application in today's modern mining operations.

Traditional Mine Haulage Modelling

Mine haulage is a simple process. A truck drives to a source location, gets loaded and then it drives to a destination and dumps its load. Most models used to calculate trucking requirements at mine sites model this process.

When modelling mine haulage, it is acknowledged that there will often be times when trucks are not available and utilisation of the trucks will not be perfect. Models are modified using factors based on past experience. Sometimes these factors are derived using information from a fleet management system.

If there was one truck and loader fleet operating by itself at a mine, the above scenario might be an accurate description of mine haulage. Unfortunately, mine haulage is more complicated at most modern mining operations and simple models like this have limited application.

Modern mines use complex mine haulage systems made up of multiple loading units and trucks, that are often different sizes, to move material from multiple sources to multiple destinations. The complexity of modern mines means that mine haulage systems are dynamic, responding to changes to numerous variables including:

- The haulage network itself
- Throughput targets
- Road conditions
- Equipment availability
- Interaction between trucks and other infrastructure

Fleet management systems are used at many large sites to help manage the mine haulage system. One of the key features of a fleet management system is the ability to allocate trucks to loading units to both meet production targets and maximise the utilisation of equipment.

Data from fleet management systems is used to report on how the mine haulage system is performing. Key metrics of the performance of the system include

tonnes moved, utilisation and availability. As well as high level statistics about fleet performance, a lot of detailed information is also 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 what the equipment is doing is collected 24/7 and details maintenance and process delays.

Comprehensive data from fleet management systems is available, but is 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.

Discrete-Event Simulation

Discrete-event simulation is a modelling technique that is widely used to model complex systems. Other industries that use discrete-event simulation include manufacturing, materials handling, healthcare, packaging and logistics.

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

Discrete-event simulation models can be built to reflect the way that complex systems actually operate; including the variability, interactions and dependencies that occur in these systems. Diagram 1 shows this system model classification.

Some examples of stochastic (random) 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.

Discrete-event simulation models are very useful when components of systems change states at discrete points in time as a result of specific events. For example, the state of a truck will normally change at discrete points during a haulage cycle.

Diagram 2 highlights the typical truck states.

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

Once a model has been created and calibrated, it can provide insight into how the system operates in real-life. Proposed operational changes can be modelled before they are implemented to understand the effects of the decisions on the whole system. The effects of the changes can be quantified which is particularly helpful when changes require capital investment or justification.

Discrete-event simulation models have been used to:

- Improve equipment utilisation
- Reduce waiting time and queuing
- Study alternative investment ideas
- Evaluate cost reduction ideas
- Train operators in overall system operation
- Support day to day decision making

- Minimise the effects of breakdowns
- Understand the impact of mixed fleet interactions

Discrete-event simulation has been used in the mining industry for some time, however it has been limited to large mining houses and specialised consultants because of the skills required to operate the software. Traditionally, models have not been managed by the in-house mine planning teams of mining companies. Simulation models received by external consultants become out of date soon after they were prepared. The dynamic nature of mining makes it difficult to keep models up to date with road networks that represent the routes changing almost daily.

The Future: Discrete-Event Simulation in Mining

This paradigm is about to change with the recent introduction of 3D discrete-event simulation software, designed specifically to model mine haulage systems.

Having a better model of a mine haulage system, means that we can quantify the impacts of changes. Decisions on changes to a mine haulage system can be based on real data rather than gut feel. Some examples of the types of questions that can be answered with discrete-event simulation models are shown below.

I can't get more than 80% utilisation from my crusher. About 10% of the time the crusher is waiting on trucks and at other times during the shift I have trucks waiting on the crusher so that they can tip:

- Do I have enough trucks to keep the crusher full?
- Should I have a stockpile near the crusher and invest in an extra loading unit?
- Does the crusher itself have enough surge capacity?
- Should I stagger the start time of the trucks?

I have a mixed trucking fleet consisting of large slow trucks and smaller fast trucks:

- Will the overall fleet productivity be improved if I keep the fleet separated rather than running them together?
- If the fleet is mixed, how often will 'fast' trucks get stuck behind 'slow' trucks?
- If the fleet is mixed, should I have areas where trucks can pass? Will the increase in production justify the expenditure for the passing lane?

I have an underground mine and there is a lot of interaction between trucks on my haulage level. They are moving ore from ore passes to a crusher. The crusher is not always fully utilised:

- Should I add a bypass so that my trucks can pass each other?
- If I add an extra truck, how much extra productivity will I get?
- Should I add extra stockpile capacity near my crusher?

We are planning an expansion of our operation and have quite an aggressive target production rate. We have two intersections that will handle most of the traffic:

- Can I model the traffic flow to see if there will be excessive waiting time?
- What if I build a round-about at the intersection rather than putting in a stop sign?

I am pre-stripping in front of my dragline and have a long haul to get to the waste dump:

- Should I add a temporary bridge to minimise the haul distance?
- Will the savings in cost to move the material justify the cost of putting in the bridge?
- What if I make the bridge one lane wide?

Conclusion

Although mine haulage is one of the highest cost areas, our mine haulage modelling techniques have lagged behind similar techniques commonly used in other industries.

The simple haulage models that are traditionally used to model mine haulage and estimate fleet requirements use high level assumptions and are not capable of modelling complex systems. Decisions are being made about complex systems using simple models that are not representative, which leads to inaccuracies in our models and under-optimised haulage systems.

Decisions to invest capital in new infrastructure or equipment can be made with more certainty with a clear picture of the outcomes. We can make much better decisions using discrete-event simulation and don't need to accept uncertainty in mine haulage.