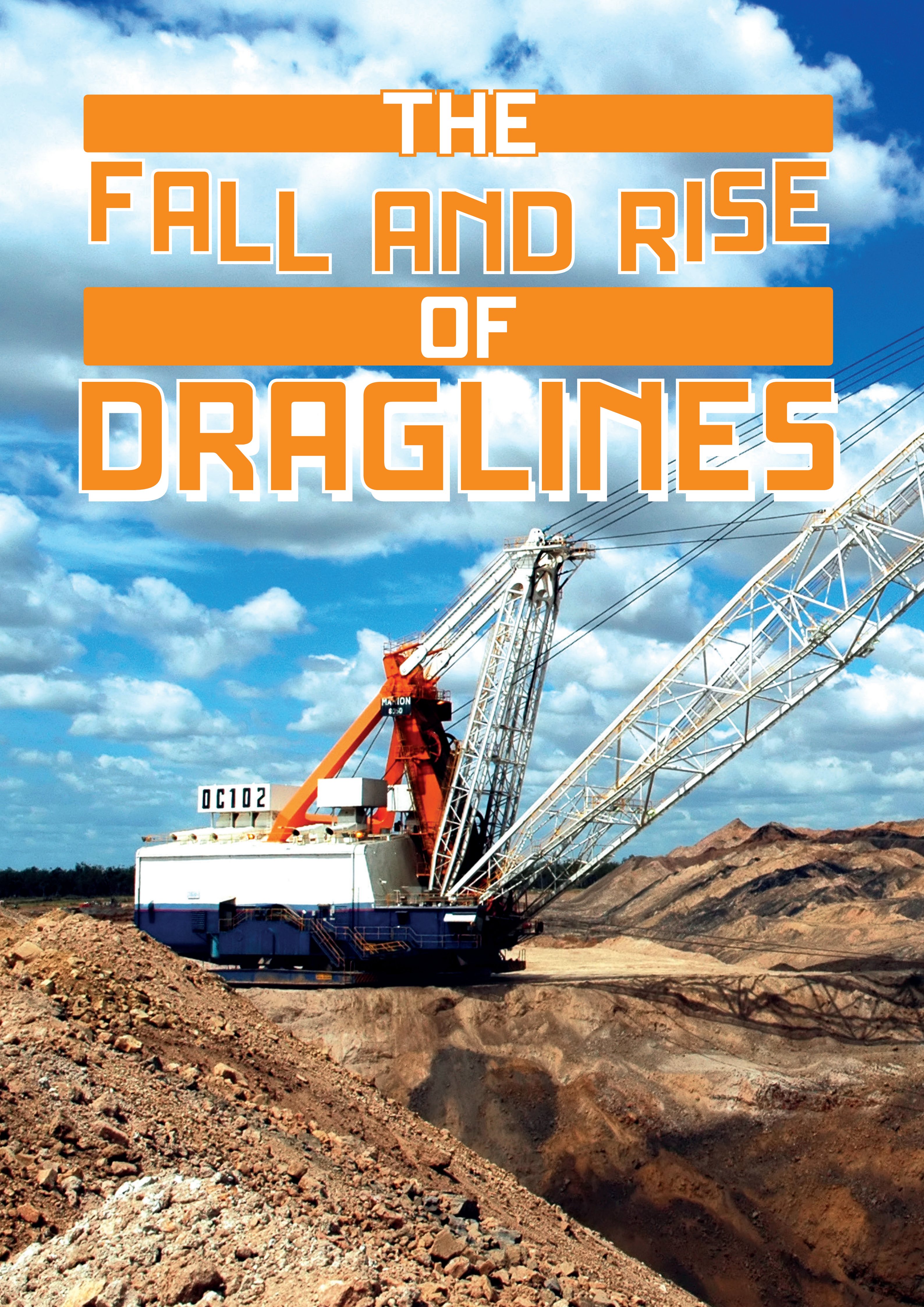
THE FALL AND RISE OF DRAGLINES



Neil Tyson, Deswik, Australia, details ways to improve dragline engineering and in turn improve planning cycle time and mitigate complex risks.

Large walking draglines are still a key part of many mining systems around the world, primarily for overburden removal in sedimentary bulk commodities, such as coal and phosphate. However, during recent boom years, the importance of these high-volume, low unit cost machines waned. Record prices encouraged mines to expand volumes, pushing pits deeper than before, while huge cash margins on incremental tonnages reduced the importance of the relative cost advantages of draglines. During expansions, the scalability and flexibility of truck and shovel/excavator fleets was also attractive, as these may be deployed in any area of the pit. As pits got deeper, the relative share of work for draglines decreased from 75 – 100% in shallow pits to as little as 10% in some large, deep operations. The result? Lower focus on optimising dragline operations.

Now, the wheels have fallen off the commodities boom. The mantra of incremental tonnage is gone, replaced by a reborn focus on productivity and unit costs. Profitability at any cost base has been replaced by razor thin or negative margins, with a large proportion of mines now navigating loss-making territory.

In this situation, the focus is firmly back on the use of low-cost mining methods and the corresponding engineering requirements to plan and execute at the lowest costs possible.

Draglines and dozers are, once again, valued components of the mining system: when margins were US$40/t a notional saving of 20 cents/bcm of overburden cost was irrelevant; now that margins are miniscule or negative, that 20 cents/bcm saving might be the difference between sinking or swimming.

Dragline engineering challenges

Draglines are typically limited to deployment in the lowest pit horizons and are inflexible with respect to geometry and volumes that may be economically allocated to them for excavation. Located in the pit bottom, draglines became the constraining factor for pit advance and hence dump advance. The dump space immediately above the dragline spoil envelope is often the cheapest for truck and shovel dumping. If this low-cost dump room is not released and available for dumping, there is an extra knock on effect: the pit highwall continues to be pushed back but the dump toe lags. Mines may find themselves 'spoil bound' i.e. they run out of dump room temporarily until more can be released at the base of the pit. Such situations have led to temporary or permanent out-of-pit dumping, sometimes requiring 100% rehandling in later years, incurring both higher haulage costs in the short term, as well as locking mines into higher-cost mining in later years as temporary dumps are moved to allow pit progression.

Another challenge is the appropriate allocation of material volumes to dragline fleets. Too much volume and the machine is unable to efficiently move all of the overburden, resulting either in higher dragline costs through increased rehandle, decreased productivity or use of higher-cost (planned or unplanned) truck-and-shovel methods. Too little volume results in opportunity costs (allocation of potential low-cost movement to higher cost methods), as well as, in extreme cases, operational (not enough material to form a bench to sit on) and scheduling (dragline advance too rapid for supporting processes) impacts.

In all cases, the draglines must be considered as part of the overall mining system, with a design and operational strategy that complements the capacities of supporting truck-and-shovel and ancillary fleets.

Finally, use of draglines and dozer push techniques introduces extra processes into the mining system, greatly increasing scheduling complexity and interactions, as well as greatly increasing the likelihood of process delays or knock on scheduling issues. It is common to experience long 'lead-times' in planning for dragline systems with changes conducted months before machine entry, increasing the need to accurately plan the dragline operation well in advance of other operating methodologies. In extreme cases, failure to manage scheduling complexity introduces a negative feedback loop. Scheduling issues cause design changes, which in turn cause further scheduling volatility and require a great deal of effort and cost to 'break the cycle'.

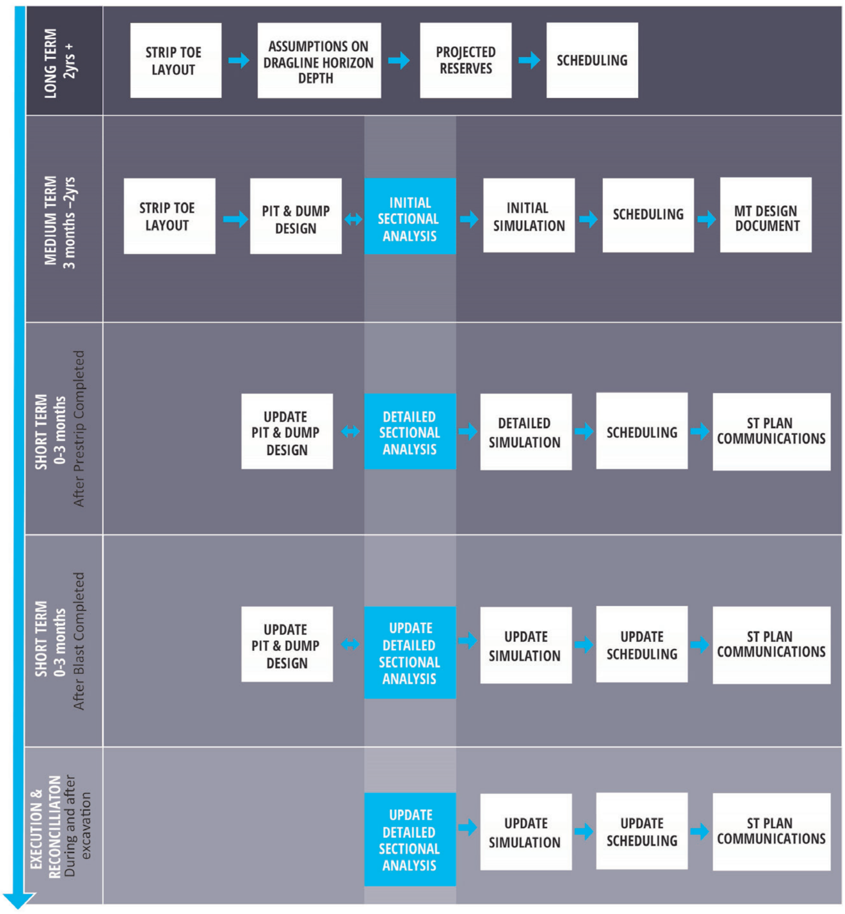


Figure 1. Dragline planning cycle.

Dragline engineering techniques and planning lifecycle

The following techniques are used in best practice engineering for dragline and dozer push operations:

- Volumetric balancing and effective pit design:
  - Feedback loop: design and volume balance informs sectional analysis.
- Sectional analysis and pass design:
  - Feedback loop – sectional analysis informs volumetric balancing.
- Schedule, cost and revenue trade-off analysis of potential dig methods.
- Dig simulation.
- Reconciliation.

Pits are generally mined in strips e.g. 60 m wide for the length of the pit. As a result, the design process is repeated for each strip – and often for sub-sections of strips that form minimum mineable sections.

Dragline strip design is an iterative process. Designs may be created or updated 2 – 3 times before commencement of digging and, in many operations plans, are updated between passes to ensure each pass plan is still valid after completion of the preceding pass.

Deswik.DD (Dragline & Dozer Section Designer) is a new tool that is used for section analysis by dragline engineers. As Figure 1 illustrates, sectional analysis is a task that is repeated within the best practice design lifecycle at least four times; however, there are a number of change triggers that can result in further iterations of the design process. By the completion of a single strip, it is possible that some or all of the design cycle has been iterated 5 – 10 times. Common change triggers include:

- Updated/changed geological information.

    - New modelling or information from blasthole drilling, top of coal surveys etc.
- Change of machine.
    - A dragline with different reach, dig depth etc. will be used.
- Sequence changes.
    - Short-term coaling requirements to meet targets trigger change in sequence and sometimes a change in pass designs.
- Adverse blast outcomes.
    - Blasted overburden distribution is different to planned: e.g. cast instead of stand-up, requiring re-design of passes and bench levels.
- More or less prestrip removed than initially planned.
- Scheduling issues.
    - More or less material allocated to dragline in order to speed up/slow down advance.

Many change triggers require rework not only for the current excavation, but in the next one or two strips as well. For instance, decisions to remove more or less material than originally planned in the current strip will change the starting conditions for the design of the next strip. If the implications are not worked through and quantified a negative feedback loop is introduced within the planning system:

- Volumes and forecasts in the medium term are inaccurate.
- As these progress to short-term design, large variances are introduced into the schedule and business plan forecasts.
- Re-work generates more re-work as knock on effects require more and more effort to bring planning back to a steady state.

Impacts of deposit geology on planning requirements

Dragline engineers are required to plan both the overall strip design, as well the individual passes that a dragline will use to progressively uncover coal for mining. Deposit geology has a large impact on the number of passes required and the complexity of each pass. This ranges from simple single or double seam operations through to operations with three or more seams targeted by the dragline and many passes per strip (Figures 2 and 3).

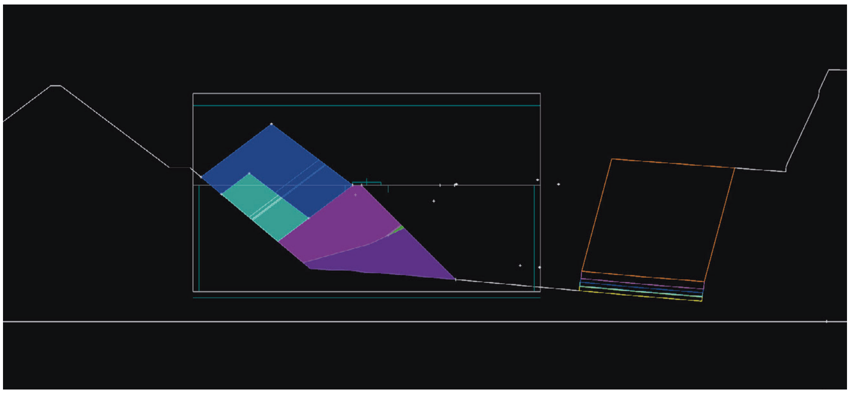


Figure 2. Single target seam, 3 dragline passes per strip.

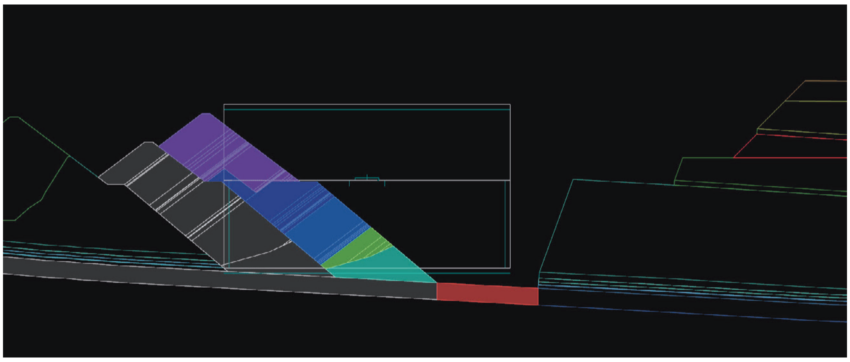


Figure 3. Target seams, 5 dragline passes per strip.

For example, Bengalla Mining Co. uses Deswik.DD for dragline planning in one of the most complex dragline operations in the world. Bengalla engineers must contend with:

- Three target seam groups with target seam ply's changing multiple times along the 2.5 km strike length of the pit.
- Captive dragline operations with limited highwall access.
    - Dragline passes must often double as walk roads to the next section of the dig.
- Single pit operations require capacity balancing.
    - Advance rates of dragline, truck and shovel prestrip, coal mining and waste dump construction must all be planned in lockstep.
    - Each process influences the next, with few opportunities for buffering. Any changes to any part of the process must be quantified to ensure downstream impacts are manageable.

Overview of sectional analysis

The sectional analysis step in a dragline engineering planning cycle helps answer the following questions:

- Can it be dug?
    - Understanding geometrical constraints on pass design (reach, dig depth, operating space etc.).
- How much and how long to dig?
    - Ability to estimate prestrip, post-strip and spoil construction material balances.
    - Estimation of rehandle requirements, used to determine total movement required.
    - Calculated factors and volumes are inputs for scheduling scenarios.
    - Modelling impacts of different dig method productivities.

Intelligent automation of sectional analysis

Deswik.DD has been designed by Deswik engineers to deliver all of the required outputs expected by mine site dragline engineers. However, the development process specifically pinpointed repetitive or manual steps in sectional analysis and focused on partial or full automation wherever possible.

The largest improvements in speed have resulted from the following processes:

- Creating a transparent, auditable record of section steps.
- Allowing users to 'step in' to a series of steps and change them without having to revise all steps from scratch.
- Copying of section steps to other sections along strike.
- Copying of section steps to other strips down dip.
  - Rapidly check the medium-term impact of short-term decisions.
- Use of extensible templates.
  - To calculate geometrical 'fit' rather than trial and error.
  - To automate repeatability between sections.
- Integration with scheduling, allowing rapid quantification of design impacts on overall schedule and cost, without post-processing in MS Excel.

Quantifying the value of design scenario automation

For short-term design, engineers typically analyse one section per 100 m, plus a few extra at points along the strike where changes occur (faults, bends, ramps etc.). An average strip design will have up to 30 or more sections, and, as illustrated earlier, the sectional design process may be iterated up to 10 times in the last two years before excavation. Results from initial use of Deswik.DD analysing a typical Bowen Basin' dragline operation showed a reduction in sectional planning time of 75%. In the context of overall planning cycle time, this is a reduction of approximately 40% in overall required planning time.

The value of using Deswik.DD for automation of dragline planning activities is realised in two main ways:

- Engineering for value through scenario analysis:
  - Engineer's time is spent looking for better outcomes, not on repetitive process steps.
  - In some cases, engineers go from having time for one plan to being able to compare and optimise multiple plan scenarios.
  - Better planning can lift dragline effectiveness by a few percentage points, which has a corresponding positive impact on cash costs and margins.
- Doing more with less:
  - Engineering teams are shrinking and sites must do more with fewer people.
  - Deswik.DD increases the planning output achievable by minimising time wasted on repetitive manual planning process steps.

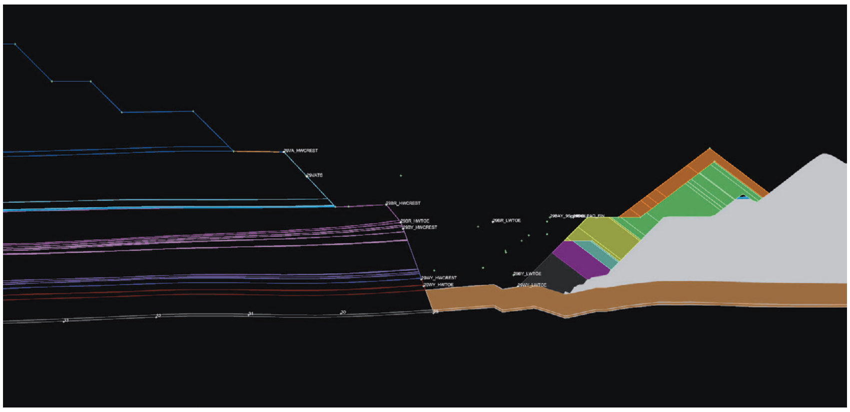


Figure 4. Bengalla: 3 target seam groups, 5+ dragline passes per strip.

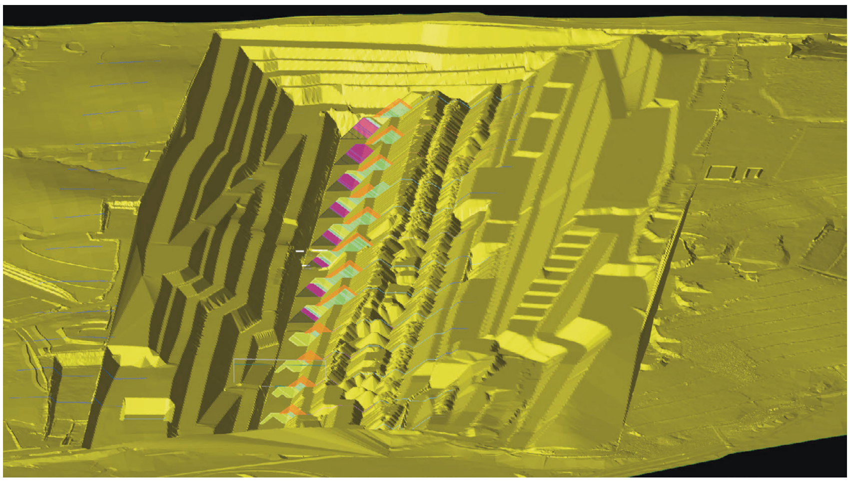


Figure 5. Bengalla pit isometric view.

Conclusion

As hostile economic conditions continue, the trend of trying to do more with fewer resources will continue. Draglines represent a great low-cost option for mines, providing best-practice engineering techniques to be used to mitigate risks from complexity and assess scenarios to develop highest value mine plans. Deswik.DD is a tool developed by dragline engineers to improve the planning cycle time, allowing engineers to devote more time on delivering better engineering outcomes and wasting less time on repetitive process steps.