
MAPTEK™
Mine
Scheduling
Reinvented

Contents

Read on to learn...

> Why your scheduling package should preserve orebody knowledge across your operation and mine life

> How knowledge can replace assumptions for effective decision making

> How tightening the connection between mine planning, scheduling and production processes provides an effective decision support framework

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Improving on tradition

The traditional mine scheduling environment presents many challenging scenarios.

Scenario 1

Planning engineers may work with scheduling solutions that only look at a siloed view of the overall success of a mining operation.

Scenario 2

Mine schedules target results that may look good in one context but have no bearing on the long term success of a mine as a business.

Scenario 3

Parametric mining and economic value models based heavily on assumption may have little or no bearing on actual performance in the mine or processing plant.

Scenario 4

Factors may be optimised that are meaningless to the overall success of the mine.

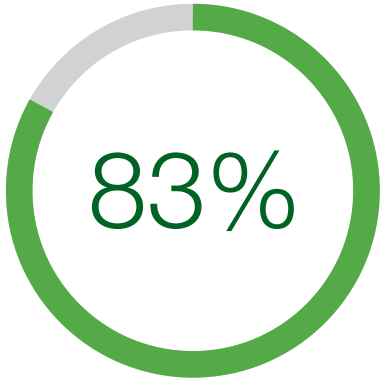
The key connection that is missing in all of these scenarios is the resource model, or more generally orebody knowledge.

Orebody knowledge should connect directly to activities and processes to exploit this resource and realise the possible economic benefits. The lack of a strong connection has been an industry weakness for a long time. Many solutions claiming to provide enterprise wide planning and scheduling capabilities simply do not.

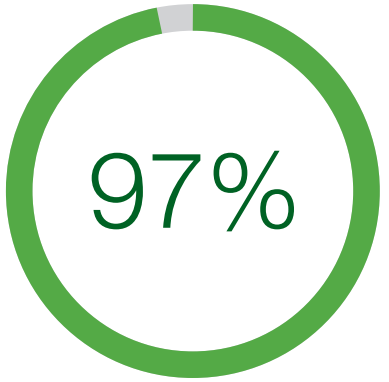
A Gantt chart is not a mine planning and scheduling solution; it is a tool to help sequence and plan tasks and dependencies.

Mine planning without reference to the geological model is unable to ensure that the economic value of an operation can be maximised over the long term. For example, ignoring downstream comminution or beneficiation processes that may be heavily influenced by mining decisions is leaving value on the table.

Evolution helps operations deliver consistent product to match customer specifications when economic conditions change. It generates practical, real-world schedules optimised against multiple objectives, either independently or simultaneously and in any combination. Operations can maximise their life of mine while maintaining production targets for each period.



83% of executives say that silos exist in their companies



97% of executives think that silos have a negative effect

Source:
McKinsey Quarterly, Five Fifty: Call your broker, McKinsey & Company, 2019

The butterfly effect

> An end of month report in a mine is a monthly reminder of how wrong you were with planning assumptions.

Evolution 2020 delivers the most comprehensive and advanced set of mine scheduling and optimisation tools on the market.

Reinventing mine scheduling is a master stroke that has implications beyond the engineering disciplines in a mine.

Integration is the key. Integration between mine planning and scheduling teams. Integration between manual and automatic sequences.

Integration between orebody knowledge and different scheduling horizons. Integration of short range activities and life of mine projections to optimise project value.

Maptek offers miners a unified mine planning and scheduling environment, providing a decision support framework for taking productivity to the next level.

Let's pay tribute to the difficult job of mine planners who need to act swiftly and decisively in the present while being mindful of the future.

Short interval control and short term planning decisions need to be made quickly and with knowledge about the impact that any changes may have on the future of the mine. This could be the next shift, next month or 5 years hence.

While it may seem unlikely at the time that short term schedule decisions can impact longer term performance of a mine, real examples exist involving resource sterilisation, geotechnical risk, energy use and processing plant performance as a result of short term planning decisions.

It is the embodiment in mining of the butterfly effect.

Mining businesses work by looking at long term opportunities to make an economic gain from a resource. An investment decision in a mine is based upon a time-frame of generally 10 or more years. Economic modelling, forecasting, research and business planning proceed to support that investment decision, and a huge amount of money is spent to realise a new mine.

The objectives at the investment stage are to achieve the planned business outcomes and meet the expectations of investors or bankers and joint venture partners.

Of course, it is not that simple. Most likely, soon after mining commences, new information becomes available, assumptions are adjusted, surprises occur and expectations are shifted.

A mine operates in an extremely complex environment, with a large number of variables. Add in random factors like the weather, and the impact can cause those investment assumptions to look less accurate as mining proceeds.

However, mining does proceed - it also costs a huge amount to stop mining!

Teams of mining professionals do their best to understand the orebody, mining equipment and techniques, the beneficiation plant and commodities markets, and then apply that learning to improve mine performance.

When a mining company fails to properly analyse and apply improved knowledge about their orebody and operation, they generally fail to meet expectations and those mines will struggle. When they do this successfully, mines are more viable and more profitable, and the companies operating them are more competitive. *We see it a lot.*

The difference between failure and success is the ability to put the information being gathered and learned about the mine, the processing plant and the orebody into the right context, and to make it usable. It must be accessible at the decision points within the mining process where it can make a difference. Latency is the enemy of control.

An end of month report in a mine is a monthly reminder of how wrong you were with planning assumptions.

Effective decision making

> "The value of an orebody is not in the ground – it is on a boat or a train, as ingots or cathodes. Mining companies make money when their product is sold, not before."

An operation needs to be able to understand the effects of decisions, including short term planning decisions, in the context of the entire mining value chain from the geology model through to the performance of the plant and product produced.

It also needs to analyse the impact of any decisions on the longer term value potential for the orebody. Evolution software tools enable all planning horizons at a mine to be targeted towards maximising the long term value of the orebody.

All planning horizons are scheduled using the same dataset through the same interface, removing the need to learn multiple software tools and avoiding ambiguity in schedules based on different input assumptions.

Long term optimisation of value is achieved by generation of cut-off grade policies. These in turn are determined by evaluation of all possible future scenarios and extraction sequences for the entire orebody, given long term assumptions about commodity prices and costs such as processing, mining or sales.

Importantly, from Evolution 6 this optimisation can consider multiple processes simultaneously within an orebody, allowing for more accurate planning across complex polymetallic operations.

It is a huge computational task, achieved using a genetic algorithm to quickly analyse, evaluate and learn from the data, leading to consistently better long term value solutions.

Conventional techniques for life-of-mine optimisation cannot match the speed or reliability of the results.

The value of an orebody is not in the ground - mining companies only make money when a product is sold.

Miners have until now been unable to properly plan for and maximise outcomes and performance across the entire value chain. This is because the technical domains and material processes downstream from the extractive mining stages (drill, blast, load, haul and crush) are very different and outside the day to day focus of a mining engineer.

This is exacerbated by the fact that obtaining a good working knowledge of mining engineering is enough of a challenge without adding an expectation to understand comminution, metallurgy and material handling. Hence engineers generally target safety, tonnage, grade and fragmentation objectives.

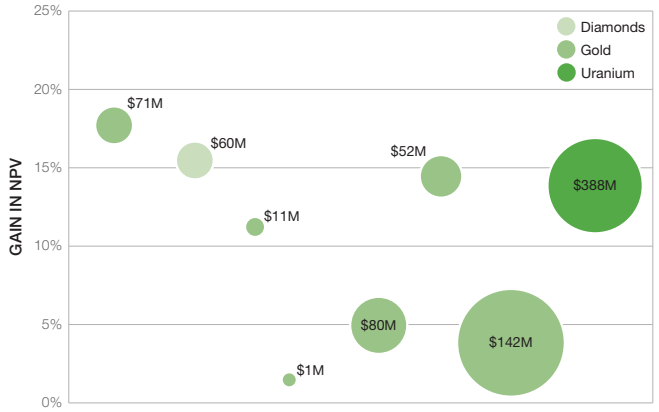
Mine processing plant performance is critical to the business success of a mine. Recovery, throughput, contaminants, consistency and energy use at any stage in the beneficiation plant are all huge influencers, and yet they are generally ignored or characterised only by poor assumptions at the scheduling stages!

A problem with the plant, or plant feed, can dramatically reduce or even halt production of the final product that mining companies need to sell, and so this needs immediate attention.

Only 20 percent of surveyed mining and metals projects are completed within parameters predicted during the feasibility study.

Source:
Optimizing mining feasibility studies: The $100 billion opportunity, McKinsey & Company, 2019

Maptek data shows that Evolution adds value to projects across different commodities



Making connections

Maptek provides a common technology platform for geology, geotechnical and engineering teams. Maptek Vulcan provides tools to model the resource and design the mine, dynamically updating plans as data changes.

An integrated mine planning – scheduling interface is critical for allowing the latest data to flow through from the resource model to scheduling, ensuring that orebody knowledge informs all activities.

Mining blocks are generated using a simple, repeatable approach. Engineers can easily add density or tonnage as populated variables for block models ready for import into Evolution, saving time and reducing the risk associated with manual editing or miscalculation.

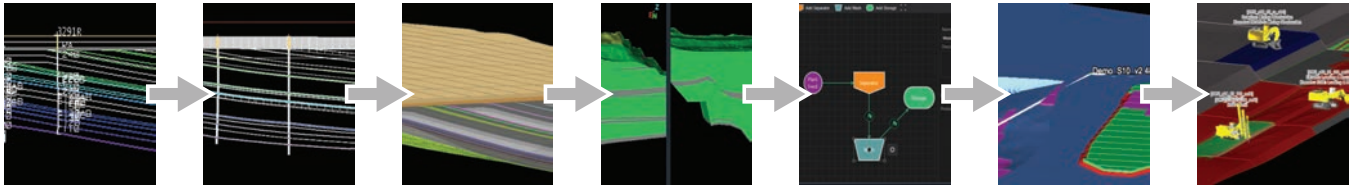
Preview, animation and reporting options allow plans to be clearly presented across the mining organisation for confident decision making.

This commitment to look beyond siloed boundaries and encompass upstream and downstream processes has led to co-development of new technologies. Maptek is now applying machine learning and augmented reality to accelerate tasks such as grade estimation, fragmentation analysis and production tracking.

Collaboration with leading industry technology providers to build on or integrate with our systems extends our capabilities. Investment in these solutions is proven to unlock new opportunities for safety, efficiency and productivity gains.

Design in Vulcan

Schedule in Evolution



Geological Model | In-situ Block Model or Grids | In-situ Mining Solids | ROM Scheduling Model | Product Scheduling Model | Scheduling (Life of Mine) Optimisation | Scheduling (Short Range) Manual

Our partnership with PETRA began in 2019 to create meaningful, actionable connections between processing plant performance, orebody knowledge and mine planning functions.

PETRA is well known for the MAXTA digital twin solution. MAXTA digital twin models enable dynamic optimisation of scheduling and planning. These models of the mining value chain created using MAXTA are able to inform detail about orebodies which can improve scheduling and planning decisions based upon mine performance.

This means integration between planning inputs, including the geological model, geotechnical model and mining processes such as drill and blast, and the performance impacts and characteristics of various processing stages, such as crusher or mill throughput or energy use, metal recovery or yield in plants, or minimisation of tailing grade or impurities.

Knowledge replaces assumptions

> “Mine planning is more connected to tangible business outcomes than ever before.”

The importance of a two-way understanding of the interaction between planning and performance cannot be understated.

This adds a huge amount of knowledge around the influences that various mining decisions can have on downstream processes that are not intuitively predicted. Given the multitude of variables and complexity of the model these influences are arguably impossible to model or predict empirically.

The information about plant feed material and mining processes can be included in Vulcan orebody models. Parameters such as plant recovery, which is specific to the actual plant that the ore will be fed into, can be therefore attributed to each block of ore. Burden, spacing and powder factor to enable ideal fragmentation for optimised crusher energy use can be included as characteristics.

These are not parametric models - this is how your whole mine actually behaves and you are now able to model it. A processing plant, or even a component within a plant, never operates exactly at nameplate specification across all the variability within an orebody – don’t assume it will.

It is also possible to optimise and schedule within this new orebody-aware framework. The MAXTA digital twin is trained by consuming production data and can then apply the learned relationships between the plant performance characteristics and the Vulcan geology model.

Mine planning decisions can be based on these analytics and included in the optimisation and schedules created by Evolution. Schedules can be created that are sympathetic to the performance of a beneficiation plant, optimise the metal recovery and provide grade and blending outcomes to suit.

Mine plans can be created that target metal produced based on real performance of the plant and the mine geology together. Blast designs can be created with knowledge about crusher and mill performance for that specific block of ore. Mine planning is now more connected to tangible business outcomes of a mine than ever before.

Those long term cut-off grade policy details are then used to plan medium term schedules on timeframes between, for example, 3 weeks and 1 year. Haulage routes and equipment details as well as information about plants, dumps, stockpiles and products are all now included in the planning model.

Complex models including multiple waste dumps, multiple fleets, multiple pits, multiple plants and numerous stockpiles and blending processes can be modelled and scheduled as one single operation.

Capital decisions

Capital decisions can be included in the modelling and optimisation to help plan fleet and equipment expense over time.

The efficient Evolution user interface and tight integration with the geology model and mine design data means that the setup of even very complex models is easily done.

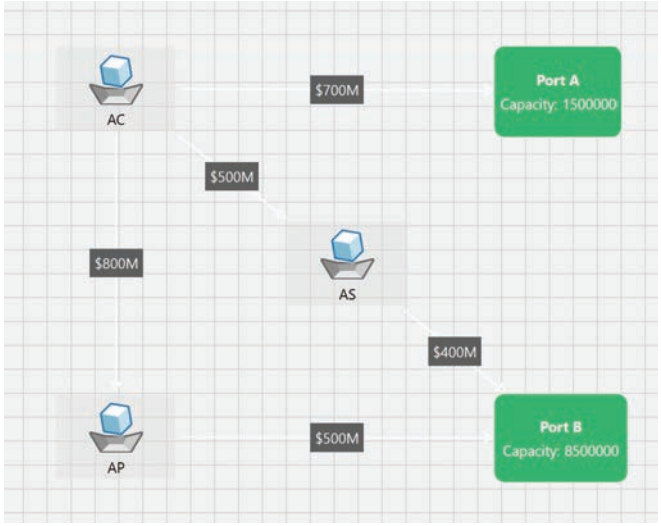
Operational mid term schedules are then determined by evaluating all possible scheduling scenarios within the model, together with the cut-off grade policy defined earlier, to determine material movement by period (total ore, waste and product) and schedule mining locations and progress.

Evolution can target multiple objectives and also capital decisions. Thousands of multiple evaluations can be run including blending, haulage, material movement and value at the same time.

Users can now optimise mining fleet sizes and expense at the same time as the orebody extraction is being optimised, reporting truck and shovel fleet demand over the scheduling period with the results.

Importantly, all these medium term planning objectives are still tied to the maximised long term orebody value.

At the short term and execution stages, a new level of detail, flexibility and visibility is required for managing day-to-day and in-shift schedules.



Evaluating capital requirements as part of the NPV during the optimisation allows operations to evaluate the truck policy and timing of capital expenditure for maximising project NPV.

In this example, Evolution is evaluating the best sequence for three different pits (AC, AP, AS) based on the infrastructure capital required to send the product to the available port. Additionally, another capital aspect that can be evaluated dynamically during the optimisation is the different processing capacity options. Evolution considers all the options globally and holistically to maximise the value.

Finally, Evolution evaluates all the options and suggests either buy or rebuild existing trucks as a result of the optimisation. Evolution will also provide the number of each type of truck required per period.

Enter Evolution Epoch

> “The operational change decisions made in the short term space are generally urgent and unplanned.”

Evolution Epoch is a dedicated short term planning tool that allows operations to manage multiple mining activities, tasks and equipment, and apply different types of dependencies. It provides a flexible environment for defining mining sequences and is ideal for planning practical schedules of up to 18 months.

Evolution Epoch handles the sequencing and scheduling of individual equipment, crews and locations, and the application of rules, task sets and precedences.

It is able to handle the variability and uncertainty in some mining situations and the need to avoid ambiguity. This ensures that all production engineers and crews know what is planned, what decisions have been taken and what impact that has on the rest of the mine.

An interactive Gantt chart linked to a 3D graphical view of the mine shows equipment, task and location for all mine resources. Short term planners and production managers can see what is planned and are in control of activities.

Operational change decisions made at this level of mine planning are generally urgent and unplanned. The nature of the mining environment means that it is difficult to consistently have control and to evaluate and communicate all changes accurately across the mine and to all interested parties.

Epoch is integrated with the orebody and the mine plan, and scheduled activities can be communicated throughout the mine on dynamic dashboards.

So what? Dashboards are in every production office.

The difference is that the short term Epoch schedule is built around achieving long term maximum value for the mine and the orebody. It has been created with all the common schedule management tools such as task sequencing, mining rules setup, resource and equipment models and integration with a graphical view of the mine.

Evolution also targets achievement of the longer term objectives of the mine. It has been created with consideration for more than short term objectives or objectives only relevant to one particular silo within the operation, such as shovel utilisation.

Short term planners can tailor the short term plan to best meet objectives using the resources and equipment available on the day and react to changes mid shift. Live links to datasets and being able to rapidly test scenarios in meetings with stakeholders proves invaluable to the adoption and deployment of practical short term schedules.

All this adds value to the short term planning engineer’s work by helping to retain a connection to the long term business plan for the orebody – through the geology and optimised mine plan.

As mid term plans are updated and adjusted, short term planning is aligned and targets these new plans because they are all working from the same data.

Mine scheduling reinvented

Development is now underway to deliver simultaneous long term scheduling and short interval control.

This will enable short term planners to immediately evaluate the impact of short term decisions on longer term mining performance and operate in a decision support environment that has never before been possible.

Connection of Evolution Epoch to the live production control systems within a mine will allow real time comparison with plan in the Gantt and graphical environment. This would also allow Evolution's genetic mine optimisation algorithm to conduct reactive evaluation of the impact of delays or deviation from plans and provide decision support in the control room that is connected to and supportive of long term value optimisation.

This approach can be extended across the full value chain to include processing stages and product recovery and yield in collaboration with PETRA's machine learning solution. This truly enables for the first time the entire mining value chain to be modelled and managed properly.

The old ways of scheduling are now irrelevant and outdated.

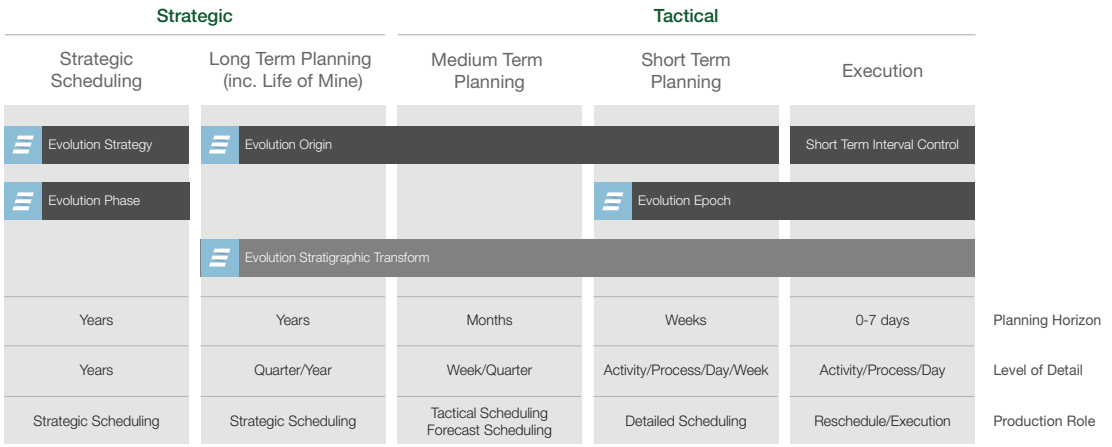
Maptek is delivering a life of mine scheduling solution that is able to work at the finest levels of short term planning and optimise across all time horizons to maximise orebody value. This is offered alongside integrated design and scheduling, which targets another key goal for mine planners, to reduce errors associated with data simplification and aggregation.

Combining multiple activities across multiple horizons allows an operation to consider all the key elements as part of a connected mine planning process. The workflow-driven interface reduces data manipulation and allows definition of high dimensional scheduling policies for even the most complex projects.

Maptek Evolution produces short, medium, long term and strategic life-of-mine schedules alongside practical production plans. It enables you to maximise the value of your deposit without compromising operations and without simplifying data.

Evolution is an enterprise-level scheduling solution that optimises NPV using cut-off grade techniques, a proven method for maximising project value. Simultaneously optimising the haulage fleet and waste dump locations can unlock cost savings early in your project.

- Dynamic, agile scheduling maximises value across all planning horizons
- Integrated strategic optimisation, long term scheduling and short term planning
- Connection with geology model and mine planning preserves orebody knowledge across operations
- Multi-element and multi-objective optimisation accounts for capital decisions and complex scenarios
- Integration with digital twin models allows optimisation for achieving downstream production objectives



Different planning horizons - single solution

Mining companies benefit from a user-driven scheduling framework allowing them to better manage and control mine planning processes to support production and revenue targets.

Cutting through the big data to make decisions. Today's mine managers must navigate a path through endless data flows with constant communication, on-demand customer needs and increasing reporting requirements. Decision-making has never been so critical, complex and time-consuming. Making sound, evidence-based decisions in a timely way will enhance your business. Of crucial importance is having the right information available. When information from various mine processes can be evaluated in the context of the vast amounts of technical data collected and reported around orebody modelling, mine planning and mine operations, valid connections can more easily be made.

Maptek does more than sell software. We develop cutting-edge applications with customers in mind. Our reliable hardware and software systems offer auditability, confidence, safety, mobility and flexibility. We listen to your concerns. We develop new tools that allow you to accurately capture, model, integrate, analyse and report technical data. We support our products. Corporate, management, supervisory and technical teams benefit from unified access to current, accurate technical data.

Intelligent systems for smart mines. Maptek offers enterprise-level solutions across the mining life-cycle. Our intelligent systems are developed with the knowledge of up and downstream processes and are designed to help you better understand and take control of your information. We future-proof your operation by ensuring accurate technical data flows through all survey, geology and engineering applications. Our modern architecture and machine learning platform link to your data science framework.

Maptek solutions are dedicated to mining. Miners who invest in purpose-developed systems from a technology provider like Maptek are ahead of the game. Our mining-specific systems are built from the ground up to solve the complex real world challenges you face every day. We pay close attention to automated workflows that slash the time you spend handling data, creating more opportunities for analysis and interpretation. You can install our systems today and reap immediate benefits for your business.

> "Mining companies benefit from a user-driven scheduling framework allowing better management and control of mine planning processes."

Maptek solutions support your operational goals.

We understand your need for efficient solutions, regardless of market fluctuations and operating parameters. We've used our decades of experience and constant customer feedback to create specialised tools for every type of deposit and operation. We can also design a custom configuration for your mine so you can confidently meet production targets and report to shareholders.

Ask us about our mining solutions.

solutions@maptek.com

Your questions answered

01 What differentiates scheduling packages?

When comparing scheduling packages most people will research what's under the hood. All of the classical mathematical models take a linear approach. They assume a single process, the scheduling sequence is predetermined and as for blending...

Based on a similar principle but using a genetic (or heuristic) algorithm, Evolution can handle multiple processes and objectives. It finds the optimum sequence from multiple scenarios and it handles blending.

02 Why are different scenarios returned?

One of the most frequently asked questions is why Evolution returns different solutions. That's correct, different scenarios are generated because Maptek applies an heuristic algorithm, which learns from each run to refine the next.

A better question might be to ask if it solves the problem.

Maptek research has proven that complex multi-objective, multi-element scenarios can be solved. The difference between the minimum and maximum values in an Evolution schedule falls within a 0.3% variation which for multi-million dollar projects corresponds to a very high confidence level.

03 What is meant by holistic optimisation?

Firstly, consider that mines move more waste than ore. A classical or linear method schedules sequentially by first assigning material movement and then calculating the equipment required for extraction. This separates the two processes and masks the potential benefits.

Secondly, if blending is required to meet customer specifications, then considering the initial haulage associated with ore extraction in isolation of reclaiming material from different locations does not account for the cost of stockpile rehandling.

Significant savings can be found by simultaneously optimising material movement, extraction, blending and haulage, in effect minimising haulage hours and reducing reclamation costs.

04 Do I need to buy all the trucks up front?

With powertrain trucks costing upwards of US$5M and with anywhere between 5 and 200 trucks in a mining operation, capex decisions such as truck purchase policy can lead to sleepless nights.

Evolution analyses capital expenditure on best truck type and best time to purchase during the mine life. It helps evaluate the pros and cons of buying a new unit or overhauling the fleet to extend the life of the asset for a few more years. Delaying investment allows an operation to gain access to more cash-flow in the early stages.

05 Live dashboard. So what's new?

Managers are expected to navigate their way through endless data flows while faced with constant communication, on-demand customer needs and increasing reporting requirements. Decision-making has never been so complex, time-consuming and critical.

Visualisation is everything. When information from various mine processes can be evaluated in context of the vast amounts of technical data collected and reported around orebody modelling, mine planning and mine operations, then knowledge replaces assumptions.

Evolution's live scheduling dashboard enables users to analyse multiple sequences to guide the execution level while remaining mindful of long-term objectives. Engineers can step forward in time to evaluate the impact of the current sequence.

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