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Mine optimization and its application using the Anglo Platinum Mine Optimisation Tool (APMOT)

A. SMIT* and G. LANE†
*Anglo American Platinum
†Cyest Corporation

Mine optimization is an integral part of the business planning process at Anglo Platinum. Optimization is done at various stages of the business plan, as well as at different levels of confidence. This may include:

- Concept or desk top optimization
- Trade-off studies on projects during the prefeasibility stage
- Optimization of shaft boundaries in the operational plan
- Trade-offs between different mine designs or layouts
- Scheduling trade-offs for a different volume of mining per shaft or mine.

The Anglo Platinum Mine Optimisation Tool has been developed in partnership with Cyest to help answer these questions easily and efficiently. APMOT is a non-graphical rules based production scheduling solution that allows a full production schedule to be done very quickly. In this way many different mine design and production assumptions can be tested and the impact compared. It does not replace the graphical design solutions in use but complements them. The APMOT solution also includes a labour and cost module that calculates activity based costs and labour for the given schedule as well as providing a valuation of the production schedule to deliver a scheduled cash flow and NPV. The rules based methodology allows rapid iteration of scenarios, as well as the ability to sequentially improve the level of detail and confidence. Because of the integration of a scheduling and costing ability, it is now possible to answer optimization questions with confidence.

Introduction

This paper discusses the optimization of the mine design and scheduling as it is applied at Anglo Platinum and more specifically, the rationale for and use of the Anglo Platinum Mine Optimisation Tool (APMOT), which has been jointly developed between Anglo Platinum and Cyest over the past four years.

Mine optimization is an inherently iterative process since all facets of mine design and scheduling are interrelated. It is not possible to change e.g. the level spacing of a mine, without affecting the scheduling, or the stoping efficiencies and number of crews without considering the development requirement. For this reason, changes to design and scheduling are usually tested using a graphic design and scheduling applications such as CADSmine or Mine2 4D. These applications allow detailed design, based on graphical information of reef contours, thickness, grade, and location. This allows an answer with a high degree of certainty about the exact tons and ounces that can be expected from a project or production schedule. Unfortunately this also means that the process can be time consuming, limiting the number of iterations or options that can be considered.

Once the schedule has been finalized the production profile is costed and a capital schedule is estimated to allow financial valuation. Changes in economic assumptions around platinum price or escalation can then also affect the project, potentially rendering it unviable due to the capital requirement or the cash flow profile. True optimization therefore needs to encompass the technical design and scheduling as well as the economic valuation of the scheduling outputs.

APMOT encompasses all design and scheduling facets from geology, layout, and scheduling to resource levelling and economics in an integrated non-graphical rules-based production scheduling application.

Problem statement 'Why APMOT?'

Anglo Platinum identified the need to improve on mine optimization efforts both in current operations, as well as for new projects. This meant considering many more options for both design and scheduling, which would lead to any number of different outcomes, such as:

- Changes to back length
- Improved stoping efficiencies
- Reduced development cost
- Additional volume
- Less dilution
- A faster ramp-up for new projects
- Production tail optimization for existing operations
- Improved Merensky/UG2 ore mix for an operation
- Extra stoping flexibility
- Improved NPV
- Improved cash flow

- Reduced overheads
- Full utilization of capacity
- Improved head grade.

Many of the above are contradictory and require detailed trade-off studies to determine what the best course of action would be. Several challenges were experienced in attempting to answer these questions.

Some of the planning challenges for the short term—budget period planning

- Disconnect between production profile and labour profile.
- The labour budget is done by HR after the production scheduling, there is seldom feedback to production planning if labour is cut.
- A disconnect between costs and the production profile.
- Continuous changes—new layouts every year. The impact of layout changes is visible only outside the budget period.
- Disregarding long-term impacts. Cuts in development lead to a reduction in the face length available over the medium term.
- Time required to build a detail plan in CADSmine.
- Disconnect between expectations and plans. This leads to cost cutting and last minute changes, resulting in the costs not being linked to production plan.
- Poor tracking against budget since the budget is not aligned to the production schedule because of changes.
- Production plans may violate logistics constraints. This is picked up only on review and may not be rectified within the required timeline.

Some of the challenges for the long-term life-of-mine planning horizon

- Inaccurate forecasting of costs—costs are not linked to production activities but are forecast on ratios at a total shaft level outside the budget period.
- Labour plan is not linked to the production profile.
- There is not enough time to consider multiple alternatives; rather, the most likely plan is done in detail.
- Changes in external factors e.g. platinum price, exchange rates, negate planning.
- Group value optimization frequently requires sub-optimal individual operations for optimal group value. This is not considered adequately in projects.
- Production plans often violate constraints in ventilation, rock-hoisting or material logistics. There is no way to check this save rigorous review. Project timelines often do not allow changing of plans to improve these issues; it remains as a risk.

These planning failures lead to a planning gap that is evident in the shortfall against production and cost targets, as well as project value tracking. In general estimates are poor for:

- Opex, specifically labour cost
- Grade—over estimated
- Ramp-up—too fast and steep
- Production profile—efficiencies are not realized.

Anglo Platinum recognized that their current planning technologies did not allow for optimization of the mine design and schedule. A mine design and corresponding production schedule generally takes a few months to produce and therefore does not afford the opportunity, due to time constraints, to consider multiple options. This final mine design and schedule is produced without a corresponding view on the unit cost, labour, profitability and ultimately the value that this design and schedule will yield for the group and is therefore not 'optimal'.

Capital project teams and current operations need to be able to test different options available around the mine design, production schedule, and mining configuration, taking all aspects associated with the geology and the resource into account. Each of these options should then be evaluated against multiple economic dimensions such as value, unit cost, profitability or cash flow to ascertain the 'optimal' option.

Therefore Anglo Platinum commissioned the development of the APMOT solution in 2006 to integrate all aspects of mine planning and scheduling so that a production schedule could be rapidly generated and therefore all alternative options considered for planning purposes. This tool was required to provide:

- Enough flexibility and speed to study multiple options
- Evaluation of grade at an acceptable level of confidence
- Linking labour and other costs to the production schedule to allow true activity based costing
- Incorporating global assumptions such as platinum price to allow trade-offs
- Incorporating of costs to allow NPV optimization
- Allow iteration and dynamic changes without requiring rework
- Allow checking against constraints to ensure the production profile is realistic.

The key requirement is the ability to iteratively arrive at the best solution by testing different options against each other.

What is APMOT?

The Anglo Platinum Mine optimisation tool (APMOT) is a non-graphical rules-based production scheduling solution that allows for the rapid generation of a production schedule taking all geological, mine design, and mining method parameters into account. The solution consists of two modules as depicted in Figure 1.

Using APMOT

In order to optimize a design or schedule, an APMOT user would follow several simple clear steps to first build a model and then use it to test different metrics against each other. These steps are:

- Define the global layout of the mine in terms of the number of shafts, levels, and mining blocks and how these relate to each other.
- Define all excavations that will be required, their dimensions and advance rates, e.g. haulages, crosscuts, raises, and stopes.
- Specify applicable geological detail such as grade and densities.
- Specify all modifying factors that will be applied to convert from resources to reserves.
- Schedule all activities.
- Define rules that will be used to do resource levelling.
- Optimize the production schedule iteratively.
- Export to the labour and cost module to derive costs, capital and NPV.

The application allows the users to input all mine design, geological, mining method, activity dimensions and lengths, mining rates, scheduling rules, and team configuration information and generate a production schedule.

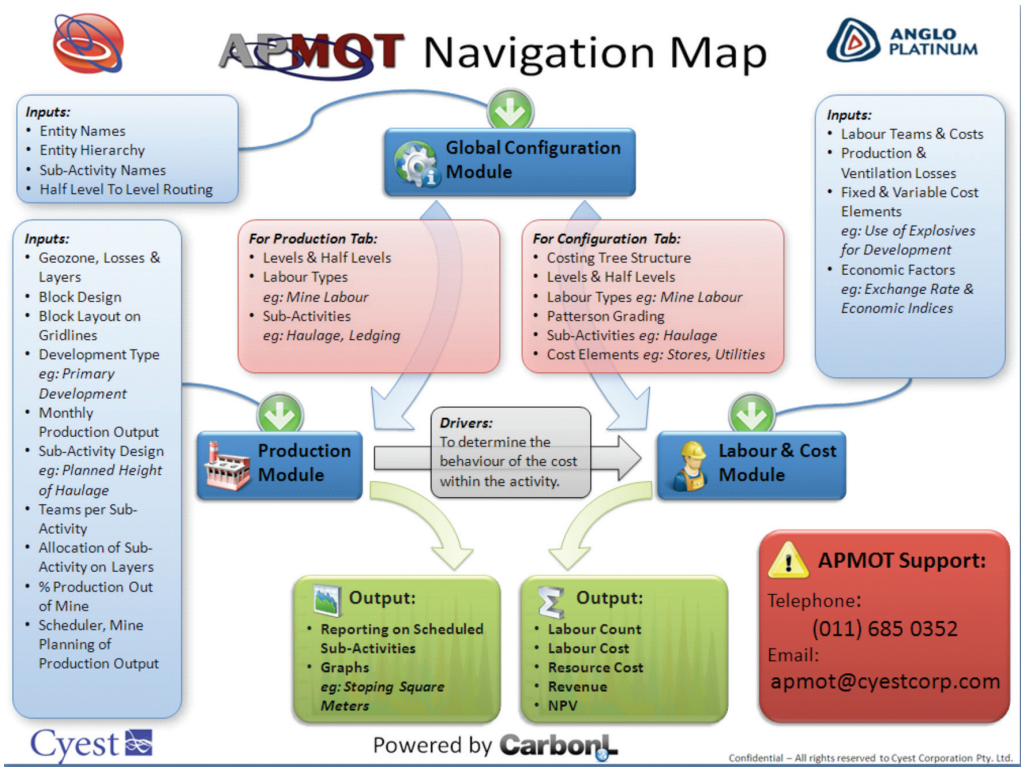


Figure 1. Summary of APMOT modules

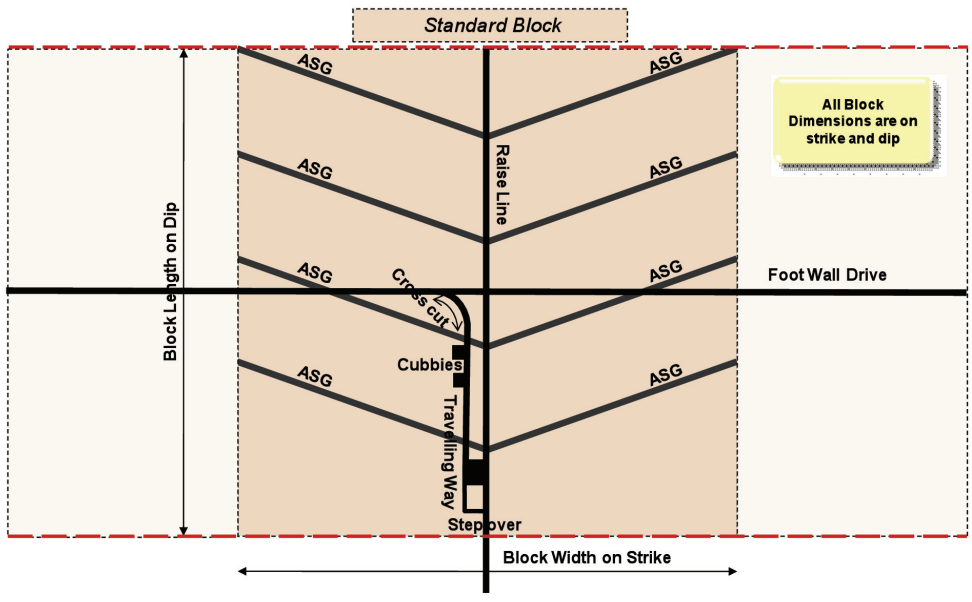


Figure 2. APMOT standard block example—scattered breast conventional mining

This data are input at a block level, where a standard block is the smallest self-contained production entity that contains all activities relevant to the mine. In the case of conventional scattered breast mining, a standard block contains a single raise line and its associated development and mining activities, as depicted in Figure 2. APMOT does not require a graphic mine design and therefore allows different mine designs and mining methods to be quickly tested to determine the impact of the change. It has been developed to cater for all conventional and mechanized mining methods for tabular underground orebodies that may be encountered within Anglo Platinum.

The user then assigns instantaneous mining rates to each activity and the activity sequencing logic with associated delays associated with any activity sequence. For example, in a conventional mine the haulage stops for a couple of days when the cross-cut breakaway is mined. This logic is then replicated across all relevant blocks within the shaft and a full production schedule is produced per block, half level, and mine. Figure 3 shows typical activity schedule logic.

Resource allocation can then be applied which will adjust

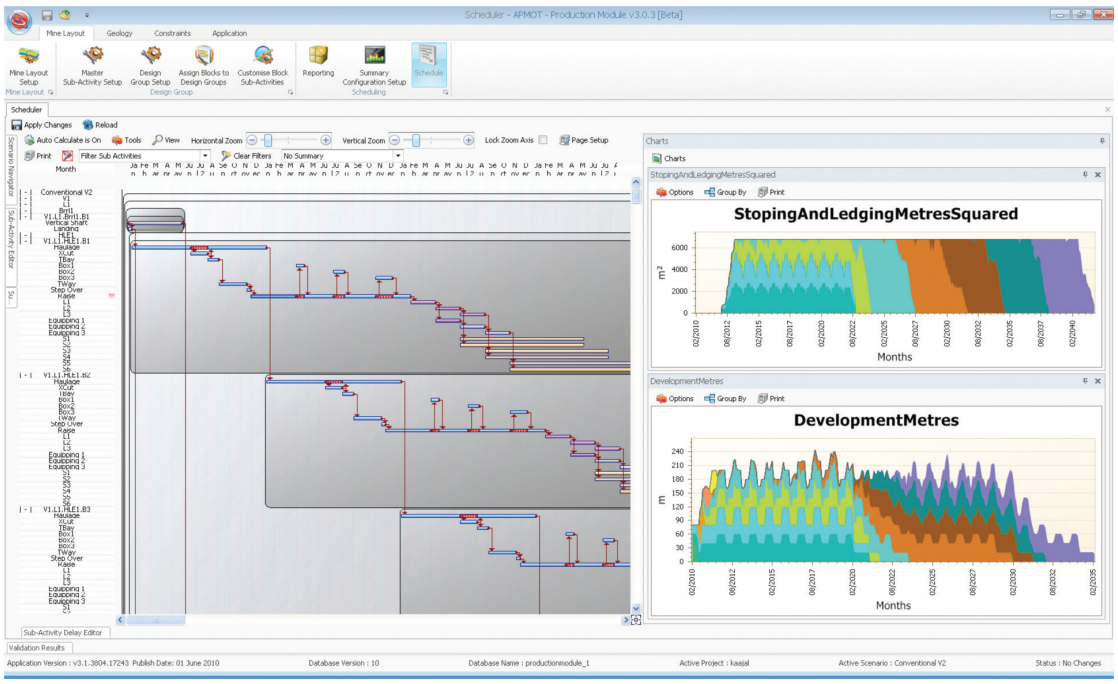


Figure 3. APMOT scheduling screen

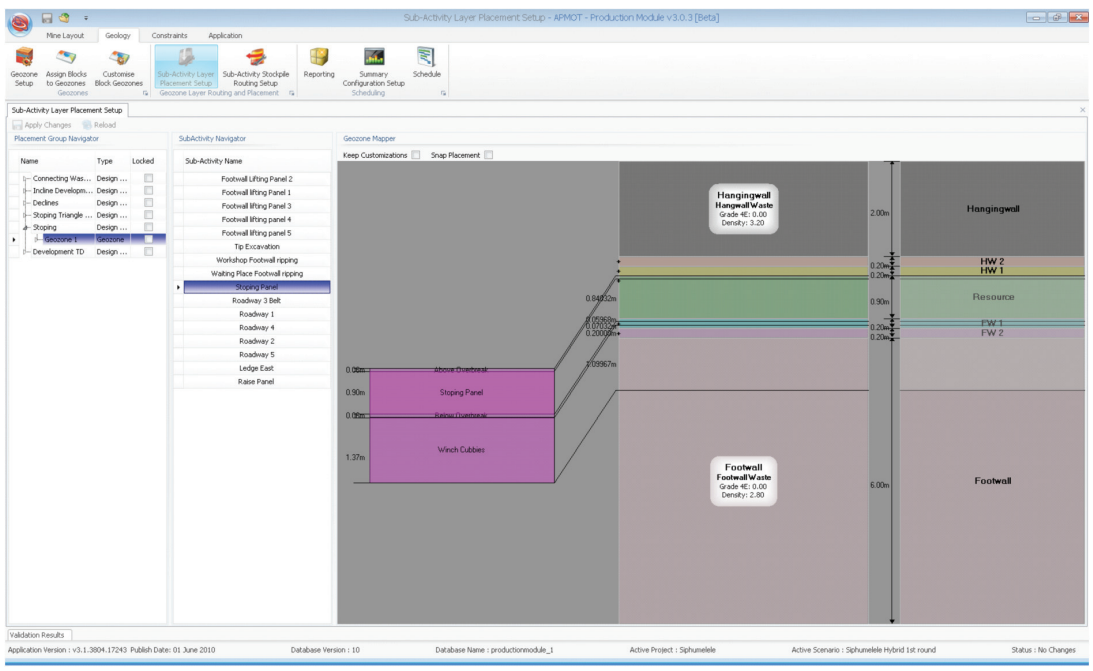


Figure 4. APMOT layer input screen

the scheduling of the mining activities to meet the resources applied. For example, for a scattered breast conventional operation a half level can be configured with 6 stoping teams and 3 development teams, and the resulting schedule will adjust to meet this resource allocation.

The application also allows grouping areas into different designs, geological zones or scheduling zones. Multiple layouts can thus be considered in the same mine with little rework required.

In order to allow accurate reporting of grades, densities and dilution, each excavation is positioned correctly within the stratigraphic layers to allocate the correct density and grade. See Figure 4.

Standard reports are embedded in the application and all outputs are available to the user via Excel Pivot table reporting linked directly to the APMOT database allowing for any dynamic reporting requirements.

Optimization

Optimization in APMOT is done using rules-based scheduling. Once the schedule has been built, as in Figure 3, the graphs in the screen can be used to evaluate the scheduled output. Rules are then applied to the schedule to constrain it to the desired level. An experienced mining engineer needs to decide what those constraints will be, e.g.

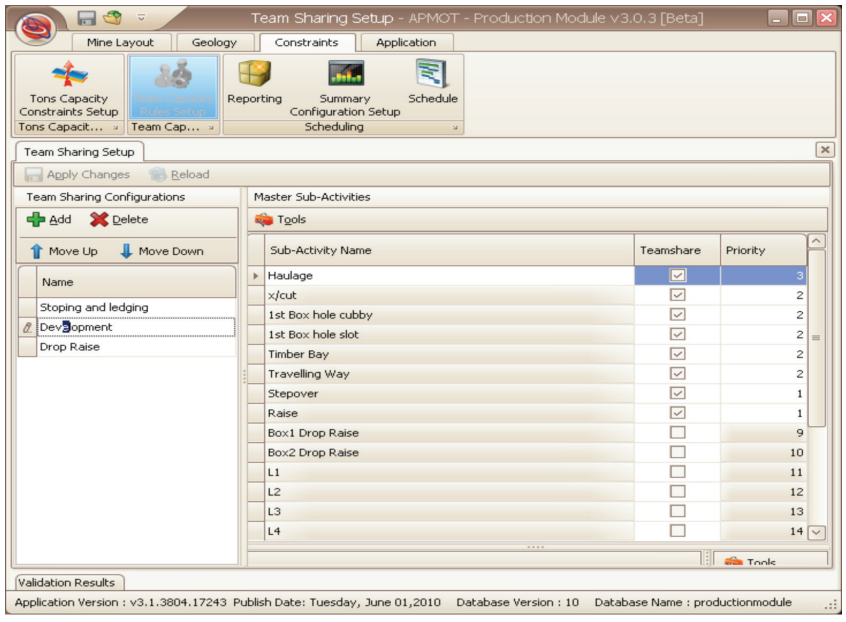


Figure 5. Team sharing configuration

- Hoisting constraints
- Half level tonnage constraints
- Development advance constraints
- Dropraising constraints
- Face length constraints.

In general the approach should be to link all activities end-to-start in sequence and to begin by constraining the first activity. This means ledging can start only once the raise is done. This would require the sequential constraining of e.g.

- Flat development based on the number of development crews
- Incline development based on the number of incline development crews
- Drop raising based on the number of machines available
- Ledging based on the number of crews
- Stoping.

Alternatively activities can be linked start-to-end, e.g. linking the start of ledging backwards to the end of development and scheduling development backwards from that point. This will lead to a just in time development profile and require only the smoothing of the stoping and ledging. The drawback is that changes in the development profile will not necessarily affect stoping.

The above resource levelling is done by applying a number of crews or resources to selected activities as per Figure 5. The development team sharing is being applied to all development activities with inclined development a higher priority than flat development and haulages being the lowest priority. This implies that if there are not enough crews to do the haulage and the cross-cut, the haulage will stop until a crew is available.

The second step is to apply the configuration to an area in the mine and to prioritize the areas. This allows certain levels, half-levels or even blocks to be mined preferentially and to be resourced differently as per Figure 6. This allows the prioritization of areas, levels, blocks or activities in the mine to allow tail management or to shape the profile in a preferred manner.

The aim is to apply rules that will change a profile from unconstrained, as in Figure 11, to a constrained profile, as per Figure 12. This should be done under the guidance of an experience mining engineer.

Labour and cost module

This module has been developed to allow for activity-based costing based on a production schedule. A production schedule with all the elements that might be used as cost drivers, e.g. m², tons and metres are imported into the labour and cost module and then used to calculate costs by using these production metrics as the driver at an activity level.

Costs can be calculated at the desired level of detail by using the appropriate production metric as a driver. Tons might be used as a first pass using only fixed variable ratios, while a more detailed estimate might be based on using m² and metres as a labour driver. Detailed labour teams are defined and linked to the production level using either efficiency for production labour or step changes for other supporting labour. In a similar manner fixed costs can be linked to infrastructure or other cost drivers.

Figure 7 depicts a screenshot where the user defines labour numbers per shift, per team, and efficiency.

These relationships and rules are then applied to the selected production schedule and the activity costs and labour complements for the full production schedule calculated.

APMOT positioning with Anglo Platinum

It is envisaged that APMOT will be used by a competent mining engineer or under the guidance of such a person. Since the required inputs are very simple, any person can build a model and import the relevant dimensions and rates from Excel. However, APMOT will not provide a ‘black box’ answer, but rather serves as a means to answer relevant questions easily and efficiently. A competent person is required to ask those questions and test the scenarios.

APMOT can be used both in the project environment and

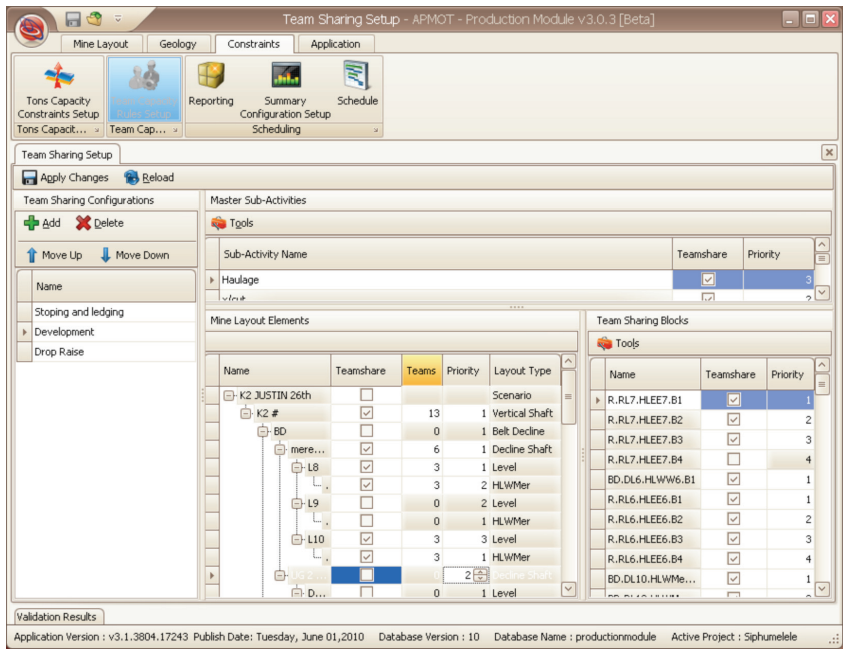


Figure 6. Application of team sharing to different levels

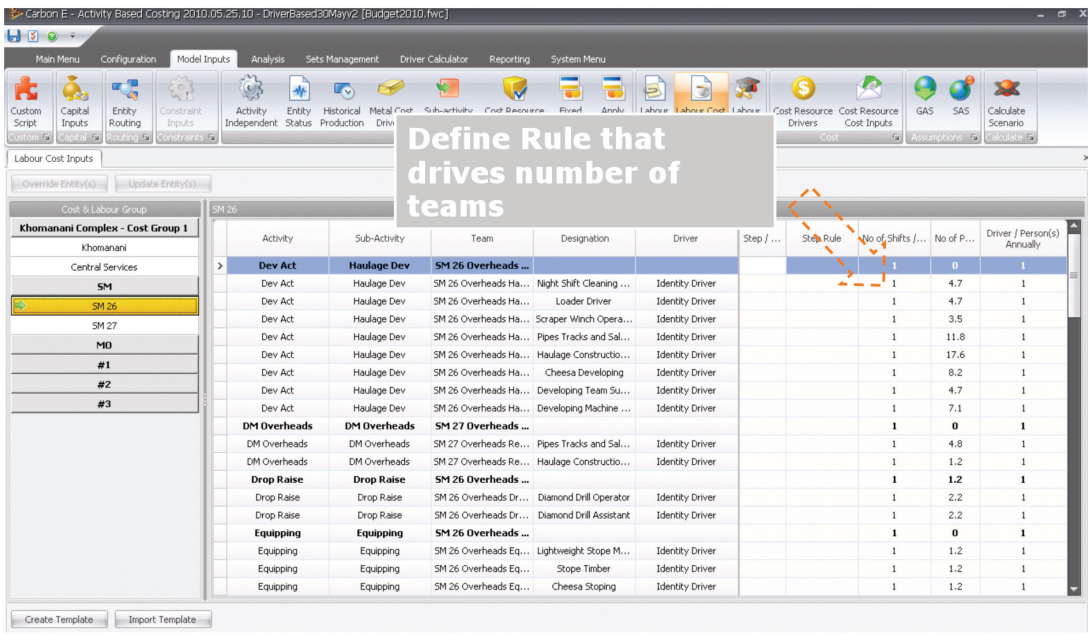


Figure 7. Labour and cost module—labour rule input screen

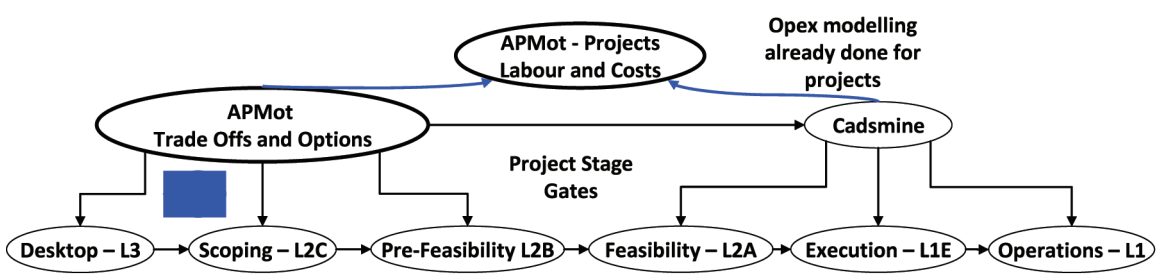


Figure 8. APMOT positioning in projects

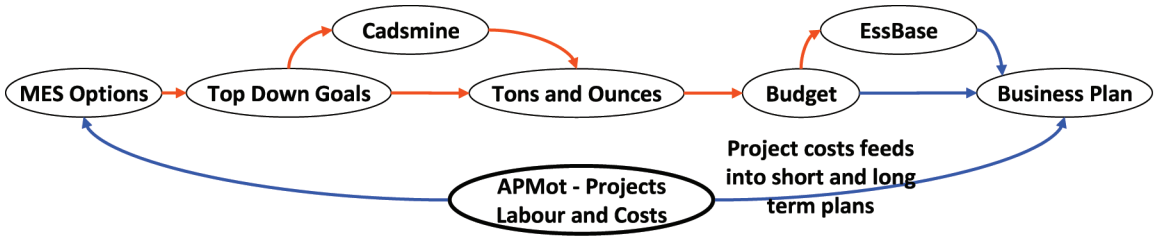


Figure 9. APMOT positioning in the annual business planning cycle

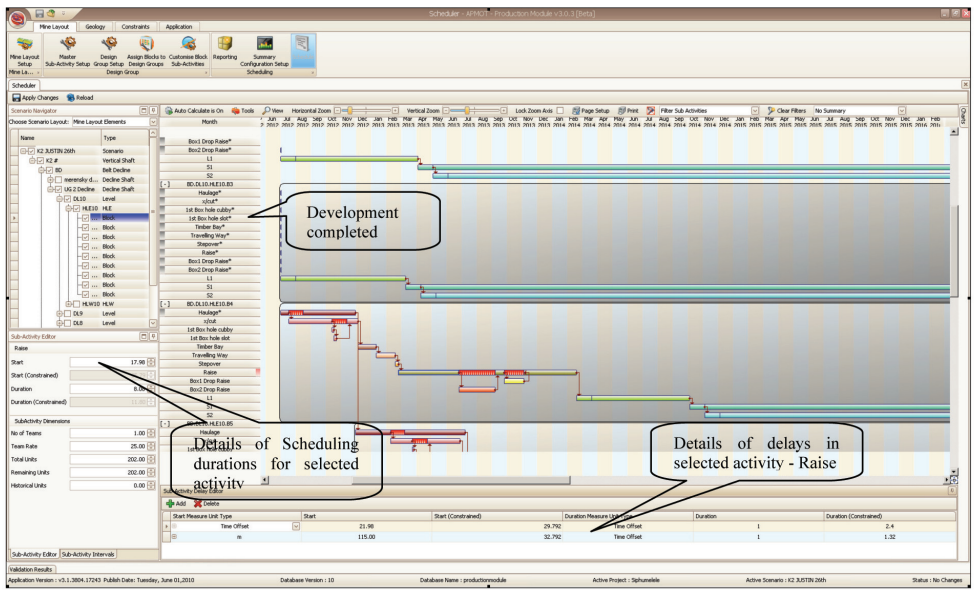


Figure 10. Scheduling screen in APMOT

the operational planning sphere. Projects at Anglo Platinum are progressed from desktop studies to feasibility through a stage gated approach with technical and financial reviews at each stage. This is graphically depicted in Figure 8. As depicted, APMOT is used in desktop and scoping studies to schedule production without the need for detailed graphic plans. At prefeasibility level APMOT is used as a trade-off tool to ensure that the correct option is scheduled in detail in CADSmine. During feasibility and at current operations, a graphic planning package such as CADSmine is the tool of choice. All opex modelling can be done using the labour and cost module regardless of which scheduling tool is used.

Business planning is also done annually progressing from short-term planning to a three-year schedule for budget purposes which is used as the starting point for the annual life of mine planning. The loop is closed by reviewing all operations annually to determine which projects have advanced to a stage of project engineering where they can be included in the business planning process. This is done annually at the start of the planning cycle during the review of the mine extraction strategy. The outputs from this process are defined as top-down goals for the operations to direct the planning effort. This annual cycle is depicted in Figure 9.

In Figure 9 APMOT is used to define and evaluate projects before they are included in the mine extraction strategy. Additionally, any asset optimization initiatives involving design or schedule changes should first be proven in APMOT before being implemented in the CADSmine schedule. Although the labour and cost module has not been used for budgeting yet, the opportunity exists to utilize this tool to substantially shorten the planning cycle and do the cost budget concurrent with the tons and ounces.

The application of APMOT at Anglo Platinum —case studies

The case studies below are examples of how APMOT has been used by Anglo Platinum to answer specific issues and questions within the current operations and capital projects.

Case study—mothballed shaft re-evaluated

During the downturn of 2008 an unprofitable shaft was mothballed until it could be brought back into production at more favourable terms. When the platinum price recovered to slightly better levels, a junior mining engineer was tasked to evaluate at what production levels the shaft could be operated. Concerns about the previous planning done in 2007 were:

- Production levels were too low to justify the overhead costs.
- There was uncertainty about the ramp-up period and desired level of production.
- Since there were several levels with limited remaining production, it was not clear for how long any particular

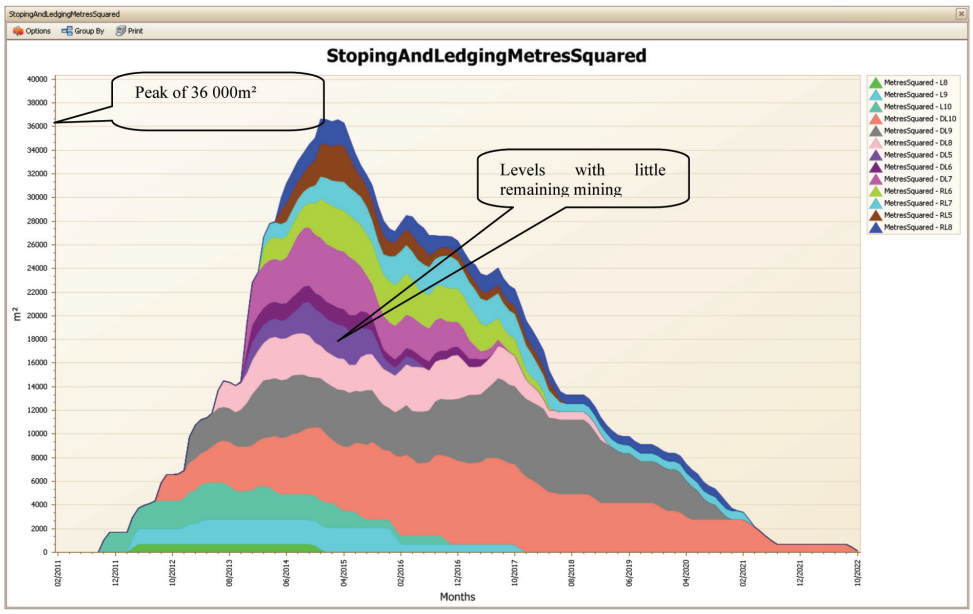


Figure 11. Unlevelled APMOT schedule—'natural schedule'

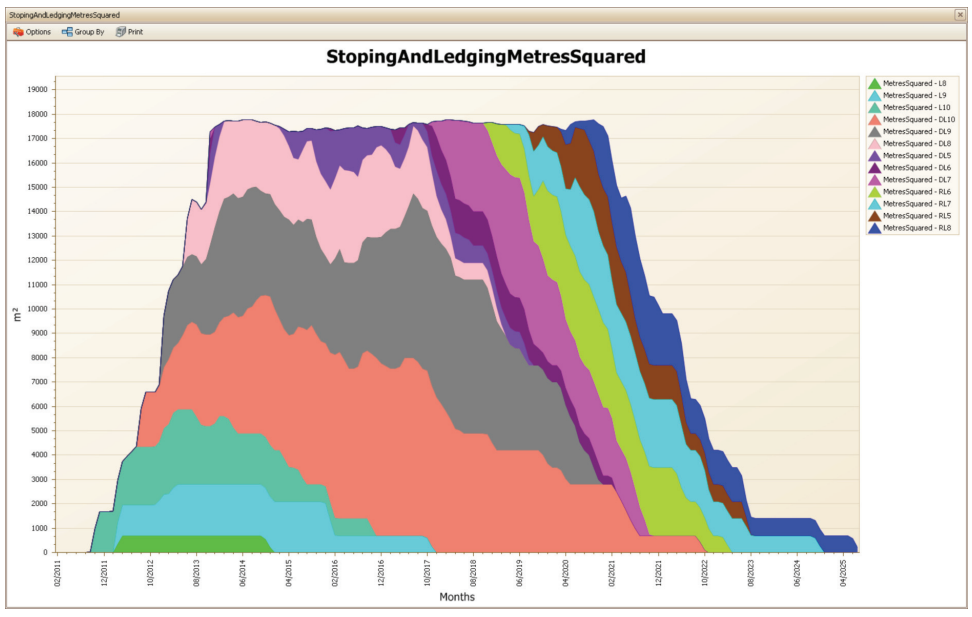


Figure 12. Levelled production profile

production level could be maintained.

- There were opinion differences about suitable crew efficiencies.
- Previous scheduling resulted in a large unprofitable tail.

The mining engineer was tasked to determine:

- A suitable production level
- An appropriate ramp-up period
- The impact of using several different crew efficiencies —was there enough face length for additional crews?
- Optimizing the tail.

The APMOT model was built using the previous CADSmine design to customize each block to the exact dimension and excavation lengths as designed. Since the question revolved around m² and tons, not much attention was initially given to grades. Once a suitable production profile has been decided on, it is easy to refine the grade to determine a more exact ounce profile. The 'historic unit' function was used in blocks that were partially mined to accurately reflect the remaining ground.

Once the model was built, the production was scheduled using the same mine design criteria as per the previous schedule shown in Figure 10. In the same scheduling window, the details of the delays, as well as the scheduling interval for the activity selected, is visible. It is also possible to edit any activity length or rate in the editor while scheduling. The result of this scheduling without any resource levelling is shown in Figure 11. It is apparent that the peak production of 36 000 m² is not sustainable with several levels mining out very quickly.

The first step in optimizing this schedule was to prioritize the long-life levels to reduce the tail to the minimum. This can be done by dragging the levels in the scheduling screen

2# and 1# separate - Tons to Concentrator stockpiles

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1# - Option 1 - 7 levels Conservative Dev & 360 m2 / team steady state	45,784	54,409	78,515	227,937	345,032	452,227	793,647	1,092,409	1,387,747	1,509,831	1,554,618	1,481,034	1,429,629
2# - Option 1 - 7 levels Conservative Dev & 360 m2 / team steady state	56,580	85,867	32,221	192,023	361,823	460,926	796,329	994,215	1,085,413	1,370,173	1,527,897	1,485,513	1,455,603
1# - Option 1 - 7 levels Dev matched to IP & 422 m2 / team steady state	45,784	56,553	84,324	300,033	396,180	415,030	645,395	808,475	1,343,412	1,555,900	1,582,107	1,445,173	1,456,824
2# - Option 1 - 7 levels Dev matched to IP & 422 m2 / team steady state	56,580	86,281	36,113	248,400	378,740	476,544	800,690	969,468	1,034,501	1,272,995	1,459,282	1,530,394	1,472,842
1# - Base Case -9 Levels Dev matched to IP & 422 m2/team steady state	45,784	56,553	84,324	312,042	456,191	729,593	1,075,770	1,392,773	1,546,590	1,549,921	1,477,998	1,493,278	1,547,230
2# - Base Case -9 Levels Dev matched to IP & 422 m2/team steady state	56,580	86,281	36,113	253,059	403,159	676,281	1,004,964	1,351,056	1,558,314	1,603,168	1,591,851	1,498,428	1,503,356
1# - Base Case -9 Levels Conservative Dev & 360 m2/team steady state	45,784	54,409	78,515	219,414	338,128	560,558	841,413	1,106,360	1,352,226	1,462,678	1,499,117	1,537,870	1,491,420
2# - Base Case -9 Levels Conservative Dev & 360 m2/team steady state	56,580	85,867	32,221	179,412	310,124	515,019	793,461	1,123,555	1,292,902	1,477,350	1,606,170	1,553,778	1,531,514
1# - Option 1 - 7 levels Dev matched to IP & 360 m2 / team steady state	45,784	56,553	84,324	255,428	351,756	457,745	789,057	1,090,929	1,355,466	1,473,196	1,496,178	1,451,927	1,379,627
2# - Option 1 - 7 levels Dev matched to IP & 360 m2 / team steady state	56,580	86,281	36,113	215,163	358,945	454,110	822,788	1,114,130	1,334,998	1,521,670	1,545,882	1,525,431	1,480,837
1# - Base Case -9 Levels Dev matched to IP & 360 m2/team steady state	45,784	56,553	84,324	245,539	346,710	567,446	853,383	1,112,016	1,360,574	1,514,583	1,552,602	1,599,923	1,564,803
2# - Base Case -9 Levels Dev matched to IP & 360 m2/team steady state	56,580	86,281	36,113	198,964	307,218	507,035	779,263	1,069,460	1,245,888	1,395,165	1,498,622	1,553,505	1,556,349

Figure 13. Tons to concentrator stocks comparison

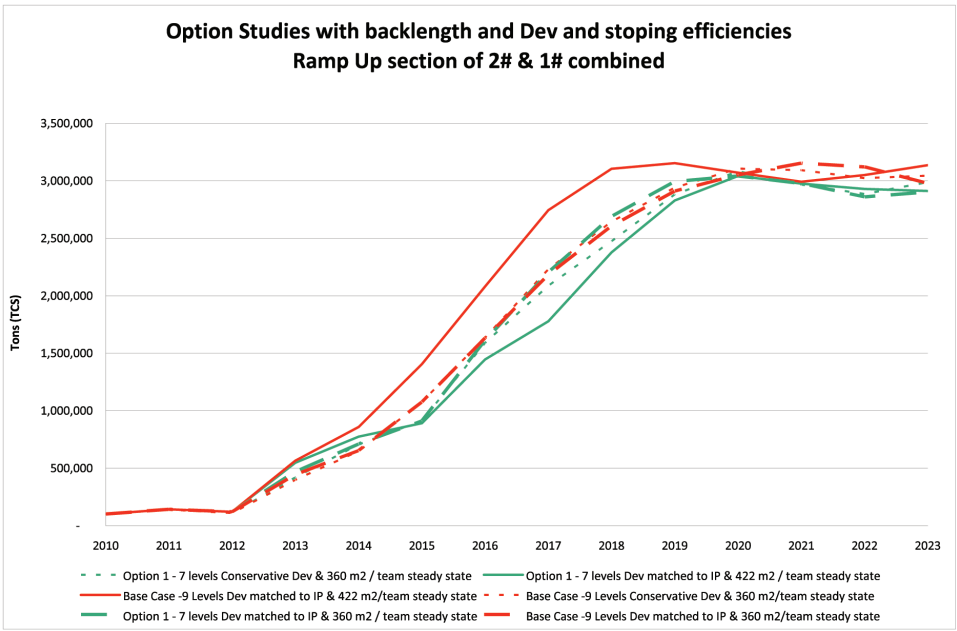


Figure 14. Graphs of tons to concentrator stocks

or by specifying priorities once resource levelling is done.

After playing with a few iterations for level priorities, resource levelling was done by constraining the number of crews active on any block and level. This constrains the production as is evident in Figure 12. It was decided to keep the higher grade Merensky levels at the front of the profile and mine them out quickly, allowing those levels to be closed off. The long-life levels thereafter form the production base with the shorter life levels filling the gap as production tails off.

From Figure 12 it is evident that production can be maintained at between 17 000 and 18 000 m² for more than seven years without a big tail. Once this profile was fixed it was possible to iterate around the crew efficiencies to determine whether enough face length would be available to accommodate more crews at a lower efficiency. This allowed the presentation of a production profile with greater confidence together with upside and downside scenarios.

Case study—improving a business case in a capital constrained environment

A downturn in the investment environment necessitated a relook at the business case of a proposed project. The mine consisted of two shafts mining conventionally with access through two separate decline systems from surface. The mine was designed with 9 levels with both shafts sinking concurrently yielding 3 million tons annually after a six-year ramp-up. The project team were tasked to investigate alternatives to the proposed schedule and capital requirement in a short period. The following were investigated:

- Reduce or postpone capital
- Reduce costs
- Reduce perceived risks due to the development and stoping rates.

This translated into the following options which would be modelled in APMOT:

- Reduce the number of levels from 9 to 7, thereby reducing capital and working cost developing costs.
- Consider the effect of reduced development rates on each option.
- Consider the effect of reduced stoping rates on each option.

This required that for each shaft, 6 options were scheduled depicting all the permutations of high/conservative development rates, high/conservative stoping rates and 7/9 levels.

The approach followed was to build two models in APMOT representing the 7 and 9 level base cases. This was then varied by changing development and stoping rates, with all options scheduled to shaft capacity. This implied that for the lower stoping rates more face length and therefore more half levels would be utilized. In Figure 13 is the results of the exercise for the first few years.

The following is evident from Figure 14:

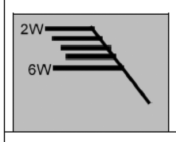
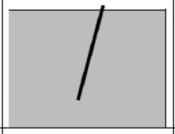
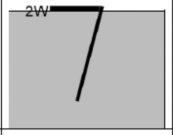
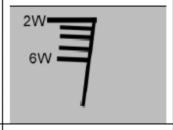
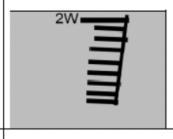
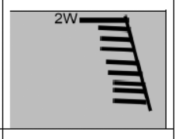
Option 1	Option 3	Option 4	Option 5	Option 8	Option 9
					
Apparent dip with access at Strike 2 to 6	True dip with surface access	True dip with access via Strike 2	True dip underground access via Strike 2 to 6	Mine through from Central shaft (all strikes)	Mine through from Central shaft (all strikes)
R 2 003 669 114	R 2 023 114 887	R 2 013 094 787	R 1 964 641 074	R 2 017 082 972	R 1 973 293 715

Figure 15. Schematic of different decline options

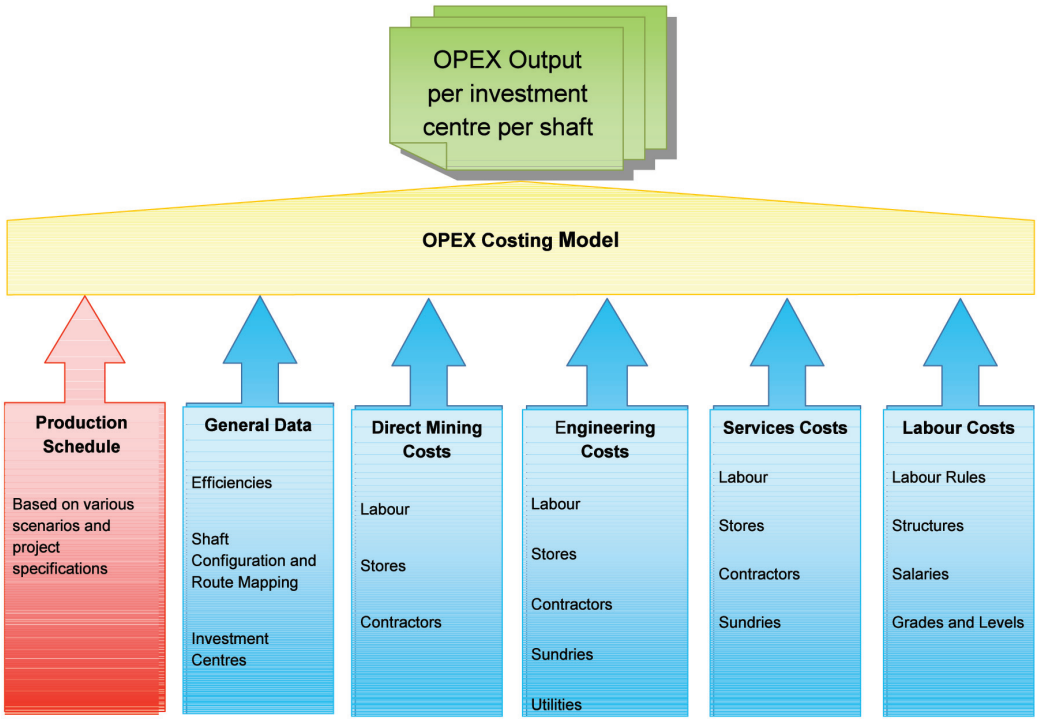


Figure 16. Opex modelling approach

- The 7 level option ramps-up 1–2 years slower than the 9 level option.
- Regardless of the production rates, it was possible to man to full production.
- The higher development rates yielded slightly higher total annual production.
- The lower stoping rates had less of a tail.

The above information enabled the project team to recommend an option based on the capital reduction and working cost reduction by removing two levels. In addition, the downside for both development and stoping achievement could be quantified with confidence. This exercise allowed the consideration of a delay in capital and ramp-up on the NPV of the project, as well as providing options to deal with the capital and cash flow constraints. The scheduling of all options was finished within a six-week period using two schedulers. This is a quantum improvement over the utilization of conventional tools.

Case study—decline position

The project team was tasked to investigate different mine design options which could not be evaluated using traditional mine planning solutions due to time constraints as the project deadline was 4 months. A senior mining engineer who was trained on the use of APMOT was assigned to the project team. Nine different mechanized mining designs and corresponding production schedules were produced. A full labour and costing model was completed for each of the options.

These different options revolved around the positioning of a new decline system as depicted schematically in Figure 15.

The design, scheduling and costing was completed for all options within three months. Once complete it was possible to workshop each option to optimize it on live models and to produce revised NPVs and production schedules for all options within that single session. Since the costs are linked to the production schedule as depicted in Figure 16, every adjustment to the schedule automatically updates the capital profile and working costs. From this it was evident that:

- Capital estimates did not vary significantly across the options.
- Cost were affected by the duration that a steady state could be maintained.

- There were not any great variances in working cost rates.

Therefore the feasibility of the different options was determined by the production scheduling yielding the highest production level for the longest period. Based on this, options 1, 3, 8 and 9 were selected to refine further at a higher production level. The higher production levels shortened the life of mine by 5–6 years and improved tail management. This resulted in a significantly higher NPV.

The work done enabled the project team to recommend the best option with confidence. In addition, it was possible to quantify the upside and to validate the consequences of higher production. This amount would not have been possible using conventional planning tools.

Further work

In addition to the above APMOT has been used to:

- Check different development layouts
  - A single level was scheduled with different development layouts e.g.
    - Conventional long cross-cut with multiple boxholes.
    - Short cross-cut with one boxhole and less stoping crews per block.
    - Lay-bye layout.
  - This allowed an informed decision on changing development layouts and thereby saving costs without unwittingly affecting the production profile in the future.
- Evaluate combining different shafts into one mine.
  - Should ground be extracted from two or three shafts?
    - Using two shafts would save huge overhead costs
    - Three shafts result in a higher production profile and shorter life of mine, possibly with a better NPV.
- Compare a hybrid layout to conventional mining practice.
- Validate production profiles or project proposals from mining partners.

APMOT into the future

The APMOT solution has a long-term roadmap in terms of the functionality that will be incorporated into the future to continually improve the rigour with which Anglo Platinum do planning.

Some of the future development plans are:

- Services and logistics module—this will validate the schedule against all constraints relating to ventilation air, ventilation mining rules, tramming and hoisting constraints, men and material supply This will ensure that the schedule produced is achievable taking all mining considerations into account.
- Stochastic modelling—all inputs may contain a probability distribution, for example grade and team efficiency, which will result in a production schedule with a probability distribution allowing for confidence levels to be set.
- Micro-schedule module—this may be a separate module that will look at scheduling of tasks within the shift and ensure that the shift cycle is achieved with the resources allocated. This will inform the APMOT production schedule of overall team efficiencies, etc. This is especially critical in mechanized mining where team utilization and number of faces available has a major impact on production achieved.

Conclusion

The APMOT solution has required significant investment from Anglo Platinum and Cyest in terms of the intellectual problem solving required in deriving the underlying logic required. The solution is now entrenched in Anglo Platinum planning processes and is yielding significant value by allowing different options to be investigated rapidly and therefore allowing a more informed decision to be made by management as well as the ability to identify asset optimization and business improvement opportunities. Optimization ideas can be tested in a short space of time, without spending valuable engineering resources on each option.

Optimization of the mine design and scheduling for an underground tabular orebody is now a reality at Anglo Platinum.

APMOT is, however, not a planning tool, used for detailed planning, but an optimization tool. Therefore it does not replace any of the traditional planning tools, but should rather be used in conjunction with those. APMOT allows the consideration of multiple options, with variation on each of those to determine the most appropriate plan. This can then be scheduled in detail in the planning tool with the knowledge that the other options have been tested.

The labour and cost module is being used as a standalone module using output from any planning tool and can therefore be used both in the long-term and short-term planning domains.

Acknowledgements

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Definitions

- APMOT—Anglo Platinum Mine Optimization Tool
- ASG—advance strike gulley
- CADSmine—graphic production scheduling software
- HR—human resource department
- MES—mine extraction strategy
- Mine2 4D—graphic production scheduling software
- Modifying factors—factors applied to convert resources to reserves.
- NPV—net present value
- OPEX—operating expenditure
- SAIMM—Southern African Institute of Mining and Metallurgy.

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Abré Smit

Principal Planning Analyst, Anglo Platinum

Abré graduated from University of Pretoria as a Mining Engineer in 1994 and started work at Western Deep Levels, Mponeng mine. This period proved valuable in gaining experience in deep level, seismically active mining, implementing various support and blasting technologies as well as high-speed trackless development. In 2004 Abré was transferred to Vaal River, Great Noligwa Mine as a Section Manager, after which he moved to platinum at Dishaba Mine in 2005. Here he achieved success in implementing in-stope anchors thereby greatly reducing rockfalls and increasing productivity and production volumes. In Anglo Platinum Abré has also been involved with JV operations, Asset Optimisation and most recently operational planning, where amongst others he assumed responsibility for developing and implementing APMot. Abré completed his MBA at UCT in 2008.

Gary Lane

Director, Cyest Corporation

Started career in 1990 as an engineer at Anglo American and was involved in various engineering and project management roles for the development of new mines across the group. Completed an MBA in 2000 and left Anglo as one of the 3 founders of Cyest Corporation. Is a director of Cyest and manages the Cyest Analytics business area which specialises in enterprise modelling and optimisation consulting and software solutions.