Computer applications in mining - Business benefits

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Abstract

The past 10 years has seen use of computers become widespread in the mining/exploration industry (including coal, precious and base metals, oil/gas and industrial minerals). This paper will concentrate on the use of computers as a tool to provide technical solutions (including data management, mine planning and operational support) to this industry rather than the use of computers to aid accounting, maintenance and inventory ("commercial") applications.

This paper will review the processes and benefits of the use of computers in mining. We then review the use of technical computing locally here in New Zealand and see what business benefits local users have found from using computers in mining.

We have, in research for this paper, spoken with mining software vendors from around the world to find out what is currently the "best practice" in the industry. The paper will then list what those vendors see as the ultimate improvement on the cards for the future of mining software.

Mining cycle and the use of technical computing

The "life-cycle" of a mining project and consequent use of technical computing can be outlined as follows.

1. Exploration
2. Mine Planning
3. Mine Operation
4. Rehabilitation

The exploration phase

Exploration includes all initial data collection (e.g. field mapping, drilling/logging, geophysical surveys, soil/stream/rock chip sampling), manipulation, analysis and modelling; preparation of resource/reserve statements; pre-feasibility/feasibility studies; and EIR Reporting and Permitting.

Use of technical computing broadly falls into three areas of information flow and manipulation:

Data

All exploration projects require the acquisition and analysis of data. The computer provides the best and most accurate method of planning data acquisition, storing data ("as collected"), analysing the data (either statistically or graphically) and outputting this data for a number of further uses and in a number of formats.

Modelling

A model of the geology is crucial and is simply a computer-based representation of what used to be in the heads of geologists and hand-drawn on plans. A number of interrogations can be made of the model to provide the required output, including mapping, cross sections, drilling plans, etc.

Once created the model can easily be updated to reflect further data collection and the refinement of deposit knowledge and understanding. It should be emphasised that the resultant model will only be as good as the input data and geologists interpretations. The fact that there is not enough data to gain sufficient confidence in the model's output may, in itself, be a significant output.

Analysis and presentation output results

Although the previous two items (data and modelling) are crucially important from a technical point of view, presentation of the results of these steps may ultimately be the most important facet from the project point of view. The ability for the technical professional to communicate with either non-technical people (e.g. management/accounting, political and public) or technical people from different fields of expertise (e.g. staff of Local Bodies, JV partners) is crucial from both the prospect evaluation and permitting standpoint.

Output ranges from the graphical, including "hard copy", for a range of "looks" in both two and three dimensional views ("cross sections", "plans", "isometric" and even "videos") to a range of reporting of modelled results. Key reporting includes statistical analysis of both modelled and "raw" data and reserve estimates of the quantity, quality, and certainty of the resource.

Estimates of geotechnical/geohydrologic effects of mining and various broadbrush/preliminary mine designs are also important outputs which may be crucial economic/ environmental/technical deciders for a project proceeding to the mining stage.

The mining planning phase

Mine planning includes mine design; grade control and scheduling; planning of the actual extraction of waste and ore; and planning rehabilitation of the mine site. Following are some examples of the use of technical computing in this phase of the mining cycle.

Two of the main features of a computerised mine planning system are: the ability to adjust all or any of the outcomes with the addition of new data; and the speed and ease of testing of "what-if?" mining scenarios.

Data

The form of data collection and storage can be similar to that used in the exploration phase. However data collection may be more directed (for specific temporal targets) and closer spaced (e.g. < 5 m drillhole spacing for gold mine ore control); but the computer techniques for database management will be the same as for exploration. The significant amount of data required for confidence in the geostatistical constraints used in mining may necessitate the use of computerised processors. In handling large amounts of data (e.g. from laboratory to technical/planning) the use of direct digital transfer of data will be more time effective and preclude a further stage(s) of potential error inherent in manual input of data.

Modelling

The basic mine planning model builds upon the model geological model developed in the exploration phase. What will differ is the intended use of the model (planning the production of a specific product to a specific time-frame). In addition closer spaced data may require different modelling parameters to better simulate the geology away from data points.

The geometries of extraction ("mine blocks") will be defined and volumes calculated by materials type.

Scheduling

Scheduling of the extraction sequence, pit optimisation, and even plant simulation/mineral processing is an important part of mine planning.

Scheduling can be performed at different time scales and can be used to test various extraction sequences and mining strategies. Additionally, scheduling will form part of the financial budgeting of the operation. A number of scheduling scenarios can be run very quickly to finalise a mine plan.

Computerised scheduling is a highly sensitive and time/cost effective way of adjusting for the effect of changing factors which affect mine feasibility. For instance, the effect on economic cut-off by a change in the market price for the ore can be very quickly assessed. Similarly new information on ore quality (e.g. production drilling) can be inserted in the model and the effect on the mine's ability to meet the required specification very quickly shown.

Pit optimisation, with both geological/grade and sophisticated financial controls and constraints can be modelled.

The mining phase

The mining phase includes the actual extraction of overburden/ waste and ore.

Ongoing data collection is essential in grade control and the ongoing refinement of the geological and mine planning models.

In addition, a host of other types of data including survey data, monitoring of groundwater/slope stability, "actual" or "run-of-mine" ore quality, geotechnical are routinely accumulated (on a daily to yearly basis) in a mining operation. This data may simply be stored and output for reconciliation, or as part of permitting conditions, or integrated with the mine planning system. Computers are of significant help in the collection, storage, analysis, and presentation of this information.

The adjustment of mine schedules to meet production targets should also be an integral part of ongoing production/mine design. The actual output from the mine(s) should be used to re-calibrate and refine the ongoing mine plan.

Equipment simulation (e.g. dragline reach, conveyor belts, truck/shovel teamwork, etc) are also a useful application of computing in mine planning and ongoing production management.

The rehabilitation phase

Inherent in a mine's life-cycle is the rehabilitation of the mined area - again as both a part of permitting and as the closing phase of a mine.

Day-to-day control on planning of backfill size and shape is essential for both rehabilitation concerns and well as to minimise rehandle costs.

Subsequent land use of the mine site can be planned, visualised, and communicated to the public and permitting authorities with the aid of computerised models.

Benefits of technical computing

General

Technical computing systems should not be seen as a *de facto* mine planning system. Similarly they will not compensate for lack of adequate data. Rather, they are a sophisticated, fast tool to aid mine planning with the capability of modelling, simulation, and presenting the results in a variety of ways to best suit the audience.

The inherent assumption is that every exploration/ mining company has a planning philosophy and a technical computing system is simply a tool to fulfil this philosophy.

Given this assumption, the potential benefits of utilising technical computing in the New Zealand exploration and mining industry include:

- space saving and security - large paper databases are both cumbersome to handle and query, and require costly storage/security systems;
- accuracy - once entered and validated (note the "rubbish in rubbish out" principle) digital data is accurate and easy to transfer/manipulate without the possibility of further "human error";
- processing power - computers are built to "crunch" numbers – the size of database will determine the appropriate hardware required for a specific project;
- analysis - the ability to easily run any number of "what if" scenarios of both mine design or ore specific (quality and quantity) characteristics by changing either/or technical and economic parameters;
- time savings - all the above increase the cost effectiveness of using computerised databases and models. In particular the addition of new data or of a new mining strategy can very quickly and easily be included into the database, modelled, interrogated and analysed;
- graphics - the ability to visualise and edit geologic and excavation structures in three dimensions is a powerful tool which cannot be easily replicated without computer tools;
- results presentation - the ability to visually communicate proposed and existing mine/ resource attributes, within both the technical planning world and to other "customers" (including those within and outside the exploration/mining company), may be almost as important as the technical details themselves. Most importantly, communication at the planning-production interface is crucial to maintain profitable and safe extraction of ore; and
- globalisation - the growth of the worldwide web and email means that the whole exploration/mining work flow (from data acquisition to results dissemination) can now be virtually "instantaneous" across the world allowing "real time" analysis and decision making in the industry.

The challenge to the mining industry

The biggest challenge in the use of technical computing is "buy in at all levels of the company."

The challenge for companies is to decide on an appropriate technical computing strategy and then to implement this strategy. This may range from the use of outside consultants on a bureau basis to the full capital investment in hardware and software and staffing. In similar fashion the specific systems selected will be dictated by the scale of the project/ mine and the mine planning philosophy.

Any investment in technical computing needs to be backed up by management with suitable implementation, training and support from qualified sources. Otherwise the full potential for the technical system will not be realised and there will be a temptation to blame the mining computing system itself rather than the way it has been utilised. The machines do little by themselves, and people factors are often overlooked. The full benefits of technical computing systems as outlined in this paper will therefore only be realised if the following are fulfilled:

- the company has an ethos and methodology of mine planning;
- the computer system is not expected to fulfil either the need for this ethos/ methodology and/or suitably trained technical staff;
- the computer system is not expected to compensate for insufficient data;
- both hardware and software chosen match the requirements and database/model size of the project;
- equal emphasis (if not investment) is put into the "non capital" items of the system (i.e. training, implementation and upgrades); and
- a flexible investment strategy is employed to allow for the expectation of upgrades to either/both hardware and software within 1.5-3 years following the initial purchase of the system.

New Zealand benchmarks – The locals speak

We canvassed a sample of the NZ mining industry and asked for their open and frank comments on their own experiences with technical computing:

- Mike O'Connell from BHP NZ Steel focuses on the reduction in people and time – the computer helps to better utilise the labour resource. Another benefit, he says, is the 3D visualisation aided communication, accuracy and presentation.
- Roger Bain from Waihi Gold sees the biggest benefit is accuracy and the fact that computerised mining software enables him to push lower into the work force those tasks which previously needed higher skilled people to do. He also sees key advantages in production reporting and delay reporting.
- David Manhire says L&M Mining has benefited from a gain in time. There is very little (other than water

modelling) which can't be done manually, but the computer does it all much faster, and encourages him to run more geological models to make fewer mistakes and test more theories.

- Dean Ferguson of Solid Energy sees the biggest benefits in the speed of delivery of mine plans and schedules, and the ability to run multiple scenarios which provides an opportunity cost saving. He also sees the 3rd dimension in 3D drafting adding significant accuracy to the mine model.
- A spokesman for Greymouth Coal sees the biggest benefit in the speed of producing plans and drafting, taking the raw data into a useable form in a hurry. Once the data is input, anything can be produced quickly.
- Chris Wills of Waste Management sees the most significant benefit as the ability to quickly run a number of different scenarios to get the optimum result. The layouts and quality options enable you to pick the one which best fits your expected demand.
- Stephen Terlesk from NZ China Clays sees the time saving in modelling assay values as a key benefit, which enables better grade control and the ability to maximise resources.
- Tony Christie from IGNS sees the major benefits in exploration work with the management of data helping to provide the direction of the exploration. He also sees advantages with the resource and analysis sides and thinks computers help to quickly sort out resources.
- Randy MacGillivray from Coeur Golden Cross finds productivity the most significant benefit – speed and cost savings of enabling design work with fewer people.

Pitfalls – Learn from fellow members

This paper would not represent a complete look at mining computing in New Zealand without a summary of the biggest pitfalls of using computers in mining. We have detailed what percentage of respondents indicated each pitfall in brackets.

Training (78%)

When the system is initially purchased it is easy to allocate funding for the computer and the software and forget to allow for the on-going costs of training so the operators can really get the most out of the system.

Rubbish in; rubbish out (55%)

While it is true in any mining calculation that the quality of the data input greatly effects the quality of the mine plan and model, it is perhaps more true than ever when computers are used. This is primarily due to the fact that the user tends to rely on, and to believe, what comes out of the computer more readily; and you have the ability to make mistakes even faster!

Initial model construction (22%)

There is a significant time and cost to constructing the initial digital model. Once that model is in, obtaining data and doing different scenarios is easy, but the initial time and cost must be allowed for.

Staff continuity (11%)

There is a problem with a mine plan over several years in that staff changeover during that time can make it challenging to know precisely what has been input and how. This change in staff can cause inconsistencies in the accuracy of the mine plan. This is also true with a manual mine plan, but even more so with the computer.

Future of software technology – The vendors speak

This information was gathered during interviews with mining software vendors from around the globe. The vendors gave the single aspect of their software which made it unique, as well as plans for their software in the future.

Data acquisition

- GPS providing challenge to use bulk data in "real time".
- Feed data back to machines (e.g. at drill and blast operations).
- Downhole probes. Grade control, gamma probe without assay.

Data analysis

- 3D/stereo representation of geologic structures will be "made real" with the use of CAVE technologies.

Mine planning and scheduling

- Optimising the schedule, not the pit.
- Pit optimiser with 2D grids for coal rather than a 3D block model.
- Mining difficult ground simplified with smarter addressing of complicated mine planning.
- Operations briefing in 3D on computer.
- Increased use of seismic in coal.
- Increased use of geotech monitoring/mapping.
- Real time truck dispatch.
- Conditional simulation for ore body modelling.
- Modular mining – GPS on bucket track of movement shovel, intersect with block model for grade.
- Deterministic algorithms rather than interpretative to optimise pit and maximise cash values.

Modelling and visualisation

- Triangle and grids numbered, with new algorithms to produce a new modelling system of kinematic modelling which changes dynamically as data is added.

- More robust algorithms to handle large amounts of data (5 m grids).
- 3D triangled picture to give production advice to operations.
- 4D visualisation – 3D vision in dynamic time.

Acknowledgements

The following are thanked for their input into this paper:

Technical computing industry

Pat Hanna, Exploration Computer Services International

Steven Sullivan, Maptek

Andy Schumack, Metech

Ian Gray, Mincom Pty. Ltd.

David Whittle, Whittle Programming Pty. Ltd.

New Zealand mining industry

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Roger Bain from Waihi Gold

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