Virtual Reality for Dragline Planners

3d-Dig acts as an invaluable mine planning and communication tool

BY TOM COBCROFT

Mining engineers are quickly discovering that there is now a newer, better tool for dragline mine planning; one that makes it possible to easily communicate a mine plan through the use of animations and other graphics. This tool is 3d-Dig, a three-dimensional digitally-rendered mining simulation tool developed by Earth Technology Pty. Ltd.

A large Australian mining company has been using 3d-Dig as a standard to plan in-detail pits and strips for up to five years in advance. A U.S. operator is using it to optimize dragline stripping around inside corners, and to accurately plan the traverse of ramps. Other users from the Hunter Valley and Bowen Basin of Australia, South Africa's Witbank coalfield and now the Powder River Basin in the U.S., are quickly finding ways where 3d-Dig can help improve their operations, too.

This new system offers several advantages over conventional mine planning software for refining their medium- and short-term planning, offering a better prediction of rehandle volumes, linear coal advance and dig time within a strip. It is a particularly useful tool for optimizing waste stripping and can accurately predict volumes and timing of uncovered coal to enhance blending and shipping reliability.

3d-Dig goes far beyond a simple range diagram analysis. Users are presented with volumetric, spoil placement and positioning data, while generating animations that communicate the plan. It mimics old sandbox style models, but allows iteration, optimization and integration into an overall three-dimensional mining model. 3d-Dig solves the two-dimensional limitations of mining software packages that can only generate plan view maps and cross-section range diagrams.

Because it facilitates communication between engineers, managers and supervisors, and allows better long-term understanding of what is required from the machines and by when, 3d-Dig enhances onsite planning and the ability to communicate that plan throughout the organization. Thus, better communications and understanding of plans results in reduced costs.

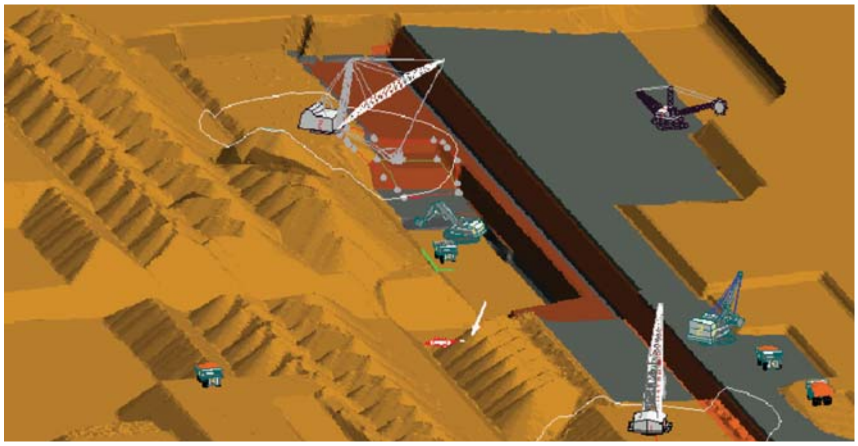

Figure 1—3d-Dig models all stages of mining including topsoil removal, prestrip, production dozer push and dragline operations.

ENHANCED COMMUNICATION

Improving communication and implementation of a surface mining plan is one of the leading advantages of 3d-Dig. Communication is enhanced because the program is used to demonstrate and communicate each and every step of the physical mining process. For example, a detailed dragline step and positioning sequence can first be easily generated by the mining engineers, and through the use of animation, it can be demonstrated to everyone in the organization, including geologists, other engineers, operators, shift supervisors, and general managers, all regardless of their technical training or experience. Terrain rendering in 3d-Dig provides updated topography on-the-fly as the simulated dragline digs and dumps. The software also models topsoil removal, shovel/truck prestrip, production dozer push, and coal mining (See Figure 1).

Several mines in Australia currently use the software as an intermediate step between the planning engineers and production to develop feasible, realistic plans that can be achieved in practice and that everyone can understand.

One of the shortcomings of two-dimensional range diagrams and most other planning software is that they are too simplistic to adequately design and then show pit access roads and ramps. 3d-Dig not only allows for the design of roads and ramps, it incorporates them into the animations, showing how pit access evolves as benches are mined and coal is exposed. The three-dimensional capabilities of this software allows for the optimization of ramp positioning and, by detailing each step of the equipment through the entire mining process, potential tight spots, access and egress issues, and problematic areas may be identified and resolved during the planning process before becoming issues in the pit.

The software may also be used to perform detailed planning years in advance based on a generalized mine schedule, with one of the outcomes being updated post-mining topography on a year-by-year or strip-by-strip basis. This post-mining topography can be invaluable for final reclamation planning purposes and can be used to guide the mine processes to achieve a required post-mining-topography or final landform contours within a given time period.

DEFINE & REFINE

3d-Dig has also been used to determine process improvements that have resulted in sizeable cost savings through total volume reduction (reduction in rehandle) via pad optimization (See Figure 2), productivity improvements and less dragline deadhead and pad step sequences.

There are numerous opportunities to enhance the entire mine planning stream through the application of 3d-Dig, result-

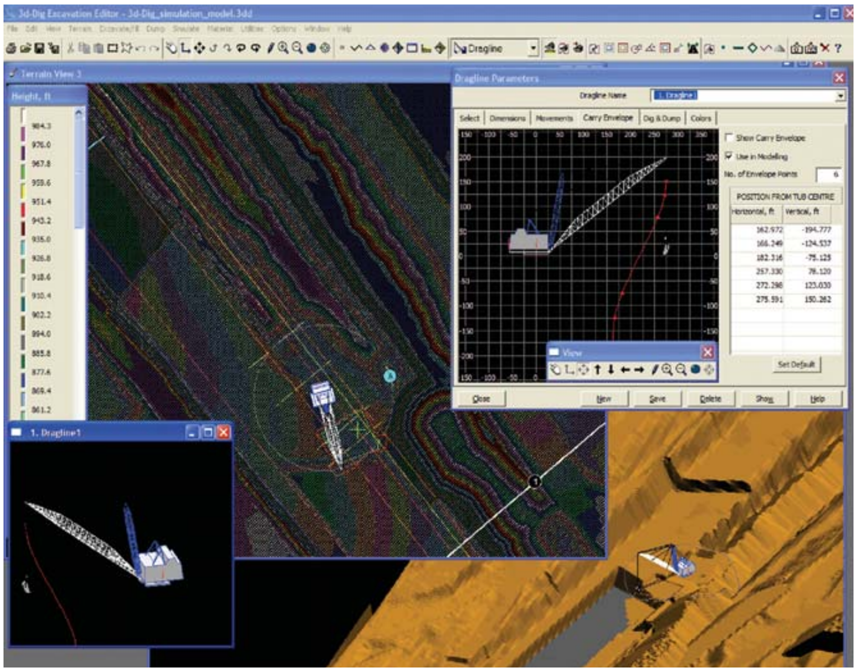

Figure 2—Dragline modeling and pad optimization in 3d-Dig.

ing in better control of the machine in the field as well as better communication of when, where and why with regard to machine positioning and spoil placement. These applications include:

- Pit design optimization;
- Dig and dump planning for equipment including truck-shovel, draglines and production dozer push tailored to the individual machines at the mine site;
- Communicating plans to operations, engineering and management personnel—both technical and non-technical alike;
- Researching, developing and validating new mining methods and approaches based on site-specific parameters including geological and geotechnical constraints, material densities and swell factors;
- Detailed topographic studies and analysis;
- Equipment scheduling—short-, medium- and long-term—including productivity estimates and cycle times; and
- Developing life-of-mine dumping and final landform strategies.

The latest release of 3d-Dig, version 2.3, provides rendered views and snapshots of pits and strips as shovels work, draglines swing and dozers push.

Using .dxf files of topography, coal roof, coal floor, wall designs (pit shells), and with models individually tailored to the specific mobile equipment and draglines at a particular mine, the software can transform a two-dimensional contour plan into a detailed sequence animation that is easily understandable.

Outputs from the program include topography, volumetrics (prime and rehandle), dragline productivities, sequence animations and pad elevations that work in and around ramps, roads, inside corners, steep-dip coal measures, or whatever else the site's geology dictates.

A WORLD OF SURFACES

3d-Dig's three-dimensional world of dig and dump breaks the limitations of traditional mine planning software. Going beyond the limitations of a two-dimensional range diagram or contour maps, 3d-Dig models the operation, sequencing and constraints, drawing it all together into a single design, something that most mine planning software fails to do.

The software works with dig and dump surfaces. A typical excavation will involve the construction of a 3-dimensional pit shell (comprised of line strings) that becomes a limit or constraint surface in the software. These boundary surfaces, combined with coal seam roof or floor horizons, constrain shovel/truck, dozer push, dragline and coal mining operations to honor the geology of the site, and the geotechnical parameters prevalent for highwall, lowwall and endwall design.

The software has the power to constrain dig and dump to not only a collection of limit surfaces, but also to digitized boundaries, elevations, or road and ramp designs and grades. For example, to construct a fill-ramp onto a dump at an 8% grade, the user digitizes a start point and dump direction, and the program takes care of the rest. Literally, a dump to be constructed in lifts can be designed using this software in a matter of minutes.

Another unique and helpful feature is the ability to generate cross-sections on-the-fly simply by digitizing a section line on the terrain surface. This line can then be dragged and dropped to other locations, thus instantly updating the cross-section with each and every move. Most other software involves a counter-intuitive route to generate a cross-section, which is often time consuming, and frequently does not yield the desired results on the first attempt.

INTO THE MINE

3d-Dig can be used in researching better ways to dig, including simple sidecasting, overhand chop extended bench, and spoil side operations. But uniquely, it also allows for "out-of-the-box" dig method analysis including a dragline pulling steep dip coal down with its bucket, or mining out a synclinal or anticlinal geological structure in a mode that is not standard. An Australian mine used 3d-Dig to analyze how a dragline could be used to directly load haul trucks; the software's animations were then used in risk assessment meetings and review sessions at the mine prior to operational rollout.

Equipment simulated within the program can be tailored to the exact manufacturer specifications of machines onsite (See Figures 3 and 4). In this way, the mod-

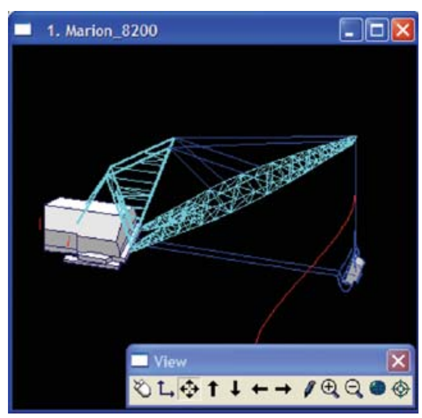

Figure 3—3d-Dig individually tailors simulations to the exact equipment used onsite.

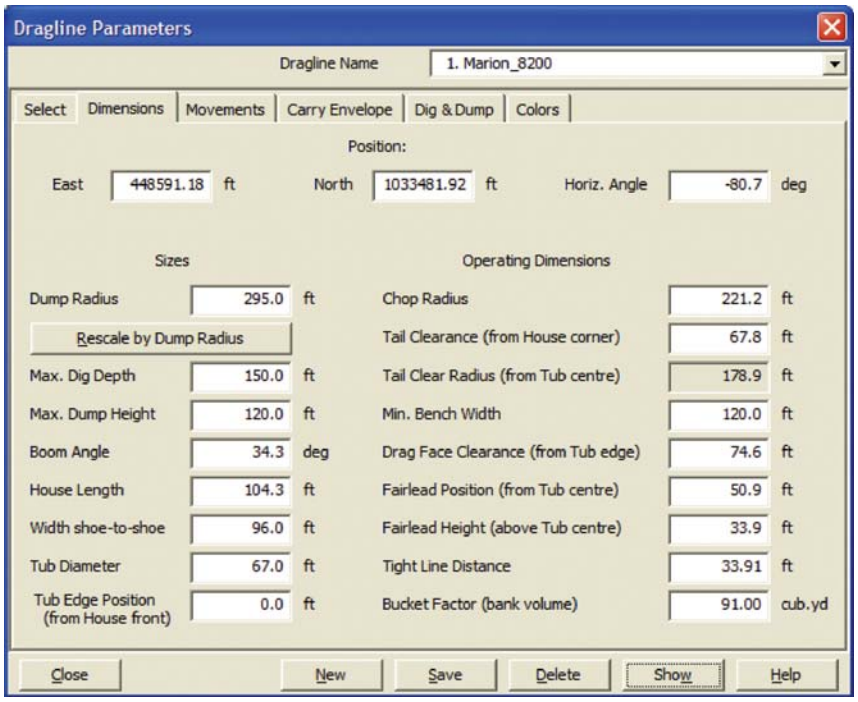

Figure 4—Equipment specifications entered into 3d-Dig for machines onsite.

el accurately represents productivity estimates and cycle times based on the manufacturer equipment parameters. This is invaluable for dig sequence determination, where the program will inform the user that the equipment is digging out of its useable range including dig depth and dump height constraints.

For example, whenever new drag and hoist ropes are installed or older ones cropped during routine maintenance, the software can be updated with the new rope lengths. The design is rechecked to ensure the machine can still physically perform its required functions based on the updated equipment geometry. This is particularly useful for final retreat from a strip, where dig depth can be critical for coal exposure, or where dump height is important for final spoil stacking. Maintenance planning can then be incorporated into the process, particularly if a new set of ropes is required to allow the dig to progress as planned.

Material volumetrics are a major portion of the program and 3d-Dig logs both prime, rehandle, in-situ and swelled volumes. The material log can be maintained so that it segregates volumes for shovel/truck movements, dozer push and dragline operations. This can be done on a block-by-block, strip-by-strip or step-by-step basis depending on the level of reporting required in the modeling.

Through volumetric analysis an operation in South Africa determined that a better overall mine sequence could be achieved by increasing material allocation to the dragline, thus easing scheduling pressure on drill and blast activities and prestrip mining. 3d-Dig modeled how the material would stack, along with a change in pad positioning to accommodate the extra material.

Sound like a range diagram analysis? 3d-Dig provided more than a range diagram could ever hope to address, indicating a realistic traverse of roads, ramps and endwalls with the increased material allocation, and just how the machine had to be positioned to achieve the geotechnical constraints stipulated.

Swell factors can be manipulated in the software to perform a sensitivity analysis. It is not uncommon that swell factors used in mine planning are derived from old data, and, consequently, may no longer accurately represent the current material being handled as mining progresses down dip, or into different geologic formations. 3d-Dig can incorporate changes in the swell factor to determine the cumulative impact on both spoil stacking and swing angle.

3d-Dig can flag any overburden material that may require selective handling and will report mined volumes and dump locations to accurately track when this material is being mined and where it is being placed. Potentially acid generating (PAG) or metal leaching (ML) material can be colored and logged within the software each time it is encountered in a dig face, and selective placement can be demonstrated to satisfy environmental constraints imposed.

Machine productivities are also routinely generated by the software during dig sequencing, which is particularly useful in determining the timing of coal release that can be critical to the success of any mine plan. Predicted productivities are based on

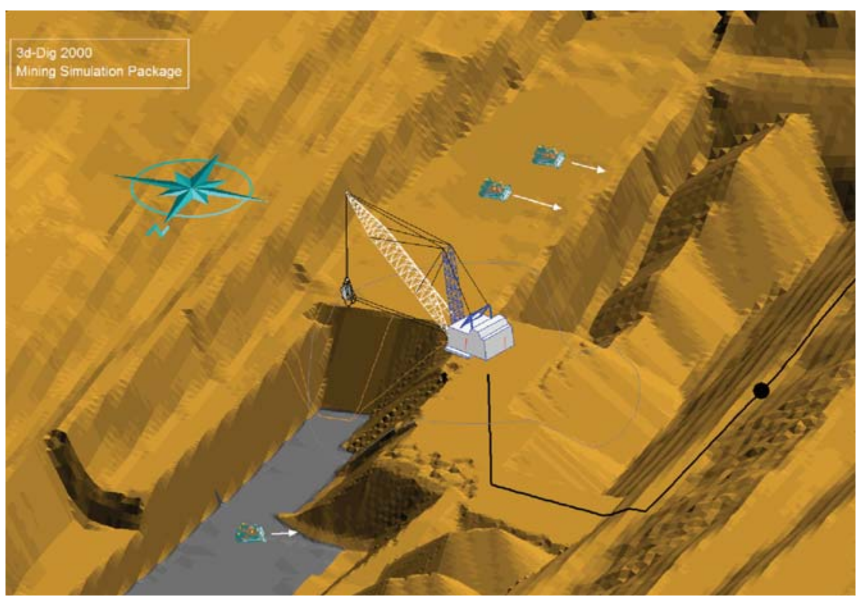

Figure 5—-Example of strip exit planning by extended key operations with upper sequence spoil and production dozer push.

an accumulation of factors including swing angles, dig depths, and dump heights as well as motor ratings and stall speeds provided by the equipment manufacturer.

3d-Dig can also optimize an open-pit or open-cast mining operation. When a dragline approaches an inside corner, spoil stacking can become tight and spoil stability can become questionable. 3d-Dig allows the user to vary such items as pad elevation, buckwall formation (stepping into the pile), spoil pull-back, or step-sequencing in order to generate a spoil profile meeting the required geotechnical parameters. Marston is currently working with a number of operations in the Powder River Basin using 3d-Dig for this purpose.

Another example of how 3d-Dig can optimize a mining operation is in the area of strip exit planning (See Figure 5), which can be problematic, particularly if a number of upper sequence simple-sidecast operations have resulted in a sizeable amount of rehandle piles on the final retreat. 3d-Dig can point the user to dig depth constraints, dump height constraints, padwork volumes, and how to elevate the machine to reach an exit point. Volumetrics and step sequence can point to the best scenario to expedite the dragline exit and ensure lowest rehandle and fastest coal release.

An Australian mine used 3d-Dig to determine that endwall exits were not the best way to go based on total volumes moved and linear coal advance. 3d-Dig assisted with modeling various exit-point scenarios, and the final outcome was a central strip exit compared to an entrenched belief that mining had to proceed to the endwall, and the machine had to be elevated in a series of benches to reach a critical exit height.

Shovel/truck operations are not excluded from 3d-Digs wide modeling capabilities. 3d-Dig can show shovel dig sequencing and elude to road and ramp access issues, dump room issues, and haulage distances by scheduled mining block well in advance of actual physical mining.

SOFTWARE DESIGN

Murray Phillips and Dr. Alex Kavetsky, the primary designers of the software, formed Earth Technology Pty. Ltd. in 1992. 3d-Dig's dig and dump algorithms and the excavation engine were subsequently developed in Russia, originally using wireframes to represent the topography and were focused exclusively on dragline operations. A sizeable amount of the development occurred in and around Australian dragline operations, and several software upgrades have followed, with increased focus on shovel/truck and production dozer push.

This has resulted in the evolution of 3d-Dig into markets other than solely dragline operations, and currently a number of sizeable mining contractors are utilizing the software for shovel/truck modeling and volumetrics to better optimize their processes.

Software development remains ongoing. Kavetsky and his team in St Petersburg are very proactive at patch development as the program continues to evolve to include the following:

- An enhanced shovel/truck module with capability in haulage cycle times and definition during the dig stages and dump advancement,
- A dozer productivity module which will include dozer optimization to minimize dozer push distance and cycle times,
- A blasting wizard, which uses a voume balance routine to blast overburden and incorporate material swell to a blasted profile,
- An improved roads module, which further increases the power of the software to dig and dump ramp systems for truck-shovel operations, and
- Other enhancements including the faster drawing of rendered triangles, feature exports and improved volumetric material logs.

Each release has further strengthened the ability of the program to model every step of the mining process. This software provides a useful tool in obtaining optimized productivities from your mining equipment through an integrated and cohesive overall mining plan and strategy. If you need to optimize your surface mine planning in order to remain competitive in today's market, then move beyond your current two-dimensional mine planning software to the world of three-dimensional modeling by upgrading to 3d-Dig.

AUTHOR INFORMATION

Tom Cobcroft is a consulting engineer with Marston & Marston Inc., in St. Louis, Missouri. He originally used 3d-Dig on-site in Australia and has continued to use it on several consulting projects in the U.S. For more information, Cobcroft can be reached at 314-984-8800 or e-mail: tcobcroft@marston.com.