

Advanced 3D Software Systems for Effective Environmental Management

I.K. Kapageridis

Maptek/KRJA Systems Ltd.

ABSTRACT

Environmental management and planning requires the integration of large volumes of disparate information from many sources and the analysis of this information with efficient tools for assessment and evaluation. Effective methods of communication that allow interactive participation in the planning, assessment and decision-making processes are also very important. The VULCAN software package from Maptek (Pty) Ltd comprises a large number of 3D graphical tools within an interactive 3D interface called ENVISAGE. These tools are designed and developed to help engineers and scientists to identify and solve environmental problems. The combination of VULCAN 3D Software and the I-SiTE 3D Laser Imaging system leads to powerful solutions for environmental management. This paper presents the capabilities of this integrated system and its applications for environmental management.

1. INTRODUCTION

In the past couple of decades the extractive industry has developed and adopted new techniques for designing the restoration and reclamation of disturbed sites. New environmental laws meant more strict design and monitoring of the reclamation process is necessary. This led to the development of new computer tools that help achieve the difficult targets that new legislation established.

The advanced visualisation and computational power provided by modern

hardware and software systems allows their use for environmental management. The sophisticated software system provided nowadays to the extractive industry are capable of transforming complex designs and simulations to virtual reality models that help understand and even improve on the effects of the extractive process to the environment. Potential environmental problems and pollution impacts can be traced using these models before or during the extractive process, or to support a public inquiry.

Maptek has been developing specialised software for the mining industry for over 25 years. Maptek's VULCAN 3D Software suite and the most recent I-SiTE Laser Imaging system are software/hardware systems developed with environmental management in mind. These systems combined can handle large amounts of data as well as environmental, local access and economic constraints integral to rehabilitation design.

Advanced software and hardware systems like VULCAN 3D Software and the I-SiTE Laser Imaging system are successfully used by companies around the world in complete mine feasibility and environmental impact assessment studies. In the pages that follow it will be explained how these systems are utilised for effective environmental management in a number of case studies.

2. 3D TOOLS & METHODOLOGY

2.1 Overview

VULCAN offers powerful modelling tools, which, coupled with state-of-the-art 3D graphics deliver a valuable solution to the mine planner. Concentrating to environmental management applications, the system provides efficient tools for data integration, analysis and communication, supporting an interactive, intuitive approach to meeting planning requirements and raising community awareness. VULCAN assimilates site assessment data in order to develop and visualize restoration strategies using 3D interactive graphics. The ability to evaluate and present all possible scenarios during planning and remediation exercises facilitates communication, ensuring optimum decision-making (Neilson & Kapageridis, 2000).



Figure 1: Matching image pixels to real world co-ordinates for texture mapping.

2.2 Texture Mapping

Texture mapping is the process of draping an image on a 3D triangulation model. The image can be an aerial photograph, a map, or any other picture of the real world. The combination of this image and the model of the surface where the image came from give a very realistic result and help to build more recognisable models. All that is necessary is a set of control points that match image pixels to real world co-ordinates (actually model co-ordinates) (Figure 1).

The image and control points are saved in a separate file, which means that any model within the image co-ordinate range can then be visualised with the image draped on it.

VULCAN handles large triangulation models that, depending on the available hardware, can consist of hundreds of thousands of faces (triangles). These models can be visualised with an image draped on them. The image colours can be shaded according to the details of the model (Fig. 2).

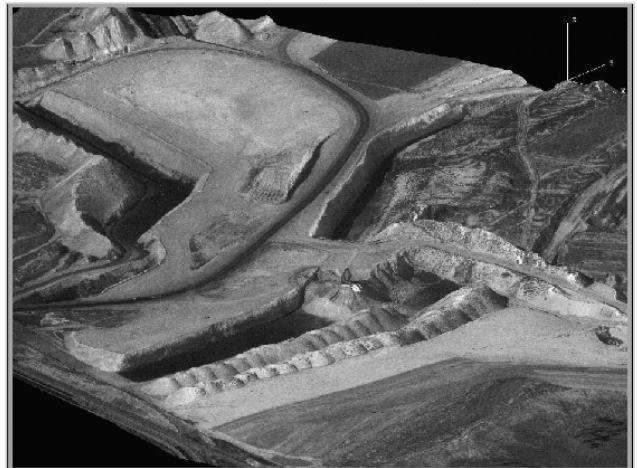


Figure 2: Image draped on triangulation and shaded according to a light source.

The result can be combined with further mine development (Figure 3).

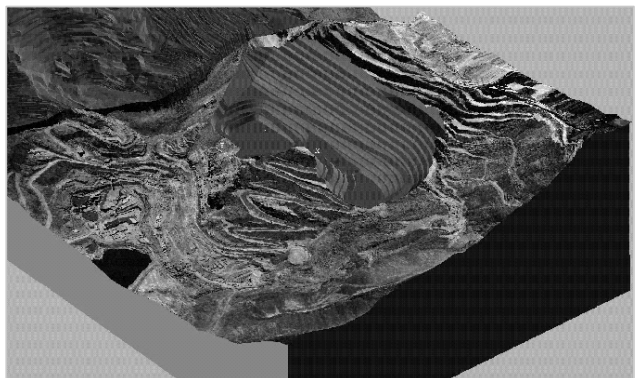


Figure 3: 3D view of mine model and surrounding topography with aerial photograph.

2.3 Imaging Options

The imaging module provides means for extracting true 3D measurements from a pair of images and a set of ground control data.

Digital images in several formats, including GIF, PhotoCD and RGB, are accepted and may be loaded into the Image Viewing window (Figure 4). In this view, zooming and panning are easily controlled to give detailed views of one or two images.

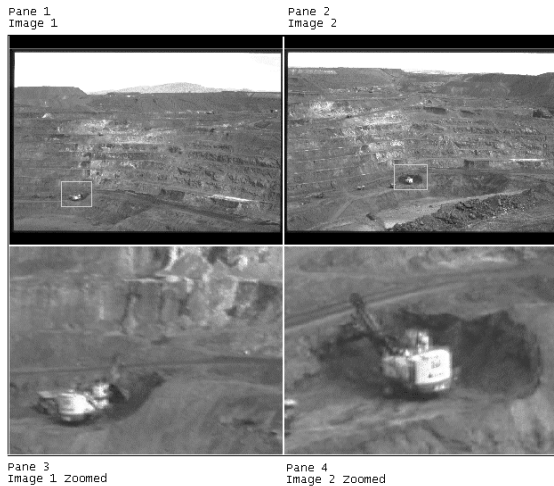


Figure 4: Different views of two images from the same mine location displayed in the Image Viewing window.

Ground control data may be entered through the specialised options. These data may then be combined with the images to produce a pexel file, or saved for further processing.

An auto-matching routine is provided that combines a pair of images, resulting in a set of matching points. These points may be then imported into the module, viewed, edited and saved. When combined with the ground control data, these points form a set of 3 dimensional, real world coordinates. They may also be used to produce a triangulation, onto which an automatically generated pexel file may be draped and from which more detailed measurements may be taken.

2.4 Animation & Real-time Navigation

VULCAN's 3D graphical environment, ENVISAGE, allows real-time movement through model space while the user is working on the model. There are various options for animation, viewing, or even navigating through the model.

The ANIMATION option allows the user to display any data set (polygons, grids or triangulations) in a specified time sequence. The main feature is the ability to drive the visibility of many objects or data sets loaded onto the screen. These data could be grouped through frames and actors in the Animation option. In this way, any data having similar spatial attributes can be grouped in the same frame and can be displayed alone at any time on the screen. It is possible to see sequential data in a realistic simulation.

The LOOK option allows the user to navigate through the model in a fly-by manner with no specific route but with mouse and keyboard controls that allow every possible movement. During this movement the models can retain all their graphical attributes including textures, shading and colour (Figure 5). The refresh rate of the movement depends on the hardware available and the number of faces, textures and overall detail of the model.

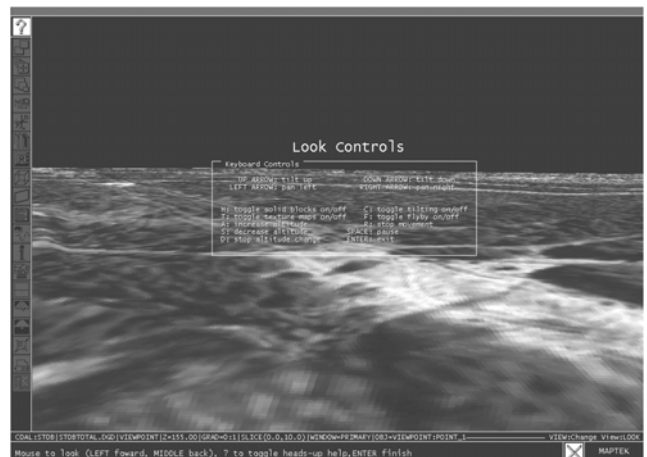


Figure 5: Navigation through model space in ENVISAGE. The heads-up display is active.

There are other options that allow specific fly-bys, viewing from specified locations, or walk and drive on specific paths.

2.5 Dragline Operation Simulation

The Dragline module is ideal for stratigraphic strip mining operations and provides a suite of tools to deal with range diagrams, reclamation

and general section design (Figure 6). Great flexibility is provided in creating very detailed range diagrams. You can effectively simulate draglining, blast casting, bulldozing, truck & shovel operations and any other kind of material movement, to develop a series of optimised range diagrams.

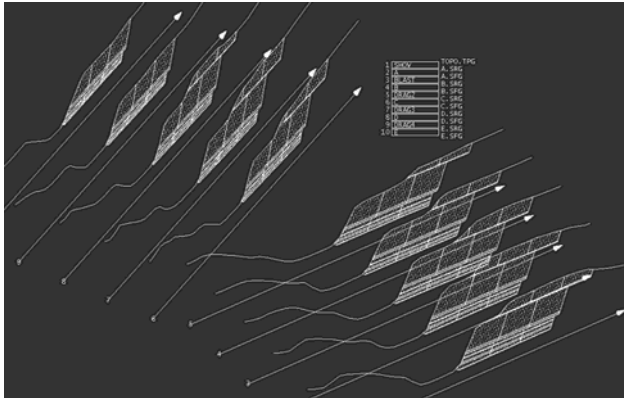


Figure 6: 3D Layout of Range Diagram Cross-sections with Horizon Legend.

Support for grids, triangulations, and Envisage design objects, allows easy development of insitu block layouts. Intersections between cross-section lines, strip plans and horizon surfaces are calculated automatically, to generate the initial range diagram sections quickly and easily. Full control is provided in setting highwall angles and bench offsets.

An exhaustive suite of tools is provided for moving blocks in a wide variety of ways, allowing the user to work in a fully interactive design environment. Complete, parametric control of all functional dragline dimensions provides a powerful, graphical tool for analysing dragline capabilities and limitations. Average dragline cycles and swing angles are also calculated. Different swell factors and repose angles can be applied to different material types moved by the different equipment.

Rehandle statistics can be accumulated on each block movement, enabling material to be tracked and monitored through each step of the mining process.

Multi-coloured operation plots can be generated automatically, showing a series of complicated mining procedures on a single, easy-to-read plot as shown in Figure 7.

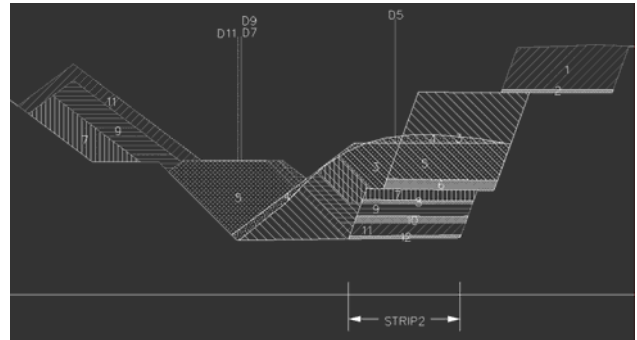


Figure 7: Operation Plot Showing Sequence of Operations Carried Out on a Strip.

Formatted reports can be generated on blocks and operations, with totals and weighted averages tallied. Reporting in CSV format enables quick and easy importation into spreadsheet packages, allowing scope for additional analysis and scheduling, if required.

Topography strings are updated automatically at every block movement. Strings from different range diagram sections can then be triangulated, to create a series of disturbed surface models (Figure 8).

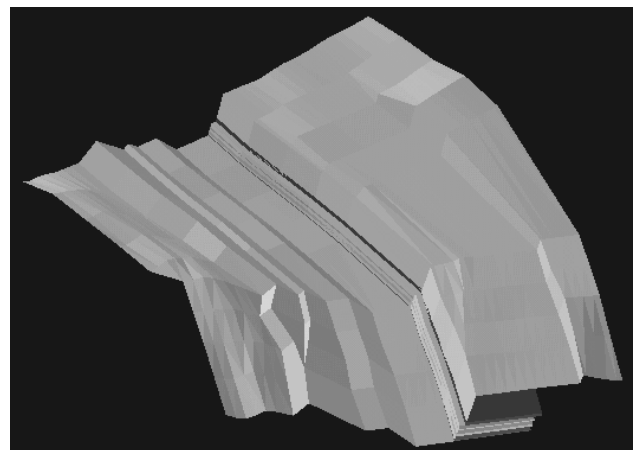


Figure 8: Series of disturbed surface models from different range diagram sections.

2.6 Shaft Mapping

Shaft transformation windows provide you with a transformed view of design data (and models) that gives a "flattened" 2D view of the walls of

an essentially cylindrical object (e.g. mine shaft or inclined drift) (Figure 9). The Shaft transformation windows use a different coordinate mapping than the normal windows. The bearing in a shaft window is mapped to the X axis, the level or depth above or below datum is mapped to the Y axis and the distance from the shaft or drift centre line is mapped to the Z axis.

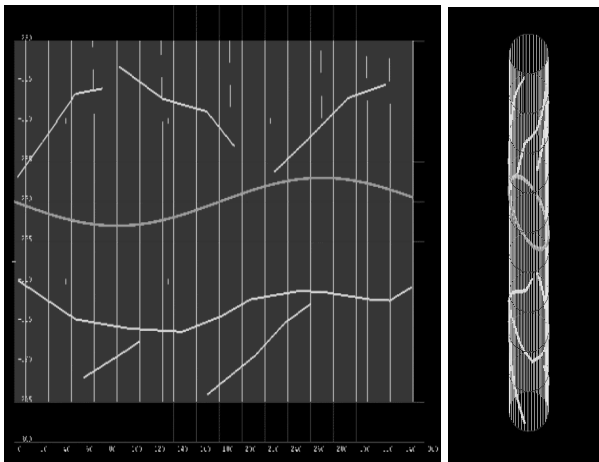


Figure 9: Shaft view (left) of shaft mapping data (right).

3. ENVIRONMENTAL APPLICATIONS

3.1 Overview

VULCAN has been used with success in a number of environmental applications such as post-mine topography design, groundwater analysis, nuclear waste management, visual impact analysis, land use management and civil engineering works.

3.2 Post-Mine Topography Design

Post-Mine Topography (PMT) is the final regraded and topsoiled surface of a mine site once earthmoving and replanting has taken place. By law, PMT plans must be submitted to regulatory authorities as an integral part of the process of gaining approval for future mining activities.

PMT design involves superimposing the regraded post-mining surface on the disturbed mining landscape in order to be able to calculate cut and fill required to produce the final PMT. Traditional computerised cut and fill

calculations use cross sectional areas which are not actually checked for 3D volumetric accuracy.

VULCAN's triangulated surface models can be viewed interactively and analysed against each other for precise volumetric balancing, making PMT design more efficient and accurate. An example of how VULCAN is used for PMT design is the Rosebud Mine in the northern Powder River basin near Colstrip, Montana, USA. Western Energy has been using VULCAN since mid-1992 to successfully meet many of its post-mine topography design needs.

VULCAN's range diagram module has been used for simulating the disturbed topography. The PMT surface and the disturbed surface were triangulated and compared for cut and fill volume balance in VULCAN. VULCAN's scheduling capabilities allowed a decision to be made to move the dragline within the area being mined into reclamation.

3.3 Groundwater Analysis

The understanding of groundwater systems is a vital step in most environmental engineering projects, where this can be used to model contaminant pathways and to identify potential water resources. The development of conceptual hydrogeological models is usually based on the same geological information as used for geotechnical evaluation, site investigation and delineation of geological features.

VULCAN can incorporate observed hydrogeological data to interface to Modflow (McDonald & Harbaugh, 1988) and Aquifem-N flow codes, improving the accuracy and confidence of the groundwater evaluation process. The tools provided enable a number of modelling processes incorporated in the groundwater analysis. Specifically, VULCAN can perform the following tasks:

- Create graphical representations of conceptual hydrogeological models
- Display the extent and flow of aquifers in 2D and 3D
- Allow advective transport modelling of potentially hazardous pathways

- Integrate topographic, geological and survey information with hydrogeological data
- Support 3D finite difference and quasi 3D finite element codes

3.4 Nuclear Waste Management

Safe disposal of nuclear waste material requires an accurate understanding of geological barriers surrounding a potential repository. Conceptual geological, geophysical and hydrogeological models are validated by analysing site investigation data in three-dimensional space and through time. VULCAN permits the integration of data from a variety of sources: site characterisation data; formation and geological data; mapping, core logging and seismic data; and specialist radionuclide transport modelling codes. Flexible design tools allow an underground waste repository to be modelled interactively, then validated against the geological, geophysical and hydrogeological data in 3D space and time.

3.5 Visual Impact Analysis

Visual impact assessment is another information-intensive task. Traditionally, computerised visualisation systems have had a terrain or an urban land-use focus. VULCAN can handle both surfaces and solids with accuracy. The system allows the calculation of a 'zone of visual influence' as a series of radii from a point on a grid that can be contoured. The virtual reality features of the software enable walk throughs and flybys or animation sequences to be stored or saved to video.

3.6 Other Applications

VULCAN has been applied to other environmental problems such as land use management, construction of waste management sites, hydroelectric dams (Fig. 10), waste water storage tanks, etc.

4. I-SiTE Laser Imaging

I-SiTE 3D Laser Imaging system delivers dynamic data capture and visualization to

instantly build 3D models with accurate coordinate placement and analysis.

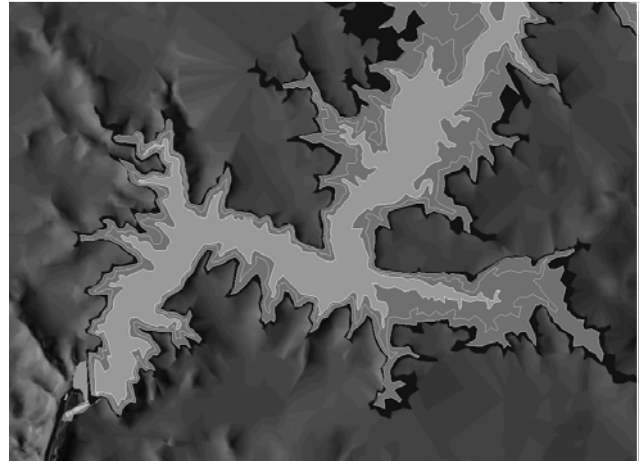


Figure 10: Hydroelectric dam design in Kayseri, Turkey.

The system records accurately the location of features and surfaces in areas such as urban and industrial settings and mine sites, both surface and underground. It is friendly to the environment since there is no need for removing vegetation from the scene of the scan. This is done in post-processing using the I-SiTE software. The system is ideal for hazardous environments where it could be otherwise impossible to make measurements.

5. CONCLUSIONS

This paper has shown the main areas of application of VULCAN and I-SiTE systems in the field of environmental management. The integration of different types of graphical and numerical information in the VULCAN – I-SiTE graphical environment enables the engineer to gain better understanding of the particular problem and reach the best solution.

REFERENCES

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