

Sustainable development of mineral resources: Improving communications using visualization techniques

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ABSTRACT

A virtual reality approach is presented that can aid entities such as mining companies and land use planners in communicating a visual understanding of a mining operation to interested stakeholders, citizens' groups, and public committees. These visualizations are particularly useful in permitting, production planning and mining closures, contributing to accurate communication and evaluation of mine plans, ultimate land use and evaluation of potential design options. A case study is presented, that was created using commercially available virtual reality tools, to emphasize the benefits of visualization technologies in the sustainable development of mineral resources.

1. INTRODUCTION

The design of surface mineral operations must balance mine planning with the principles of sustainable development of mineral resources, including the protection, environmental mitigation, restoration and ultimate post-mining, land use.

Sustainable development focuses on social, economic and environmental issues (MMSD, 2002). Within the mining life cycle, mining plans and extraction processes must be presented to permitting agencies, as well as to local authorities and communities for certification, financing or public acceptance. Many environmental laws and local political groups are interested to "see" how the standards of the particular environmental or social action will be maintained. In many cases, it is the public opinion that plays an overriding role in

the final success of a project. Technical communities must realize, therefore, that irrespective of the validity of a technical solution, proper documentation and effective presentation to interested stakeholders is vital.

The term 'computer graphics' was originally coined by Boeing Corporation in 1960 (Vince, 1995). Since that time, great strides have been made in both computer graphics hardware and software. Tools that are typically used by mining engineers, land use planners and managers include mine design and GIS-based systems. In most cases, these systems lack the three-dimensional perspective that can produce an easily recognizable image, one that can be appreciated by non-technical viewers. In recent years, a new generation of tools has been developed that can facilitate visual understanding, including multimedia presentations and virtual reality (VR) applications.

Current desktop computers are capable of displaying virtual environments in real-time, i.e. a synthetic representation of a real or imagined scene can be presented that allows interaction by the viewer in real time.

With the advent of distributed computing environments and the low cost of desktop computing power, it is now common for small engineering groups to use visualization tools for modeling an orebody, or a mining process such as loading and tramming.

2. IMPORTANCE OF COMMUNICATION IN SUSTAINABLE DEVELOPMENT

Open and honest communications are a key feature of sustainable development. Indeed,

"communication for development" has already become a recognized field among many decision-makers (Fraser, 1994). The increased significance of the communications field results from the acknowledgement that, in sustainable development, there are multiple stakeholders with varying backgrounds and representing different interests, all generating and exchanging information. There is, therefore, a need to link different viewpoints and to create a common "communication language" among different groups.

The contrasting interpretations of reality between rural inhabitants and policy makers, or between scientists and field personnel, are challenges faced by the field of communication for development. Suitably planned communication efforts should be aimed at linking different stakeholders. Hence, communication for development is about aiding different groups of individuals in jointly understanding needs and assessing opportunities. It should provide them with the methods and media to reach common meaning, and should enable them to negotiate with other groups with contrasting perceptions and interests (Ramírez, 1998). Such groups may be categorized as (MMSD, 2002):

- Occupational Communities – Mining activities are responsible for all or most income.
- Residential Communities – Mining affects the area in which the community resides but is not responsible for all or most income.
- Indigenous Communities – Mining activities are operating in or around a community with cultural or ancient attachment to the land.

Röling (1994) offers a clarifying perspective by proposing three different roles that communication for development can play in natural resource management (Ramírez, 1998):

- Making Things Visible: explaining biophysical information (increasingly aiming at creating new perspectives rather than transferring pre-packaged solutions);
- Fostering Policy Acceptance: enacting and promoting policies, focusing on interactive policy making rather than persuasive advertising;
- Facilitating Platform Processes: giving a voice to different stakeholders through platforms where negotiation among different

parties can take place with regard to natural resources.

Currently, this communication gap can easily be bridged using commercially available tools. This paper discusses the successful application of virtual reality technology to enhance the communication of a various mining and reclamation options between the stakeholders for a surface granite quarry, emphasizing the sustainable development approach of the company.

3. DATA COLLECTION

The data needed for most visualization applications include:

- Data that are readily available in mine offices, such as the mine geometry, mining and scheduling plans, topographic maps, access roads, location of boreholes, etc.).
- Data that need to be acquired or generated in order to complete the visualization, such as:
 - Aerial photographs of the area to provide the appearance and texture of mining and non-mining related data, including the look of the exposed orebody, the overburden material, the reclaimed area, the landscape, etc.
 - 3D representations of surface structures, equipment, landscape features, etc., that are external add-ons to the base map of the area.

Today, most mines are designed using a Computer Aided Design (CAD) program. Generally, CAD packages can extract the mine design information (e.g. in Document Exchange Format or DXF). Direct use of the mine design will increase the accuracy of the mine visualization. This information should include the terrain and locations of surface features and structures. If non-mine data is to be included in the visualization, then 3D or pseudo-3D representations of the data should be collected or created.

For instance, if the visualization is to include stationary or moving vehicles, fences, houses, streams, power lines, cars, roads, trees, etc., these objects should be represented as 3D models. There are several libraries of 3D models available, with generic equipment models that can be customized for the purpose

of a particular visualization. If a model is not readily available then it can be created using a 3D modeling tool. Schafrik et al., 2002 have presented in detail the use of standard tools for visualization applications.

The quality and accuracy of the models should also be considered. The greater the accuracy and quality of the model, the more computer resources it will use to create and display the model. Viewers of the visualization may not require perfectly realistic models in order to understand the purpose of the visualization. Figures 1 and 2 present examples of objects created to aid in the realistic presentation of objects.

4. QUARRY VISUALIZATION

A Virginia quarry that has been in operation for over 30 years and an expected future mine-life of up to 40 years, was selected as a case study. The mine is located off a secondary highway in a rural section of Virginia and it produces approximately 500,000 tons of crushed and broken granite per year. The work effort at the quarry is in the order of 30,000 work-person hours per year. The topography of the county and land surrounding the quarry is generally flat and rolling. There are no significant bodies of surface water in the vicinity of quarry. A small stream flows along the western end of the current pit and is considered a border for the pit, since current legislation does not allow its diversion.

Because very little exploration work was performed during the initial design of the



Figure 1: Examples of objects created to aid in the realistic presentation of scenery.

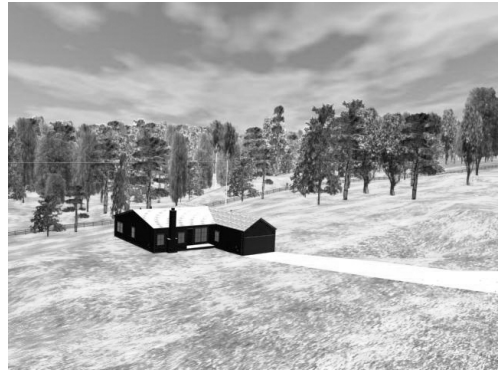


Figure 2: Examples of objects created to aid in the realistic presentation of scenery.

quarry, it is not surprising that recent exploration has determined that the highest quality ore is under the current plant. In addition, the quarry is currently considering acquiring several adjoining land parcels to allow for pit development. Future mine planning and development for this quarry involves the critical evaluation of the following scenarios:

- Continue mining on current plan
- Move plant location and expand pit
- Move plant location, buy surrounding land and expand pit

In the last two cases, appropriate permits need to be obtained from a number of agencies and committees. As already mentioned, sustainable development is based, among other things, on proper communication of “reality” between engineers, scientists, citizens, policy makers, and other stakeholders. In this case, a virtual reality visualization depicting the state of the mine after each of the above scenarios, allowed the public to accurately perceive quarry development in future years.

4.1 Preliminary Analysis

For the mine site itself, a final pit, spoil pile and plant layout were designed. These were completed using a CAD system. A U.S. Geological Survey (USGS) Digital Elevation Model (DEM) and Digital Line Graph (DLG) were acquired for the quadrant wherein the quarry resides. Additionally, the aerial photos available from the state of Virginia, as well as the quarry's own aerial photos were collected.

Initially, the mine plans were imported into a simple interactive VR model, which allowed the viewer to “fly” around the operation. The model was created by the procedures described by Schafrik et al. (2002) and was displayed in the Cosmo Player VRML viewer. While viewing the final pit designs in 3D several problems were identified. It became apparent that the expanded pit designs created a spoil pile with a high elevation. This was mainly due to the fact that the good quality orebody lies deeper in the future mining horizons. If the pit had been designed originally with more accurate exploration data, this problem could have been avoided. Because the surrounding area is generally flat and rolling, an investigation into the surrounding elevations was conducted using the USGS DEMs. It was revealed that in the case of the expanded pit, the spoil pile would be the highest point in the county. Alternative scenarios that address the usability of the spoil pile after mining were generated. These scenarios are currently confidential to the company.

The final land use plan includes filling the pit with water. Because of the close proximity of a stream, the water level can be controlled. In all three scenarios, the pit is large enough to be used for recreation activities. This is especially desirable because of the lack of large bodies of water near the mine. Additionally, the quarry will not be shutting down operations for another 30 to 40 years. By that time, it is expected that there will be new residential development due to the presence of a large Virginia city close to the quarry. In this case, the large body of water would be useful as a potable water source for a large community.

4.2 Virtual Reality Models

Figure 3 presents a topographical map of the quarry, depicting current mining practice. As already explained, non-mining persons cannot easily comprehend this map. However, when the same map is viewed as a virtual reality scene, the landscape morphology can easily be communicated. Furthermore, such a visualization can offer multiple view points of the same landscape depending on the perspective of each stakeholder, as well as focus on any particular details that may be of interest.



Figure 3: Topographic map of current quarry operations

Figures 4 and 5 show alternate future mining scenarios, i.e. the projected mine map after several years of operation, when the pit would



Figure 4: Topography map of future quarry operations (scenario I)



Figure 5: Topography map of future quarry operations (scenario II)

be deeper and the spoil piles higher. Figure 6 portrays future mining scenario I through a VR representation, while Figure 7 shows a VR representation of scenario II. Finally, Figure 8 presents the pit reclaimed as a lake for scenario I. It can easily be deduced that VR representations are much more intelligible to the public.

Although successful visualizations, including proper depiction of mining and non-mining objects, realistic representation of textures and electronic rendering of each scene can be

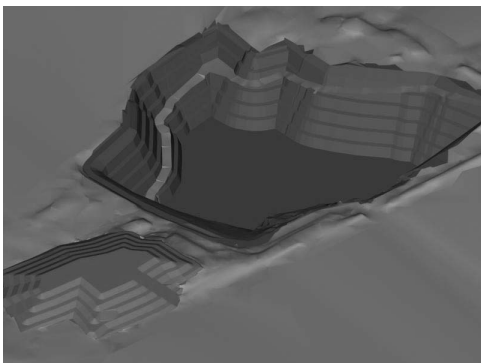


Figure 6: Virtual reality representation of future quarry operations (scenario I).

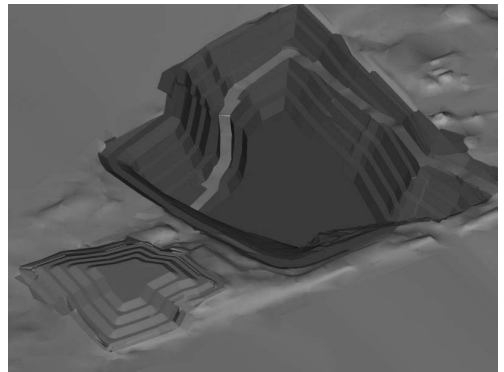


Figure 7: Virtual reality representation of future quarry operations (scenario II)

realized on a desktop computer, such tasks require significant computer time. Modeller expertise can considerably decrease the time expended on trial runs and thus produce faster results.

5. CONCLUSIONS

Virtual reality technology is an important tool in facilitating improved communication and understanding of minerals development projects. Mine design changes, mine closure and reclamation options and other mine planning activities can be difficult to communicate and to present to the general public. This is especially true when communicating with people who have little or no understanding of the mining process.

Utilizing readily available virtual reality technologies greatly mitigates communications difficulties. This is primarily because 3D representations are both realistic and visual. The visual aspect is especially beneficial when communicating with international audiences, because translation into a variety of languages is not necessary.

Effective communications with all stakeholders involved in a mining activity, including the local community, can promote a sustainable development framework.

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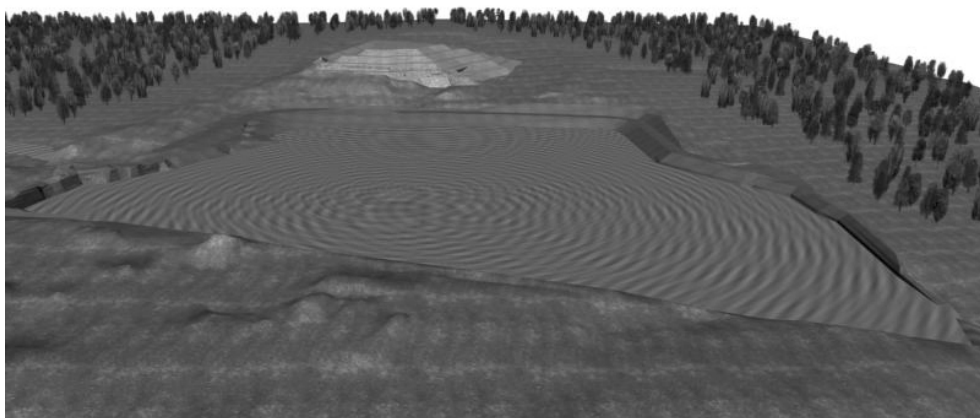


Figure 8: Virtual reality representation of quarry pit reclaimed as a lake.

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