Appraisal of Commonly used Mine Planning and Design Software in Ghanaian Surface Mines*

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Abstract

Mine planning and design software improve productivity at every stage of a mine's life and simplify mine planning and design processes so that a given deposit can be mined safely and economically. This study was set out to appraise Surpac and MineSight as the commonly used mine planning and design software in most Ghanaian surface mines. Questionnaires were administered to users in seven (7) producing mines using seven (7) appraisal criteria which include: ease of installation/configuration; user friendliness; performance capability; customisation (scripting) capability; compatibility with other software; cost effectiveness; and vendor support. Secondary data from Abosso Goldfields Limited (AGL) was used to plan and design AGL's Huni pit using the two software to validate responses from the questionnaire administration. This enabled a comparative assessment of the strengths and weaknesses of the two software to be done. Surpac was ranked ahead of MineSight in all the seven (7) appraisal criteria, except for performance capability. The two software during the validation process gave good solid model volume and tonnage estimates but had little differences in the volumes and tonnages of partials. Surpac showed strength in installation and learning, block modelling, and partials extraction and estimation whilst MineSight showed strength in multiple user flexibility, pit design, and solid model creation and estimation. Recommendations to improve the two software have been offered as part of the study and a careful consideration of Datamine is suggested as they are making inroad into the Ghanaian market especially with their underground modules.

Keywords: Mine Planning and Design, Surface Mining, Mining Software, Surpac, MineSight, Datamine

1 Introduction

Surpac and MineSight have been the commonly and widely used resource modelling, reconciliation, and mine planning and design software in most Ghanaian surface mines. These software improve productivity at every stage of a mine's life (Mireku-Gyimah, 2014) and also simplify mine planning and design processes so that a given deposit can be mined safely and economically.

It will, however, be necessary to appraise these software based on some criteria such as: ease of installation/configuration; user friendliness; performance capability; customisation (scripting) capability; compatibility with other software; cost effectiveness; and vendor support.

This will go a long way to assist the software developers to deal with the flaws and difficulties encountered by users hence making the latest versions of these software easier to use at competitive prices. This is what this study seeks to accomplish.

1.1 Mine Planning and Design Software

According to (Kapageridis, 2005), Mine Planning and Design software play crucial roles in the operations of many of the world's mining operations and projects. They provide the mining industry with a fast, accurate, cost effective and efficient tools. Every aspect of the mining industry is today using some form of mine planning and design software.

Mine planning and design software companies are constantly under pressure to evolve products to meet new challenges and solve new problems. Development of software is a result of both programming foresight and reaction to industry demands. Without mining industry feedback, many of the products now available would probably not have been developed. Mining software is an extremely competitive market which constantly drives the levels of development to new heights (Kapageridis, 2005).

There are a number of software products on the market today covering a large range of capabilities. Many packages are aimed at one particular market, such as database management and surveying. Others concentrate on Computer Aided Design (CAD) functionality. However, over the past couple of years, a number of software packages have evolved to carry out most of the functionality required on an operation or project. The standard functionality carried out by these packages includes (Kapageridis, 2005):

(i) Mine planning;
(ii) Modelling;
(iii) Visualisation;
(iv) Database management;
(v) Reserve calculation; and

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(vi) Mine design.

Table 1 shows the producing surface mining companies in Ghana and the type of planning and design software in use as at the time of the study. This paper assesses Surpac and MineSight as the commonly used mine planning and design software in most Ghanaian surface mines.

Table 1 Mine Planning and Design Software used in Ghanaian Surface Mines

Mining Company	Mine Planning and Design Software in use	
Abosso Goldfields Ltd.(Damang Mine) - Damang	Surpac	MineSight
Goldfields Ghana Ltd.(Tarkwa Mine) - Tarkwa	Surpac	MineSight
AngloGold Ashanti (Iduapriem Mine) - Iduapriem	Surpac	Datamine
Chirano Gold Mines Ltd., Chirano	Surpac	Datamine
Ghana Manganese Company Ltd. - Nsuta	Surpac	
Golden Star (Bogoso) Ltd. - Bogoso	Surpac	
Newmont Ghana Gold Ltd. - Kenyasi		MineSight
Newmont Golden Ridge Resources - Akyem		MineSight
Golden Star (Wassa) Ltd. - Akyempim	Surpac	
Adamus Resources Ltd. - Nzema	Surpac	

2 Resources and Methods

The resources that were utilised in the study include: questionnaires, secondary data from AGL, Surpac and MineSight software. The method employed include questionnaire administration, validation of the responses from the questionnaire by using Surpac and MineSight to design the Huni Pit of AGL, and comparative assessment of the strengths and weaknesses of Surpac and MineSight Software.

Questionnaires were administered to 42 users of Surpac and MineSight software who appraised both software based on: ease of installation/configuration, user friendliness, performance capability, customisation (scripting) capability, compatibility with other software, cost effectiveness, and vendor support criteria using a five (5) point Likert scale rating (Excellent, Very Good, Good, Average and Poor). The users of the two most commonly used mine planning and design software in Ghanaian surface mines were selected from seven (7) surface operating mining companies in Ghana namely: AngloGold Ashanti, Iduapriem Mine; Abosso Goldfields Ltd, Damang Mine; Chirano Gold Mines Ltd., Chirano; Ghana Manganese Company Ltd., Nsuta; Golden Star Ltd., Bogoso; Newmont Golden Ridge Resources, Akyem; and Perseus Gold Mine, Ayanfuri. Out of the 42 users, 18 have used both Surpac and MineSight software and were classified as multiple users whilst 24 who have used either Surpac or MineSight were classified as single users.

Validation exercise involved the acquisition of secondary data on AGL's Huni open pit, definition of planning parameters for pit design, block modelling, final design and estimation of volumes, tonnage and grades using both Surpac and MineSight software.

Comparative assessment of the strengths and weaknesses of Surpac and MineSight Software was conducted from the practical application of the two software during the validation exercise.

3 Results and Discussion

3.1 Analysis of Data from Questionnaire

3.1.1 Biographical Inventory of Respondents

Figs. 1, 2, 3 and 4 present the sex, educational level, age and working experience of respondents respectively. It could be observed from Fig. 1 that 81% of the respondents were males with 19% being females. This shows the dominance of males in the mining industry. From Fig. 2, all the respondents had university education with 24% possessing postgraduate degrees. This indicates that the respondents were highly literate.

From Figs. 3 and 4, 74% and 71% of the respondents were above 40 years and had more than 5 years working experience respectively. Hence, it could be inferred that most of Mine Planners were mature and experienced.

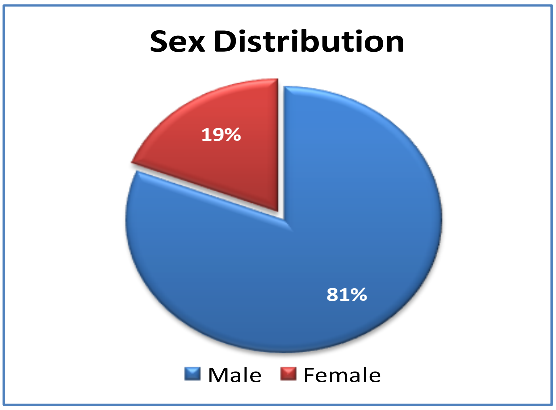

Fig. 1 Sex Distribution of Respondents

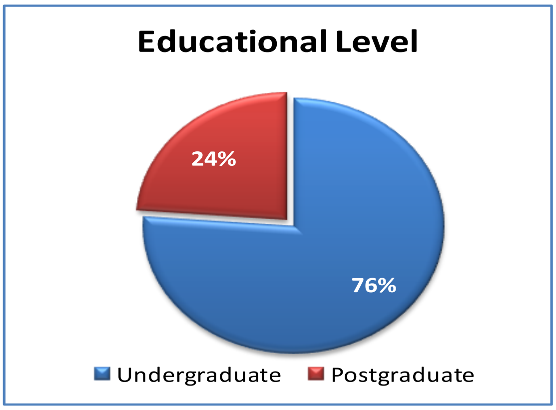

Fig. 2 Educational Level of Respondents

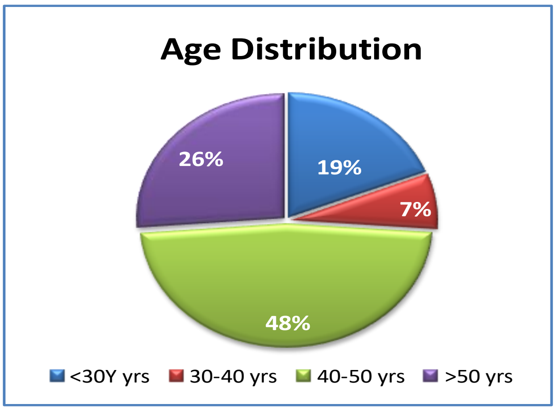

Fig. 3 Age Distribution of Respondents

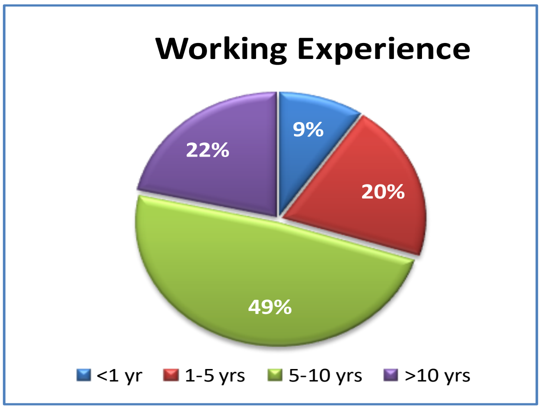

Fig. 4 Working Experience of Respondents

3.1.2 Assessment of Surpac and MineSight Software by Respondents

Figs. 5 and 6 present the results of assessment by single users of the two software and Table 2 presents the results of assessment by multiple users.

From Figs. 5 and 6, the seven (7) criteria were rated as excellent, very good or good for both Surpac and MineSight except in the case of Vendor Support for MineSight where 57.2% of the respondents rated it as Average. This therefore shows that the single users are very satisfied with the two software.

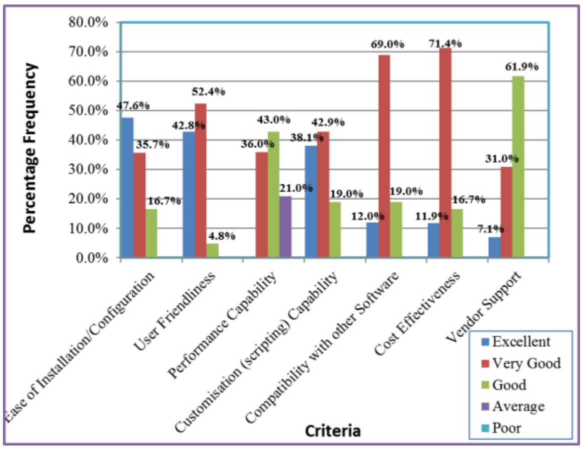

Fig. 5 Assessment of Surpac Software by Single Users

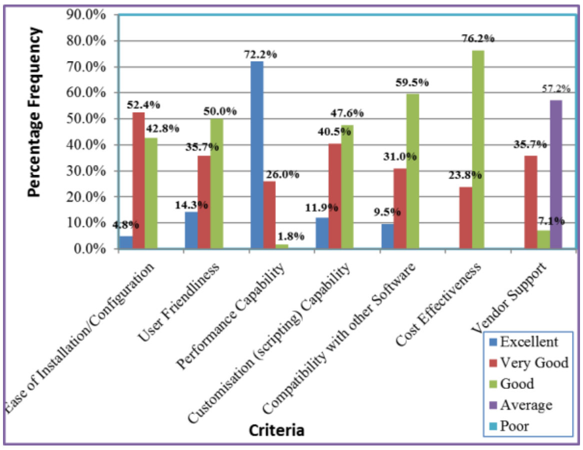

Fig. 6 Assessment of MineSight Software by Single Users

From Table 2, it could be observed that Surpac was rated above MineSight in all the seven (7) criteria except for Performance Capability criterion where as many as 72.0% of multiple users rated MineSight ahead of Surpac. This could be highly attributed to, among other reasons, the fact that MineSight is an integrated software; i.e. it has its optimisation tools incorporated in the software whilst Surpac will require Whittle for optimisation to make it complete. This is also corroborated by the results from the single users where as many as 72.2% of respondents rated the Performance Capability of MineSight as excellent but no respondent rated the Performance Capability of Surpac as excellent but rather the highest rating was good (43.0%) (see Figs. 5 and 6).

However, Surpac enjoys wider use in Ghanaian surface mines as indicated in Table 1 and could be attributed to its cost effectiveness and the other highly rated criteria such as compatibility with other software, user friendliness, ease of customisation and good vendor support.

Table 2 Comparative Assessment of Surpac and MineSight Software by Multiple Users

Criteria / Scale	Ease of Instal. & Configuration	User Friendliness	Performance Capability	Customisation Capability	Compatibility with other Software	Cost Effectiveness	Vendor Support
Excellent	77.8%		72.2%		72.2%		
Very Good		66.7%		61.1%	27.8%	94.4%	55.6%
Good	22.2%	33.3%	27.8%	38.9%		5.6%	44.4%
Average							
Poor							

Legend Surpac MineSight

3.2 Validation Exercise - Planning and Design of AGL's Huni Pit using Surpac and MineSight Software

3.2.1 Planning

The planning stage in this research entails the selection of the pit design parameters which were based on: the geotechnical parameters of the rock masses such as density, angle of internal friction, failure plane dip and so on; the pit wall slope angle safety since this greatly influence pit stripping ratio; the reach of the excavator equipment used at AGL; and the haul road width which was chosen based on the maximum width of dump trucks used at AGL. Legal factors coupled with loading equipment constraints highly influenced the ramp and working face gradients. The design parameters are presented in Table 3.

Table 3 AGL's Huni Pit Design Parameters

Surpac		MineSight	
Parameters	**Values**	**Parameters**	**Values**
Ramp width (m)	15	Elevation (m)	0.00
Ramp Gradient (%)	45	Step Size	3
Final Pit Slope Angle (°)	60	Step/Berm	1
Operating Pit Slope (°)	70	Face (Batter) Slope (°)	70
Bench Height (m)	6	Pit Slope (°)	60
Dump Truck width (m)	6.5	Berm (m)	5
Switch Back (SB) Parameters		**Road Parameters**	
Start level (m)	150	Level (m)	0.00
SB Radius (°)	2.5	Grade (%)	45
SB Angle (°)	180	Width (m)	15
SB Grade (%)	45	Direction (Clockwise)	1
SB Width (m)	15	**Switch Back (SB) Parameters**	
Ramp Gradient (%)	45	Level (m)	150
Final Pit Slope Angle (°)	60	SB Grade (%)	45
Operating Pit Slope (°)	70	Width (m)	15
Bench Height (m)	6	Direction (Anticlockwise)	0
Dump Truck width (m)	6.5	SB radius	2.5
Bench Width (m)	5	SB length Multiplier (m)	3

3.2.2 Block Modeling

The steps used in the block modelling process in Surpac and MineSight involved the following:

(i) Creation of an empty block model using block extent values;
(ii) Addition of attributes (directly done in Surpac but by cloning in MineSight);
(iii) Addition of constraints;
(iv) Filling of the created model with attribute values and characters; and
(v) Constraining of block model in Surpac but optioning of block model in MineSight.

Table 4 outlines the block extents used in the block model creation in both Surpac and MineSight. Figs. 7 and 8 present the created block model and constrained block model in Surpac whilst Figs. 9 and 10 present the created block model and optioned block model in MineSight respectively.

Table 4 AGL's Huni Block Model Extents

Direction	Description	Minimum (m)	Maximum (m)	User Block Size	Minimum Block Size
East (X)	Columns	9 600	10 600	2	2
North (Y)	Rows	23 500	27 500	5	5
Elevation (Z)	Levels	300	1 200	3	3

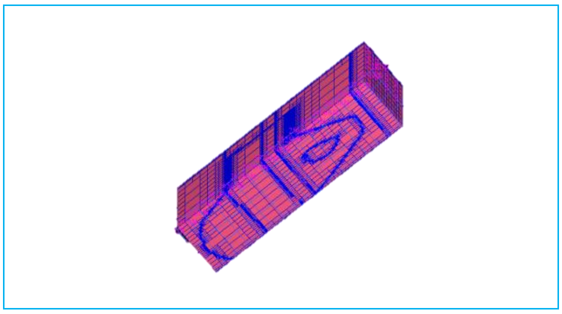

Fig. 7 Surpac Created Block Model

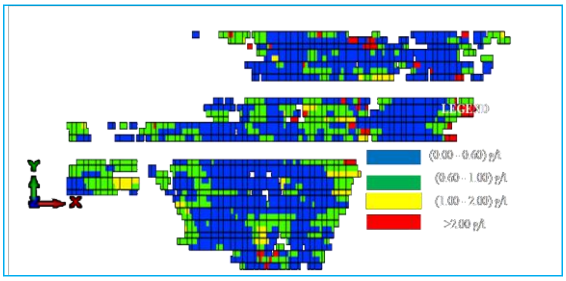

Fig. 8 Surpac Constrained Block Model

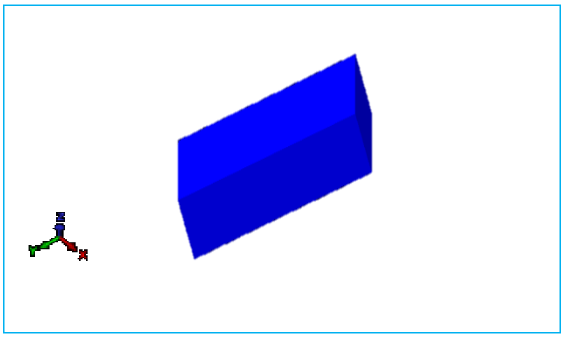

Fig. 9 MineSight Created Block Model

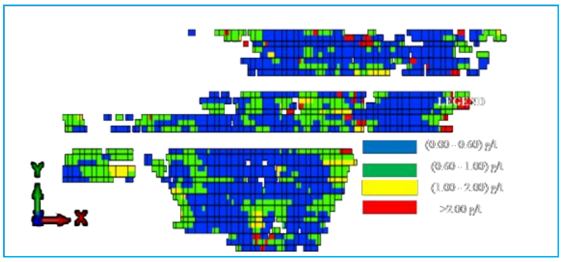

Fig. 10 MineSight Optioned Block Model

3.2.3 Final Pit Design

The optimal pit outline used for the pit design was that of AGL. Unlike Surpac where the optimal pit outline was imported from Whittle, MineSight has an integrated optimisation tool where the optimised pit outline which served as the base string and the pit bottom was viewed in graphics prior to the design process. The pit design process involved the following:

(i) Definition of pit base string;
(ii) Ramp definition and creation;
(iii) Crest and toe strings expansion; and
(iv) Pit and topography intersection.

The final designed pit from Surpac and MineSight are shown in Figs. 11 and 12 respectively.

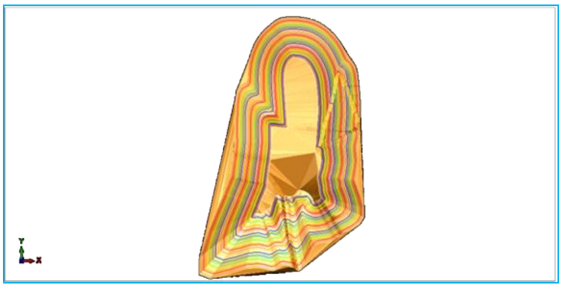

Fig. 11 Surpac Designed Final Pit

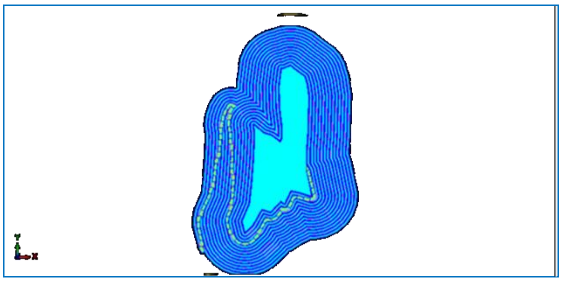

Fig. 12 MineSight Designed Final Pit

3.2.4 Estimation of Volume, Tonnage and Grade

Unlike MineSight which has both integration and analytical methods of volume computation for a whole solid, Surpac does this without considering any of these methods but by summing the volumes of each of the triangles to an arbitrary plane of either the whole solid model or between the upper and lower surfaces of the solid model. With regards to the solid created using Surpac, elevations (0-1005) within the solid were considered by Surpac software for its whole solid volume and tonnage computation.

The integration method in MineSight, calculates volume based on 3D integration. This volume is an approximation, as it is generated by piercing vectors through the solid and totalling the lengths between where they enter and leave the solid, then turning that into a volume, based on the spacing between the piercing vectors. The closer the vectors, the more accurate the result, but the slower the calculation. This method can only be used for closed solids, it gives an invalid signal in case the solid being evaluated is opened.

The analytical method on the other hand, calculates the true mathematical volume of the solid based on a 3D matrix determinant calculation. This method is 100% accurate and automatically checks if any selected element or any solid inside of a merged shell element has openings. If openings are found, the volume calculation is terminated and a warning message pops up. The calculate "Analytical Volume(s)" with "Selection function" was used for the solid volume computation because it allows multiple solids to be included and totalled in the volume calculation.

Figs. 13 and 14 present the solid and partial block models from Surpac whilst Figs. 15 and 16 present solid and partial block models from MineSight for volume, tonnage and grade computation respectively. Table 5 presents the results of the volume, tonnage and grade computation using Surpac and MineSight for AGL's Huni Pit.

Both Surpac and MineSight software gave good estimates of the volume and tonnage of the solid models but had little differences in the volumes and tonnages of the partials. The variations in the estimates could be attributed to: internal rounding differences; the individual repair effects on invalid solids after creation of solids; elevations within the created solids and partial blocks considered by each software (thus within 897 m to 969 m elevations for the purpose of this study) for grade volume and tonnage estimations; and failure to clip the two surfaces used for the solid formation with the digitised boundary string in some instances.

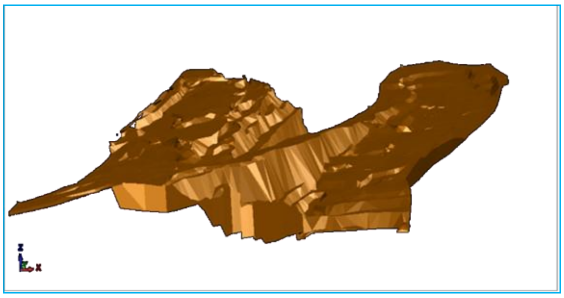

Fig. 13 Surpac Created Solid Model

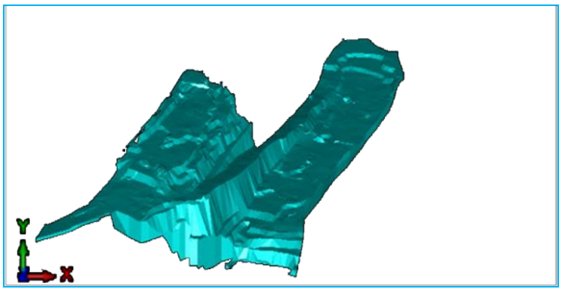

Fig. 14 MineSight Created Solid Model

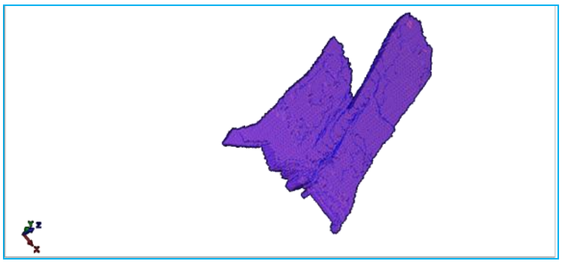

Fig. 15 Surpac Extracted Partials

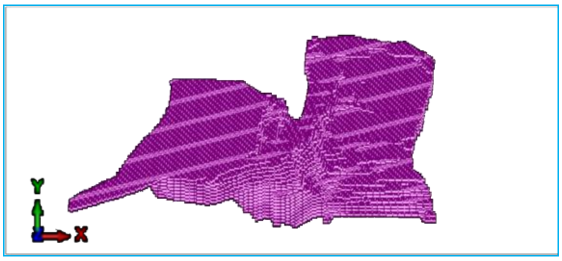

Fig. 16 MineSight Extracted Partials

Table 5 AGL's Huni Block Model Extents

Parameters	Surpac	MineSight
Solid Block Estimation		
Volume (m^3)	1 797 101	1 797 101.48
Tonnage (t)	4 995 941	4 995 942.11
Partial Block Estimation		
Volume (m^3)	1 797 136	1 719 554
Tonnage (t)	4 900 088	4 728 668
Avg Grade (g/t)	0.002	0.002

3.2.5 Comparative Assessment of the Strengths and Weaknesses of Surpac and MineSight

The strengths and weaknesses identified with Surpac and MineSight during the validation exercise were comparatively assessed, summarised and tabulated as shown in Table 6. Surpac showed strength in:

(i) Installation and learning;
(ii) Block modelling; and
(iii) partial block extraction and estimation.

MineSight showed strength in:

(i) Multiple user flexibility;
(ii) Pit design and solid; and
(iii) Model creation and estimation.

Table 6 Comparative Assessment

	Activities	Surpac	MineSight
1	Installation and Learning	Easy to install	Lengthy installation steps
2	Multiple User Flexibility	Only one user per dongle	Multiple users per dongle
3	Block Modeling	Easier block modeling procedure	Lengthy and time consuming block modeling procedure
3a	Block Attribute/Items Addition	Direct addition	Requires cloning
3b	Addition of Block Constraints	Easy constraint addition	Software Crash encountered
3c	Saving of Block Constraints	Cannot save block constraints	Permits saving of block constraints
3d	Block Model Adjustment	Crash free process	Crashing encountered
3e	Block ASCII Data Uploading.	Simple process	Lengthy and Time consuming
4	Pit Design	Lengthy steps involved	Simple and easier
4a	String manipulations in Pit Design	Time consuming	Easy string manipulation ability
5	Solid Model Creation	Difficulty in solid formation	Easy solid formation capability
5a	Solid Model Repairs	Average repairs capability	Very good repairs capability
5b	Solid Model Validation	Validates solid block but produces false and open solid report	Validates and produce true and closed solid report
6	Partial Blocks Creation	Simple process	Lengthy process with software Crash
6a	Partial Block Estimation	Simple and direct process	Lengthy process and requires PIRES procedure
7	Data Transfer/ Compatibility	Huge data transfer ability	Accepts data only in AutoCAD DXF. Format from Surpac
8	Digital Terrain Model (DTM) Formation	DTM is string dependent	DTM is string independent

Note: Red font indicates where the software shows strength

4 Conclusions

The study has assessed Surpac and MineSight the two most commonly used software in Ghanaian surface mines by:

(i) Engaging 42 respondents through questionnaire administration using seven (7) criteria such as: ease of installation; user-friendliness; performance capability; customisation (scripting) capability; compatibility with other software; cost-effectiveness; and vendor support;
(ii) Validating the findings by practically designing the Huni Pit of AGL using the two software; and
(iii) Outlining the strengths and weaknesses of the two software from the validation process.

(i) All the criteria were ranked as excellent, very good or good for the two software except for Vendor Support for MineSight which was highly rated as average;

(ii) Surpac was ranked ahead of MineSight in all the seven (7) criteria except for Performance Capability;

(iii) The two software gave good estimates of the volume and tonnage of the solid models but had little differences in the volumes and tonnages of the partials. The variations in the estimates could be attributed to:

- Internal rounding differences;
- The individual repair effects on invalid solids after creation of solids;
- Elevations within the created solids and partial blocks considered by each software for the grade, volume and tonnage estimations; and
- Failure to clip the two surfaces used for the solid formation with the degitised boundary string in some instances.

(iv) In general planning and design, Surpac showed strength in the installation and learning, block modelling and partials extraction and estimation whilst MineSight showed strength in multiple user flexibility, pit design and solid model creation and estimation.

4.1 Recommendations

The recommendations made to improve Surpac software include:

(i) Surpac dongle once plugged in should allow the user to work on more than one Graphical User Interface at a time. This will help the user to work on more than one project at a time;
(ii) Tool for querying center of mass of solids and for saving constrained models should be introduced;
(iii) There should be an inbuilt tool to help solve Crashing during solid repairs; and
(iv) The software's internal engine should be interfaced with MS Office Applications to enable an output report template setup.

The recommendations made to improve MineSight software include:
(i) The software should be configured such that it can be easy to install, learn and use. This will be of great help to especially beginner users;
(ii) A tool to best simplify scripting (customization) in MineSight should be introduced;
(iii) Block modelling, partial block creation and pitres estimation procedures should be configured such that they can be less time consuming. This will help save users project execution time and also eliminate errors; and
(iv) MineSight vendors should step up their efforts and frequently visit their users to address pertinent issues during the use of the software.

It should be noted that Datamine has been a very powerful resource modelling software for Ghanaian mines and are currently making inroad into the Ghanaian market especially with their innovative underground modules. This should serve as a caution to Surpac and MineSight vendors who are currently enjoying high patronage in Ghana.

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