NETPRO/MINE

TESTING 3D OREBODY MODELLING AND MINE PLANNING SOFTWARE

Final Report

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INTRODUCTION

Contemporary mining science and technology require to model and design mines in 3D prior to production. Therefore, integrated computer programs are required to model and design all mining processes ranging from exploration to mine closure.

Netpro/MINE is an integrated software that performs 3D geological solid modelling and mine planning. Development of this software was initiated in 2010 with a collaboration between TUBITAK (Scientific and Technological Research Council of Turkey), Hacettepe University, NetCad Software Inc. and TKI (Turkish Coal Enterprises) and completed in 2012. The product has currently been used by a number of mining companies.

NetCad aims to increase the domestic use of Netpro/MINE software and to sell it abroad. Therefore, Hacettepe Teknokent Teknoloji Transferi Ar-Ge Danışmanlık Enerji Sağlık Çevre İletişim San. Ve Tic. A.Ş (HT) has been commissioned by NetCad to update the software in accordance with the recent developments in mineral resource/reserve estimation, to test the compatibility of existing functions with mining science and technology, and to develop a new function/calculation tools. HT authorized Prof. Dr. A. Erhan TERCAN, Prof. Dr. Bahtiyar ÜNVER, Assoc. Prof. Dr. Mehmet Ali HİNDİSTAN, Assist. Prof. Dr. Güneş ERTUNÇ and Dr. Fırat ATALAY, who are the member of the faculty of mining engineering department at Hacettepe University, to carry out these studies. The report contains the results obtained from these studies.

Test studies are divided into seven categories. These include;

- Drilling,
- Solid Modelling,
- Block Modelling,
- Geostatistical Estimation,
- Surface Mining,
- Underground Mining, and
- Visualization.

Each section contains a series of topics, processes, and sub-processes. These processes to test are selected from the most basic functions used during the evaluation of the exploration results and the mineral resource/reserve estimations. The tests have been carried out on a coal deposit and then a porphyry copper deposit.

1. Drilling Operations Tests

Construction of the drilling database is the first and most important step of mineral resource estimation and involves the collection and evaluation of primary and secondary data. The primary data consist of geological, geochemical, geophysical, and topographical and core assay data. The secondary data are derived from the interpretation of primary data such as geological projection, block model, and cutoff grade. The database must be free of errors and verified before use. Data entry and management topics are basically examined under the drilling operations section. Table 1 shows the test results of the process and sub-processes considered in data entry and management.

Table 1. Process and sub-processes tested for data entry and management (✓: test successful, ×: test failed).

Process	Sub-process	Result	Explanation
Creating a new project file	Trouble-free template layer structure	✓	When a new project is created, and the template layer structure is added to the project, all boxes should be empty.
Defining field properties	Project Information	✓	In the Project Properties/Project Information section, term ”Continues” should be added to the project due date section.

	Operational Information	✓	When boundaries are selected in the Project Properties/Operational Information section, they must be canceled or deleted.
	Attributes	✓	The Kcal/kg in the Project Properties /Attributes/Units section must be corrected into kCal/kg.
	Lithology Definitions	✓	
	Seam Definitions	✓	
Creating project data	Usage of the data controls section with the objective of controlling the distance between drill holes during transmission of drill hole data.	✓	In the transmission processes except for drilling, the data controls section must not be activated or removed.
	Seamlessly transferring Excel drill hole data to the Netpro/MINE screen.	✓	
	Seamlessly transferring the collar information on the basis of each drilling.	✓	Close button should be added to the Read icon.
	Seamlessly transferring the lithology information on the basis of each drilling.	✓	

	Seamlessly transferring the survey records on the basis of each drilling.	✓	
	Seamlessly transferring the raw data records on the basis of each drilling.	✓	Null values should not be reflected in the report while the rawdata.csv file is loaded into the project.
	Adding drill hole into the project which the data have already been transferred.	✓	While adding new drill hole data, a “*” must be in the mandatory lines and the new drill hole data should not be added when these lines are not entered. While adding new drill hole data, the data controls section should be able to use. If the "survey" data were not entered while adding new drill hole data, by default dip should be -90 degree and azimuth 0 degree.
	Addition of symbology definition for lithologies	✓	In the data reading operation, a report should be provided on what data has been updated or not updated

			when new data is added to existed data. For lithology that does not include any data, a standard color should be assigned.
	Thematic visualization of drill holes on the screen according to lithology symbology	✓	
	Thematic visualization according to the raw data values of drill holes	✓	The request is solved, and the related operation can be performed.
	Adding transparency to 3D drill holes	✓	
	Label identification of drill holes via Netpro/MINE screen	✓	
	Managing drill holes from different angles via Netpro/MINE main screen.	✓	
	Adding groups to drill hole data	✓	
	Selecting multiple drill holes and adding them to a group	✓	The group name should change its color when the drill holes are dragged on the group.

	Selecting single or multiple drill holes and moving them with drag-and-drop method	✓	
	Viewing drill hole axes	✓	
	Transfer of selected drill holes to 2D environment	✓	
	Transfer of traces of inclined drill holes	✓	
	Synchronization of drill holes to 2D screen as a group	✓	After a group is defined for the drill holes, only the groups that are intended to be transferred to the 2D should be activated and these groups should be transferred. Passive groups will not be transferred. With this operataion, the drill holes can be transferred to 2D screen by group separation.
	Transferring drill holes to Google Earth	✓	
Drill hole log report	Receiving drill hole log report correctly	✓	The one-page fit drill hole button must be

			attached to the main page.
Drill hole analysis	Calculating statistics (Length and Attribute) using drill holes	✓	Under statistics section, length-weighted mean should also be able to be calculated on a new line for the attributes.
	Calculating statistics only for the desired drill holes by adding a group to the drill holes	✓	When drill hole data are analyzed by adding a filter, analysis should be made considering the filter.
	Calculating the weighted averages over selected drill holes	✓	The name “weighted average” must be changed to “Weighted Average by Attributes”. When calculating weighted average by using drill holes, a window should be opened, and in the pop-up window, multiple lithologies should be selected from the lookup list.
	Filtering the drilling data by selection based on drilling name, Z	✓	Filter skills can be increased.

	value, Depth, Attribute Weighted Average, Lithology / seam.		

Test operations indicate that all the data entry and management processes work in a functional way.

2. Solid Modelling Processes

Geological models are the three-dimensional computer representation of the main characteristics of mineralization. These models are based on the interpretation of lithology, tectonic structure, alteration, mineralization and other data by using cross sections and plans and extending these interpretations to three dimensions. It is possible to divide the approaches used to form three-dimensional solid models of geological structures into two groups: top-bottom surface approach and cross-sectional approach. Netpro/MINE includes both approaches. Netpro / MINE includes both approaches. Under solid modeling processes, the following topics were investigated; creating surface from drill holes, adding fault, creating solid model between the surfaces, creating cross-sections, creating solid model from cross sections and creating thickness map from solid model. Table 2 shows the test results of the process and sub-processes considered in creating surface from the drill hole data.

Table 2. Process and sub-processes tested for surface creation from drilling data (✓: test successful, ×: test failed).

Process	Sub-process	Result	Demand Description
Surface generating	Generating surface by selected 3D layer name	✓	
	Creating seam surface of selected lithologies	✓	Changing the error window that is opened when the drill holes are clicked accidentally in the boundary selection

			process with a warning window.
	Creating seam surface using at least 3 seam definitions	✓	
	Creating seam surface using geostatistics and fault information	✓	
	Producing surfaces using multiple line objects	✓	
Filtering	Filtering according to the coordinate (top, bottom, lowermost, etc.)	✓	
	Filtering according to boundaries and drill holes	✓	
Surface arithmetic	Performing surface arithmetic operations	✓	
	Upper and lower surface correction processes	✓	
	Simplification and combination	✓	
	Creating surface intersections or external boundaries	✓	
	Draping the boundary generated by line model over surface	✓	
	Cutting inside or outside the selected boundary	✓	

	Thematizing the surface according to elevation	✓	
	Drawing contours according to the specified intervals on the surface	✓	
Adding processes	Adding one or more faults altogether by add fault operation to the surface	✓	
	Adding platforms to the surface in appropriate parameters along the route	✓	
	Adding surfaces in 3D layers to the project surfaces	✓	
	Displaying properties of the selected surface in 3D screen	✓	
Seam points	Identification of the seam with the "Identify seam points" procedure	✓	The seam modeling method for sedimentary formations can be developed as a separate module.
	Editing seam points	✓	
	Visualization of related seam definitions in drill hole properties	✓	During the addition of the seam definitions into the characteristics of the project, lithology of that seam should be selected, but different lithologies should not be selected in

			the determination of the vessel points.
	Interfering seam markers after the addition of the seam points.	✓	
	Deleting added vessel definitions	✓	

Test operations show that all processes and sub-processes about creating surface from drilling data work functionally.

Faults have an important role in solid modeling. The process and sub-processes considered for faults are tested and the test results are shown in Table 3, indicating that the basic operations of the faults are functional.

Table 3. Process and subprocesses tested related to faults (✓: test successful, ×: test failed).

Process	**Sub-process**	**Result**	**Demand Description**
Faults	Drawing fault line from 3D screen with "Add Fault" operation.	✓	It is necessary to determine the sudden slope changes on the seam surface or topography prior to fault addition. The limit slope value should be able to be entered by the user. For example; when the change is +30%, these areas should be visible on the surface in a separate thematic.

	Opening the fault characteristics window after the operation	✓	Stereographic projection of faults should be able to be displayed on 3D screen.
	Entering heave, reverse slip fault, dip values in the Fault Properties window.	✓	
	Adding fault measurements from Excel to the project with the "read fault" operation	✓	
	Extending the fault plane from the top and bottom	✓	
	Adding faults to different surfaces	✓	
	Adaptation of fault slips to topography	✓	

After testing for faults, solid modeling functions were tested between surfaces. The test results are shown in Table 4, indicating that the solid modeling processes between the surfaces are working functionally.

Table 4. Process and subprocesses tested related to creating solid model between surfaces (✓: test successful, ✖: test failed).

Process	Sub-process	Result	Demand Description
Solid Modelling Between Surfaces	Creating solid model from upper and lower surfaces produced from vessel points	✓	While creating solid model between surfaces, Expressions "Select Upper Surface" and "Select Lower Surface" in the command line should be changed to

			"Select 1st Surface" and "Select 2nd Surface".
	Creating solid model from surfaces (upper, lower, lowermost, etc.) produced from lithology definitions	✓	When the same surface is selected one after the other, the result should not be produced.
	Selecting boundaries after selecting upper and lower surfaces	✓	
	Producing solid models between elevations according to the selected surface	✓	
	* Producing solid model from STR files	✓	
	Cutting the solid model from selected boundary with solid model cut process	✓	The side surfaces of the new solid model produced after solid model cutting process must be able to be closed.
	Cutting solid model by entering min and max elevation inputs within solid model cut operation	✓	
	Calculating the average lithology thickness according to the selected lithology and different calculation methods	✓	The "All Lithology" option should be active as the calculation method in the average lithology thickness calculation.

	Calculating volume from the selected boundary, lower surface and/or upper surface with "calculate volume between surfaces" process	✓	After creating solid model, the calculated volume values must be integer. The three digits after the point must not be shown.
	Viewing the solid model properties by selection from the 3D display	✓	
	Creating solid model from fault-attached surfaces	✓	The side surfaces of the new solid model produced after solid model cutting process must be able to be closed.
	Adaptation of fault slips to topography	✓	

The cross-section plotting operations were tested and the test results are shown in Table 5. Table 5 shows that the cross-section plotting is working properly.

Table 5. Process and subprocesses related to cross-section plotting (✓: test successful, ×: test failed).

Process	Sub-process	Result	Demand Description
Cross-sectioning	Taking cross-sections in slice thickness (type, step distance, from left/right) determined by clipping over drill holes for cross-sectional digitization operations	✓	

	Displaying the section plane after cross-sectioning	✓	
	Digitization of cross sections by visualization of drill holes with the assistance of point capture mode on the plane	✓	
	Editing of cross sections produced	✓	
	Selecting drill holes from 3D screen in automatic cross section plotting process	✓	
	Lithology/seam filtering in automatic cross section plotting process	✓	
	Upper and lower coordinate filtering in automatic cross section plotting process	✓	
	1st and 2nd edge extensions in automatic cross section plotting process	✓	
	Performing line smoothing in automatic cross section plotting process	✓	
	Producing new cross-section(s) with the parameters determined between the two sections selected by the inter-sectioning process	✓	

	Splitting by selecting a point or line with the “Split Section” process	✓	

Solid model creation processes were tested in cross sections and test results are shown in Table 6. Table 6 shows that the solid model creation process works fonctionally.

Table 6. Process and subprocesses tested related to creating solid model from cross-sections (✓: test successful, ×: test failed).

Process	Sub-process	Result	Demand Description
Creating the solid model	Solid modelling by selecting cross sections from 3D screen	✓	
	Solid modeling collectively from cross sections	✓	
	Opening cross-section files with *.STR extension	✓	
	Saving digitized cross sections with * .STR extension	✓	Reopening the export feature that was open in previous versions.
	Displaying the properties of the solid model created	✓	
	The production of a single solid model from the solid models selected by the “Union solid” process	✓	Geometric operations should be made for intersecting solid models.
	Creating solid model from drill holes in 3D display with all solid model operation	✓	

	Creating solid model depending on the parameters between selected cross-section and a point, with the solid model operation from section to a point	✓	
	Taking a cross-section through a solid model	✓	
Isopach curve	Creating the lines of equal thickness (isopach map) from the solid model	✓	
	Splitting process by selecting a point or a line with Split section process	✓	

3. Block Modelling and Estimation Processes

While 3D solid models define the geometry of the ore deposits, the block modeling shows how the grade changes spatially within the solid model. For this purpose, solid models are divided into blocks with the same size and shape, and then the average grades or the respective variable values of these blocks are estimated. For this purpose, the basic processes used in block modeling are tested and the test results are shown in Table 7. Table 7 shows that the block modelling process works functionally.

Table 7. Process and sub-processes tested related to block modelling (✓: test successful, ×: test failed).

Process	Sub-process	Result	Demand Description
Creating a block model	Creating blocks and sub-blocks according to the parameters defined in the block modelling operation	✓	

	Displaying the properties of the blocks created	✓	
	Saving the block model in * .xls or * .ncblk formats with Export command.	✓	
	Creating a copy of the block model	✓	
Block Modelling Post Processes	Calculating the average seam thickness	✓	
	Creating a block model from the solid model	✓	The visibility of the triangular borders on the blocks must be user defined.
	Limiting the blocks located above or below of the selected surface	✓	
	Limiting the blocks located inside or outside of the selected boundary	✓	
	Limiting the blocks located inside of the selected solid model	✓	

The estimation of the average grade of the blocks or the corresponding variable values requires a compositing process. Estimation should be performed by various methods ranging from the simplest (nearest neighborhood) to the most complex (geostatistical methods) using this composite data. Geostatistical methods require variogram calculation and modeling and the use of the variogram model in the kriging process. For this purpose, the basic functions of the estimation processes are tested, and the test results are shown in Table 8, indicating that the estimation processes works functionally.

Table 8. Process and sub-processes tested related to estimation process (✓: test successful, ✗: test failed).

Process	Sub-process	Result	Demand Description
Compositing	Defining general, core, lithology, drill hole and other criteria	✓	The analysis values should be accessible from the compositing window.
	Automatic filling of sample records in the database for each drilling after the compositing process	✓	
	Displaying composites with Composite Display Settings	✓	The desired composite value based on graphics must be erased.
	3D displaying based on grade using Composite Display Settings	✓	
Composite analysis	Producing histogram and scatter diagram of composites	✓	The description in the window must be arranged to involve only inside the solid model. Diagram name must be changed graphically. Scatter plot / histogram should be obtained from the block model.
	Calculating the summary statistics related to length and attribute values of the composites.	✓	

Variogram calculation and modelling	Entering the attribute, tolerance, band width values	✓	The head attribute must be changed to the Primary Attribute and the tail attribute to the Secondary Attribute.
	Horizontal and vertical direction selection	✓	
	Calculating number of lag, lag distance and lag tolerance values automatically	✓	
	Drawing experimental variogram graph	✓	It should be able to intervene to the variogram model interactively on the graph.
	Creating model variogram based on the parameters like nugget effect, sill value and range	✓	Variance line calculated from composite values used in variogram calculation should be sketched to the graphic screen.
	Adding the generated variogram model under Variograms icon when the Variogram window is closed with pressing OK	✓	All variogram windows must be floating.
Estimation methods	Estimation based on the nearest neighborhood method	✓	

	Estimation based on inverse distance weighting interpolation method	✓	
	Estimation based on kriging method	✓	
	Estimation based on cokriging method	✓	
	Estimation based on indicator kriging method	✓	
	Performing geostatistical simulation	✓	
Kriging	Performing kriging based on the variogram model created	✓	
	Performing cross validation	✓	The seam modeling method for sedimentary formations can be developed as a separate module.
	Generating scatter plot after cross validation	✓	
Block model reports	Getting block report based on the assumed density value	✓	Alternative units (btu, calorie, joule etc.) should be added as user-defined. It should be reflected on the outputs during the project process.

	Generating grade-tonnage curve report	✓	Based on the results, tonnage should be calculated for each cutoff grade and a graph should be created accordingly.
Post processing of block estimations	Generating attribute surface from the block model	✓	
	Generating solid model based on attribute and value range selected via block model	✓	
	Filtering the block model based on center XYZ, width XYZ and attribute values	✓	Un-estimated and integer value assigned block values should be changed to null.
	Updating the block report after adding filter, based on filter	✓	
	Editing the thematic values of the block model	✓	
	Thematic update of the Block Report obtained after the thematic editing process	✓	Based on the results, tonnage should be calculated for each cutoff grade and a graph should be created accordingly.

4. Open Pit Mine Design

Mines are produced by surface or underground operation methods. In open pit mine design, horizontal and vertical roadways, platforms and slope should be defined and blasting process must be designed. Template platform definitions must be ready, and these template platforms must be able to be selected when requested. The designed road must be cross-sectional and surface-oriented. Surface mine design processes were tested and the test results are shown in Table 9, indicating that surface mine design processes work functionally.

Table 9. Process and sub-processes tested related to the surface mine design (✓: test successful, ✗: test failed).

Process	Sub-process	Result	Demand Description
Adding a pit	Adding a pit with command "add a pit"	✓	Netigo and file objects should be integrated to Netpromine.
Adding the surfaces for mine site	Transferring the 2D field model created on 2D screen into 3D screen	✓	
	Draping raster data on topography	✓	
	Adding top and/or bottom surfaces inside the pit	✓	Desired top and bottom surfaces should be added in the pit by using the pit added under the Open Pit Mining section.
Determining the pit limits	Adding the digitized pit limits inside the pit by selecting from the screen	✓	

	Draping the pit limit on the selected surface	✓	
Pit slope definitions	Creating default bench definitions related to the pit by keeping the bench width constant	✓	Detailed explanations for each parameter should be added to the mine design command window.
	Creating a desired number of benches automatically based on the default bench definition	✓	
	Creating individual benches with the create top/toe of the bench command	✓	
	Editing pit slope lines with user intervention	✓	
	Fixing Z values during editing process	✓	
	Deleting lines produced under pit lines	✓	
Pit ramp definitions	Adding express or shift ramps to the parameters specified in the pit	✓	
	Production of ramps between steps	✓	
	Observing ramp definitions on renewed pit surface	✓	

Resulting Pit surfaces definitions	Creating roof/bottom and pit surface after renewing all surfaces	✓	
	Adding the project surfaces by combining the resulting surfaces (roof, base, pit surface) generated.	✓	
	Saving the changes made in the pit area	✓	
Processes between levels	Creating solid model between elevations for the pit designed	✓	
	Limiting the block model within the solid model	✓	
	Synchronizing the top surface, bottom surface, pit surface and pit lines for the generated pit to 2-D screen.	✓	The elevation values on the contour map should be readable and written sparsely.
Transition definitions	Adding a transition to the project by entering the default bench slope	✓	
	Adding the areas selected from the screen into the transition definition with specified angle value	✓	

	Adding the generated transition definition to the default bench definitions	✓	
	Observing angle changes in the transition areas after bench creating process	✓	
Adding roads	Adding road through a route drawn on the 3D screen	✓	
	Editing horizontal path definitions of the road (curve radius)	✓	
	Editing vertical path definitions of the road (curve radius and slope)	✓	
	Creating platform definitions for the road as user defined	✓	
	Applying platform definitions on the field surface	✓	
	Calculation of rock fill volume for the road	✓	
	Receiving a road report	✓	
Add blasting	Selecting machine (drilling) in the general parameters of blasting	✓	
	Choosing the explosive type in general parameters of blasting	✓	

	Entering hole information for to blasting design	✓	
	Choosing blasting pattern (square, staggered)	✓	
	Entering the bench height for blasting	✓	
	Calculating field width and field length automatically after blasting surfaces are chosen	✓	
	Calculating blasting parameters automatically based on the calculation method selected in the blast hole information	✓	
	Calculating total hole and charge amount, specific hole and charge amount automatically in blasting metric information	✓	
	Entering total and specific cost information in blasting metric information window	✓	
	Entering particle size in the blasting evaluation information window	✓	
	Drawing a particle size graph as a result of the parameters entered in particle size calculation section	✓	

	Selecting the surfaces to be blasted from the 3D display on the pit	✓	
	Time input to the blasting holes	✓	
EIA (Environmental Impact Assessment) Report	Calculating the air shock values for blasting based on the total amount of charge and effective zone interval	✓	
	Calculating the noise values for blasting using the entered parameters (relative humidity, approximate noise level etc.).	✓	
	Calculating the vibration (ground shaking) values for blasting using the parameters entered (coefficient based on rock type, field coefficient, etc.)	✓	
	Automatically calculating the amount of flyrock for blasting	✓	
	Sketching the resulting impact area to the 3D screen by selecting the surface	✓	
	Transferring influence of area to the 2-dimensional screen	✓	

5. Underground Mine Design Processes

An underground mine can be considered as the sum of any openings connecting the mineralization to the surface such as face, bottom roadways, galleries and shafts. Therefore, these openings should be designed. Underground mine design processes were tested and test results are shown in Table 10, indicating that underground mine design processes work functionally.

Table 10. Process and sub-processes tested related to the underground mine design (✓: test successful, ✗: test failed).

Process	Sub-process	Result	Demand Description
Adding a gallery	Creating the gallery plan by using solid model or surface (gallery axes points or routes) in 3D environment.	✓	
	Using the "Add Gallery" command, digitizing the free gallery design using the desired coordinate or distance, slope or angle values in 3D environment.	✓	
	Editing galleries after or during gallery digitization.	✓	
	Deleting galleries from 3D screen or gallery list.	✓	
	Undoing deleted galleries	✓	
	Entering the general parameters in the opened gallery properties window.	✓	

	Calculating volumes automatically	✓	
	Selecting gallery profile from the profile list.	✓	
	Determining support values (support and application range) in the gallery properties window	✓	
	Calculating ventilation values based on coefficient of friction and friction factor.	✓	
Creating a gallery	Creating a gallery by selecting from the 3D screen or layer.	✓	
	Assigning profile and group to selected axes.	✓	
	Displaying galleries with their axes or profiles via right key axis display feature.	✓	
	Transferring galleries to 2D screen with their thematics.	✓	
Gallery list	Displaying digitized galleries from gallery list.	✓	
	Intervening gallery properties from gallery list.	✓	
	Turning off visibility of the selected galleries from the Gallery list via the graphic display.	✓	

Choose a profile	Selecting the digitized profile on the 2D NetCad screen by transferring it to the 3D screen.	✓	
	Displaying the selected profile from gallery profiles list.	✓	
	Displaying the newly added profile from the 3D screen with command "show axes".	✓	
	Deleting the newly added profile from the profile list.	✓	
Add access roads	Creating the access roads of the galleries by entering parameters like access road length, distance between roads, distance to starting point.	✓	
	Displaying the created access roads correctly on 3D screen after parameter input.	✓	
	Displaying added access roads into the gallery list	✓	
Add spiral	Creating spiral by entering parameters (radius, grade, number of segments etc.) to the opened window with "add spiral" command.	✓	

	Displaying the properties entered in the opened spiral window correctly on the 3D display.	✓	
	Displaying the added spiral on the gallery list.	✓	
Add a curve	Opening curve window with command “add curve”.	✓	
	Adding curve to the selected gallery routes after parameter entry.	✓	
Gallery list report	Getting a gallery list report	✓	
Show axis	Adding profile to the gallery axes with command “show axis”.	✓	
	Rotating the screen after adding a profile.	✓	
	Adding transparency to galleries.	✓	
Thematic	Adding thematic to the gallery based the desired attribute.	✓	
Add installation	Opening an installation properties window by making digitization from the screen with “add installation” choice	✓	

	Adding installation by choosing desired gallery with "add installation to gallery" choice	✓	
Installation list	Displaying installations added to the project from installation list window	✓	
	Editing added installations from the installation list window	✓	
Thematic	Adding thematic to the installation definitions	✓	
Reports	Getting report about installation definitions with installation list report	✓	
Add fan	Adding fans to the galleries with "add fan" option	✓	
Fan list	Displaying the fans added to the project in the fan list	✓	
Add ventilation door	Adding a ventilation door to the galleries with "add ventilation door" option	✓	
Ventilation door list	Displaying the ventilation doors added to the project in the ventilation doors list	✓	

6. Visualization

Visualization processes were tested and shown in Table 11, indicating that visualization processes are working functionally.

Table 11. Process and sub-processes tested related to the visualization (✓: test successful, ×: test failed).

Process	Sub-process	Result	Demand Description
Panel	Examining the project depending on panels in different directions (right-facing panel, bottom- facing panel, etc.).	✓	
Camera Link	Controlling the screens from different angles by connecting to windows divided into panels with camera link feature.	✓	
Grid	Adding 3D grid to the project	✓	
	Controlling grid properties (distance between grid lines, show surfaces, font color etc.)	✓	
Remember the image	Saving project images from different angles with command “remember the image”.	✓	
	Dynamically switching to recorded images at any time.	✓	
	Exporting and saving the images in different formats.	✓	
Scale	Adding linear scale to the project	✓	

	Changing scale of the screen	✓	
Legend	Adding legend to the project	✓	
Record a video	Recording a video while managing the project screen.	✓	
Transparency	Changing the transparency of the project layers	✓	
Styles	Changing the style features (color, borders, thickness etc.) of the project layers.	✓	
Rotating the drawing	Rotating the project screen automatically	✓	
Interaction	Using different mouse usage features (Default, trackball camera, etc.)	✓	

CONCLUSION

In the scope of the project initiated with the financial support of TUBITAK (Scientific and Technological Research Council of Turkey) and with cooperation of Hacettepe University, NetCad Software Inc., and TKI (Turkish Coal Enterprises), an integrated software was developed, that provides the user with three-dimensional orebody modeling and mine design. This software, called Netpro/MINE, was completed in 2012 and has been available to the mining industry of Turkey starting from this date.

In this project, a series of studies were carried out with the technical staff of the company in order to update the software in accordance with the recent developments in mineral resource/reserve estimation, to test the suitability of existing functions according to mining science and technology, and to bring in new functions and calculation tools. As a result of these studies, as detailed in the tables above, all the functions of the software were tested with actual data, approved by us and additional demands were made for some additional improvements.

Consequently, the improvements required for the next version of the software were largely completed during the testing process.

This report is signed on 02.01.2017 and is prepared by the researchers named below within the frame of the protocol signed between NetCad Software Inc. and Hacettepe Teknokent Teknoloji Transferi Ar-Ge Danışmanlık Enerji Sağlık Çevre İletişim San. ve Tic. A.Ş. on 20.04.2017.

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