

New Items in 3D-Dig Version 4.2

Welcome to the new 3D-Dig Version 4.2, presented through our website www.earthtechnology.net. This version represents further development of 3D-Dig Version 4.1. You will notice many improvements in Version 4.2 over Version 4.1, especially in modelling of various mining machinery, 3D and 2D graphics, and management of graphics colors.

In 3D-Dig we proudly present further development of our new Execution & Dumping module and its applications to Terrain Reshaping, Bulldozer simulation, and Truck/Shovel simulation. This module provides intuitive graphical access to Automated Excavation & Dumping. New tutorials in 3D-Dig Execution & Dumping are available from our website www.earthtechnology.net/downloads and from our online courses. Our online course in 3D-Dig Execution will be released shortly.

3D-Dig Version 4.2 presents a new Bulldozer Productivity Model as described below. Further development of this model and other important additions to Bulldozer Modelling are planned for Version 4.3 (Beta).

Compatibility with Version 4.1 and Earlier Versions of 3D-Dig

Write Compatibility

3D-Dig Version 4.2 will write all versions of 3D-Dig starting from Version 3.6 i.e. Version 3.6, 4.0 and 4.1.

This is available through the menu File/Save As..., choosing the appropriate file type in the "Save as type" pull-down list.

The written files will contain data that are common between 3D-Dig Version 4.2 and the earlier version chosen.

Read Compatibility

3D-Dig Version 4.2 will read all builds of 3D-Dig Version 4.1, 4.0 and 3.6.

We expect that 3D-Dig Version 4.2 will read files from all earlier versions of 3D-digPlus and 3D-dig2000.

Generic Simulation (Base) Program

Drawing Layers

Added the ability to draw more than 127 layers.

Undo After Surface Area

Blocking Undo after Surface Area calculation has been corrected. Undo is now available in this situation.

Delete All Road Segments

Now it is possible to delete all road segments one by one.

Surface & Layer Highlight Colors

Surface and Layer highlight color is now settable in Section Settings.

Lock in Dump Settings/Dump Parameters

In Dump Parameters add options to

"Lock % of Log to Dump"

or

"Lock Volume to Dump"

Surface Selection in Cross-Sections

Improvements have been made in selection of surfaces for cross-sections.

Log Data to Excel

Excel file to be on top after writing log data to Excel.

Material Logs New Button

A new button has been added to the Material Logs. This is called "Send to Excel All Logs".

This button will send all log information to Excel.

Details of this button still need to be considered and possibly altered.

Highlight the Selected Surface

Show the selected surface and layer in the section using the colored legend buttons.

Zoom With Mouse Wheel

Mouse wheel zoom now gives the same zoom ratio for Zoom-in and Zoom-out. This allows repeatability of view changes.

Default Undo/Redo Stack Size

The default Undo/Redo stack size has been increased from 30 to 100.

Saved File Names

This Build fixes problems with dots "." entered in saved file names. Everything after the last dot in an entered file name was omitted from the saved file name. This has now been corrected.

Image Capture Speed Increased

Writing of individual image files during capture in various simulations has been significantly speeded-up. This is done using multi-threading, with images saved to file in a separate thread.

Confirmation Windows Centering

In multi-display configurations, confirmation windows are now centered on the same screen as the main window.

Machine Appearance Changes Immediately

Changes in machine parameters through various Machines Parameters Windows are now reflected in the machine appearance on the terrain surface. This is done by redrawing machines on the terrain as soon as the Machine Parameters window is closed, without the need to directly redraw the terrain.

Execution & Dumping Module

A new *Execution & Dumping* module is available in 3D-Dig. This gives intuitive access to 3D-Dig Automated Excavation & Dumping.

An *Execution* consists of:

- A Polygon to define limits of digging

- Dig direction
- Dig step
- Dig batter
- Pass Surface

Executions are created from the Excavation Settings Dialog Box.

Each Execution is a subsequence in Automated Excavation & Dumping. A new toolbar icon group allows Executions to be created, assigned to dump hierarchies and excavated. Order of excavation as usual is controlled by a supersequence. Additional ease of access is provided by **Multi Excav** buttons which allow all Executions from selected templates to be processed together.

Image Capture Speed Increased

Writing of individual image files during capture in Execution has been significantly speeded-up. This is done using multi-threading, with images saved to file in a separate thread.

Dashboard Capture

This version allows capture of AVI video files with OpenGL turned off to save a dashboard with the graphics window. This is accessed through the check box "Capture Dashboard" in the dialog box opened by Options/Capture Settings...

Tutorials and Execution Course

New tutorials in 3D-Dig Execution & Dumping are available from our website www.earthtechnology.net/downloads. A new online course in 3D-Dig Execution & Dumping is in advanced preparation stage and will be released soon.

Single Step Dragline Simulation Module

Image Capture Speed Increased

Writing of individual image files during capture in Execution has been significantly speeded-up. This is done using multi-threading, with images saved to file in a separate thread.

Confirmation Windows Centering

In multi-display configurations, confirmation windows are now centered on the same screen as the main window.

Dragline Appearance Changes Immediately

Changes in dragline appearance through the Dragline Parameters window are now reflected in the dragline appearance on the terrain surface. This is done by redrawing draglines on the terrain as soon as the Dragline Parameters window is closed, without the need to directly redraw the terrain.

Dragline Tub Diameter and House Width Independent

Dragline tub diameter and house width are now set independently of each other. Previously one was automatically calculated from the other. This made it impossible to set some necessary values.

ARC Area Dump in US Units

Parameters for the Arc Area Dump are now set correctly in US units. Previously they were always in metric, which is inappropriate for US setting.

Automated Dragline Simulation Module

Image Capture Speed Increased

Writing of individual image files during capture in Execution has been significantly speeded-up. This is done using multi-threading, with images saved to file in a separate thread.

Dragline Appearance Changes Immediately

Changes in dragline appearance through the Dragline Parameters window are now reflected in the dragline appearance on the terrain surface. This is done by redrawing draglines on the terrain as soon as the Dragline Parameters window is closed, without the need to directly redraw the terrain.

Moving Arc Area Dump During Position Indexing

This Build of Version 4.2 correctly moves the Arc Area Dump during Dragline Position Indexing in Automated Dragline Simulation.

ARC Area Dump in US Units

Parameters for the Arc Area Dump are now set correctly in US units. Previously they were always in metric, which is inappropriate for US setting.

Dragline Appearance Changes Immediately

Changes in dragline appearance through the Dragline Parameters window are now reflected in the dragline appearance on the terrain surface. This is done by redrawing draglines on the terrain as soon as the Dragline Parameters window is closed, without the need to directly redraw the terrain.

Confirmation Windows Centering

In multi-display configurations, confirmation windows are now centered on the same screen as the main window.

Dashboard Capture

This version allows capture of AVI video files with OpenGL turned off to save a dashboard with the graphics window. This is accessed through the check box "Capture Dashboard" in the dialog box opened by Options/Capture Settings...

Reshaping and Transport Analysis Module

Image Capture Speed Increased

Writing of individual image files during capture in Execution has been significantly speeded-up. This is done using multi-threading, with images saved to file in a separate thread.

Confirmation Window in Multi-Window Displays

The confirmation windows are now centered on the same screen as the main window, in multi display configurations.

Triangulation-Based Reshaping

This Version includes an option to reshape based on triangulation.

Dozer Simulation and Optimization Module

User-Supplied Productivity Model

A new productivity model called the "User Supplied Productivity" model or USP model has been added to the Dozer Model. This model calculates Dozer Productivity from the equation

$$\text{Productivity} = A + B \times \text{Distance} + C \times \text{Grade}$$

Productivity is in Bank Cubic Meters (or US equivalent) per hour

Distance Units are meters or feet.

Units for Slope %grade, (Negative down , Positive up)

Distance and Slope are taken from the model simulation, using the internal model calculations for each dozer path. Productivity is averaged over all dozer paths. In this way, productivity is averaged for each region, and overall.

Values of A,B,C are calculated from user measurements.

We are planning to add a facility to enter user data and calculate best-fit values of A,B,C.

Visualization of Dozer Rim Pull Curves

Dozer Rim Pull Curves in 3D-Dig allow different curves for Forward and Reverse movement. Visualization of Forward and Reverse Rim Pull Curves has been added to Dozer Settings.

Dozer Region Excavation Corrected

This Build of Version 4.2 has corrected a problem in Dozer Simulation, where some Dozer Regions were not fully excavated. This is for the Execution option of Dozer Simulation.

Dozer Appearance Changes Immediately

Changes in dozer appearance through the Dozer Parameters window are now reflected in the dozer appearance on the terrain surface. This is done by redrawing dozers on the terrain as soon as the Dozer Parameters window is closed, without the need to directly redraw the terrain.

Automated Excavation and Dump Simulation

Dashboard Capture

This version allows capture of AVI video files with OpenGL turned off to save a dashboard with the graphics window. This is accessed through the check box "Capture Dashboard" in the dialog box opened by Options/Capture Settings...

Image Capture Speed Increased

Writing of individual image files during capture in Execution has been significantly speeded-up. This is done using multi-threading, with images saved to file in a separate thread.

Confirmation Window in Multi-Window Displays

The confirmation windows are now centered on the same screen as the main window, in multi display configurations.

Truck/Shovel Simulation

Improved Truck Positioning

Positioning of trucks being loaded by an excavator in Truck/Shovel simulation has been improved. Trucks will now choose the position which is nearest to the level of the excavator.

Excel File on Top

Excel file to be on top after writing log data to Excel.

Image Capture Speed Increased

Writing of individual image files during capture in Execution has been significantly speeded-up. This is done using multi-threading, with images saved to file in a separate thread.

Confirmation Window in Multi-Window Displays

The confirmation windows are now centered on the same screen as the main window, in multi display configurations.

3D-Dig Version 4.2 Beta Build 0x0240329

Truck and Excavator Appearance Changes Immediately

Changes in truck or excavator appearance through the Truck Parameters window and the Excavator Parameters window are now reflected in the Truck and Excavator appearance on the terrain surface. This is done by redrawing Trucks and Excavators on the terrain as soon as the Truck Parameters or Excavator Parameters window is closed, without the need to directly redraw the terrain.

Dashboard Capture

This version allows capture of AVI video files with OpenGL turned off to save a dashboard with the graphics window. This is accessed through the check box "Capture Dashboard" in the dialog box opened by Options/Capture Settings...

New Items in 3D-Dig Version 4.1

Welcome to the new 3D-Dig Version 4.1, presented through our website www.earthtechnology.net. This version represents further development of 3D-Dig Version 4.0. You will notice many improvements in Version 4.1 over Version 4.0, especially in 3D and 2D graphics.

3D-Dig was rebranded from 3d-DigPlus. All the familiar modules and rich functionality of 3d-DigPlus are present in 3D-Dig, along with many improvements as detailed below.

In 3D-Dig we proudly present our new Execution & Dumping module. This module provides intuitive graphical access to Automated Excavation & Dumping. New tutorials in 3D-Dig Execution & Dumping are available from our website www.earthtechnology.net/downloads

Compatibility with 3D-Dig Version 4.0 and Earlier Versions

Version 4.1 of 3D-Dig will read all builds of 3D-Dig Version 4.0, all builds of 3d-DigPlus Version 3.6 and earlier versions of 3d-DigPlus. In addition, Version 4.1 can write design files for the final builds of 3D-Dig Version 4.0 and 3d-DigPlus Version 3.6. These files will contain all data that are common between 3D-Dig Version 4.1 and the earlier versions.

OpenGL Graphics

3D-Dig 4.1 fully utilizes modern (core-profile) OpenGL Version 3.3. This further improves graphics performance using advanced OpenGL technologies such as Vertex Buffer Object (VBO), OpenGL Shading Language (GLSL) and Uniform Buffer Object Geometry Shaders.

OpenGL graphics is used in both 2D (sections) and in 3D views, throughout all modules of 3D-Dig.

Generic Simulation (Base) Program

1. New Crest Line and Toe Line Finder

Version 4.1 has a first version of the 3D-Dig Crest Line and Toe Line Finder. This is found under the menu "Utilities/Find Crest and Toe". You must either draw or select a polygon within which the Crest and Toe of terrain will be found.

This functionality is designed to find one crest and one toe within the selected area i.e. one bench. It does not work so well when there are many benches or spoil piles within the terrain. In that case, the terrain needs to be broken into smaller areas for the search.

2. Redraw Sections in OpenGL Graphics

Sections are now redrawn in advanced OpenGL graphics. This leads to much faster redraw when there are many inner surfaces and layers.

3. Printing of Graphics Improved

Printing of graphics through File/Print has been improved by increasing the resolution of printing.

4. Copy High-Resolution Image to Clipboard

The Edit/Copy Graph menu now copies a high-resolution image to the clipboard.

5. Redraw of Horizontal Sections Improved

Redraw of Horizontal Sections using OpenGL is much faster.

6. Undo/Redo of Dump Settings Improved

Undo/Redo of Dump Settings has been completely rewritten and stabilized.

7. Many detailed improvements

Many detailed improvements and relatively minor corrections have been relatively minor corrections made in base and modules software.

8. Rotate by Mouse functionality

Pressing and holding the central mouse wheel activates a Pan/Rotate function independently of the toolbar. The graphics view will Pan or Rotate with mouse movement (depending on mode set in toolbar), as long as the mouse wheel remains pressed.

9. Min and Max Data Limits in Paste

Data limits (minimum and maximum) now change when using Paste into Data graphics windows.

This was not done previously. This meant that a feature which is away from existing data might not immediately appear in the graphics window. Only after zooming out in the window would the feature appear.

This has now been corrected and pasted features will always appear in Data graphics windows.

10. Capture Window in AVI Capture

3D-Dig Version 4.1 supports capture of a sequence of video images when capturing through "Capture Window" in AVI capture mode.

This means that separate capture commands will generate a video made up of the individual images captured in each capture command.

Duration between individual frames in the video is set by a parameter available to users when choosing AVI capture. Default value of this parameter is 1 second.

11. Negative Block Numbers Generated

3D-Dig version 4.1 allows for negative block line numbers in the Block Line Generator.

12. Clip to Work Area – Triangulation

3D-Dig version 4.1 fixes an issue with triangulation in Clip to Work Area, when there are no data points or features.

Execution & Dumping Module

A new *Execution & Dumping* module is available in 3D-Dig. This gives intuitive access to 3D-Dig Automated Excavation & Dumping.

An *Execution* consists of:

- A Polygon to define limits of digging
- Dig direction
- Dig step
- Dig batter
- Pass Surface

Executions are created from the Excavation Settings Dialog Box.

Each Execution is a subsequence in Automated Excavation & Dumping. A new toolbar icon group allows Executions to be created, assigned to dump hierarchies and excavated. Order of excavation as usual is controlled by a supersequence. Additional ease of access is provided by *Multi Excav* buttons which allow all Executions from selected templates to be processed together.

New tutorials in 3D-Dig Execution & Dumping are available from our website www.earthtechnology.net/downloads

1. Wider Field for Execution Polygon (Subsequence) Name

Dashboard in Automated Excavation & Dump now has a wider field for the subsequence/execution polygon name.

2. Excavators Assigned to Polygons (Subsequences)

This is done through a new "Assign Excavators to Subsequences" button in Simulation Settings for Automated Excavation & Dump.

3. SUPER SEQUENCES EDIT icon for Execution

The SUPER_SEQUENCES_EDIT icon for Execution is now correctly opening the Supersequence Editor.

4. Preset Productivities and Dumps

3D-Dig 4.1 fixes an issue with order of assignment of Preset Productivities and Dumps to Subsequences. If Present Productivities are assigned before any Dumps are assigned, the assigned Preset productivities were lost. This has now been corrected.

5. Capture Window in AVI Capture

3D-Dig Version 4.1 supports capture of a sequence of video images when capturing through "Capture Window" in AVI capture mode.

This means that separate capture commands will generate a video made up of the individual images captured in each capture command.

Duration between individual frames in the video is set by a parameter available to users when choosing AVI capture. Default value of this parameter is 1 second.

Single Step Dragline Simulation Module

1. Changes in Dragline Parameters Shown

Changes in dragline parameters (and parameters of other machines) through Dragline Parameters Windows are now shown immediately in the machine appearance on the terrain surface. This is done by redrawing machines on the terrain as soon as a Dragline Parameters window is closed.

2. Capture Window in AVI Capture

3D-Dig Version 4.1 supports capture of a sequence of video images when capturing through "Capture Window" in AVI capture mode.

This means that separate capture commands will generate a video made up of the individual images captured in each capture command.

Duration between individual frames in the video is set by a parameter available to users when choosing AVI capture. Default value of this parameter is 1 second.

3. Negative Block Numbers Generated

3D-Dig version 4.1 allows for negative block line numbers in the Block Line Generator.

Automated Dragline Simulation Module

1. Changes in Dragline Parameters

Changes in dragline parameters (and parameters of other machines) through Dragline Parameters Windows are now shown immediately in the machine appearance on the terrain surface. This is done by redrawing machines on the terrain as soon as a Dragline Parameters window is closed.

2. Capture Window in AVI Capture

3D-Dig Version 4.1 supports capture of a sequence of video images when capturing through "Capture Window" in AVI capture mode.

This means that separate capture commands will generate a video made up of the individual images captured in each capture command.

Duration between individual frames in the video is set by a parameter available to users when choosing AVI capture. Default value of this parameter is 1 second.

3. Dragline Position Indexing

This Build of Version 4.1 correctly moves the Arc Area Dump during Dragline Position Indexing in Automated Dragline Simulation.

4. Dragline Positioning on Bench

The greatest acceptable difference between dragline bench height and terrain height has been changed from 0.2m to 0.4m when auto-positioning the dragline on the terrain.

5. Negative Block Numbers Generated

3D-Dig version 4.1 allows for negative block line numbers in the Block Line Generator.

6. Final Redraw on Completion

A final redraw is now done after completion of Auto Dragline Simulation.

Reshaping and Transport Analysis Module

1. New Crest Line and Toe Line Finder

Version 4.1 has a first version of the 3D-Dig Crest Line and Toe Line Finder. This is found under the menu "Utilities/Find Crest and Toe".

This finder can be of assistance in appropriately setting reshaping polygons in the module.

You must either draw or select a polygon within which the Crest and Toe of terrain will be found.

This functionality is designed to find one crest and one toe within the selected area i.e. one bench. It does not work so well when there are many benches or spoil piles within the terrain. In that case, the terrain needs to be broken into smaller areas for the search.

2. Capture Window in AVI Capture

3D-Dig Version 4.1 supports capture of a sequence of video images when capturing through "Capture Window" in AVI capture mode.

This means that separate capture commands will generate a video made up of the individual images captured in each capture command.

Duration between individual frames in the video is set by a parameter available to users when choosing AVI capture. Default value of this parameter is 1 second.

Reshaping Polygon Color

Polygons created from within the Reshaping/Reshape Surface... dialog box are now automatically selected and drawn in the "Selected Poly Color". The labelling of the polygon color button has been changed to this name.

Dozer Simulation and Optimization Module

New Dozer Productivity Method

A new method of calculating Dozer Productivity has been added to the Dozer Model in 3D-Dig Version 4.1. This method is based on the new Execution Module in 3D-Dig.

This is a global option for the Dozer Model, on the Machines & Settings Page of Bulldozer Simulation Settings. The option is in the group named "Simulation" on this page. This new option is termed "Execution", the original option is named "Classic".

Calibration of the Dozer Model for this new productivity option is in progress.

2. Capture Window in AVI Capture

3D-Dig Version 4.1 supports capture of a sequence of video images when capturing through "Capture Window" in AVI capture mode.

This means that separate capture commands will generate a video made up of the individual images captured in each capture command.

Duration between individual frames in the video is set by a parameter available to users when choosing AVI capture. Default value of this parameter is 1 second.

3. Changes in Dozer Parameters Shown

Changes in dozer parameters (and parameters of other machines) through Dozer Parameters Windows are now shown immediately in the machine appearance on the terrain surface. This is done by redrawing machines on the terrain as soon as a Dozer Parameters window is closed.

Automated Excavation and Dump Simulation

1. Zoom During Simulation

This build also allows zoom during Truck/Shovel and Automated Excavation and Dump and Truck/Shovel simulation.

2. Wider Field for Subsequence Name

Dashboard in Automated Excavation & Dump now has a wider field for the subsequence name.

3. Excavators Assigned to Subsequences

This is done through a new "Assign Excavators to Subsequences" button in Simulation Settings for Automated Excavation & Dump.

4. Single-Pass Subsequence Auto-generation

Auto-generation of subsequences now works correctly for a single pass.

5. Capture Window in AVI Capture

3D-Dig Version 4.1 supports capture of a sequence of video images when capturing through "Capture Window" in AVI capture mode.

This means that separate capture commands will generate a video made up of the individual images captured in each capture command.

Duration between individual frames in the video is set by a parameter available to users when choosing AVI capture. Default value of this parameter is 1 second.

4. Preset Productivities and Dumps

3D-Dig 4.1 fixes an issue with order of assignment of Preset Productivities and Dumps to Subsequences. If Present Productivities are assigned before any Dumps are assigned, the assigned Preset productivities were lost. This has now been corrected.

Truck/Shovel Simulation

1. Changes in Truck and Excavator Parameters Shown

Changes in Truck and Excavator parameters (and parameters of other machines) through Truck or Excavator Parameter Windows are now shown immediately in the machine appearance on the terrain surface. This is done by redrawing machines on the terrain as soon as a Parameters window is closed.

5. Capture Window in AVI Capture

3D-Dig Version 4.1 supports capture of a sequence of video images when capturing through "Capture Window" in AVI capture mode.

This means that separate capture commands will generate a video made up of the individual images captured in each capture command.

Duration between individual frames in the video is set by a parameter available to users when choosing AVI capture. Default value of this parameter is 1 second.

New Items in 3D-Dig Version 4.0

Welcome to the new 3D-Dig, rebranded from 3d-DigPlus and presented through our website www.earthtechnology.net. All the familiar modules and rich functionality of 3d-DigPlus are present in 3D-Dig. Along with these, you will notice many improvements, especially in 3D and 2D graphics.

We also proudly present our new Execution & Dumping module. This module provides intuitive graphical access to Automated Excavation & Dumping.

Compatibility with 3d-DigPlus Version 3.6 and Earlier Versions

Version 4.0 of 3D-Dig will read all builds of 3d-DigPlus Version 3.6 and earlier versions of 3d-DigPlus.

In addition, Version 4.0 can write design files (*.3dd files) for 3d-DigPlus Version 3.6. These files will contain all data that are common between 3D-Dig Version 4.0 and 3d-DigPlus Version 3.6.

OpenGL Graphics

3D-Dig 4.0 fully utilizes modern (core-profile) OpenGL. This significantly improves graphics performance through the use of advanced OpenGL technologies such as Vertex Buffer Object (VBO), OpenGL Shading Language (GLSL) and Uniform Buffer Object Geometry Shaders.

OpenGL graphics is used in both 2D (sections) and in 3D views, throughout all modules of 3D-Dig.

Generic Simulation (Base) Program

1. Auto Recalculate Outer Polygon

The Outer Polygon is now automatically recalculated after moving or editing the Inner Polygon. This option is controlled by a flag ***Auto Recalculate Outer Polygon*** on the ***Excav Polygons*** page of the ***Excavation Settings*** dialog box. Default value for this setting is ON.

2. Copy Option When New Inner Surface is Created

Creation of a new surface allows users to create an empty new surface, or to select which data from an existing surface will be copied to the new surface. This option is accessed through the ***Terrain/Surfaces/Edit*** menu, then press the ***New*** button.

3. Save Design Files (*.3dd files) for 3d-DigPlus Version 3.6

This option is accessed through the menu ***File/Save As...***, then choose the ***Save as type:*** option ***All program Data for 3.6 Version (*.3dd)***.

4. Multiple Monitors

If a window does not fit in the saved position when monitor configuration is changed, it will expand to the first monitor.

5. Rarefy Feature Points on Import

An option ***Rarefy Feature Points (inc. Surf. Feat.)*** has been added to the ***Data Input/Output*** page of ***Terrain/Editor Settings***. This option uses a ***Min. Spacing*** setting to remove points that are closer together than this distance in East-North. Default value is 0.001m (1mm). This will remove duplicate points and points that are very close together, without significantly altering the shape of the imported feature.

6. Unicode and Chinese Language Interface

3D-Dig supports Unicode. This allows the interface to be developed in multiple languages. A Chinese language interface is being developed for 3D-Dig.

7. Undo-Redo for Excavation Settings Dialog Box

The Excavation Settings dialog box has acquired additional settings with the addition of the Execution & Dumping module. This has required an upgrade to the Undo/Redo functionality that affects this window. Work on this upgrade is complete in 3D-Dig Version 4.0.

8. Polygons with Center and Area on Cross-Sections

Polygons may be drawn on cross-section windows, through the usual **Add Polygons** icon on the toolbar. The Centre and Area is shown for each polygon. Settings for the color of the polygons and whether to show them on each section are found on the **General** page of the **Section Settings** dialog box.

9. New option Utilities/Playback Capture

A new option to play back already captured images has been added to the Utilities menu. This plays back images, which were captured as per epy settings in Capture Settings. The settings in Capture Settings are used to access and display the captured images.

10. New Hot Keys and Automatic Redraw

New Hot Keys for Undo and Redo (Ctrl-Z & Ctrl-Y) have been added.

Automatic redraw after use of Hot Keys for setting the Next Template active (1 and 2) has been added.

11. Feature Colors in DXF and Export of More Features Types

Export of Surface Features, More Features Types as DXF has been implemented. Colours are preserved in the DXF through Export/Import.

12. Recalculation of Contours During Calculation

Recalculation of Contours on Rendering during simulation has been added as an option in the Terrain Window Appearance. This is the **Recalc Coutours** check box on the **Rendering** page. This should be used with caution, as it may cause significant slow-down of calculations and re-display.

13. Autosave File Name

The Autosave file name is now set to the design file name with appended **_autosave**. So **myfile.3dd** will be autosaved to **myfile_autosave.3dd**.

14. Select Traces to Show Button

A new **Select Traces to Show** button has been added for inner surface traces. This is on the **Edit Surface** dialog box, accessed through the menu **Terrain/Surfaces/Edit...** . This allows surfaces which show up as inner traces to all be selected from the one dialog box.

15. Separate Excavation Settings Dialog Boxes in Execution & Dumping Mode

Excavation Templates set in Execution & Dumping mode are shown in a separate list in the Excavation Settings Dialog Box. The dialog box with the Execution list is shown only through the new **Execution/Create...** menu item.

16. Option to Hide Inner Surface Traces

A **Hide Inner Surf. Traces** check box has been added to the **General Page** of the **Terrain Appearance** dialog box. This flag will apply to the selected graphics window.

17. New Fast Draw Settings

New settings now apply in the Fast Draw Settings dialog box (*Terrain/Fast Draw Settings...* menu). The two settings connected with data shown in graphics are:

(a) Grid Rendering Speed Up

This has two options of either **Use Full Grid** (the default) or **Use Grid Thinning** with its associated **Thinning Level** setting. This controls the grid frequency i.e. how much of the grid is used in graphics rendering. It is useful to speed up graphics in cases with very large terrains, fine grids and slow graphics cards. This setting may be particularly useful in simulation.

(b) Fit Loaded Grid Data to Screen

In this option, only the part of a grid visible on the screen is loaded to the graphics card. This option will speed up continuous redrawing during simulation e.g. in Truck/Shovel Simulation. The disadvantage is that only the part of the grid loaded is available to the graphics, although the full grid is still present and used in simulation.

For example, zooming out will only show the part of the grid before zoom. To reload more (or less) of the grid to the graphics card, simply refresh the screen.

18. Min. Lift Height in Staged Dumping

Staged dumping now has protection against a first small lift being created. This is through the **Min Bench Height** setting on the **Dump Pass Parameters** dialog box. This dialog box is accessed through the **Set Parameters** button on the **Staging** page of the **Dump Settings** dialog box.

19. New Multi Triangulate and Multi Calculate Grid Buttons

New buttons **Multi Triangulate** and **Multi Calculate Grid** have now been added to the **Triangulate** and **Calculate Grid** dialog boxes. These allow users to select multiple surfaces for triangulation or gridding.

Execution & Dumping Module

A new **Execution & Dumping** module is available in 3D-Dig. This gives intuitive access to 3D-Dig Automated Excavation & Dumping.

An **Execution** consists of:

- A Polygon to define limits of digging
- Dig direction
- Dig step
- Dig batter
- Pass Surface

Executions are created from the Excavation Settings Dialog Box.

Each Execution is a subsequence in Automated Excavation & Dumping. A new toolbar icon group allows Executions to be created, assigned to dump hierarchies and excavated. Order of excavation as usual is controlled by a supersequence. Additional ease of access is provided by **Multi Excav** buttons which allow all Executions from selected templates to be processed together.

Examples of using the Execution & Dumping module are available through annotated videos and example design files.

Single Step Dragline Simulation Module

1. OpenGL Graphics

All graphics operations and displays in the Single Step Dragline Simulation module now use full OpenGL Graphics.

2. New Default Carry Envelope

A new Default Dragline Carry Envelope has been included in the Dragline Simulation model.

3. Corrected Cycle Time Calculation

This build fixes an error in calculation of Cycle Time in Dragline Productivity calculation. The calculation of Productivity and Dig Time were not affected by this error.

4 Draping of Bound Excavation and Dump Polygons and Boom Dump Features

When draglines with bound Excavation and Dump polygons or Boom Dump Features are moved, these structures are draped on the terrain surface for each position of the dragline. This means that they calculate their z-coordinates on each step.

5. Display of Bound Excavation and Dump Polygons

When draglines with bound Excavation and Dump polygons are moved, now only the active polygons are shown, if that is the setting in Window Appearance.

6. Check Rarefy Features

There is a setting new option for checking Highwall and Lowwall toe features in Single-Step Dragline Simulation. The option will check if the selected features have too many points and will offer to rarefy the features. This is done through the flag ***Check Rarefy Features*** on the Single-Step page of Dragline Simulation Settings.

Automated Dragline Simulation Module

1. OpenGL Graphics

All graphics operations and displays in the Automated Dragline Simulation module now use full OpenGL Graphics.

2. Assigning Draglines to Subpasses

The ***Draglines and Subpasses*** page of the ***Dragline Simulation Settings*** dialog box now has a setting **<none>**. This shows that no dragline is assigned to the current subpass.

3. Optional Dashboard Display

Showing the Dashboard is now optional for all of Auto Excavation & Dump, Truck/Shovel and Auto Dragline simulations. New Dashboard functionality has been developed for these modules, for compatibility with OpenGL.

4. Check Rarefy Features

There is a setting new option for checking Highwall and Lowwall toe features in Automated Dragline Simulation. The option will check if the selected features have too many points and will offer to rarefy the features. This is done through the flag ***Check Rarefy Features*** on the Steps page of the Excavation Settings dialog box.

Reshaping and Transport Analysis Module

1. OpenGL Graphics

All graphics operations and displays in the Reshaping and Transport Analysis module now use full OpenGL Graphics.

2. Improved Drawing of Transport Arrows

Drawing of Transport Analysis arrows has been significantly improved in this module.

3. New % Grade column

A column with %Grade has been added to the Excel Report in Transport Analysis.

4. Redrawing During Iterations

Terrain grid redraw during simulations has been implemented. This means that Reshaping will redraw in grid display modes (such as Angle Colors) during iterations.

Dozer Simulation and Optimization Module

1. OpenGL Graphics

All graphics operations and displays in the Dozer Simulation module now use full OpenGL Graphics.

2. Slot Dozing

A new Dozer Slots option has been added to the Dozer Module. The setting for this is located on the Machines & Settings page of the Bulldozer Simulation Settings dialog box. Choosing Dozer Slots disables the Cut-Fill Regions page and enables the Dozer Slots page of the Bulldozer Simulation Settings dialog box.

Dozer Slots are generated in a similar way to auto generation of Dozer Regions. However they can be quite narrow. For this reason, a fine grid option is included on the Slot Slots page.

3. Additional Options for Reference Surface

A new Bridge Surface from Reference Surface has been added for dozer simulation.

4. Reference Feature

A new reference feature for dozer simulation has been added. The reference point for bridge surface level in each region is taken as the mid-point of a nominated feature in that region.

5. Dozer Report Improvement

The Dozer Report output has been improved to make it easier to understand.

6. Clear Button for Dozer Report

A Clear button has been put on the Dozer Report. This is on the report table accessed through the *Simulate/Simulation Report* menu.

Automated Excavation and Dump Simulation

1. OpenGL Graphics

All graphics operations and displays in the Automated Excavation & Dump Simulation module now use full OpenGL Graphics.

2. Variable Pause for Display on Dashboard

When no dumps are assigned to a subsequence, excavation of the subsequence was shown on the dashboard with no pause. This meant that such subsequences, with no dump assigned, effectively were not seen on the dashboard.

A variable pause has been added to the display of blocks on the dashboard in Auto mode. This pause is applied for subsequences when there are no dumps connected. This ***Dashboard Pause*** setting is located on the Simulation Settings dialog box for Automated Excavation & Dumping.

3. Optional Dashboard Display

Showing the Dashboard is now optional for all of Auto Excavation & Dump, Truck/Shovel and Auto Dragline simulations. New Dashboard functionality has been developed for these modules, for compatibility with OpenGL.

Truck/Shovel Simulation

1. OpenGL Graphics

All graphics operations and displays in the Automated Excavation & Dump Simulation module now use full OpenGL Graphics.

2. Three *Multi Excav* Buttons

Three new ***Multi Excav*** buttons have been added for Truck/Shovel Simulation. These are mainly intended for simulations using Executions, although they will be available for all Truck/Shovel simulations.

These buttons are located on the Dumps page, Roads page and Trucks&Excavators page (Assign Trucks/Prods to Subsequences) of the Truck/Shovel Simulation dialog box.

3. Optional Dashboard Display

Showing the Dashboard is now optional for all of Auto Excavation & Dump, Truck/Shovel and Auto Dragline simulations. New Dashboard functionality has been developed for these modules, for compatibility with OpenGL.

New Items in 3d-DigPlus Version 3.6

Generic Simulation (Base) Program

User-Defined Default Colours

It is now possible for users to define several Default Colours. These are the 2D section Background Colour and Section Line Colour, and also the Base Colour for terrain rendering set in Terrain Window Appearance.

This possibility means that the first use of each colour will be set by the user-defined default colour.

The dialog window to set default colours is opened through the Options/Default Colors... menu item.

Set Next Template Active (Menus and Hot Keys)

New menu items "Set Next Template Active" have been created in the Excavate/fill and Dump menus. These set active the next Excavation Template and Dump Template respectively.

After each change, the new Active Template is temporarily shown in the status bar at the bottom of the screen.

Repeated application of each will cycle through the Excavation or Dump templates in order as they appear in the template lists in the Excavation Settings and Dump Settings dialog boxes. After reaching the last template in the list, the next template will be the first one in the list.

Hot Keys "1" and "2" (for Next Excavation and Next Dump respectively) have been implemented to allow quick access to this functionality.

This functionality is particularly useful to speed-up repeated operations in Single-Step Dragline Simulation. After each change of active template, the new active templates will be reflected in the Single-Step Dragline simulation settings and can be seen on the Single-Steppage of the Dragline Simulation dialog box.

Connect Excavate to Level and Common Vertex Height

A new check box has been added to the Excavation Settings dialog box to connect the "Excavate to Level" value (Constraints page) to the "Common Vertex Height" value (Excav. Polygons page).

This check box is called "Connect Comm.Vert.Ht" and is located on the Constraints page next to the "Excavate to Level" value.

Switching on this setting on the Constraints page will cause the "Common Vertex Ht" radio button to be selected (if it is not) and will cause the Common Vertex Ht and Excavate to Level values to always be equal. Changing one of these values will change the other.

The connection can be broken simply by turning off the "Connect Comm.Vert.Ht" check box.

Link Values in Excavation Templates to Values in Dump Templates

New buttons have been added to the Excavation Settings and Dump Settings dialog boxes. These allow values in Excavation and Dump templates to be linked. Two such links are possible:

(1) Link "Common Vertex Height" in the Excavation Template to "Dump to Level" in the Dump Template

and

(2) Link "Bind to Surface" in the Excavation Template to "Dump to Surface" in the Dump Template.

Either link can be set up from the Excavation Template ("Bind Dump" button) or the Dump Template ("Bind Excavation" button).

Show More Surfaces on Excavation Settings, Constraints Page

More constraint surfaces, can now be seen and edited on the constraints page of the Excavation Settings dialog box. This opens a separate window through a "Show More Surfaces" button located on this page. This is similar to the "More" buttons located on the Constraints page of the Dump Settings Dialog Box.

Notebooks Open to Same Page as Last Time

The notebooks in the Excavation Settings, Dump Settings, Dozer Simulation Settings and Dragline Simulation Settings dialog boxes open to the same page as the last time they were opened, in the same session.

This can be convenient when repeatedly changing the same settings on a particular page.

Dump Layer Option "Add to" Added

On the Layer Material page of the Dump Settings dialog box, an option "Add to Dump Layer" has been added. This is in addition to the default "Replace Dump Layer" option previously used.

Import of Vulcan .rsp Files Supported

Vulcan .rsp files can now be read, along with associated ETI files. This will "automatically" create the surfaces and layers as specified in the .rsp file.

Maximum Size of Recent Files List Increased

The maximum size of the Recent Files List at the bottom of the "File" menu has been increased from 9 to 19. This is set through the Options/Settings menu.

Marking Constraints Page of Dump Settings Dialog Box

Marking of "Constraints" page of the Dump Settings Dialog Box with a '*' to indicate active constraints, sometimes did not work correctly. This has been fixed.

Re-ordering of Surfaces Improved

Changing order of surfaces for passes in Excavation Settings, Steps and Staging and in Dump Settings Staging has been improved.

Drawing Points in OpenGL

Drawing of data points, terrain feature points and dump points has been improved in OpenGL.

Feature and Polygon Colours for DXF

Feature/Polygon colours are now read from DXF and written to DXF.

Changes in Toolbar Icons

Some changes have been made to the colours of a few toolbar icons.

Double-click on File Names Containing Blanks

Double-Click on a .3dd file name or directory containing blanks sometimes did not work to open that file. This has now been corrected.

ETI Import and Export

- (1) ETI file import and export now have the option of using Metric or US units.
- (2) ETI Export of the Terrain Surface has been set to "From Grid" as the default.

Sorting of Surfaces by Depth

Some problems with Sorting of Inner surfaces by depth under OpenGL have been corrected.

Outer From Inner Improvement

A problem recently found in calculation of Outer Polygons by angle has been corrected. Segments on the Inner Polygon were not split before calculating the Outer Polygon through "Outer from Inner". This could lead to inaccurate Outer Polygon shapes in cases where the terrain surface changes height rapidly in the areas where the Outer Polygon should fall.

Commas in Big Numbers

Commas have been inserted in display of big numbers in some material log tables and in single-step dragline reports. These ease interpretation of big numbers.

Generation of Multiple Block Line Groups

The block line generation window now stays opened after generation. In this way, users can create multiple block line groups in the one session.

Distance Along Section Features

Display of an optional distance scale has been added to section features. This is similar to the distances which may be displayed along roads. The setting for this is located in Terrain/Window Appearance dialog box, Features & Block Lines tab.

Single-Step Dragline Module

Bug Fixes

(a) In Single-Step Dragline Simulation using "General Dumping", the greyed out setting of Arc Area Dump is no longer confused with Area Dump.

(b) Some problems connected with re-starting a simulation and with Master Polygons have been corrected.

(c) A problem with Dragline Boom Dump in Single Step Dragline simulation has been corrected. The Boom Dump behaved incorrectly when IsAdvancingDumpOnLine is set in General Line Dump.

(d) When an excavation of dump polygon that is bound to a dragline is deleted, selecting the dragline sometimes leads to a crash. This has now been corrected.

(e) A spurious warning in Dragline Simulation Settings Single Step mode has been removed.

(f) When a Dragline with Inner Polygon is moved by Drag-and-Drop, a crash occurred if the surface to which the inner polygon is bound has been deleted. This has now been corrected.

(g) Draglines remain drawn in full detail after simulation under OpenGL

(h) Arc Area Dump selection of HW and LW features for Single-Step Dragline Simulation has been corrected for OpenGL.

Boom Dump for Single Step Simulation

All settings in Boom Dump have now been fully implemented for Single-step Dragline Simulation.

Show Productivity & Show Report Buttons

A Show Productivity button has been added to the Dragline Report window shown after Dragline Simulation. A corresponding Show Report button has been added to the Dragline Productivity window.

Import of Vulcan .rsp Files Supported

Vulcan .rsp files can now be read, along with associated ETI files. This will "automatically" create the surfaces and layers as specified in the .rsp file.

Set Next Template Active (Menus and Hot Keys)

New menu items "Set Next Template Active" have been created in the Excavate/fill and Dump menus. These set active the next Excavation Template and Dump Template respectively.

After each change, the new Active Template is temporarily shown in the status bar at the bottom of the screen.

Repeated application of each will cycle through the Excavation or Dump templates in order as they appear in the template lists in the Excavation Settings and Dump Settings dialog boxes. After reaching the last template in the list, the next template will be the first one in the list.

Hot Keys "1" and "2" (for Next Excavation and Next Dump respectively) have been implemented to allow quick access to this functionality.

This functionality is particularly useful to speed-up repeated operations in Single-Step Dragline Simulation. After each change of active template, the new active templates will be reflected in the Single-Step Dragline simulation settings and can be seen on the Single-Steppage of the Dragline Simulation dialog box.

Connect Excavate to Level and Common Vertex Height

A new check box has been added to the Excavation Settings dialog box to connect the "Excavate to Level" value (Constraints page) to the "Common Vertex Height" value (Excav. Polygons page).

This check box is called "Connect Comm.Vert.Ht" and is located on the Constraints page next to the "Excavate to Level" value.

Switching on this setting on the Constraints page will cause the "Common Vertex Ht" radio button to be selected (if it is not) and will cause the Common Vertex Ht and Excavate to Level values to always be equal. Changing one of these values will change the other.

The connection can be broken simply by turning off the "Connect Comm.Vert.Ht" check box.

Dozer Module

Auto-Generation of Dozer Regions

Auto-Generation of Dozer Regions has been developed. The generator is located on the bottom right of the Cut-Fill Region dialog page of Bulldozer Simulation Settings dialog box. Here are the settings for the Auto-Generation of Dozer Regions:

Outline Polygon

This is a larger polygon limiting the area you want to doze. All the regions are generated inside this polygon. So dozing takes place exactly in the area inside this polygon and perpendicular to the Dozer Push Direction Feature.

Dozer Push Direction Feature

It is important to know that *the dozer moves perpendicular to the Dozer Push Direction Feature*. This feature can be multi-point so it is not necessarily straight.

Set Push Arrow

Clicking the "Set Push Arrow" button tells the system which side of the Push Direction Feature the dozer is pushing towards. Once you have the regions, the system still needs to know whether the Direction of Push in each region is one way or the other, perpendicular to the Push Direction Feature. This Push Arrow lets you do this.

Generating Region Polygons

The Region Polygons are generated *perpendicular* to the Dozer Push Direction Feature, i.e. along the push direction. These polygons are created by "chopping up" the outline polygon. Think of two lines perpendicular to the Dozer Push Direction Feature. These lines are a Region Width apart. Project these lines up and down to cut the Outline Polygon. These two lines plus the chunks of the outline polygon between the two lines then make up a generated Dozer region.

All regions are generated with one press of the "Generate Regions" button.

Many dozer regions are generated at the same time, to fill up the outline polygon. Generated regions might overlap, depending on the shape of the push direction feature. Usually this is not a problem for the model.

Selection for Auto Generation of Dozer Regions

The region Outline Polygon and Dozer Push Direction Feature can be selected from existing features/polygons as well as drawn afresh.

Dozer Regions Can Be Selected or Drawn

The selection is from among polygons on the terrain surface. There is an option to delete the selected polygon after forming a Dozer Region using that polygon.

Dozer Cut Limit Polygon

This polygon limits the "cut" area in the Dozer Model to be within the polygon. Areas outside the polygon will then not be excavated during dozing simulation.

Use of this polygon in the Dozer Model is optional. The interface for creating the Cut Limit polygon is located in the Bulldozer Simulation Settings dialog box, on the Cut/Fill Regions page (near the top).

Schedules Module

A new Schedules Module has been added to 3d-DigPlus. This allows users to import Block Schedules in various formats. These schedules can then be used to feed material to dumps created and optimized in 3d-DigPlus. It is planned to include addition of other schedule formats, and import of schedules based on solids (rather than on blocks).

Dump Sources for Block Schedule Simulation

Dump Sources can now be created for Schedule Simulation. These are accessed through the menu "Simulate/Block Schedule/Settings..."

A Dump Source is presently defined by the following:

- Material Type
- Period range of excavation
- An optional polygon

During excavation of the schedule, each block can be assigned to a Dump Source using its Material, Period and whether the block is inside the plan-view polygon.

Users can define as many Dump Sources as they see appropriate. They can then assign a hierarchy of 3d-DigPlus dumps to each Dump Source. The schedule simulation then runs excavation and dumping simultaneously. As a Dump fills during simulation, it will automatically switch to a new dump in the dump hierarchy.

A flexible interface allows users, if necessary, to adjust the dumping throughout the life of the schedule.

Stages for Evo Schedules

A new Settings dialog box with Stages has been added to Dump Sources for Evo schedules.

Import of NPV Scheduler More Flexible

.csv schedules has been made more flexible, by the addition of parameters allowing for a flexible number of certain columns in the .csv files.

Automated Excavation and Dump Module

Supersequence Repeat Runs Problem Fixed

Running the same supersequence many times in Automated Excavation & Dump (such as after Undo, or after a Restore Point) led to errors in selecting the correct order of subsequences. This has now been fixed.

Dragline-Prestrip Integration Module

Ramps to Fit Low-Wall Height

Situations leading to "Steps" or "Ridges" around ramps in Dragline/Prestrip Integration have been corrected to give a smooth join between the Ramp and the rest of the low-wall. Such situations arise when there is not enough material to form the low-wall.

Shape of End-Walls

Shape of end-walls for generated strip lines has been adjusted to always consist of a single line. This line joins the ends of two successive strip lines. If strip lines are truncated by an outline polygon, then the end-wall line joins the intersections of successive strip lines with this outline polygon.

Other Improvements

Parallel ramps joining to end wall elevated ramps (improved)

Deleting elevated ramp also deletes connected parallel ramps

A bug in Dragline/Pre-strip Integration occurred, in which the terrain was not drawn (black screen) when selecting a Ramp Toe feature. This problem only occurred in OpenGL and has now been fixed

Truck-Shovel Simulation Module

Virtual Roads Error Corrected

An error in setting up distance along a virtual road, caused truck motion to sometimes go far beyond the target dump point. This has now been corrected.

Eco Module

(aka Reshaping and Transport Analysis Module)

Cut and Fill values shown in Transport Analysis

These now change depending the setting of the filter on transport arcs.

Reshaping Polygons

Only Displayed Polygons are now selected for Reshaping.

Calculation and Reporting of Ponding Volumes and Pump Time

A new system has been added for Ponding calculations in the Drainage section of the Ecology Module (Reshaping & Transport Analysis).

Users nominate sub-polygons to calculate water volumes. A pumping time for the water in each sub-polygon is also calculated. This is based on a user-input pump speed. A separate pump speed can be assigned for each sub-polygon. This is done before the sub-polygon is created, using the same field. The pump speed and pumping time are shown in the table in the dialog box. This table can be exported to Excel.

Very small amounts of water ("pot holes") can be filtered out and not show up in the ponding calculation and display. The filtering is done through a "Minimum Pond Size" setting (metres or feet).

A "Capture Ponding" button allows an image of the graphics window showing the ponding to be captured to a file. The settings for this image are found in Options/Capture Settings...

Automated Dragline Simulation Module

Some problems with drawing of simulation blocks have been corrected.

New Items in 3d-DigPlus Version 3.5

This Version of 3d-DigPlus contains important upgrades, additions and bug fixes in each of the 3d-DigPlus Modules. Notable are the 64-bit memory access, improvements to OpenGL graphics mode and the addition of Hot Keys.

The description below lists only major upgrades and new items. It applies to changes from Version 3.4 of 3d-DigPlus. Some additional bug fixes can be found in the file "readme.txt" in the 3d-DigPlus install folder. The list of new items in Version 3.4 is repeated below this Version 3.5 list.

Generic (Base) Program

64-bits Build With Visual Studio 2017

This version of 3d-DigPlus uses a 64-bit memory model. It is build with Microsoft Visual Studio 2017. This allows access to the full memory of the computer. Much bigger models can now be built and simulated in 3d-DigPlus.

Improvements in OpenGL Graphics

The OpenGL graphics engine greatly increases redrawing speed in 3D graphics operations. This version of 3d-DigPlus contains many improvement to the OpenGL graphics released earlier.

OpenGL Graphics is turned on through the "Use OpenGL for 3D Graphics" check box found from the Options/Settings menu. OpenGL graphics will work for most 3d-DigPlus editing and simulation. Improvements in Version 3.5 include:

- The "Use OpenGL for 3D Graphics" setting now stays ON between 3d-DigPlus sessions.
- Improved selection and editing of Polygons and Features in OpenGL.
- Improved positioning of labels in the Mine Grid and other labels drawn by OpenGL.
- Re-appearance of dialog windows and/or the mouse symbol after graphics actions in Current Plane, various direction settings, block lines creation and others, has been corrected.
- Contours on Rendering Mine Grid and Compass are drawn so that they will not be partly "rubbed out" by the terrain.

There are too many other fixes and improvements to list them all here.

"Navigate by Mouse" Mode Improved

Operation of the "Rotate/Pan and Zoom by Mouse" has been improved to be more reliable.

- This mode is accessed through the "White Mouse" toolbar icon, left-most of the navigation icons.
- Moving the mouse with the left button pressed will then either rotate or pan the terrain.
- Rotate or Pan is selected depending on the setting of the "Toggle Rotate/Pan" icon.
- Pressing the "Ctrl" key while moving the mouse in this way, switches "Rotate" to "Pan" and vice-versa.

2D Cross-Section Export to DXF

An export facility to export 2D cross-sections to DXF has been added. This is accessed through the menu item File/Export, then select the item "Section 2D-Features (*.DXF)".

This exports a cross-section as a DXF feature with X and Y containing the cross-section values of “Distance along Section” and “Terrain Height”.

“Hot Keys” Added

Hot Keys have been added to this version of 3d-DigPlus.

- The list of Hot Keys is shown below.
- Hot Keys can be viewed in 3d-DigPlus by pressing the F2 key.
- A start-up message about Hot Keys has been added.
- The start-up message can be turned OFF permanently by clicking an appropriate check box in the message.

The hot keys list is tabled below:

Hot Keys List

Hot Key	Action
F2	Show list of Hot Keys
A	Terrain Windows Appearance
Ctrl-A	Cross Section Appearance
C	New Cross Section
D	Dump Settings
E	Excavation Settings
L	Logged Material
P	Restore Points
Q	Create Supersequence
R	Refresh
Ctrl-R	Create Road
S	Save

Ctrl-S	Simulation Settings
T	Terrain Editor Settings

“More Feature Types” Improved

The "More Feature Types" functionality has been improved to remove situations where all feature types would be selected for display.

Show More Surfaces and Features/Polygons on Dump Constraints Page

More constraint surfaces, features and polygons can now be seen and edited on the constraints page of the Dump Settings dialog box. This opens a separate window through "More" buttons located in Dump Settings, Constraints Page, near the Dump To Surface Check Box, near the Dump To Features Check Box, and near the Dump To Polygons Check Box.

Mark Dump Constraints Page for Active Constraints

If any of the dump constraints are ticked on for the chosen active dump template, a “*” is added to the end of the title of the “Constraints” tab. This lets the user know that this dump template has active constraints. If all constraints are ticked off then the symbol will turn off.

Current Dump Layer Interface Simplified

The interface for adding a coloured Dump Layer to 3d-DigPlus Layers during formation of a Dump has been simplified. This new interface is found in the Dump Settings dialog box, on the Layer Material page. The new dump layer is always added to the Current Dump Layer

Other Improvements

1. Reorder Surfaces

The "Prime Surface" is now always second in the list of surfaces. Previously "Reorder Surfaces" allowed this surface to change position, which led to problems in "Construct Inner Surface".functionality.

2. Construct Inner Surface

Some problems in the Terrain/Surfaces/Construct Inner Surface functionality have been removed.

3. Surface Area

Very slow calculation of the Surface Area Utility under some circumstances has been corrected. This happened when a very large triangulation was present in the surface.

Actual Surface Area in US units is now correctly displayed as sq yds, previously it was sq m.

4. Blast Wizard

Any direction of drawing the cross-section in the Blast Wizard will now work correctly.

5. ETI Import and Export Units

ETI files can now be imported and exported in either metric or US units. A setting on the import and export dialog boxes controls this. ETI files themselves do not contain any information about their units.

6. Contours on Rendering Set Heights

A "Set Heights" button has been added to the Contours on Rendering settings.

7. Feature Split

Feature Split caused a "stuck" cursor when clicking on the end of the feature to be split. This has been corrected.

Automated Dragline Simulation Module

Switch Between Continuous and Step-by-Step Modes, Esc Key Reaction Improved

This Build of 3d-DigPlus has improved the way Auto Dragline Simulation changes between CONTINUOUS and STEP-BY-STEP Modes. The reaction to a key press now works more reliably. The reaction to Esc to exit the simulation has also been made more reliable. A single key press is enough to exit. The simulation will stop on the next excavation, after the current dumping has completed.

Re-Created Area Dumps Marked as Empty after Each Step

Arc Area Dumps are now marked as "empty" when re-created after re-positioning of the dragline after each step. This means that arc area dumps that fill during a step are not permanently turned off after that step is completed.

Clip Dump to Surf Bndry Flag to Not Influence Bench Surface Constraints

The "Clip Dump to Surf. Bndry" flag on the Constraints page of Dump Settings should not influence bench surface constraints in Bench Dumps and Arc Area Dumps. Previously, if this flag was ON, it would apply the constraint to Bench Surfaces even if the "Dump to Surface" flag was turned OFF. This is because bench dump surfaces turn on this "Dump to Surface" flag in the code. This extra application of the "Clip Dump to Surf. Bndry" flag to bench surface constraints is clearly wrong and has been removed from the code.

Highly Curved HW and LW Toes Handled

Dragline simulation blocks are now generated correctly for highly curved HW and LW toes. Previously such HW and LW toes were a problem for the simulation. This has now been fixed and the simulation works correctly even for highly curved toes.

Reshaping and Transport Analysis Module

Drainage and Ponding Calculations

To calculate Drainage and Ponding for a (reshaped) surface:

1. The Drainage Calculation is accessed in the Reshaping/Drainage Surface menu item.
2. Use the full terrain, or Select or Draw a polygon within which the Drainage calculation is to be done.
3. Press the "Calc. Drainage" button to carry out the drainage calculation.
4. Press the "Show Ponding" button to view areas in which ponding will occur.
5. Press the "Show Catchment Areas" button to view areas which receive more or less drainage water from other areas.

Dozer Module

Version 3.5(Beta) has four upgrades to the Dozer Model. These are:

(i) Dozer Regions Included or Excluded from Simulation

We have added a check-box for each region on the "Cut-Fill Regions" page of the Bulldozer Simulation Settings dialog box. These check boxes are in a group "Include in Simulation". Each region's check box selects that region for simulation. If the check box for a region is not selected, that region will not take part in the simulation. The "Delete Region" button present in earlier versions has been removed.

(ii) Offsets Added to Topo and Limit Surfaces

An offset has been added to the Final Dozer Topography and to each of the limit surfaces. This addition has been made on the Cut-Fill Regions Page.

(iii) Repose Angle Setting For Each Region

A separate Repose Angle setting for each region has been added to the "Dump Param" page of the Bulldozer Simulation Settings dialog box. A "Set All" button allows the same repose angle to be set for all regions.

(iv) An Optional "Preferred Max. Push Distance" for Each Region

A "Preferred Max. Push Distance" has been added to the "Cut-Fill Regions" page for each region. By default this distance is set large, so it will have no effect on the model. If users set it smaller, this will begin to affect the model results. The simulation will preferentially select push distances which are smaller than this distance.

New Items in 3d-DigPlus Version 3.4

This Version of 3d-DigPlus contains important upgrades, additions and bug fixes in each of the 3d-DigPlus Modules.

The description below lists only major upgrades and new items. It applies to changes from Version 3.3 of 3d-DigPlus. Bug fixes can be found in the file "readme.txt" in the 3d-DigPlus install folder. The list of new items in Version 3.3 is repeated below this list.

Generic (Base) Program

New Option Terrain/Features/Rarefy

This functionality has one parameter named "Deviation". This parameter controls the degree of rarefaction of a feature. It sets how far the middle point of three points can deviate in x,y distance from a line drawn through the two "outer" points.

So if the points in order are P1, P2 and P3, a line is drawn through P1 and P3 and the 2D distance of P2 from this line is calculated. If this distance is greater than the "Deviation" parameter, the point P2 is kept, if less then P2 is discarded.

This test is applied to all points in the feature in order to rarefy the feature. Duplicate points are discarded separately as part of the rarefaction.

Rarefaction also applies to groups of selected features. In that case, each feature is rarefied separately.

Current Plane Used Directly for Excavation

The Current Plane can now be used for binding inner polygons and excavating, without having to save it separately to an inner surface. Previously trying to use the Current Plane directly for Excavation resulted in a crash.

"More Feature Types" Enhanced to Show in Different Windows

The "More Feature Types" functionality has been enhanced to allow Feature Types to be shown in some terrain graphics windows and hidden in other windows. This gives greater flexibility in use of these Feature Types.

Feature Items Added to Right-Button Popup Menus

Menu items Terrain/Features: Break, Copy Parallel, Copy Parallel Whole, Project Parallel, Project Parallel Whole have been added to right-button popup menus on individual Surface Features and Data Features.

Window Sub-Title Added to Terrain Windows

A new Window Sub-Title has been added to the General Page of the Window Appearance Dialog box. This adds a text to the title of each Terrain Window, after the "Terrain View #".

Improved Interface for Contours on Rendering

An improved interface for changing settings of Contours shown on Rendering has been added to the Render Page of the Terrain Appearance dialog box.

Automated Excavation & Dump Module

Lifts Generated in Single Pass Situation

In auto-generation of Subsequences, lifts can now be generated for the situation where there is only one Pass. Previously, this was impossible.

Single-Step Dragline Simulation Module

“Boom Dump” Added to Single-Step Dragline Simulation

The Boom Dump has been added to Single-Step Dragline Simulation. Previously the Boom Dump was available only in Automated Dragline Simulation. All of the Boom Dump functionality is not yet implemented in this Version.

To access the Boom Dump in Single-Step Dragline Simulation:

(a) Bind the Dump Template to be used for the Boom Dump to the dragline on the Single Step page of the Dragline Simulation Settings dialog box. For this, select the "Bind to Dragline" check box.

(b) Select the Highwall and Lowwall toes on the Single Step page of the Dragline Simulation Settings dialog box.

(c) On the Dump Type page of the Dump Settings dialog box, choose the "Dragline or Other Dump" as the setting for the Dump Option.

(d) Then on the Dump Type page of the Dump Settings dialog box, choose "Dragline Boom" as the Dragline or Other Geometry setting.

(e) On the Boom Dump page of the Dump Settings dialog box, choose the settings for the Boom Dump.

Note the "Show Help" button on the Boom Dump page, which explains many of these settings.

The Boom Dump will behave very similarly to a General Line Dump. Its Dump Template should be bound to the dragline and the Boom Dump will then move with the dragline when the dragline is moved using "drag and drop". As the dragline is moved using "drag and drop", the Boom Dump is recalculated using the Highwall and Lowwall toes.

“Arc Area Dump” Added to Single-Step Dragline Simulation

This version 3d-DigPlus adds the Arc Area Dump to Single-Step Dragline Simulation. Previously the Arc Area Dump was available only in Automated Dragline Simulation.

To access the Arc Area Dump in Single-Step Dragline Simulation:

(a) Bind the Dump Template to be used for the Arc Area Dump to the dragline on the Single Step page of the Dragline Simulation Settings dialog box. For this, select the "Bind to Dragline" check box.

(b) Select the Highwall and Lowwall toes on the Single Step page of the Dragline Simulation Settings dialog box.

(c) On the Dump Type page of the Dump Settings dialog box, choose the "Dragline or Other Dump" as the setting for the Dump Option.

(d) Then on the Dump Type page of the Dump Settings dialog box, choose "Dragline Arc Area" as the Dragline or Other Geometry setting.

(e) On the Arc Area Dump page of the Dump Settings dialog box, choose the settings for the Arc Area Dump. Note the "Show Help" button on the Arc Area Dump page, which explains many of these settings.

The Arc Area Dump will behave very similarly to a General Area Dump. Its Dump Template should be bound to the dragline and the Boom Dump will then move with the dragline when the dragline is moved using "drag and drop". As the dragline is moved using "drag and drop", the Arc Area Dump is recalculated using the Highwall and Lowwall toes.

Binding of Multiple Excavation and Dump Templates to a Dragline

This version 3d-DigPlus allows binding of multiple Excavation Templates and Dump Templates to the dragline in Single-Step simulation mode. The excavation polygons, dump lines and dump areas used these Templates move with the dragline. Binding and un-binding is done in the Dragline Simulation Settings Dialog Box, on the Single Step page.

Automated Dragline Simulation Module

"Update Raw Sequence" Functionality Added

This Build of 3d-DigPlus completes a first version of the "Update Raw Sequence" functionality. This is accessed on the "Staging" page of the Excavation Settings Dialog box. It is only available in Automated Dragline simulation. The idea is to add elements to the Raw sequence without affecting a first Raw Sequence and Sub-Passes.

New Items in 3d-DigPlus Version 3.3

This Version of 3d-DigPlus contains important upgrades, additions and bug fixes in each of the 3d-DigPlus Modules.

The description below lists only major upgrades and new items. It applies to changes from Version 3.2 of 3d-DigPlus. Bug fixes can be found in the file "readme.txt" in the 3d-DigPlus install folder. The list of new items in Version 3.2 is repeated below this list.

Generic (Base) Program

Extended Feature Types Added

Any number of "More Feature Types" can now be added to Surface Features through the More Feature Types dialog box. This dialog box is accessed through the "More Feature Types" button on the Features & Block Lines page of the dialog box opened through "Terrain/Window Appearance" menu item.

At present these additional Feature Types will appear in all Terrain Windows. Future versions will allow Feature Types to be shown in some selected Terrain Windows and not shown in others.

Surface Traces Appear on All Surfaces

Surface Traces will now appear on all surfaces. When a surface (accessed through Terrain/Surfaces/Edit) has the "Show Trace on all Surfaces" flag turned ON, its trace will appear on all surfaces where the surface has a trace.

Feature Operations Have a "Whole" Option

Feature functionality accessed through "Terrain/Features" now has a "Whole" option for each operation. These operations are "Copy Parallel Whole", "Project Parallel Whole", "Drape Whole" and "Project Whole". These "Whole" options apply to the full feature. In this case users do not have to select the portion of the feature to be processed, they only need to nominate the feature.

New Surface Area Utility

A new utility "Surface Area" has been developed. This is located under "Utilities/Surface Area".

Users select an existing polygon and the "Plan View" and "Actual" Surface Areas are reported to a dialog box.

More Surfaces Visible on Constraints Pages

Buttons have been added to the Constraints Pages of Excavation Settings and Dump Settings Dialog Boxes. These open another dialog box to show a longer list of inner surfaces which may be selected as constraints. This saves extra scrolling, when there are a lot of inner surfaces.

Adjustable Block Line Label Positions

Block Line label positions can now be adjusted. In "Terrain/Window Appearance..." on the "Features&Block Lines" page, users can set a "Label Position Along Block Line" as a % of block line length. Trial-and-error can be used to find the optimum setting so the Block Line labels do not obscure other important information.

Show Block Lines Only for Active Pit

Display of Block Lines can be set to show only the Block Lines of the Pit set in the active Excavation Template. This setting is the check box called "Active" located on the Features&Block Lines page of the Terrain Window Appearance dialog box in the Block Lines group.

The Active Pit is set in the Excavation Settings dialog box, Constraints Page, "Pit Name" field.

Dump Limit Features and Polygons Customized

Dump Limit Features and Polygons can be customized for name, colour and thickness. These properties can be changed through Right-Click and choosing "Customize" from the pop-up menu. Feature and polygon names can now be of any length.

Contour Setting for Contours on Rendered Views

Contours shown on Rendering can now be changed. Contours on Rendering are set through a "Show Contours" check box on the "Rendering" tab of the Terrain Window Appearance dialog box.

The Contour settings are taken from the Contours section on the Frame tab of the Terrain Window Appearance dialog box. Settings are taken from Mono Color Contours.

A two-step operation is needed to change the contour settings on Rendered View:

1. Change from Rendering to Frame/Contours, Mono Color in the Terrain Window Appearance dialog box. Then set the contour parameters and press "Apply".
2. Change back to Rendering on the General Page of the Terrain Window Appearance dialog box and press "Apply".

The new contour settings will then appear on the rendered view.

Dip Angles Displayed in Degrees, %grade or Ratio

Angles of dip on cross sections and on the bottom line when moving the terrain cursor, can now be displayed as "Degrees", "%grade" or "Ratio". The units to display dip angles are set in the Settings dialog box, accessed through the "Options/Settings" menu item.

Meaning of the units are shown on the status bar when standing on one of these items.
%grade is $100 \times \text{Vert}/\text{Horiz}$ displacement, while Ratio is Horiz/Vert .

Delta-Coordinates Shown on Status Bar

Delta-coordinates (change in E, N and Z from last fixed cursor position) are shown in the status bar when moving the terrain cursor over the terrain.

Reversing Terrain Sections

Terrain Sections can be reversed i.e. shown in the reverse sense in cross-section windows. This is done through a new “Reverse” option on the popup menu that appears after right click on the section.

Network “Floating” Licenses

A Network License option is available with 3d-DigPlus Version 3.3. This allows 3d-Dig*Plus* Base and Modules to be used by computers on a Local Area Network. For details please contact 3d-Dig*Plus* distributors.

Single-Step Dragline Module

Bind Excavation Polygons to Dragline

This Build of 3d-DigPlus allows binding of an excavation polygon to the dragline in Single-Step dragline mode. This is done through a "Bind to Dragline" check box on the Single Step page of the Dragline Simulation settings dialog box.

When the dragline is moved through "drag and drop", the bound excavation polygon moves with the dragline.

When the Active Excavation Template is changed, either through the Single Step page or through the “Set Active” option after right-click on an excavation Polygon, the excavation polygon of the new active template is then bound to the dragline.

Binding of multiple excavation polygons will appear in upcoming Versions of 3d-Dig*Plus*.

Dump Limit Polygons Added, Dump Limit Features Customized

Dump Limit Polygons are drawn on the terrain surface using a new icon in the Dump group on the Toolbar and a new item in the Dump menus (Dump, Create Limit Polygons).

Dump Limit Polygons form a separate list on the Constraints page of the Dump Settings Dialog Box, next to the Dump Limit Features list. As for Dump Limit Features, the Dump Limit Polygons applied in the given Dump Template are selected through check boxes.

Dump Limit Features and Polygons can be customized through a right click on the feature/polygon. The customization allows change of name, colour and thickness. The names of features and polygons appear in the interface of Dump Limit Features/Polygons. Feature and polygon names can be of any length.

Application of Dump Limit Polygons behaves as follows:

(a) As for Dump Limit Features, when material dumped on a point outside a Dump Limit Polygon begins to cross the Dump Limit Polygon, this leads to the dumping on that point stopping and moving on to other dump points.

(b) No dumping can occur within a Dump Limit Polygon. So any points within a Dump Limit Polygon cannot have material dumped on them

Automated Dragline Simulation Module

Simulation Map

A Simulation Map display is now available. This is accessed through the menu item "Simulate/Simulation Map". It shows the current (or default) Dragline Simulation and its supersequence. Other Supersequences are shown after this.

Dumps assigned to Subsequences in Automated Excavation & Dump Simulations and in Truck/Shovel Simulations are also shown.

Step-by-Step Simulation Mode

A new step-by-step mode has been added to the Automated Dragline Simulation. This mode is always available. It can be turned ON and OFF through the keyboard.

Start of Simulation

By default Automated Dragline Simulation starts in CONTINUOUS mode.

The simulation can be started in STEP-BY-STEP mode by checking the "Start in Step-by-Step Mode" flag on the Automation Results page of Dragline Simulation Settings dialog box.

CONTINUOUS Mode

In CONTINUOUS mode:

- (i) The simulation can be switched to STEP-BY-STEP mode by holding down the BACKSPACE key.
- (ii) To EXIT the simulation, **hold** the Esc key.

(holding is important as the program only checks for a key press at the start of each step).

STEP-BY-STEP Mode

In STEP-BY-STEP mode:

- (i) The next step is executed by pressing the Enter key.
- (ii) To switch to CONTINUOUS mode press the Spacebar.
- (iii) To exit the simulation, press the Esc key.

Arc Area Dump

A new dump type "Arc Area Dump" has been added to the Automatic Dragline Simulation.

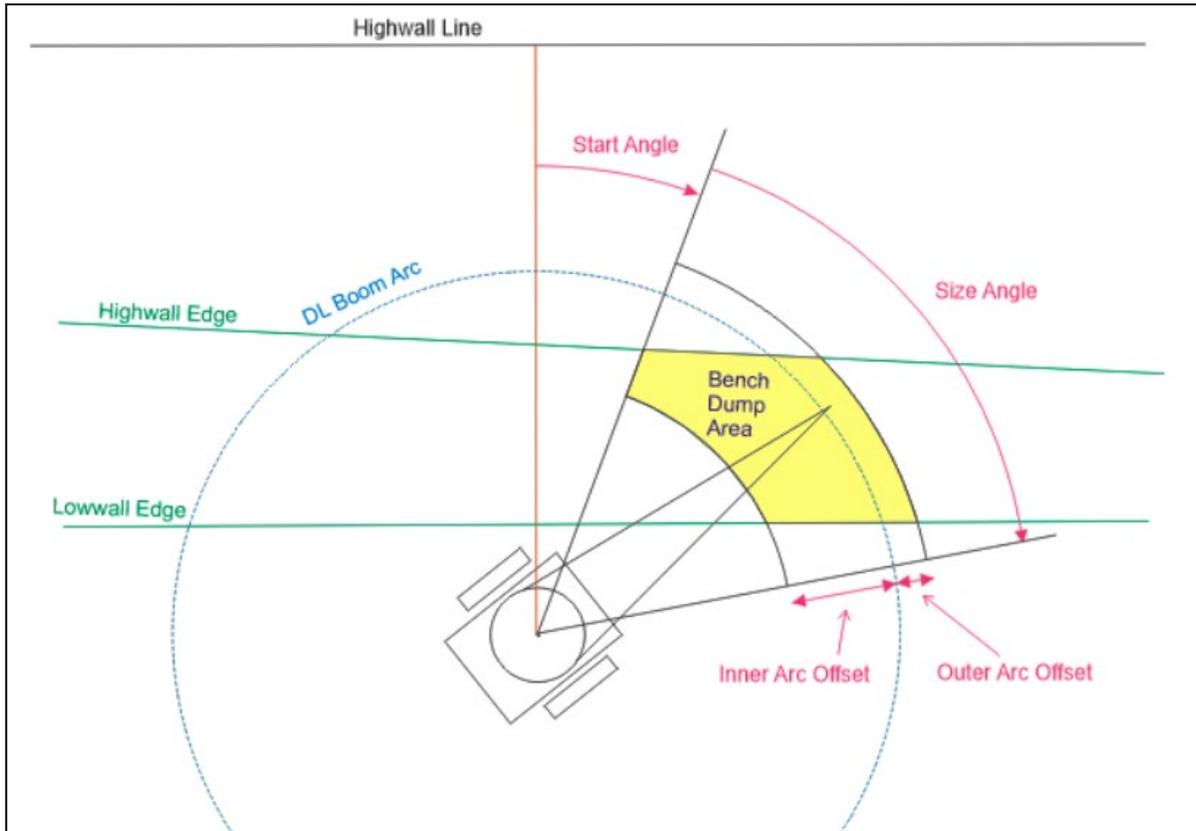
This new dump type is set as another type of Dragline Dump on the Dump Settings Dialog Box, Dump Type page.

The Arc Area Dump has a geometry similar to the Boom Dump. For this reason, the **Start Angle, Size Angle,** and Reference **Swing Direction** (Clockwise or Anticlockwise) parameters are the same as in the Boom Dump.

The Arc Area Dump is applied to a segment slice between two circles. The position of the two circles relative to the Dragline Boom Arc is defined by two parameters: the **Inner Arc Offset** and the **Outer Arc Offset**. In addition, the Arc Area Dump is optionally clipped by two Bench Edge Features: the **Highwall Edge** and the **Lowwall Edge**. A **Bench Fill Direction** defines whether the Arc Area Dump is filled Clockwise, Anticlockwise,

from Outer Arc to Inner Arc or Inner Arc to Outer Arc. The Arc Area Dump shape and parameters are shown in the diagram below.

The Inner Arc Offset and Outer Arc Offset are both measured from the Dragline Dump Arc with positive towards the dragline. So a negative offset places the arc outside the Dragline Dump Arc.



Multiple Draglines

Automated Dragline Simulation works with different draglines assigned to different subpasses.

Extended Feature Types Added

Extended Feature Types are available in the Base Program. As they are very useful for Automated Dragline Simulation, they are also described here.

Any number of “More Feature Types” can now be added to Surface Features through the More Feature Types dialog box. This dialog box is accessed through the “More Feature Types” button on the Features & Block Lines page of the dialog box opened through “Terrain/Window Appearance” menu item.

At present these additional Feature Types will appear in all Terrain Windows. Future versions will allow Feature Types to be shown in some selected Terrain Windows and not shown in others.

Dump Limit Polygons Added, Dump Limit Features Customized

Dump Limit Polygons are drawn on the terrain surface using a new icon in the Dump group on the Toolbar and a new item in the Dump menus (Dump, Create Limit Polygons).

Dump Limit Polygons form a separate list on the Constraints page of the Dump Settings Dialog Box, next to the Dump Limit Features list. As for Dump Limit Features, the Dump Limit Polygons applied in the given Dump Template are selected through check boxes.

Dump Limit Features and Polygons can be customized through a right click on the feature/polygon. The customization allows change of name, colour and thickness. The names of features and polygons appear in the interface of Dump Limit Features/Polygons. Feature and polygon names can be of any length.

Application of Dump Limit Polygons behaves as follows:

(a) As for Dump Limit Features, when material dumped on a point outside a Dump Limit Polygon begins to cross the Dump Limit Polygon, this leads to the dumping on that point stopping and moving on to other dump points.

(b) No dumping can occur within a Dump Limit Polygon. So any points within a Dump Limit Polygon cannot have material dumped on them

Automated Excavation and Dumping Module

Simulation Map

A Simulation Map display is now available. This is accessed through the menu item "Simulate/Simulation Map". It shows the current (or default) Dragline Simulation and its supersequence. Other Supersequences are shown after this.

Dumps assigned to Subsequences in Automated Excavation & Dump Simulations and in Truck/Shovel Simulations are also shown.

Truck/Shovel Simulation and Optimization Module

Simulation Map

A Simulation Map display is now available. This is accessed through the menu item "Simulate/Simulation Map". It shows the current (or default) Dragline Simulation and its supersequence. Other Supersequences are shown after this.

Dumps assigned to Subsequences in Automated Excavation & Dump Simulations and in Truck/Shovel Simulations are also shown.

Reshaping and Transport Analysis Module

New Surface Area Utility

A new utility "Surface Area" has been developed. This is located under "Utilities/Surface Area".

Users select an existing polygon and the "Plan View" and "Actual" Surface Areas are reported to a dialog box.

Angles of Slopes Displayed in Degrees, %grade or Ratio

Angles of slopes in the Reshaping Module can now be set and displayed as “Degrees”, “%grade” or “Ratio”. The units %grade are $100 \times \text{Vert}/\text{Horiz}$ displacement, while Ratio is Horiz/Vert .

The slope units are set in the Slope Units in the Reshape Surface dialog box.

Contour Setting for Contours on Rendered Views

Contours shown on Rendering can now be changed. Contours on Rendering are set through a “Show Contours” check box on the “Rendering” tab of the Terrain Window Appearance dialog box.

The Contour settings are taken from the Contours section on the Frame tab of the Terrain Window Appearance dialog box. Settings are taken from Mono Color Contours.

A two-step operation is needed to change the contour settings on Rendered View:

1. Change from Rendering to Frame/Contours, Mono Color in the Terrain Window Appearance dialog box. Then set the contour parameters and press “Apply”.
2. Change back to Rendering on the General Page of the Terrain Window Appearance dialog box and press “Apply”.

The new contour settings will then appear on the rendered view.

Dragline/Prestrip Integration Module

Protection Against Ramps Conflict

A protection for conflict between perp. and par. end wall ramps has been added to Dragline/Prestrip Integration.

New Items in 3d-DigPlus Version 3.2

This Version of 3d-DigPlus contains the first release version of the Automated Dragline module.

This version also contains the following new items, in each of the 3d-DigPlus Modules. The description mostly applies to changes from Version 3.1 of 3d-DigPlus.

The list of new items in Version 3.1 is repeated below this list.

Generic (Base) Program

Superimpose Contours on Rendered View

An option to superimpose mono-coloured contours on a rendered view of the terrain is now available. This is through a “Show Contours” check box on the “Rendering” tab of the Terrain Window Appearance dialog box.

Contour settings are taken from the Contours section in the Frame tab of the Terrain Window Appearance dialog box.

Options to “Move Observer” or “Move World” for Rotate/Pan

A new setting has been added to give users a choice of moving the observer or moving the world when rotating and panning in Terrain Windows.

This setting is located in the “Settings” dialog box accessed under the menu item “Options/Settings”. This is the group “Rotate/Pan Options” and offers the options “Move Observer” and “Move World”.

Offset on Limit Surfaces in Excavation Templates

Offsets have been added to limit surfaces in Excavation Template constraints. This is on the Excavation Settings dialog box (Excavate/Fill, Excavation Templates menu item), on the Constraints tab, table when “Limit by Surface” check box is turned ON. I

Similar offsets have been added to limit surface on the Steps tab in the same Excavation Template. This is for the Automated Dragline simulation. If the same surface appears in both lists, the more stringent constraining (higher offset or less negative offset) will be used.

Eight More Feature Types

Eight more Feature Types have been added to Terrain Surface Features. These feature types are edited through the

"More Feature Types" button in the Window Appearance dialog box, Features&BlockLines tab.

New feature types can be named, coloured and their drawing turned ON and OFF. Unlike the existing “Crest”, “Toe” and “Other” feature types, settings for New Feature Types are not window-specific i.e. they are drawn the same way in all windows.

A "Hide All" check box on the "More Feature Types" dialog box lets users turn off display of ALL the new feature types features quickly, and then turn them all on again with the same settings. That helps to get a video capture in one window without permanently losing features display settings.

New Features are drawn according to the Current Feature Type setting on the resulting dialog box. Feature types may also be customized.

Dump Limit Polygons Added, Dump Limit Features Customized

Dump Limit Polygons are drawn on the terrain surface using a new icon in the Dump group on the Toolbar and a new item in the Dump menus (Dump, Create Limit Polygons).

Dump Limit Polygons form a separate list on the Constraints page of the Dump Settings Dialog Box, next to the Dump Limit Features list. As for Dump Limit Features, the Dump Limit Polygons applied in the given Dump Template are selected through check boxes.

Dump Limit Features and Polygons can be customized through a right click on the feature/polygon. The customization allows change of name, colour and thickness. The names of features and polygons appear in the interface of Dump Limit Features/Polygons.

Application of Dump Limit Polygons behaves as follows:

(a) As for Dump Limit Features, when material dumped on a point outside a Dump Limit Polygon begins to cross the Dump Limit Polygon, this leads to the dumping on that point stopping and moving on to other dump points.

(b) No dumping can occur within a Dump Limit Polygon. So any points within a Dump Limit Polygon cannot have material dumped on them

Option to Set Current Plane From Three Points

The Current Plan interface and functionality have been improved. An additional way of forming a Current Plane has been added by choosing 3 terrain points and putting the plane through these points. The X-Y coordinates of these points can be chosen graphically or changed manually. Their elevations can also be changed manually, or set from a surface chosen in the interface.

Construct Inner Surface

Construct Inner Surface (Terrain/Surfaces/Construct Inner Surface...) will optionally over-write the data for an existing surface with the new constructed surface.

Improve Dump Height Limit for Line Dumps

The way the dump height limit is handled for line dumps has been improved. Now when the dump height limit is reached, the last-dumped parcel of material is removed from the terrain and the discrete dump volume is reduced by a factor of 10. Dumping on that same point is then repeated until the dump height limit is again reached. The last-dumped parcel of material is again removed from the terrain and dumping on that point ceases.

This produces a dump which is slightly below the dump height limit. It also gets rid of the "flat top" effect seen with the previous method which "shaved" the terrain to be exactly at the dump height limit.

Roads Undo Fixed, Sharp Bends Improved

This Build also fixes some problems in Undo of Roads Excavation. This Undo should now work correctly. Also messages about overlapping polygons will occur less frequently for sharp bends in roads.

Named Views

This version of 3d-DigPlus fixes a problem with saving Named View to a *.NMV file. View names longer than 15 characters were not saved correctly to file. This has now been corrected.

Material Properties Order

Order of material properties in all places where logs are shown is now consistently shown as "Bank SG, Swelled SG, Swell Factor". Recalculation of these three connected values is now correct when any one of them is changed.

Pass Type Message

A message is shown when Pass Type properties are changed from the Excavate Pass Parameters dialog box (Staging Page of Excavation Template, press Set Pass Parameters and then press Edit/Set Pass Types on the resulting dialog box). The message warns that properties of existing logs (maybe derived from pass types) will not be changed by this operation.

ETI Format Supported in Vulcan 10, Nominate Terrain on Import

The ETI interface allows writing and reading of files with extension *.ETI. Export and Import of ETI files is accessed through the menu items File|Export and File|Import.

Input and output of the ETI format is now supported in Maptek Vulcan 10.

Now any surface imported into 3d-DigPlus through ETI to be nominated as the Terrain Surface. Many surfaces can be imported at once, and one of them is nominated in the interface as the terrain surface.

Currently this library provides a fast way of exporting multiple surfaces from 3d-DigPlus. Since 3d-DigPlus also imports files of this type, this can be used to rapidly move surfaces between design files.

We will add other objects to the ETI Library as the need arises.

Copies of the ETI Library code for use in interfacing with 3d-DigPlus may be obtained from Earth Technology on request.

Dragline Module (Including Released Automated Dragline Simulation)

Most of the effort in the Dragline Module has concentrated on the just-released new Automated Dragline Simulation Module. This module has now been released in 3d-DigPlus Version 3.2.

New Utilities/Dragline Items

These items calculate the Primary Pit Shell, Pass Shell, and Highwall Toes and Lowwall Toes for upper passes. Input includes the Highwall Toe and Lowwall toe for the deepest pass.

Dragline/Generate Primary Pit Shell.

This functionality has almost the same interface as the Dragline Prestrip module. However the settings are applied only to a single strip. The outputs of this function are: Primary Pit Shell with low wall profile, Highwall Toe, Low Wall Toe.

Dragline/Generate Pass Shell.

This functionality generates a Pass Shell including spoil profile. It also produces a Highwall Toe and a Lowwall Toe as Surface Features with appropriate names.

Dragline/Generate Highwall Toe.

This functionality creates a Highwall toe line as a Surface Feature on the Terrain. This highwall toe is generated as the intersection line between the Pass Surface and the highwall of the Primary Pit Shell.

Dragline/Generate Low wall Toe.

This functionality creates a low wall toe line as the intersection between the non-ramp spoil profile for the Primary Pit Shell and the Pass Surface.

Automated Excavation and Dumping Module

Re-Ordering of Supersequences

This Version of 3d-DigPlus has a new option for re-ordering of supersequences. This is done through the new menu item "Sequence/Reorder Supersequences..."

Raw Sequence Generation to Include All Blocks

This Version of 3d-DigPlus changes the generation of Raw Sequences to include all blocks inside the outline polygon. Previous versions of the Raw Sequence generator would leave out blocks for which no material was excavated.

With this change, even blocks which excavate no material during generation of the Raw Sequence are still included in the Raw Sequence. These blocks are then included in subsequences defined from the generated Raw Sequence.

Truck/Shovel Module

Dump Heirarchies to Use “% of Log To Dump”

Dump heirarchies used in Truck/Shovel simulation have dumped material until each dump is filled, before moving on to the next dump in the dump heirarchy. The dump parameter “% of Log to Dump” (on the Dump Parameters tab) has been ignored in this dumping process.

This change will use this “% of Log to Dump” parameter in dumping to each dump in the heirarchy. So dumping in each dump will stop and move on to the next dump in the heirarchy, when the given percentage of the log has been dumped.

For example, suppose there are three dumps and the “% of Log to Dump” parameter is 50%, 50% and 100% for the three dumps. If there are 1000 cub m in the log, 500 cub m will be dumped in the first dump, 250 cub m in the second and the remainder in the log (250 cub m) will be dumped in the third dump.

Units Errors on Report Files Corrected

Some errors with units in Truck/Shovel Report Files have been corrected.

Dozer Module

Only Regions Completely Within Final Surface Modelled

Dozer simulation will now not model dozer regions in which the complete region is not within the final surface.

Problem With Older Files Fixed

This version of 3d-DigPlus fixes a problem with Dozer Simulation which led to no action on some older files. This has now been corrected.

Reshaping and Transport Analysis Module

Sub-Region Polygon Kept and Information From Sub-Region Exported

This upgrade keeps the Sub-Region polygon persisting and will export information from the sub-region or from the whole TA region,

Centroids Calculated for Transport Analysis

Centroids of the transported material are calculated and reported for Transport Analysis.

Dragline/Prestrip Integration Module

Colour of Strip Line Numbers

The colour of strip line numbers in Dragline/Prestrip Integration is set to Black if a White background is chosen for the Graphics Window in which strip lines are drawn (strip lines are always white, and the colour of the strip line numbers is taken as the graphics window background colour).

Naming Confusion Resolved

The confusion between naming of both Dump Surface and Dump Limit Surface has been resolved.

Dump Limit Surface Settings Not Influence Lowwall Generation

A bug in Dragline/Prestrip Integration was fixed. The Dump Limit Surface settings influenced the low-wall generation, which is incorrect. This has now been corrected.

New Items in 3d-DigPlus Version 3.1

This Version of 3d-DigPlus contains the following new items, in each of the 3d-DigPlus Modules. The description mostly applies to changes from Version 3.0 of 3d-DigPlus.

Generic (Base) Program

1. New Interface ETI Library Implemented

A new interface library for use with 3d-DigPlus has been implemented. This library implements writing and reading of files with extension *.ETI. Export and Import of ETI files is accessed through the menu items File|Export and File|Import.

Currently this library provides:

- (a) A fast way of exporting multiple surfaces from 3d-DigPlus. Since 3d-DigPlus also imports files of this type, this can be used to rapidly move surfaces between design files.
- (b) A link between 3d-DigPlus and mine planning packages. ETI files are currently supported (reading and writing) in Deswik CAD. We expect other mine planning packages will support this format in future.

We will add other objects to the ETI Library as the need arises.

Copies of the ETI Library code for use in interfacing with 3d-DigPlus may be obtained from Earth Technology on request.

2. Multi-Bench Dump Design

The multi-bench dump design allows users to draw a footprint on the terrain and design a multi-bench dump fitting maximum material within that footprint. Parameters control the design of the dump.

The multi-bench dump design interface contains brief descriptions of the parameters through Help Tips, and a Help file explains use of the functionality and parameter meaning in more detail. It is also described in the 3d-DigPlus Documentation.

3. Graphical 2D Zoom and Pan For Section Windows

Graphical Zoom and Pan functionality has now been implemented for all Cross Section, Longitudinal Section and Road Vertical Alignment windows. This new functionality is accessed through the same Zoom, Pan and Fit All icons on the toolbar used for 3D zoom and pan. Instructions are issued on first use of the Zoom In icon.

4. Change of Terrain Surface by Opening a New *.TOP or *.BIT File

Terrain can now be replaced through File|Open using a *.TOP or *.BIT file, keeping all surfaces and simulations in place. The Prime Surface is reset to the Terrain Surface, with the existing Prime Surface being saved to a surface under the name "Old Prime Surface".

As the terrain scaling is left in place when a new terrain replaces an existing terrain, objects such as polygons, machines, roads etc on the "old" terrain will stay at the same coordinates on the new terrain.

The new terrain data (TOP, BIT) is checked for very large coordinate differences from current terrain data. If the coordinate difference from current data is too large, new data cannot be read.

5. Identify Roads Through “Active Road”

Nominating a road as the “Active Road” and display of the "Active Road" is now implemented. This provides a way of identifying roads on the terrain.

Note: A road must be (1) nominated as “Active” and (2) display of the Active Road must be turned on, for this to work.

Nominating the Active Road

The active road is the road selected in the Roads list at the top of the "Create Roads" dialog box. In addition, a right click on the Road in the graphics window will offer the option to apply "Set Active" to this road. This newly-selected road will then appear selected in the Roads list at the top of the “Create Roads” dialog box.

Marking the Active Road

The Roads page of Terrain|Window Appearance now allows users to enable marking of the active road. The active road is marked on the terrain graphics with a symbol "A". The Window Appearance also allows users to select the option of showing only the active road.

6. Multiple Excavation of a Road, Undo of Roads Excavation

This version of 3d-Dig*Plus* changes Road Excavation and Undo/Redo functionality. Roads can now always be excavated, irrespective of previous excavation history. This means (for example) that a road can be moved graphically and excavated again in another place.

Undo/Redo of roads excavation is now on the general undo/redo stack.

7. Export of Contours+Grid to DXF in One Operation

Export to DXF of both Terrain Contours and Terrain Grid in one operation has been added as File|Export|Contours+Grid Points.

8. Import of multiple inner surfaces as *.DXF, *.XYZ, *.TOP, *.BIT

Multiple inner surfaces can now be imported as as *.DXF, *.XYZ, *.TOP and *.BIT files. This is accessed through the menu option File | Import Multi Files... . The type of imported file is chosen on the Filer that is offered through this menu option.

9. Construct Inner Surface, Surface Name Kept Constant

The Construct Inner Surface functionality has been changed to keep the same surface number ID after creating a new surface, in cases when the new surface over-writes an existing surface with the same name.

The surface name offered to the user in Construct Inner Surface will now be kept constant within a session, unless the user changes it. Then it will stay at the new name until changed again etc. This allows the same surface to be over-written a number of times while experimenting with different parameter values.

10. Restore Points and New Logs

New logs created after a Restore Point is set are kept, but their contents are now zeroed when the Restore Point is applied.

11. Section Settings Dialog Box, “Select All” and “Deselect All” Surfaces and Layers

The Section Settings Dialog Box is accessed through the menu item Utilities|Section Settings. The Section Settings now have “Select All” and “Deselect All” buttons on Surfaces and Layers pages.

12. Named Views Saved and Read from File

Named views can be saved in *.nmv file (binary) and can be read from this file. (File|Save as... and File|Open... menu options).

13. Default Initial Horizontal Angle

The Default Initial Horizontal Angle has been changed to look North. This will only affect the first creation of a Surface.

14. Creation of Spoil Layer

Creation of a Spoil Layer is now allowed even if there are no layers in existence.

15. “Reorder” Button Added to Dump Settings Dialog Box

A “Reorder” button has been added to the Dump Settings dialog box. This allows users to change the order of full Dump Templates lists shown everywhere in 3d-Dig*Plus*.

16. “Reorder ...” Buttons Added to Edit Surface and Edit Layers Dialog Boxes

“Reorder Surfaces” or “Reorder Layers” button has been added to the Edit Surface and Edit Layers dialog boxes. These dialog boxes are accessed through the Terrain|Surfaces|Edit... and Terrain|Surfaces|Layers... menu items. This allows users to change the order of Surfaces and Layers lists shown everywhere in 3d-Dig*Plus*.

17. “Exaggerated” Option Added to Section Settings

An “Exaggerated” option has been added to the Section Settings Dialog Box. This is on the General page. Users can also enter an Exaggeration Factor. Use of this setting allows users to control the displayed vertical scale of sections.

Dragline Module (Including Upcoming Automated Dragline Simulation)

Most of the effort in the Dragline Module has concentrated on the upcoming new Automated Dragline Simulation Module.

1. Single-Step Dragline Simulation Dialog Box Upgraded

The Dialog Box for the simulation in the Single-Step Dragline Module has been upgraded to include settings relevant to the the Automated Dragline Simulation. Users of the Automated Dragline Module will be able to choose the dragline simulation module from this dialog box. They will choose Single Step (the present Dragline Module) or Automation (the new Module currently nearing completion).

2. New Columns Added to Simulation Report

Some new columns have been added to the Dragline Simulation Report. The report is accessed after a simulation through the menu option Simulate|Simulation Report....

The new columns are Prime Volume Bank, Rehandle Volume Bank, and Total Volume.

3. Export of Selected Columns From Simulation Report (To File or Excel)

The Dragline Simulation Report (accessed after a simulation through the menu option Simulate|Simulation Report...) allows export of selected columns from the report to a file or to Excel.

4. Dragline Bench Design

Context-sensitive Help has been added for the Dragline Bench Design dialog box.

Automated Excavation and Dumping Module

1. Pass Type Settings Added to Passes

New Pass Type Settings have been added to Passes. Surface and Layer now has an associated Pass Type. These can be accessed through the Terrain|Surfaces|Edit and Terrain|Surfaces|Layers dialog boxes (Edit/Set Pass Types button).

Pass Type is also accessed through the Staging Page of the Excavation Settings Dialog Box. On this page, press the Set Pass Parameters button. On the resulting Pass Parameters dialog box there is also a Edit/Set Pass Types button.

Pass Type is used in a number of places in Automated Excavation and Dumping and Truck/Shovel Simulation.

Filters for Passes by Pass Type have been added.

A colour has been added to Pass Types. Subsequence display names are colour-coded to this Pass Type. Subsequences belonging to a single pass will optionally be showing with this colour in the Supersequence Editor and in Excavation Templates.

Pass Log material properties are now assigned by default according to a Pass Type's Default Material Properties (Change Logs button on Pass Parameters Dialog Box, accessed through Staging Page of the Excavation Settings Dialog Box, press the Set Pass Parameters button).

Pass Types can now be assigned to multiple passes (Edit/Set Pass Types button on the Pass Parameters Dialog Box).

2. Auto-Generation of Subsequences Extended

Subsequences Auto Generation is extended to 9 Sub-Ranges.

3. Filters in Supersequence Editor

Subsequence Filters to Hide certain Subsequences (by Hide Used, by Pass Name, by Block Range, by Pass Type) have been added to Supersequence Editor.

4. Percent Utilization Added to Preset Productivity

This version implements a percent utilization parameter in calculations of elapsed time (vs digging time) for Automated Excavation and Dump. The percent utilization is specified in Excavator Operating Parameters (for Truck/Shovel Simulation only) and in Preset Productivity Parameters (for Automated Excavation and Dump and for Truck/Shovel Simulation).

5. Naming Rules For Subsequences Kept When Changing Subsequence Contents

Subsequence names are copied to the naming rules name field when a subsequence is selected and the "Replace Contents of Current Subsequence" flag is ON. Selecting a range of raw sequence will then restore the name generated by the naming rules. This allows users to keep a subsequence name while changing its contents, and also to change the name of a subsequence without altering its contents.

6. Replace Button Added to Supersequence Editor

Button "Replace" was added to the Supersequence editor.

7. Multiple Digging of the Same Subsequence Allowed

Multiple digging of the same subsequence in a supersequence will now occur.

8. Autogeneration of Subsequences

A rules-based system for Autogeneration of Subsequences has been added. Subsequence Autogeneration operates with a selectable list of passes. It allows selection of passes and lifts ranges. Users can specify block ranges.

Autogeneration limits are remembered between applications of the autogeneration of subsequences.

9. Marking Dumps as "Filled" Only For One Subsequence

Dumps filled in one subsequence and marked as "filled" are now unmarked when the next subsequence is dug. This allows the same dump to be used several times in different subsequences.

10. Hiding Used Elements from Raw Sequence

Now it is possible to hide used elements from a raw sequence during subsequence generation. This is on the subsequence page of the excavation settings dialog box.

11. New "Sequence" Top-Level Menu Item

On user request, a new menu item "Sequence" has been added to the top-level menu. This contains items which allow access to Subsequence and Supersequence operations from one place. The menu item "Run Supersequence" as been moved from the "Simulate" menu to the

Truck/Shovel Module

1. Optimization of Number of Trucks in Each Block

Optimization of number of trucks per block is done. Optimization is done relative to the maximum productivity, which has the excavator fully utilized. Users can specify a minimum percentage of this maximum productivity e.g. at least 90% of maximum productivity. The optimization then tries different numbers of trucks, and finds the number which will just achieve at least this productivity.

2. Excavator Idle Times Calendar

A calendar to take account of Excavator idle times has been added to excavators. It is accessed through the Truck/Shovel Simulation Settings dialog box.

3. Operating Cost Added to Truck and Excavator Models

An Operating Cost setting (\$/hour) has been added to the truck and excavator models. The resulting calculated cost for each block has been added to the truck/shovel report.

4. Excavator Name added to Report File

A column with the name of the excavator used to dig each block has been added to the Report File. If several excavators were used, the names are concatenated with an “_” symbol between them.

6. Truck/Shovel Performance Report (Added Excavator Summary, Report File to Excel Button)

The dialog box shown at the end of a Truck/Shovel Simulation has been upgraded. This dialog box is also accessible after a simulation through the menu item Simulate/Last Simulation. The dialog box now shows a summary of excavator performance (**Total Dig Hours, Total Elapsed Hours, Volume per Dig Hour**), for each excavator used in the Simulation.

A new “Report File to Excel” button has been added to the dialog box. Pressing this button opens Excel with the optional report file generated during simulation loaded and parsed into columns.

7. Trucks Data Base

Truck Database files (*.TRB) have been added to 3d-DigPlus Truck/Shovel Module. These are accessed through buttons on the Truck Parameter dialog box. A standard version of the Truck Data Base is installed with 3d-DigPlus Version 3.1.

8. Percent Utilization Implemented

This version implements a percent utilization parameter in calculations of elapsed time (vs digging time) for Automated Excavation and Dump and Truck/Shovel. The percent utilization is specified in Excavator Operating Parameters (for Truck/Shovel Simulation only) and in Preset Productivity Parameters (for Automated Excavation and Dump and for Truck/Shovel Simulation).

9. Access Properties Assigned to All Dumps

An option to assign the currently selected access road properties to all dumps of selected subsequences has been added on the Roads page of Truck Shovel Simulation Settings.

Dozer Module

Option to Include or Omit Push Direction When Copying Regions

When regions are copied in Dozer Simulation Settings, a new option allows users to either include or omit push direction in the parameters to be copied.

Offsets from Bridge Surface Optimized

This Build of 3d-Dig*Plus* contains an addition to Dozer Optimization. This allows a surface to be nominated as the bridge surface. Offsets from this surface can then be optimized.

Reshaping and Transport Analysis Module

This Build also calculates centroids for Transport Analysis.

This Build completes the upgrade to Transport Analysis. This upgrade keeps the Sub-Region polygon persisting and will export information from the sub-region or from the whole TA region. This Build has the first version of an upgrade to Transport Analysis. This upgrade keeps the Sub-Region polygon persisting and will export information from the sub-region or from the whole TA region. This upgrade is not fully complete in this Build.

1. Multiple Reshaping Polygons

This version of 3d-Dig*Plus* upgrades the reshaping functionality to allow multiple selected polygons to be iterated over in one reshaping session.

Reshaping functionality for Select/Deselect multiple polygons is now complete. These are selected/deselected one at a time from the Dialog Box.

2. Reverse Settings for Reshaping

Reshaping can now be "Reversed" (to a limited extent) using the Reverse page of the Reshaping Dialog Box. This can be used when iterating for reshaping and the smoothing process is taken too far. Reversing will steepen the Terrain again so that a smaller degree of Reshaping can be used. This is described in new documentation.

3. Reshaping Parameters Remembered to 3dd Files

Reshaping parameters are now remembered to design (*.3dd) files. So reading a design file will return the reshaping parameters in use when it was saved.

4. Transportation Analysis Extra Parameters and Default Values

Some improvements have been made to the Transportation Analysis interface and default values.

An extra parameter ("iteration coefficient") has been added to the Transport Analysis interface. This parameter allows users to control the total number of iterations before the calculation stops. In this way, some arrows that carry very small amounts of material may be eliminated.

Transport Analysis "Display Arcs" now defaults to false.

5. “To Excel” Output of Transport Distances

"To Excel" output from Transport Analysis has been completed.

Dragline/Prestrip Integration Module

Many upgrades, improvements and fixes have been applied to the Dragline/Prestrip Integration Module. This Module is now complete.

New Items

New items added to this module include:

1. Show Right buttons to identify the “Right” side of strips
2. Show Toes button to show toe feature lines used in the simulation
3. A Dump Surface (using user-set parameters) and Pre-Strip Dump surfaces have been added.
4. Perpendicular End Wall Ramps do not require setting ramp toes now. They have their own batter angle.
5. Some shape changes for end wall area and slopes have been made.

All Ramp Types

Here is a full list of all types of ramps now supported in this module:

1. Internal Perpendicular ramp.
2. End Wall Perpendicular ramp (Left/Right).
3. Parallel Ramp bound to internal Perpendicular ramp (Left/Right).
4. Parallel Ramp bound to End Wall Perpendicular ramp (Left/Right).
5. Parallel Ramp bound to End Wall Left/Right).