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## Optimize the Performance of AutoCAD® Civil 3D®

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Learn tips and tricks that will help you optimize the performance of AutoCAD Civil 3D. These techniques will be applicable to engineering designs of any size. You will gain an understanding of best practices in data management which will improve drawing performance. Making good decisions early in the design process can pay dividends in the plan production phase. Strategies with working with larger models will also be presented. We will also cover various system and style settings which can influence the drawing size and display performance. Strategies for working on a Wide Area Network will also be presented.

#### Key Topics

- Optimizing Drawing Performance
- Optimizing Drawing Size
- Drawing Display Performance
- Managing Large objects
- Best Practices with Large Models
- AutoCAD Civil 3D on a Wide Area Network

#### **About the Speakers:**

Daniel is a software development manager for the civil engineering products in Autodesk's AEC Division. He has managed the design and implementation of the AutoCAD Civil 3D product since its inception. Daniel joined Autodesk in 1998 and has also managed the development of several releases of Land Desktop, Autodesk Civil Design, and Autodesk Survey. [daniel.philbrick@autodesk.com](mailto:daniel.philbrick@autodesk.com)

Nick is a quality analyst for the civil engineering products in Autodesk's AEC Division. He has worked in the past as a consultant and trainer helping clients across North America be successful using Autodesk solutions. Currently, Nick is responsible for the AutoCAD Civil 3D beta program as well as product testing. [nick.zeeben@autodesk.com](mailto:nick.zeeben@autodesk.com)

Ray has been the IT Director for Wright-Pierce for 12 years during which time his company has doubled in size and revenues and migrated from a one-office company to a company with six offices throughout New England. In the 80s Ray was a pioneer innovating networked solutions for early versions of AutoCAD and in recent years he has been an innovator for Wide Area Network solutions for the current versions of Autodesk products. [ray@sirois.com](mailto:ray@sirois.com)



## Introduction

AutoCAD Civil 3D offers fantastic design and analysis functionality for land planners, civil engineers and highway designers. In order to get the most out of the product, there are many optimizations which should be considered when deploying and using the software. In this session, we are going to explore tips and tricks for getting the most performance out of AutoCAD Civil 3D. The topics which will be covered include hardware, style optimization, modeling considerations, data management and network WAN performance. All of these aspects should be considered in order to get the best performance out of AutoCAD Civil 3D.

## Hardware Selection

If you are planning to model large, complex sites the first consideration is the optimal hardware. Following is a breakdown of some specific suggestions that will help to increase performance of AutoCAD Civil 3D.

### RAM

For optimum performance on a 32bit operating system 4 Gigabytes of RAM is recommended. 32 bit operating systems cannot use memory beyond this amount.

### Hard Drive

Having a hard drive with faster data transfer rates can help increase boot time of AutoCAD Civil 3D. If drawing data is saved locally to the machine, save and open time can also be increased. 10,000 RPM SATA hard drives are common place in the market today.

### Graphics

Using a certified graphics card can enable the 3D graphics advancements that have been added to the AutoCAD platform in the last few years, this includes the improved orbit functionality, materials applied to objects on screen without rendering. Performance when performing these actions will be vastly improved with a good quality video card from the certified hardware list. The list is available here:

<http://usa.autodesk.com/adsk/servlet/index?siteID=123112&id=7107053&linkID=9240618>

### Multiple Processors/Multi-cores

New multi-core processors put what is essentially two or more processors on a single chip. This means Multi-cores and Multiple processors are very similar in how they work with computer software. At any given moment in time a processor can run instructions from a single process on your computer.

Some applications are written with multiple process's some are a single process, AutoCAD Civil 3D runs as a single process, this means using a multi-core chip or multiple chips will not result in performance increasing by two, however today's computers run many processes all the time(Anti-Virus, Firewalls, etc). This means with multiple cores or chips available AutoCAD Civil



3D may not have to wait for the processor to become available, which can result in performance increases.

It is also common to multitask, this can mean doing work in Word, Excel or email while designing or drafting in AutoCAD Civil 3D, again having multiple cores or processors can help in these situations.

### 3 Gig Switch

32 Bit Windows operating systems have an internal configuration switch that can be set which allows programs access 3 gigs of memory space. A 32 bit operating system can only access a total of 4 gigs of ram, windows configures this with 2 gigs for user programs and 2 gigs for windows itself. By adjusting this switch windows reserves only 1 gig and allows programs up to 3 gigs of memory. This will allow AutoCAD Civil 3D access to some additional memory and raise the memory limits\*. It should be noted that all processes that are running which are not part of windows take away from this 3 gig total, closing additional applications can allow AutoCAD Civil 3D access to more RAM, meaning larger models can be opened.

To enable the 3 Gig switch see the following link:

<http://usa.autodesk.com/adsk/servlet/ps/item?siteID=123112&id=9729516&linkID=9240697>

It should be noted that some programs will not run with the 3 Gig switch enabled, this should be tested in your environment before large scale use. Initial testing has shown that larger datasets can be used in AutoCAD Civil 3D, however extensive testing has not been done.

### 64-Bit Operating Systems

The AutoCAD Civil 3D install as it ships on the DVD will not allow you to install on a 64-Bit O/S. Using the steps outlined below it is possible to install on a 64-bit operating system. It should be noted that this does not increase the amount of memory AutoCAD Civil 3D has access to.

Note: The Civil 3D team has only performed preliminary testing with Civil 3D 2008 in 64-bit environments. If you choose to implement this workaround and then experience system crashes, drawing corruption or other abnormal behavior, Autodesk Support may not be able to provide aid in the troubleshooting process. The following steps can be used to install on 64-bit OS.

On a workstation with a 32-bit operating system create either a standalone or network deployment based on your licensing requirements. For instructions on how to create a deployment see the network administrator's guide located on the product DVD under \DOCS\ACAD\_NAG.PDF.

When prompted to add a Service Pack to the deployment it is recommended that you apply the latest Service Pack. The Service Pack must be applied to the deployment because it will not install when applied directly to the application while running on a 64bit OS. For instructions on how to add a Service Pack to a deployment see the Service Pack's Readme file. The latest



service pack can be downloaded from the following location: Civil 3D Updates & Service Packs:

<http://usa.autodesk.com/adsk/servlet/ps/dl/index?siteID=123112&id=2334435&linkID=9240698>

Download and install Orca from Microsoft. For download and installation instructions see the following location, "How to use the Orca database editor to edit Windows Installer files":

<http://support.microsoft.com/kb/255905>

Browse to the AdminImage folder of the Civil 3D deployment and backup the C3D.msi and Setup.ini files.

Using Orca, open the C3D.msi and delete the action found in the table InstallExecuteSequence" that is called "CheckFor64BitOS" Delete the same line under table "CustomAction" then save and close C3D.msi.

Using Windows Notepad open the Setup.ini and delete the line under  
#=====

Platform Requirement" that is labeled "PLATFORM=NO\_WOW\_64\_PROCESS" .

On the 64 bit workstation, install the deployment by double-clicking on the shortcut in the deployment folder.

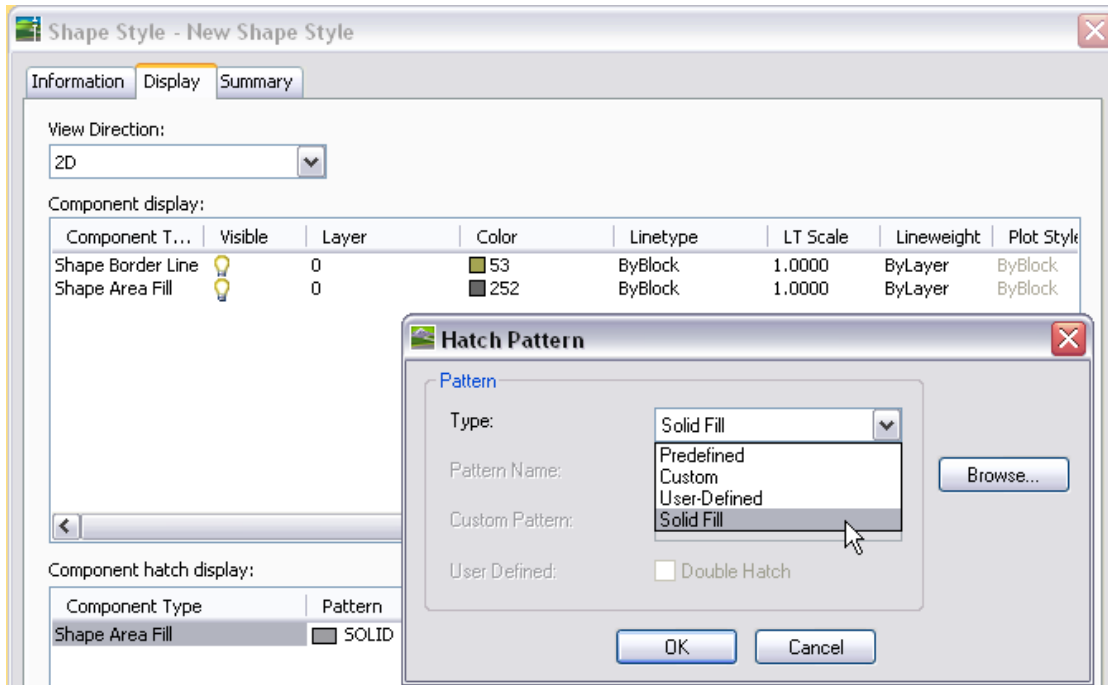
Some support paths under the "Files" tab of the configuration dialog box have incorrect paths. The installer adds an extra "\AppData\AppData" to some support paths located in the user profile.

## Display Performance

The display of the model has a significant impact on the drawing performance. You will notice this in particular when you regen the Civil 3D model. The first consideration should be to develop a collection of styles which are optimized for performance in both the 2D and 3D display configuration. During the design phase of a project you should use styles which minimize the display while at the same time provide enough engineering information to effectively design. Minimizing the display of large objects is also an effective way to reduce the memory consumption of large objects. A second set of styles can then be used for the plan production phase of a project. The following section contains some guidelines for some of the performance intensive style settings.

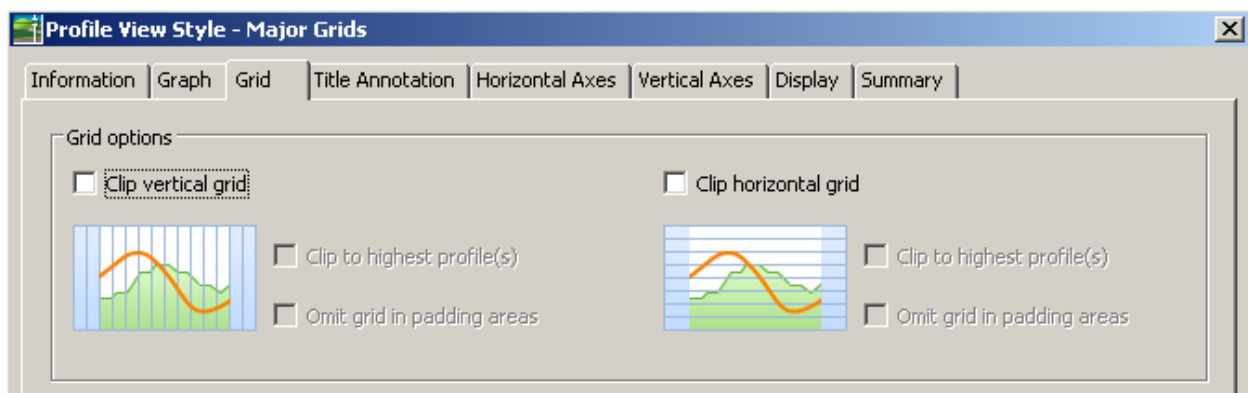
## Corridor Design

In the case of corridor design, you can create more efficient subassemblies by ensuring that the shape style for each one is defined with no fill, or at least a solid fill rather than hatch patterns.

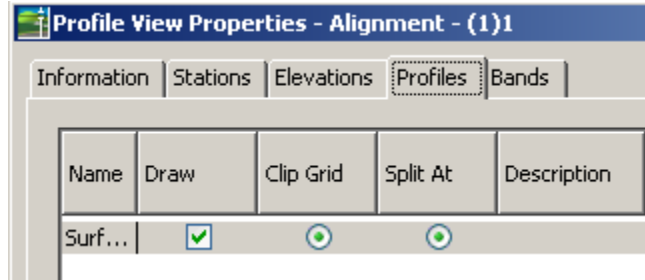


## Profile Views

The clipping the grip to a specific profile involves more computations to compute the grip. These settings are on the Profile View Style and are shown in the following dialog. These options are indication as to clip the vertical grid, the horizontal grid, or both.



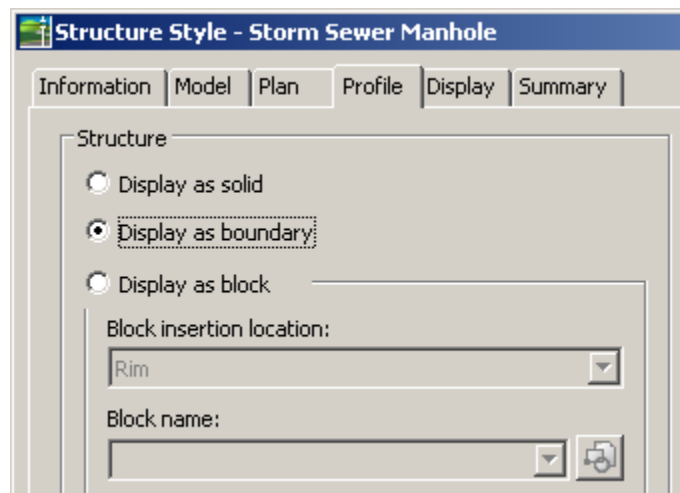
The actual selection of the profile is on the Profile View properties – only one profile can be selected for a grid clip.



As an example, for a 7 mile length of road, the clipping option on the EG profile is about 4 times slower than the non-clipped setting. Therefore, if you do need this setting, limit the user of this to the plan production phase of the process.

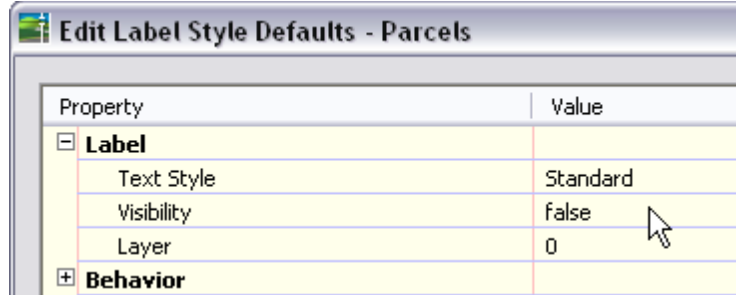
### Pipe parts in Profile Views

When drawing Pipe parts in profile view it is more efficient to use the boundary options as opposed to the model options. The model contains more detailed geometry and is more time consuming to display. The following dialog as the Structure Style option for the Boundary selected.



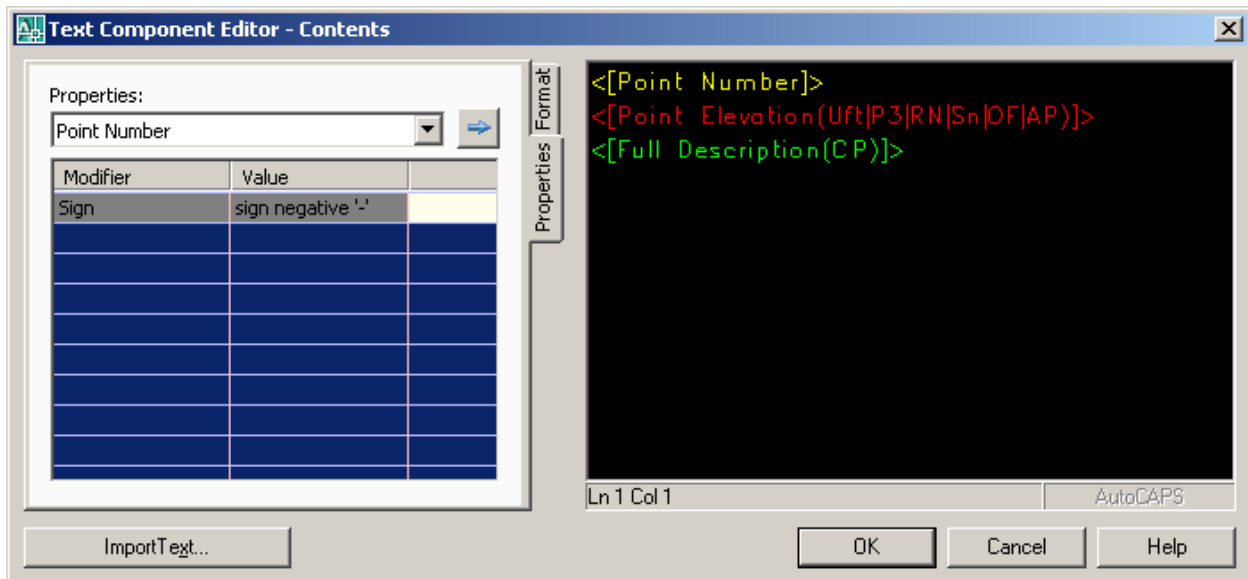
### Label Styles

As with object styles, you can design separate label styles for use at different project stages, and for different audiences. An empty “No Label” style is useful, especially for alignments, profile views, and other objects with label sets. You can easily switch off all labels for an object by applying this style. A convenient way to turn off all labels for a feature is to right-click the feature node on the Toolspace Settings tab, and then click, Edit Label Style Defaults. Doing this opens a dialog box where you can set label visibility to false, as shown below.



In fact, you can just as easily turn off the display of labels for all features in a drawing if you right-click the Drawing node, click Edit Label Style Defaults, and then set label visibility to false. If you want to create a label design that has just the essential data and can be drawn quickly, simplify all text and graphic elements, including the use of rotation, borders, and plan readability. Another useful tactic is to leave a style in place, but temporarily edit the style to turn off the label visibility.

For example, let's look at the display performance of COGO points with labels displayed. The number of text components in the label style will directly impact the display performance of the label. A drawing with Point Number, Elevation and Description in separate label components takes 13 times longer to display as compared to the same drawing with only the Point marker displayed. The label draw performance can be slightly improved by included all label attributes in a single text component as opposed to have 3 separate text components. In the following figure you can see that there is one text component with 3 label properties.





## Modeling Optimization

The Corridor and Surface have significant impact on the performance of the overall model. There are tactics which can be employed to improve the performance of large site design which include COGO points, Surfaces and Corridors.

## Large Surface Models

Surface models are often the largest object in a Civil 3D model. In order to represent the surface model, the following memory requirements are needed for each point in the surface:

TIN surface	96 Bytes / TIN Point
DEM Surface	16 Bytes / Grid Point

As a result, a surface which contains 600,000 TIN points will be approximately a 60 Meg file. This will also translate in to the amount of memory required for modeling the surface. However, this does not account for any of the requirements to display graphics such as contours, triangles and the boundaries. As a result it is critical to only model the data which is absolutely required when working with large surface models.

There are some best practices which can be employed when working with large surfaces.

## Building Surfaces from Point Data

External point files should be used as source data where possible. COGO points have the overhead of an additional object for the display of the COGO point information. Import the data from an external point file of the appropriate format. Another option to keep in mind is the Surface Snapshot. If you do create a surface snapshot, the surface will not need the external file for a rebuild. As a result the build time will be much faster, however, the surface snapshot requires copying the points into the surface object so you will find the drawing size is significant increased. The use of snapshots is more viable with small surfaces. The presence of a snapshot results in faster surface rebuilds because the system references the snapshot rather than redoing the operations that created it.

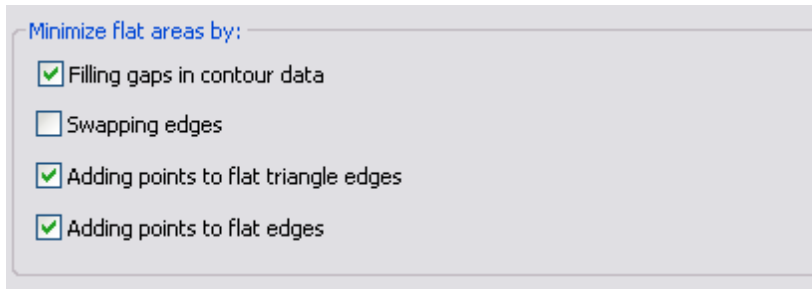
You will also find that adding a single large point file is more efficient than having a number of smaller point files. If possible, add all the points to the file in a single operation.

## Contour Data

When you add contour data to a surface, it is important to understand how to use the settings for minimizing flat areas. Otherwise, the minimizing operation can run very slowly, and the resulting surface can be inaccurate. By way of background, as surface triangles are created around contour data, erroneous flat triangles can appear in regions where contour lines follow tight curves, creating a condition where all three points of a triangle can be on the same contour. If you add the entire contour data in a single operation, AutoCAD Civil 3D corrects flat



areas very well by checking the surrounding elevations and interpolating new points. After you right-click Contours -> Add in the surface definition on the Toolspace Prospector tab, the Add Contour Data dialog box includes default settings to minimize flat areas, as shown below:



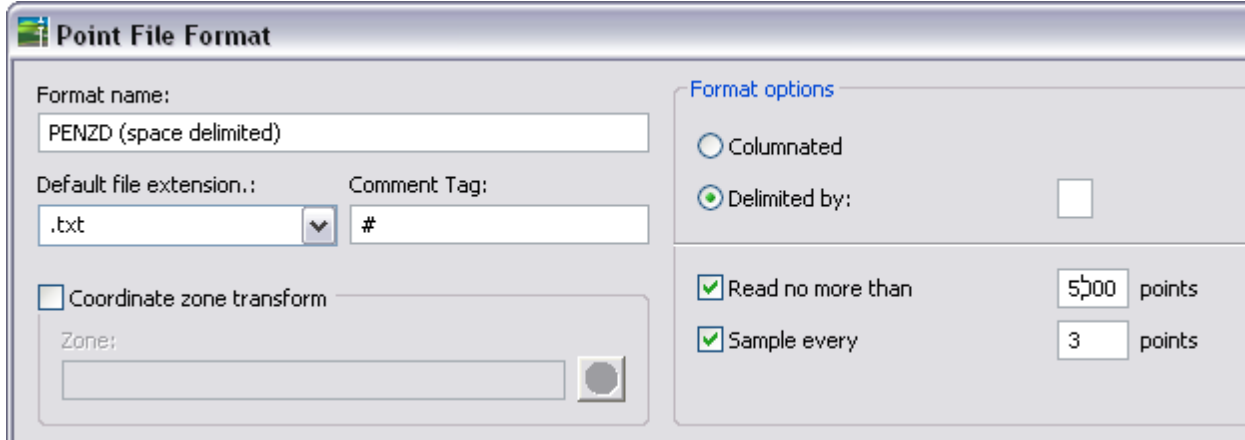
If you add contour data in two or more batches, you should clear the check boxes so that the minimizing of flat areas operation occurs only once, after the last collection of contours has been added. When it is time to minimize the flat areas, you can use either the settings in the Add Contour Data dialog box, or you can click Surfaces menu ->Edit Surface -> Minimize Flat Faces. If you run the command from the menu you will have a dedicated dialog for the settings shown above. The surface definition will have operation in the list for the minimizing of the flat faces.

## Filtering Point Files

When working with LIDAR it is often necessary to filter the data so that the terrain can be effectively built in AutoCAD Civil 3D. Ensure that your point file does not contain many more points than what is required for your surface. Excessive points can mean a coverage area that is too large, or a point density that is unnecessarily high. In either case, it means extra processing every time the surface is saved or regenerated. The following section covers several strategies for filter large quantities of point data such as those obtained from a point cloud.

## Point Import Option

If you know that your point file includes more points than necessary, you can filter the file at the time of import, limiting the number of points imported, or sampling a fraction of the points. To do this, configure the point file format in advance. On the Toolspace Settings tab, click Point ->Point File Formats, and then select the type of file you want to import. As shown below, settings exist on the lower right for reducing the size of the imported file.



This type of filtering often makes sense when using LIDAR data, which contains points in a very small grid. The disadvantage is some data which is important to the surface definition may be lost since it is not using a mathematical thinning algorithm.

### Reconstruct Surface Model using Contour Data

Large surface models made of point data often contain much more data than is necessary for modeling the surface. Each of the TIN points contributes to the memory consumption of the surface. One effective method for simplifying the surfaces is to build a surface from the point data and then contour the surface. If there is sufficient memory to contour the surface then the contours can be extracted by one of 2 methods. First, the surface can be exploded and the result is 3D Polylines. Secondly, the surface contours can be extracted to 3D polylines. Both methods will result in a 3D Polyline representation of the surface.

Once you have the 3D polylines you can now recreate a surface from the contour data. This is done by creating a new surface and adding the Contour data to a new surface.

Let's take a look a comparison of how this method impacts the accuracy of a surface. In the following example will look at a surface that contains approximately 3 million points. The performance of the model can be improved if the surface size can be reduced without sacrificing accuracy.

The test surface is made from a NEZ txt file and it contains 3.05 million points. A surface of this size will require approximately 300 MB of memory. If the surface is built from the point file and then contoured at 2 different intervals (2/10m and 1/5m) the comparison of the surfaces is shown in the following table.



	Baseline	2/10m Contours	1/5m Contours
<b>Number of points</b>	3045856.00	737205.00	1264633.00
<b>Minimum elevation (m)</b>	592.27	594.00	593.00
<b>Maximum elevation (m)</b>	853.17	852.00	853.00
<b>Mean elevation (m)</b>	710.59	710.74	710.58
<b>2D surface area (sq. m.)</b>	12178507.13	11991342.84	12115183.56
<b>3D surface area (sq. m.)</b>	12308862.23	12089080.9 (1.7%)	12226023.82 (0.67%)
<b>Minimum grade/slope</b>	0.00%	0.00%	0.00%
<b>Mean grade/slope</b>	9.89%	8.21%	8.77%

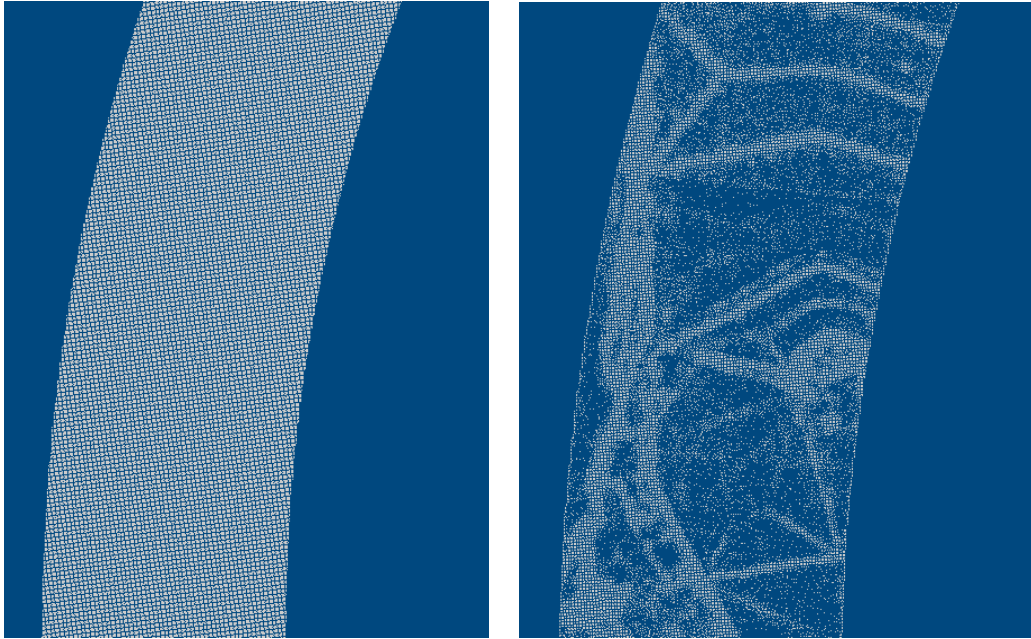
The number of points was reduced by more than 50% for the 1 and 5m contours and the 3D Surface Area was still within 0.67% of the original data. For many applications such as preliminary design or route selection, this accuracy is more than sufficient.

### Surface Model Point Decimation

Accurately reducing the size of a surface is most efficiently accomplished via the concept of Point File Decimation. There are several commercial software packages on the market which are effective in thinning a surface. The methodology of for thinning preserves the integrity of the surface since the algorithms are designed to weed only data which is not critical to the surface definition.

These tools can be used to process data before bringing the data into AutoCAD Civil 3D. Let's look at an example of this approach using the mesh simplification tools in one of these products called VRMesh ([www.vrmesh.com](http://www.vrmesh.com)). This tool lets you import point data and then simplify the resulting surface. The algorithm for surface simplification preserves the data in regions where the data is required and removes redundant or unnecessary points. Let take a look at the results.

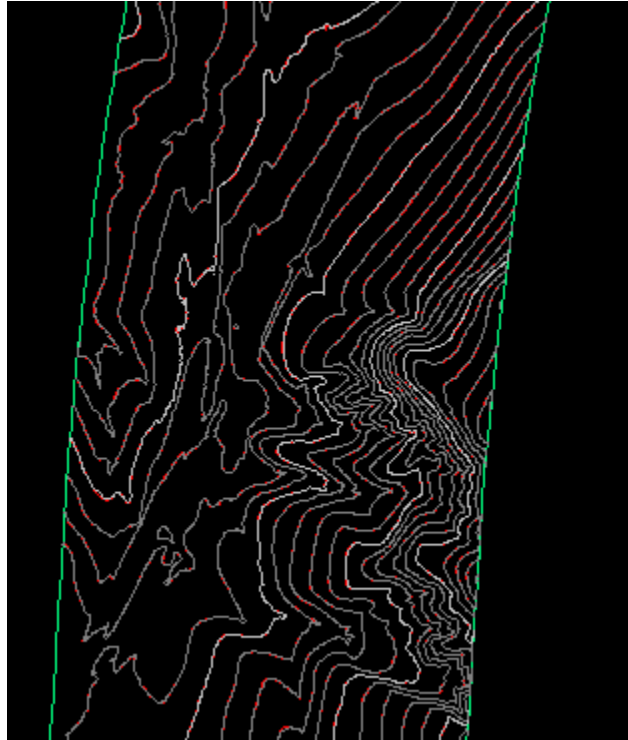
The example being considered is a surface which contains 3.04 million points. Often times there are more points in the surface than is required to accurately model the surface. Therefore the surface data can be decimated in an accurate way to preserve the integrity of the surface. A good way to see how the algorithm preserves data is to compare the resulting points in the surface. As an example, the surface with 3.05 million points was decimated by approximately 50% and the surface results compared. In the following figures, the original mesh is on the left and the decimated mesh is on the right. It is clear that the decimated mesh preserved accuracy in the areas of high slopes and where data is required to accurately model the surface.



Here are the surface statistics of the surface being analyzed:

	Baseline	Decimated 50%
Number of points	3045856	1504116
Minimum elevation (m)	592.27	592.27
Maximum elevation (m)	853.17	853.037
Mean elevation (m)	710.59	710.59
2D surface area (sq.m)	12178507.13	12178649.31
3D surface area (sq.m)	12308862.23	12308008.76 (.0069%)
Minimum grade/slope	0.00%	0.00%
Maximum grade/slope	3260.44%	3260.49%
Mean grade/slope	9.89%	9.81%
Number of triangles	6087606	3004152
Maximum triangle area (sq. m)	390	502.25
Minimum triangle area (sq. m)	0.04	0
Minimum triangle length (m)	0.041	0.016
Maximum triangle length (m)	69.971	69.971

If we visually comparing the contours of the original surface and the decimated surface reveals that the contours are very close. The following figure shows the original contours in Red and the surface with half the number of points in Gray.

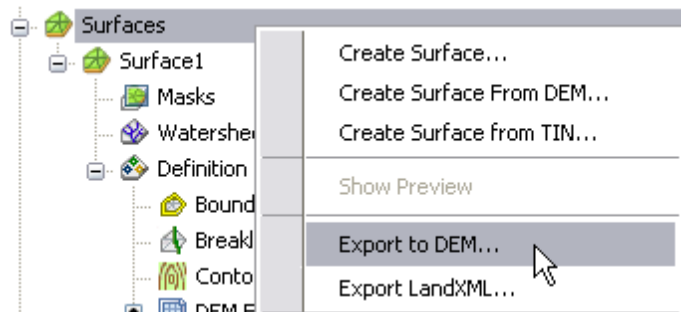


It is clear from this comparison that the contours are virtually identical.

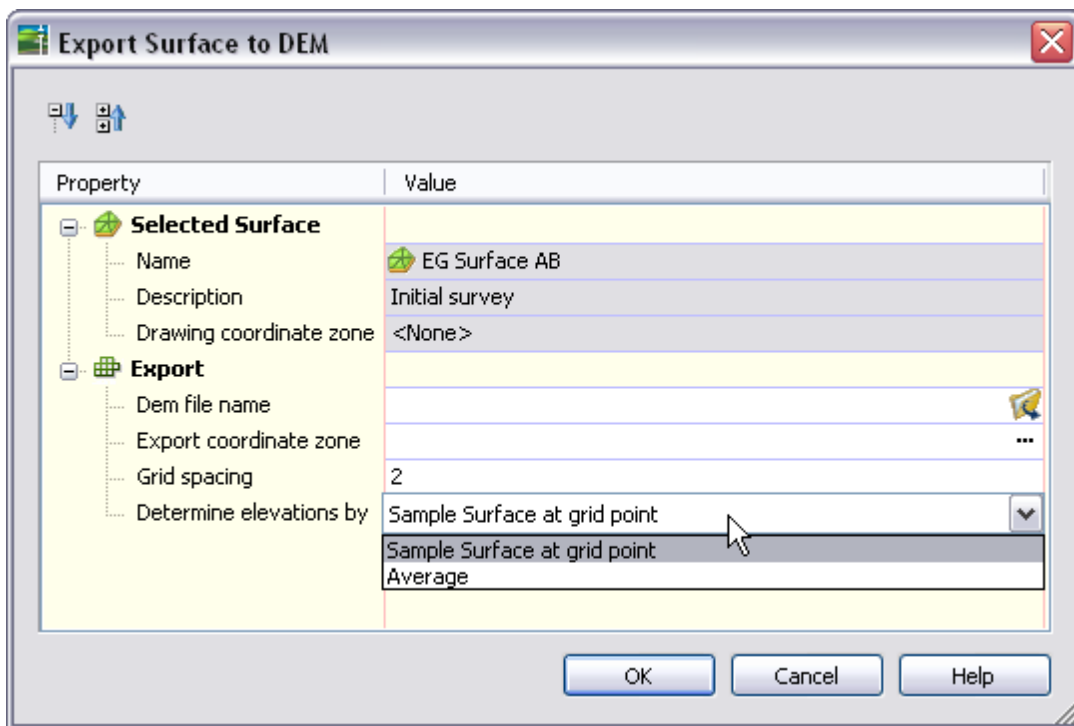
### Grid Surface

If you have a choice of source data for your existing ground surfaces, create grid surfaces rather than TIN (triangulated irregular network) surfaces whenever possible. The difference in system memory requirements is quite significant for large surfaces. As a general rule, a grid surface requires about one-sixth of the memory space required by the same surface in TIN format.

A new feature for AutoCAD Civil 3D 2008 enables you to export DEM (digital elevation model) files from a surface. At the time of export, you can expand the grid spacing to make the file smaller. The figure below shows the menu selection used to start the export process.

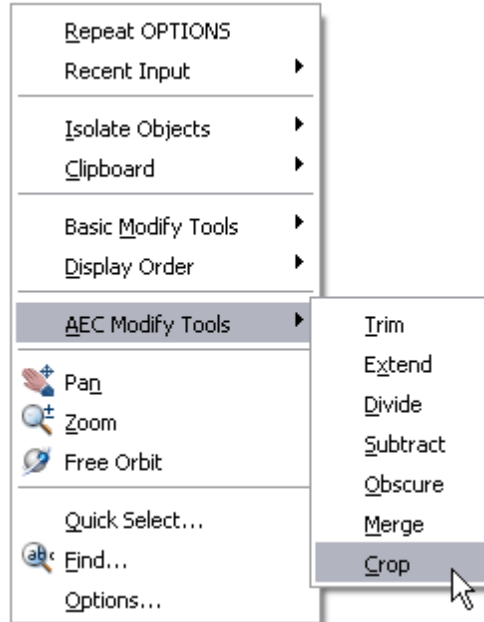


The Export Surface to DEM dialog box allows you to set the grid spacing in the exported DEM file. A grid spacing of 2 covers a given area with one quarter the number of points required by a grid spacing of 1. Use a higher numeric setting here to create a DEM file that is smaller in size, and less accurate. Another important export setting is the method for determining elevation at each point. You can choose to either sample the surface elevation at the grid point, or compute the average elevation from surrounding points. The latter method (averaging) is very time consuming. For greater efficiency, use the surface sampling option, as shown below.



### Editing Contour Data

Before you add contour polyline data to a surface, consider whether it includes some terrain that is not needed for design purposes. If so, you can use the AEC modify tools to crop unwanted portions of the contours. These tools are available on the right-click menu when no objects are selected.



If you are doing design alternatives, you can work with specific regions of the surface using the crop command and this will alleviate the need to have the entire surface built all at once.

## Reducing the Display of the Surface Model

The display of contours and triangles can greatly impact the display performance of the surface. Let's take a look at an example. Here are some statistics from a surface built from contour data. The sample surface has 765,000 points in the definition. If just the border is displayed, the regen time is virtually instantaneous. If 1' contours are added, the surface model takes 1.5 seconds to regen. Now if we add triangles, the regen time is approximately 3 seconds. Adding the Point data increases the regen time to 7-8 seconds. This point of these statistics is to emphasize that the more data which you display, the more time it will take to update the display of the model.

Memory is also significantly impacted with the display of the subcomponents of the objects. For example, for the 765,000 point file, the following table has the memory usage for various display components for the surface:

Nothing displayed:	Baseline
Surface Border:	16 Mb Increase
Surface Contours:	26 Mb Increase
Surface Triangles:	198 Mb Increase
Surface Points:	319 Mb Increase

## Creating a Surface Boundary

To reduce the processed surface area, create a smaller outer boundary around the region of your design. Areas outside the boundary are not drawn or included in calculations, but they remain in the file, available for future use.

If you later need to enlarge the boundary and restore deleted portions, simply rebuild the surface without the boundary. This is a good way to work with a smaller portion of a large surface. You will find that both the memory consumption and the regen display will be improved.

## Creating a Mask

A mask is another way to limit the display of the surface. The mask will only display the portion of the surface which is on the interior of the mask. By using a mask, the entire surface is still available for operations such as creating surface profiles and computing volumes.

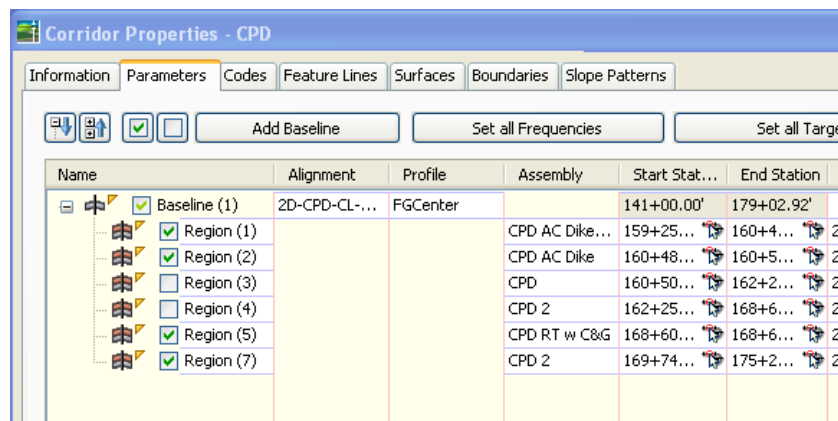
## Corridor Modeling – Techniques for Optimizing Performance

### Rebuild Automatic

While extremely convenient, rebuild automatic can impact performance in unintended ways. Upon opening a file which contains a corridor (or corridors), with rebuild automatic toggled the corridors will all be rebuilt. This can have an adverse impact on open times for drawings. As corridors also have a linear relationship on performance, the longer the corridor, or the smaller frequency, the longer a rebuild operation will take.

### Region Control

When working on a complex corridor model a designer will often be focused on a particular portion or region of a corridor. As edits are made rebuilds will be required, in corridor properties it is possible to toggle regions that are not of interest currently off. The rebuilds will only apply to regions which are toggled on and significant time can be saved.





## Corridor Cross sections through xref's

Due to the large quantity of data that cross sections result in, they can often create performance issues. AutoCAD Civil 3D 2008 added the ability to create cross sections through xrefs. In order for this to work you need to first create a data reference to the baseline alignment of the corridor that you want to cut sections through. The next step is to Xref the drawing which contains the Corridor. Below are some statistics that show the performance that can be gained. The drawing used for this sample was quite simple. A simple time difference shows some of the savings available, however these savings will also apply to design changes like corridor rebuilds.

Regen Time	
Sections in DWG	13
Sections in Xref	2
Xref Regen	8

The following steps are used for creating Cross Sections/Cross Section Views through an Xref:

- 1.) Create corridor model as usual
- 2.) Create a data reference in vault or using data shortcuts to the baseline alignment of the corridor you wish to create cross sections of
- 3.) Create a new drawing file
- 4.) Create a data reference to the baseline alignment
- 5.) Create an external reference of the file containing the corridor
- 6.) Create sample lines as usual. The corridor model will appear as a selection to cut samples through.
- 7.) Create cross section views.

## Editing Corridor Sections

When starting the view/edit section command there is often a particular section or area that you intend to make edits in. When launching the command picking on a particular section on the corridor will launch the view/edit at that section.

## AutoCAD Settings which impact Performance

### Proxygraphics

Proxygraphics is an AutoCAD setting which specifies whether to save proxy graphic images in the drawing. Proxygraphics require space in the drawing file and are required only for display in applications other than AutoCAD Civil 3D. If you do not need to share drawings with users of

AutoCAD or other AutoCAD-based applications, you can save space by turning off proxy graphics. If you do need to share drawings with AutoCAD users, the AutoCAD Civil 3D Object Enabler should be used.

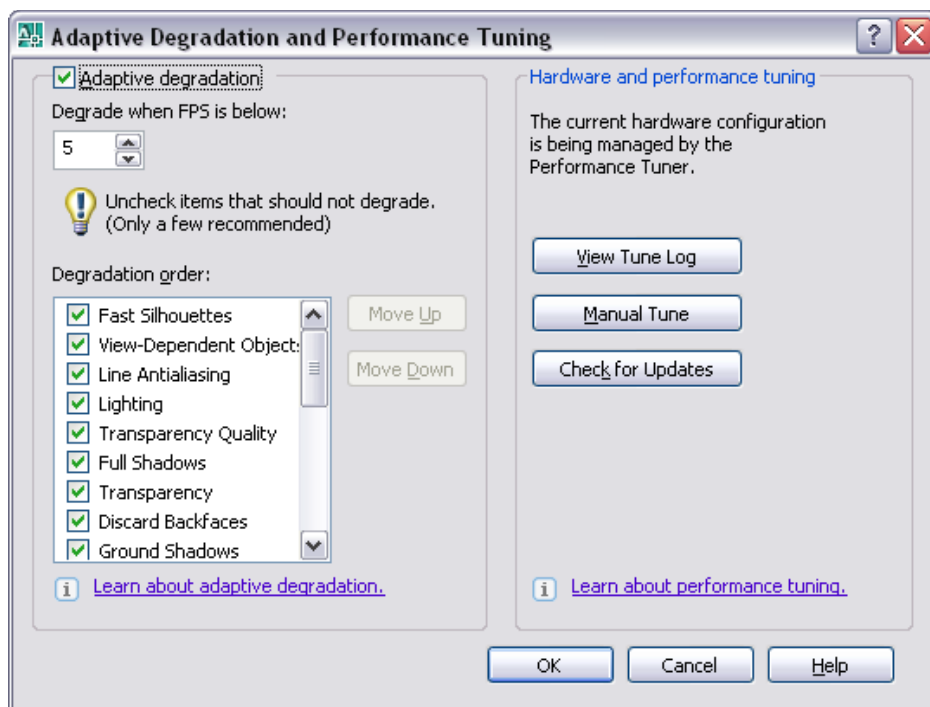
The main downside of enable proxygraphics is that the drawing size will be increased which will impact drawing load time and checkin time if you are using Vault. Here are a few statistics of the impact of Proxygraphics.

Surface with Contour Displayed:	Proxygraphics off	Baseline
Surface with Contour Displayed:	Proxygraphics on	10% increase in drawing size
Surface with Contours and Triangles	Proxygraphics on	70% increase in drawing size

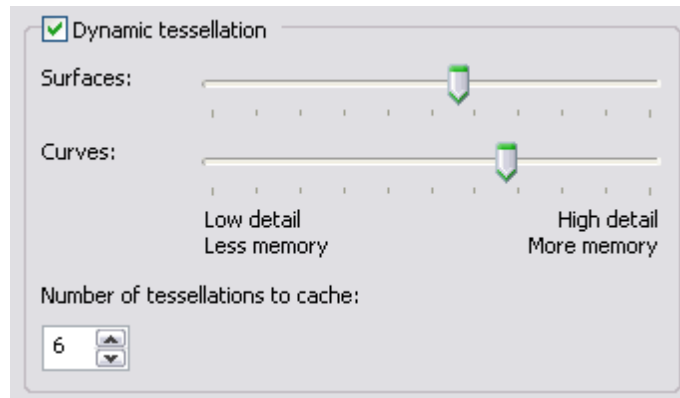
The recommended setting for Proxygraphic is to set it to 0 (off).

### 3D Display Configuration

The display of a complex surface in 3D is very memory intensive, especially if the surface includes graphic detail such as material rendering or a draped image. You can improve performance of 3D display at the expense of graphic detail, a trade-off that may be quite acceptable during the design process. In the final project phase, you can revise these settings to get more detailed images for presentation purposes. The main settings for 3D display are accessible when you enter the AutoCAD command 3DCONFIG. The Adaptive Degradation and Performance Tuning dialog box is show below.



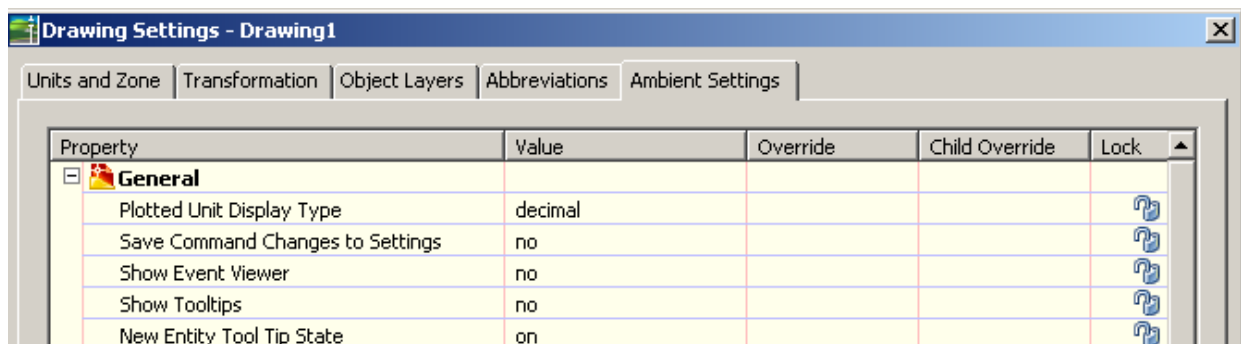
The adaptive degradation settings shown indicate that if the display speed drops below five frames per second, the system starts to degrade the display quality of fast silhouettes, view-dependent objects, and other items selected in the Degradation Order list. Depending on the data you are displaying and the graphics card in your computer, you may get better performance by turning off adaptive degradation. Another useful setting in the Adaptive Degradation and Performance Tuning dialog box is accessible when you click the Manual Tune button, which opens the Manual Performance Tuning dialog box. If you clear the check box for Dynamic Tessellation,



you can significantly improve the display speed of pipe networks as 3D solids. With dynamic tessellation turned off, system resources are not used to store surface tessellations in memory for different zoom levels. To compensate for this setting, after you have set your 3D display to the desired zoom level, regenerate the display (REGEN) to synchronize the tessellation level.

## Event Viewer and Tooltips

Both the event viewer and tooltips may not be necessary during the design process. These tools can both be disabled for more efficient viewing of the model. The settings for these tools can be found by editing the Drawing Settings and turning off both the Show Event Viewer and Show Tooltips options.





## Data Management

Data management is a very important consideration when you are working with large, complex datasets. Decisions early on can have a significant impact on the drawing performance during the later parts of the Plan Production process.

Data references are essential when working with large datasets. In general, data references offer the following benefits:

- You only need to include the specific model information which is needed in a particular drawing.
- A referenced object consumes very little space in its host drawing.
- Each data reference is automatically updated when the source object changes.
- The data reference is a read-only copy, so the source object is protected from unintentional changes.
- Engineering data of the source object is available for analysis in the data reference. For example, you can reference a surface, and then create a profile based on that surface in the host drawing.

## Project Collaboration Setup

In order to effectively manage data you need to understand the various approaches in Civil 3D. Here is a summary of the different approaches.

### Single drawing

The single drawing method is probably the simplest, but consequently, the least flexible, method for managing your Civil 3D model information. It entails storing all of your projects data in a single drawing that is used for all design aspects of the project. You can apply some techniques leverage AutoCAD features, like separating out any existing conditions into a linework drawing, and then Externally Reference that into your main project drawing, but essentially, all your data is stored in a centralized drawing. This method is advantageous for small teams where one person will be doing the bulk of the creating and editing of the project data. Obviously, this doesn't work very well for larger teams where multiple people need to create and edit multiple design objects at the same time.

### Data Shortcuts

A data shortcut is essentially an external reference for individual objects in the Civil 3D model. Shortcuts allow you to break apart the model into separate drawings, called source drawings, which contain the individual objects. You then reference the objects from the source drawings into base or engineering drawings to create the model. The feature of a Data Shortcut is that the reference object may be labels independently from the Source drawing.

The advantage of using data shortcuts is that you can share typical design tasks with various team members, and break the design workload down into more manageable segments. Data shortcuts also allow you to keep the design synchronized across a set of drawings, because if any of the source drawings are edited or updated, the base or engineering drawings that



reference objects from these drawing can be synchronized to them, and thus inherit the latest changes. The downside to using data shortcuts is that it requires a lot of manual input from the user, in that they have to export a design object as a data shortcut to a file, then they have to import that data shortcut file in another drawing in order to create the data reference to the object. When a project increases in size, it can become difficult to manage all the data shortcut files for the project, and there is a risk that information can get lost or overwritten.

## The Vault Data Management System

The third option is use Autodesk Vault to manage the Civil 3D model in a project. Autodesk Vault is data management solutions which contains a server component where the project data files are stored, and a client application, in this case Civil 3D. The Vault solution is integrated into Civil 3D through the Prospector Toolspace, and give the user a simple but powerful interface for interacting with, and managing the Civil 3D data in a project. Vault uses the same technology as Data Shortcuts, but adds a level of sophistication in that the server manages all the shortcuts and file dependencies automatically, making for a smoother and easier to use system.

It is important to note that the methodologies recommended in this paper for setup and management of project drawings can be used for both Data Shortcuts and when working with the Vault. However, Vault offers distinct advantages offer data shortcuts.

## Data Reference and Data Shortcuts – Definitions

In order to understand the data management in Civil 3D, it is essential that you understand two concepts; Data Shortcut and Data Reference. These concepts apply to both the Data Shortcut model and the Vault data management system.

### Data Shortcut

A Data Shortcut is an external XML file, which is the shortcut (AutoCAD DWG file name and path as well as the object name) to the source object. This allows the data in the source drawing to be shared with other users. The publisher of the source drawing creates a Data Shortcut for other users to consume via a Data Reference. The XML file contains the essential information so that the object in the source drawing can be found.

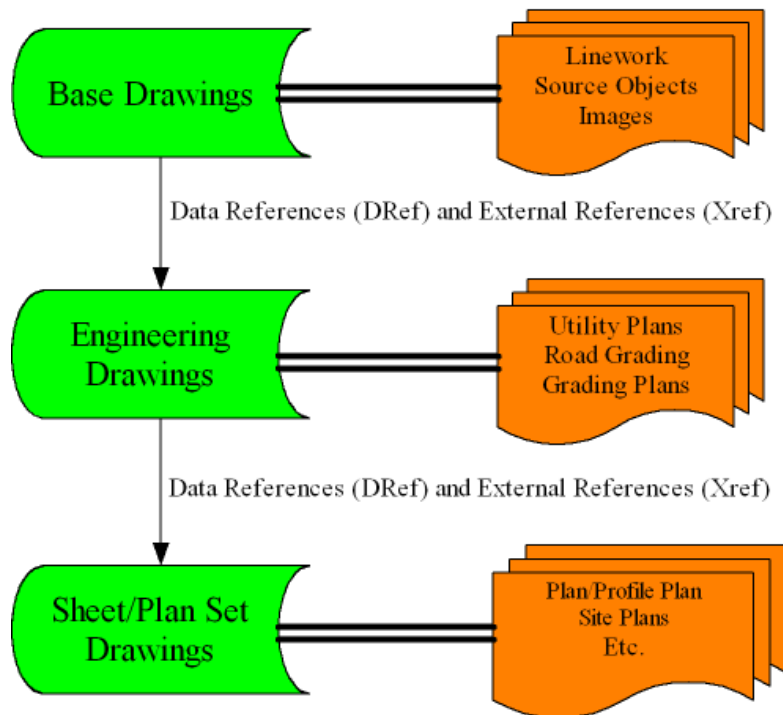
### Data Reference

In order to use the Source object in another drawing, the user needs to create a Data Reference to the object. The user of the data shortcut creates a Data Reference object, or light-weight object, in the local drawing. The reference objects have read-only geometry, but provide the user with the ability to apply a local object style, annotation, limited analysis, and access to the source object's properties. The reference object takes up less file space when the drawing is saved. Therefore, you can have one version of a design object and it can be referenced into all drawings which require that object. When the object is modified, all objects that contain the Data Reference will be updated.

## Civil 3D Project Management Workflow

The key to successful data management in either the Data Shortcut model or the Vault Data Management system is to segregate your project data effectively for collaboration. The key goal is to separate your design objects and Engineering drawings from Plans Production drawings.

The figure shown below illustrates an effective way to segregate the drawings for efficient data management.

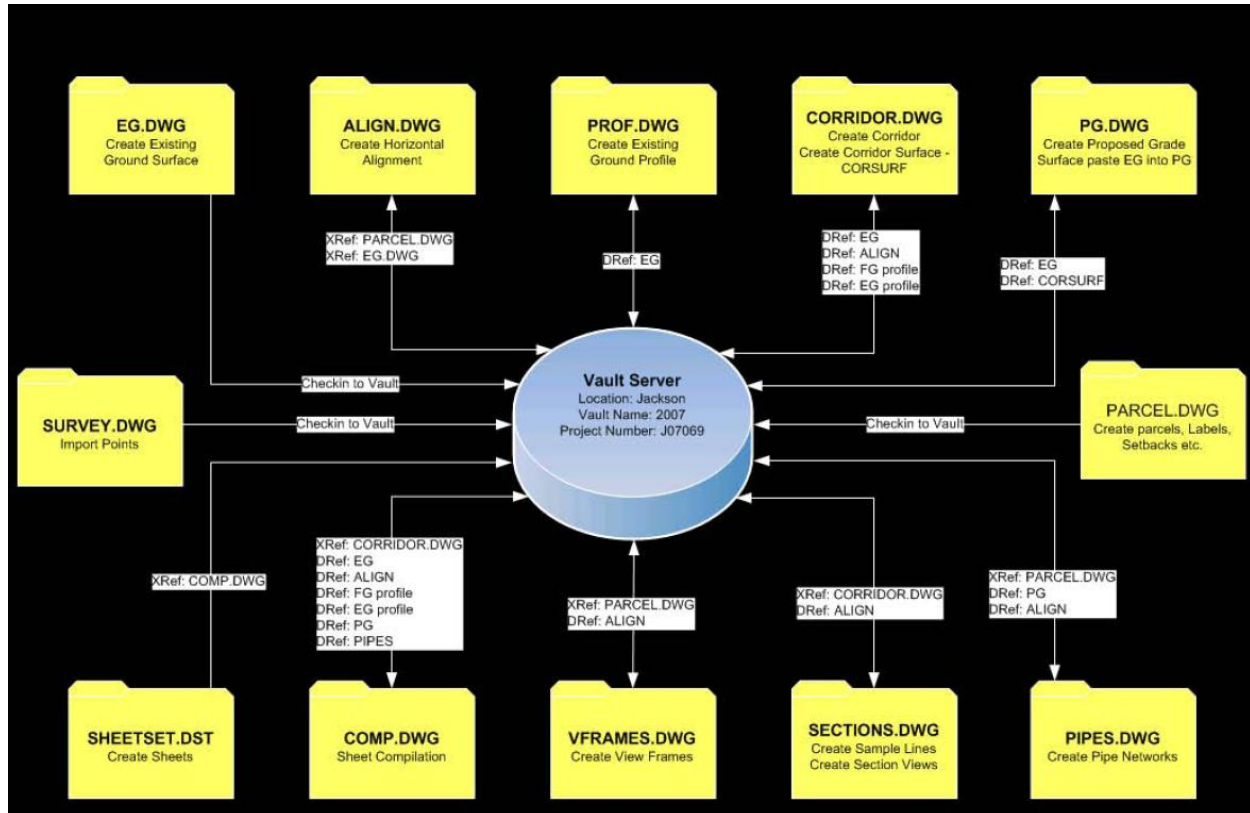


This workflow consists of three levels. In the first level, you create drawings for managing individual design objects, such as alignments and surfaces. These are the **Base Drawings**. Examples of Base Drawings are Source Civil 3D drawing objects, Linework Drawings and Image files. These drawings will be used throughout the project.

After you create your design objects you use data references to reference these object drawings to create Engineering Drawings in AutoCAD Civil 3D. This process comprises the development of **Engineering Drawings** as outlined in the above workflow. For example, you would design all of your individual alignments in the first stage, and then data reference them in the second level to create a parcel geometric layout drawing. Other examples of Engineering Drawings include Utility Plans, Road Grading and Grading Plans.

Once you have these Base drawings and Engineering drawings, plans production drawings can then be constructed. An example of this would be a plan and profile sheets for a section of road. These are created by a combination of XREF's of these mid-level Engineering plans and

Data References of the Design Objects. The strength of the system is revealed when a Base Level design object needs to be modified. The design change will ripple through the Engineering Drawings and the Plans Production drawings.

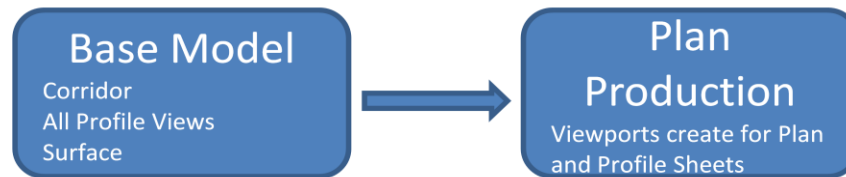


By using this workflow, you take advantage of one of the most powerful features of Autodesk Civil 3D: the dynamic link between labels and referenced objects. If someone makes a change to a design object in the Base level, such as an alignment, that design object will dynamically update in all drawings that reference it, from the Engineering drawings through the Plans Production drawings. As a result of this automatic process, any annotation which is done in the Plans Production phase will remain dynamic with the model.

## Impact of Data Management on Drawing Performance

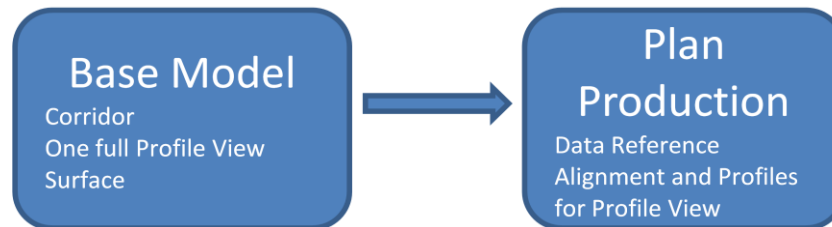
We will now take a look at how data management can impact perform. In this example we will compare two scenarios. In the first case, we will design a Corridor and create the Profile Views in the same drawing as the model. In order to create the sheets, this base drawing will be Xref'ed into a plan production drawing.

In the first scenario, the drawing will be setup with the Base Model containing the Model and the Profile Views for Plan Production. The Plan Production sheets will then be created by Xref'ing in the Base Model and creating viewports for the specific Profile View and Plan location.



## Xref Base Model into Plan Production

In the second scenario, the drawing will be setup with the Base Model containing the Model and just a full profile for the Alignment. The Plan Production will Xref in the Base Model, but the Profile Views will be created via Data Shortcuts in the Plan Production drawing.



## Xref Base Model into Plan Production

A good way to evaluate the impact on performance is to compare the Regen times for selecting the Layout. For this test case the Plan Production drawing which leverages Data References is **40 % faster**. This type of improvement is going to be noticed for any operations which require users to be working with the viewports. This may include additional drafting, annotating as well as plotting speed.

## Surface Tiling

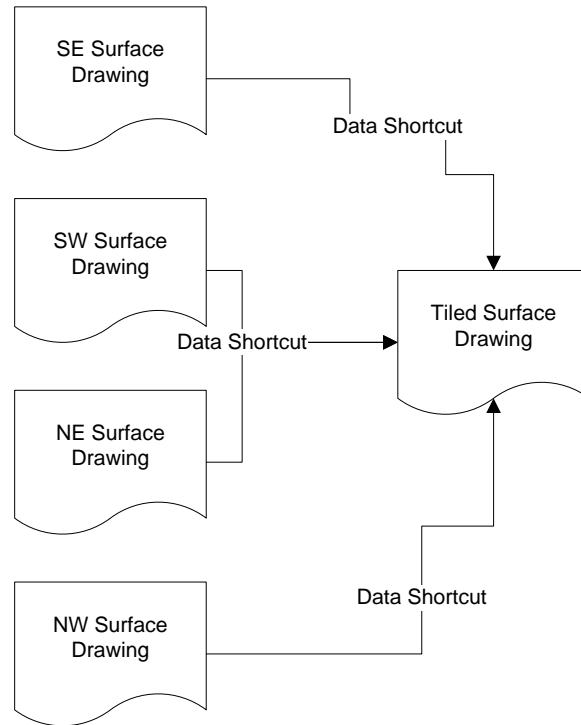
For very large models, it is not practical to try to model the surface in its entirety. Using tiled surfaces saved in separate source files allows work on large datasets while not exceeding memory limitations discussed earlier.

In the example below, four drawings have been created, each containing a single surface. A data shortcut has been created for each of the surfaces, then reference objects created in a single file with the border only style applied. This example was constructed using data shortcuts, however the same methodology can be used in a Vault environment as well. The tiled surface drawing contains the following:

- 4 Data Shortcut Surfaces (Using border only display, to minimize memory usage)
- 1 Design Alignment
- 1 Profile View
- 4 EG profiles (1 Per existing ground surface)



- 1 Finished ground surface



By having a single design alignment/profile this enables the user to create a continuous alignment across multiple tiles, while limiting the amount of surface data that must be loaded into memory. Surface editing can be performed in any of the 4 source surface files without exceeding memory limitations.



## Using Autodesk Civil 3D on Wide Area Networks

Most medium and large sized Autodesk customers have more than one office location, and most often these offices are not isolated islands of design and production. Rather, employees using Autodesk products are frequently in different offices working together on the same projects. Drawings and models need to be accessed and shared over long distances and X-Refs need to be resolved between different offices. Civil 3D is an example of an Autodesk product that integrates well with Wide Area Networking (WAN) acceleration technology to make employees in different offices work on the same Civil 3D models concurrently, in real time.

### Wright-Pierce Case Study and Background

Wright-Pierce is a medium sized engineering firm with 150 employees. Prior to the year 2000 all of their employees worked in their one office located in Topsham, Maine. Strategically, in order to grow their business, Wright-Pierce had to expand geographically into the states in southern New England. The first office they opened was in Middletown CT in January 2000. The end-user's expectation was that the performance to copy files to and from the main office was going to be just as fast and easy as when those files were on servers within their own building. To further complicate matters, expensive production errors were occurring because of a lack of revision control. With slower access to copies of drawings and documents being progressed in different offices, and too much dependence upon human procedures to ensure work done in one office was always copied back to the main office each night, Wright-Pierce was not able to profitably grow their business as envisioned. IT Manager, Ray Sirois, leveraged some thin client replication software, and some automatic ways to "sign out" drawings from the main office to ease the pain. This helped, and he published an article in *Cadalyst* magazine in September 2002 entitled "Working on the WAN". Ray also presented his solution at Autodesk University in December of that year. However, he and his users still hoped for a better solution.

Soon after his article was published, he was contacted by a new start up company which was developing a WAN accelerator appliance which reportedly could make their WAN links behave just as fast as a local area network (LAN). Wright-Pierce became a beta test site for this company (which later became known as Riverbed), and later Wright-Pierce became the first US customer of that company in the Spring of 2004.

Today in 2007, Wright-Pierce has branch offices in Portland ME, Portsmouth NH, Andover MA, Middletown CT, and Providence RI. Their employees, including the AutoCAD users work in real time over their WAN. There is no data saved to servers in the branch offices. Everyone works on the servers in the main office. So, X-Refs resolve easily between disciplines, and there is virtually no possibility for revision control problems. There is only one version, one copy of all drawings and documents, just like when they all worked under one roof.



## Testing Civil 3D in the WAN Environment

In 2006, Wright-Pierce, with the help of an outside consultant, completed a Civil 3D project in tandem with their legacy Land Desktop. Besides benchmarking, and building setups, one of the objectives of the project was to conduct a live test of the Civil 3D software over their accelerated WAN. Halfway into the project, the Civil 3D consultant was asked to physically move to one of Wright-Pierce's branch offices to continue the design over the WAN, with the data still residing in the main office. The test was a success. There was no difference in the user experience in working on this project data over the WAN when compared to working on the LAN. There are many other success stories like Wright-Pierce's where Civil 3D and Vault technology is working in these enhanced WAN environments.

## The Technical Challenges Posed by Wide Area Networks

Back when Ethernet first became the predominant local area networking medium, the bandwidth of those early Ethernet networks was 10 Mbps. This was first cabled using coax cable, later unshielded twisted pair wire known as CAT5 was used with hubs and this was called 10BaseT networking. Within a few years, most LANS were running 100BaseT which was 10 times faster, and today many are using 1000BaseT also known as GigE. However, once you leave your building and need to purchase connectivity between your buildings, one standard level of service is called a point to point "T1" line. T1 speed is considered "fast" in Internet Service Provider circles. However, it is only 1.5 Mbps, which is far slower than the bandwidth we have enjoyed on our local area networks for decades. A point to point T1 is also very expensive. It can easily cost \$1000 per month for this type of a private network connection between two offices that are in adjacent states, and if you need to go across the country, a T1 is often considered cost prohibitive. Fortunately, with the Internet, it is relatively inexpensive to buy broadband Internet service at both locations, and create a virtual private network (VPN) connection that leverages encryption to ensure the data are private while passing over the public Internet. VPN's solve the problem of the high cost of T1 private networking. But, they are subject to the same type of bandwidth limitations as their T1 counterparts.

The following chart compares different network connection types, and uses the highway analogy to illustrate the differences between them. POTS is "plain old telephone service" or dial-up.

NAME	BANDWIDTH	BPS	HIGHWAY ANALOGY
POTS*	-	64,000	3 foot garden path
ISDN	2 POTs	128,000	6 foot sidewalk
T1	12 ISDNs	1,544,000	4 lane highway (72 ft.)
ETHERNET	~ 6.5 T1s	10,000,000	26 lane highway
T3	28 T1s	43,232,000	112 lane highway
FAST ETHERNET	~ 65 T1s	100,000,000	260 lane highway
OC3	3.6 times T3	155,000,000	~ 1 mile wide highway

(1000BaseT or GigE is literally off this chart.)

As if the bandwidth constraints were not enough to discourage us, a second problem exists in Wide Area Networking, and in many ways it is even more challenging than the bandwidth problem. That problem is called "latency". It is characterized by a longer round trip time for a server resource to respond to a client's request for data over the WAN compared to over a LAN.

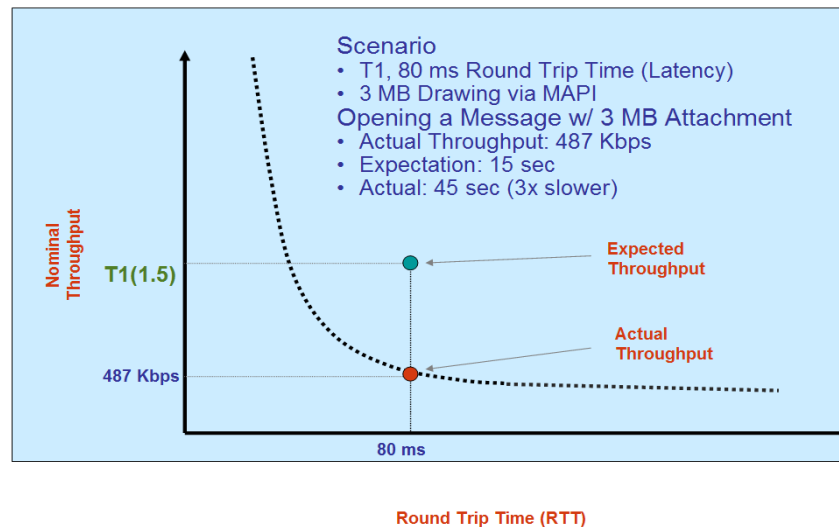
In the figure below we can see how a server on a local area network can reply in less than 1 millisecond, but a server in a different state can take an average of 37 milliseconds to respond. In WAN links that go across the country, latencies of 100ms are commonplace.

```
C:\WINDOWS>ping google.com
Pinging google.com [216.239.37.99] with 32 bytes of data:
Reply from 216.239.37.99: bytes=32 time=36ms TTL=235
Reply from 216.239.37.99: bytes=32 time=36ms TTL=235
Reply from 216.239.37.99: bytes=32 time=40ms TTL=235
Reply from 216.239.37.99: bytes=32 time=37ms TTL=235
Ping statistics for 216.239.37.99:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 36ms, Maximum = 40ms, Average = 37ms

C:\WINDOWS>ping 192.168.2.1
Pinging 192.168.2.1 with 32 bytes of data:
Reply from 192.168.2.1: bytes=32 time<1ms TTL=128
Reply from 192.168.2.1: bytes=32 time<1ms TTL=128
Reply from 192.168.2.1: bytes=32 time<1ms TTL=128
Reply from 192.168.2.1: bytes=32 time<1ms TTL=128
Ping statistics for 192.168.2.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

This round trip time (RTT) is what really slows down software application performance over the WAN. Many applications are "chatty" and require dozens or hundreds of round trips for even simple transactions like opening up a file, or saving it. In the formulas for calculating end user perceived speed of a network, RTT always shows up in the denominator. The graph for  $1/x$  is a hyperbola. So as the denominator grows, the actual performance of a network starts to degrade exponentially as illustrated in the email file attachment example below.

## e-Mailing a 3.0 meg File Attachment



Traditional tactics like file caching, applying file or packet compression, QoS, and remote control, have somewhat reduced the impact of bandwidth and latency problems. However, those tactics have never solved them entirely for many types of real world applications.

### Solutions

Fortunately, for Autodesk customers, today's WAN acceleration marketplace has exploded with a number of excellent technologies that actually **solve** both the bandwidth problem **and** the latency problems, and they work remarkably well with many different types of networked applications, including Civil 3D and Vault as tested by end users. The WAN acceleration market has grown from a \$254 million dollar marketplace in 2004 to nearly \$1 billion in 2007 according to analysts as reported by CNN earlier this year.

There are several excellent vendors in this marketplace, for example, Riverbed, Packeteer, Juniper Networks, Cisco Systems, Expand Networks, and others. Some of the manufacturers are very familiar to us who are in the networking business. Some of them are new start ups who have great solutions.

### How Do These Technologies Work Exactly?

Well, most of them leverage the fact that an awful lot of the data on our networks is redundant hour after hour, day after day. The project that "Harry" was working on yesterday is the same project that he is working on today. When he opens the file or saves the file, there is a high level of traffic that our networks see over and over again. Some of these products operate on the IP packet level and identify sequences of packets. So the fact that a file may have a different name or path does not really matter. The traffic or sequences of packets is the same. Others learn how different applications transact with the server, and can drastically eliminate in great proportion the number of costly "round trips" over slow WAN links. "The fastest round trip



is the one you don't have to take," claims one of the vendors in explaining how latency can be overcome once their appliance understands the type of transactions that need to take place between an application and its server side data share. Still others use some common sense moves like ensuring that the "bus is full" before leaving the station. In this way, one larger round trip can service many different remote users' traffic, rather than each remote user causing dozens or hundreds of round trips of traffic over the wide area network link. Some of these vendors combine all these strategies together along with others, as well as some of the traditional tactics like QoS to maximize performance.

The bottom line is that AutoCAD Civil 3D users can realize LAN-like network performance over these accelerated WAN links. This enables many medium even large sized design firms who had to de-centralize data in different offices to re-centralize all their data. This not only eliminates IT infrastructure and remote office backup headaches, but these technologies can systematically improve how productive our project teams are when located across different offices. As one might expect, larger Civil 3D data sets (>10-20 Mb) may still be problematic on slower WAN links. However, Autodesk is hearing how important this functionality is to medium and large customers with multiple offices. In the future, Autodesk, and other software providers, will continue to optimize their products for the accelerated WAN environment.

## Conclusion

In order to maximize the productivity of your engineering firm, it is important to get the most out of your design software. AutoCAD Civil 3D has great functionality for dynamically modeling a Civil Engineer or Land Planning Site. Learning how to get the most performance out of the software can make you and your firm more profitable. The class provides techniques and ideas for how to get the most out of AutoCAD Civil 3D.