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Get Your Head out of the Point Cloud:

Using AutoCAD® Civil 3D® for Large Surface Datasets

Dana Breig Probert, Engineered Efficiency

CV310-4 These days, we seem to be buried in data -- but how much data is too much? It's often difficult enough to open our data files, let alone build a meaningful TIN surface from them. We know we need to use high-tech field-collection information, such as LIDAR, Aerial Topography, and GPS points, so let's figure out a way to use it with the software and computer systems we currently have in our office.

About the Speaker:
Dana received her Bachelor of Science in Civil Engineering from Georgia Tech in 1998. Since then she has worked on a variety of civil projects in the U.S. and Canada, using Land Desktop, Civil Design, Raster Design, Map 3D and Civil 3D. In addition, Dana works with several firms on their Civil 3D pilot projects and implementation plans, and has taught many Civil 3D classes. Dana has been an instructor at AU, worked on Autodesk courseware projects, and is coauthor of the book, "Mastering AutoCAD Civil 3D 2008," which can be purchased at www.masteringcivil3d.com. Dana is also a contributor to www.civil3d.com.
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Get Your Head Out Of the (Point) Cloud!

We've all struggled with massive surfaces… You spend all day trying to import the data without locking your machine. Once you finally succeed in getting the points into the drawing, you find yourself crashing when you build the surface, or dealing with painfully slow regeneration times.

The goal of this class is to provide you with some plain and simple techniques for filtering through the chaff and digging into the wheat to build a great surface. These ideas and techniques may not be terribly flashy or high tech, but I find that they work for most large surface applications such as large point files, LIDAR data and aerial topographic data. Many techniques in this class can also be applied to other Civil 3D objects and applications.

This class assumes:

1. You are familiar with building surfaces in Civil 3D including adding breaklines (both proximity and standard), and boundaries.
2. You know how to "read" TIN and indentify surface problems.
3. You can create a surface data reference using either a data shortcut or Vault.
4. You are familiar with basic AutoCAD Map tools.

> ♩ Since Map tools are a skill gap for many civil users, I will be showing quick steps on how to set up the map queries and do Map cleanup in the live demo portion of this class. Additional information can be found in tutorials under the Help menu, AU classes, AUONLINE, skill builders and AOTC. My shortlist of highly recommended skills for civil users includes: attaching a drawing, creating queries, importing GIS data through Map>Tools>Import as well as through the FDO.

Best Practices?

What is best practice for me could be completely wrong for you. Conventional wisdom on the use of Civil 3D is constantly evolving. Many people don't like sharing their best practices because any time you "stick your neck out" and show procedures you open yourself up for scrutiny and potential criticism. For me, I like to share information because it starts a dialog and encourages others to share their approach. The techniques in this presentation are intended to assist you in opening the Civil 3D bag of tricks and *launch you on your own journey to discovering your own Best Practices*.

Much of work that is ongoing is documented on blogs like www.civil3d.com and the Autodesk discussion groups, so become a regular reader, and when you feel ready, a contributor.

The Truth About Hardware

If you are working with large surface datasets, it may seem like buying the most expensive computer out there with the most muscle would be all you need for success. The truth is that a

lot of the limitations on large surface datasets are not hardware related, but limitations from Civil 3D itself. There are, however, some hardware elements that can help.

A lot of people ask me for advice when spec'ing a new system. I'm not a hardware geek, so I can't tell you what is best for you. But I can tell you what has worked for me and what I have learned through asking questions and observing hundreds of workstations where Civil 3D is installed.

Minimum Specifications

Yes. You need AT least the following (from the Autodesk website):

System Requirements

AutoCAD Civil 3D Recommended Configuration (excluding server components that are used with Project Management capabilities):

- Intel® Pentium® IV processor, 3 GHz or higher, AMD Athlon TM
- Microsoft® Windows® XP Professional(SP2), Home Edition(SP2), Windows 2000 (SP4), 32 bit Windows Vista Enterprise, 32 bit Windows Vista Business, 32 bit Windows Vista Ultimate or 32 bit Windows Vista Premium
- 2 GB RAM
- 5 GB free disk space for installation
- 1280x1024 video display with true color
- OpenGL-capable, workstation-class graphics card or DirectX® 9 support
- MS-Mouse compliant
- Microsoft Internet Explorer 6.0 (SP1 or later)
- DVD drive

✓ Note: All of the following refer to work with systems running Windows XP. I would imagine that Vista workstations would have similar needs, but please do your own homework.

Because someone will ask…

My specifications at home:

AMD Athlon 64 X2 Dual Core Processor 4000+
2.01 GHz
4GB of Ram (with 8 total slots for future expansion)
ATI FireGL V5200

My specifications on the laptop used to give this presentation:

Intel Centrino Duo
2.33 GHz, 2GB of Ram
NVIDIA Quadro FX 350M (256 MB)

Dual/Quad Core Processors

Civil 3D 2008 doesn't take full advantage of multicore processors. Multicore processors will help with multitasking, such as keeping your stormwater software running while using Civil 3D. Civil 3D is built on AutoCAD, and some AutoCAD functions, such as rendering, will take advantage of the multiple cores.

Verdict: Yes on new machines, but don't rush out to get one right now.

Video Cards

I noticed a real improvement when I upgraded to my current video cards, and I have heard the same from many other users. Anecdotally, we all notice better real time panning and zooming, more stability in 3D views and just fewer visual hiccups. Check out the Autodesk website for a list of certified cards and read the Help file and online resources for proper tuning and configuration (3DCONFIG).

> ✓ Before you upgrade you card, experiment with tuning your current card. Sometimes that is enough to make a difference.

Verdict: Properly tuned, workstation class video cards make a difference. It is worth replacing yours and buying the best you can afford on new machines.

Ram

I personally noticed a difference in processing time when I added more ram to my desktop machine. Be sure to read the article called "The 3 GB Switch and Civil 3D" which can be obtained here: http://usa.autodesk.com/getdoc/id=TS1071001. The future of all software seems to point towards more ram, so don't skimp on new machines.

Verdict: Ram is cheap. Add more to your current system and be sure to leave lots of room for expansion on new systems.

Civil 3D Limitations for Large Surfaces

There is no official maximum for surface size in Civil 3D 2008, however my inside source tells me…

> **"You should have reasonable success with 2 million (TIN) points per surface."**
>
> ***-identity concealed to protect the innocent***

My personal experience with users is more like…

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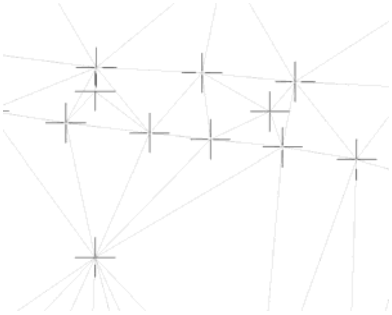
"Try to keep it under a million points per surface, and make sure they are a meaningful million."

-Dana Breig Probert, no warranty implied.

What are TIN points?

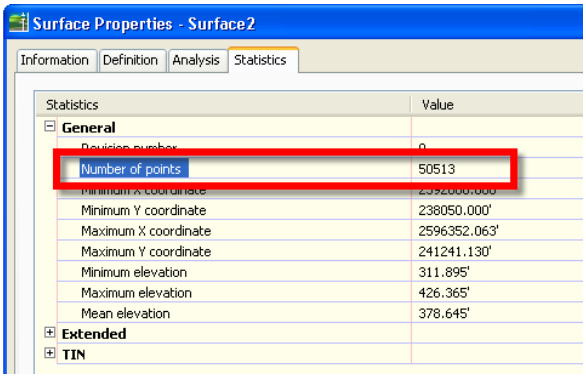
TIN points are data points or vertices used to build the surface. Every bit of data added to the surface contributes points. For example, the location of a COGO point would be a TIN point, or the vertices of a breakline. You can get a feel for TIN points by turning on points in your Surface style display tab.



The "+" shapes represent TIN points at triangle vertices.

How do I know how many I have?

Right click on your surface (either in the drawing or in Prospector) and choose Surface Properties. Expand under **General** and note **Number of Points**.



What are quality TIN points?

Quality TIN points come from data that is only as detailed as necessary. Quality data is not excessive, overly precise, overly accurate nor redundant. Read on…

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I Paid Good Money For These Points and I'm Gonna Use Every Stinkin' One of Them!

In Civil 3D, the surface game isn't so much "How do I use all of this data in Civil 3D?" as "What is the minimum amount of data I can live with?" That can be hard to swallow if you've been sold the promise of super duper precision.

Ask yourself:

1. What is the intended purpose of this plan?
2. What is the desired accuracy for vertical information?
3. What is the terrain like? Hilly? Flat?
4. If I had sent a crew out in the field, what kind of accuracy would I expect? How much precision? Does this project require more or less?

Spend some time with your surveyor, your legal counsel, with industry guidebooks such as those found in the References section at the end of this paper. Figure out exactly what you need versus what would be nice.

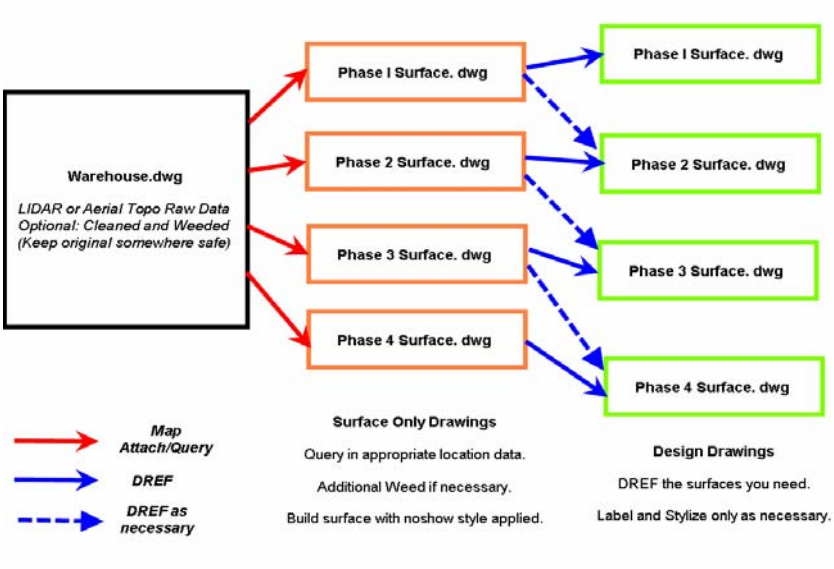
Ideas for Drawing and Data Organization

Your drawings should be organized to take advantage of the strengths of the software.

1. Only keep surfaces you need in a drawing.
2. Keep individual surfaces to less than a million points.
3. Label only where necessary.
4. Stylize only where necessary.
5. Avoid XREFing drawings containing surfaces, especially styled or labeled surfaces.
6. Use data references and style application instead of XREF and layer control to share surface information between drawings.

> ✓ Civil 3D labels are regenerated every time you change views or switch layout tabs. This includes when the labels are XREF'ed into another drawing. The biggest performance problems I have encountered in Civil 3D 2008 are related to label regeneration.

Keeping the previous three items in mind, you might consider having three types of drawings: **Warehouse** Drawings, **Surface Only** Drawings and **Design** Drawings.



Warehouse Drawings

The Warehouse drawing will keep the original data or linework for the entire site, such as the data from the LIDAR contours or aerial topography drawing. Keep this data in a safe place, and consider making it read only. Later in the paper we will talk about weeding data. You might want to make a "weeded" warehouse drawing at some point.

Drawing template: Make a plain template with no styles.

In your warehouse drawing, you might decide where logical breaks would be for smaller surface creation, perhaps marking with rectangles.

✓ Investigate the Map Books tool in AutoCAD Map and/or the Plan Production tool in Civil 3D to possibly assist in semi-automatic sheet creation based on your phases.

Surface Only Drawings

Surface Only drawings will house individual "tile" surfaces. Using Map Tools, raw data is queried for the appropriate location. After checking your TIN, apply a no-visibility style to your surface and avoid labeling. You can leave the attachment for future queries or break the connection. Experiment with erasing the AutoCAD entities, snapshots and build operations to find a drawing size that works best. Consider querying small chunks for use in detailed phase design, and larger chunks that are then weeded for a bigger surface that is a lower resolution.

Drawing template: Make a simple template that includes no object styles except a no-visibility surface style and a triangle only style.

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Design Drawings

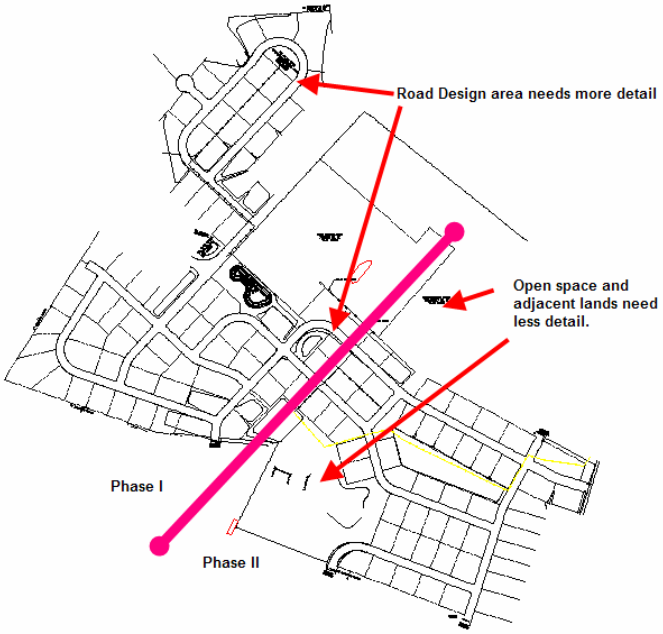
Data Reference (through data shortcuts or Vault) only the surfaces that are necessary in that drawing for design, daylighting, profile work, etc. Label only as necessary. Maintain as few layouts with as few viewports as possible and use data references and styles to control visibility rather than xrefs and layer control. Avoid xrefing drawings with surfaces, or any other civil 3d objects that are heavily labeled.

Drawing template: Use your company standard design template.

Planning Your Large Surface Strategy

Before you start creating drawings and importing data willy-nilly, sit down and make a plan. Take pencil to paper and sketch out a drawing and data organization plan that gives you what you need. Maybe print out an overall plan of your site and make some notes while you work through these questions:

1. Will the project be done in phases?
2. Are there phases of the project that require more detail?
3. Are there areas of the project that are being shown for “trend” or “background” information only that may not be critical to the design?
4. Would higher resolution surfaces be required for fine design, such as parking lots, where lower resolution surfaces suffice for other tasks, such as preliminary watershed studies?
5. How many surface drawings will I need, and what will I build in each one?



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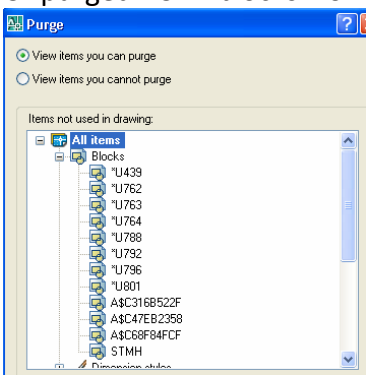
A Large Drawing Is NOT a Badge Of Honor

Before you even consider building a surface in your drawing, take a look around and make sure your drawing is big for good reason.

Common Culprits:

1. Unpurged 3D blocks or “blocked in” drawings
2. Unpurged *UXX blocks from exploding Civil 3D objects



3. Remnants such as land desktop polyface meshes, linework at elevation, things that don’t have to be in this drawing
4. Excessive layouts or viewports
5. Drawing errors

Don’t get me wrong… I’ve had 2 meg drawings that behaved like dogs and 20 meg drawings with large corridors and surfaces that behaved really well.

What is a big drawing? While every drawing must be examined individually, I use the following sizes as my “red flag” for further investigation:

Civil 3D drawing template: 1 Meg
Simple drawing containing only 2D linework: 1 Meg
Drawing for approximately 100 lot site containing alignments, parcels, corridor, and surfaces: 12-15 Meg
Large Surface Drawing: 15-20 Meg

If you start from a clean drawing but notice your drawing size getting large or performance beginning to lag, try cleaning it out first, then apply data organization techniques discussed below.

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Techniques To Practice For Large Surface Data Preparation

Don't Use..	**Instead Learn...**
Import Points	Adding Points directly to surface; applying weeding to point files
Object Viewer	View>3D Views; 3DDWFPUBISH
Converting AutoCAD Points to Civil 3D Points	Add AutoCAD Points directly to surface
QSELECT, Select Similar, other selection tools	Map Query for location and property
Insert another drawing as a block, or copyclip	Map Query
Map Trim, EXTRIM	Map Query for location
Flatten, or properties change	Map Query with Alter Properties
Adding every bit of data just because it is there	Choosing the important and meaningful data

Building Surfaces from Typical Large Datasets

Three extremely common large surface datasets are point files, LIDAR contours and aerial topographic information.

Large point files might come from a state agency, internet site or perhaps from privately contracted LIDAR work. These files are typically text files in the format of .txt or similar. The points used in this presentation come from North Carolina Flood Mapping. There are lots of publically available LIDAR point files. Try Google to search, or your state's geospatial data clearinghouse.

LIDAR contours are typically the export of some sort of LIDAR post processing software. Instead of sharing the large point files, someone has converted the data into a terrain model and exported the contours as polylines in an AutoCAD drawing. There are lots of publically available LIDAR contour files. Try Google to search, or your state's geospatial data clearinghouse.

Aerial Topographic Data is typically privately contracted. The aerial topography company will often provide two drawings. The first drawing will contain contours, features and labeling. The second drawing will contain points and breaklines. These companies can often provide you with other formats upon request.

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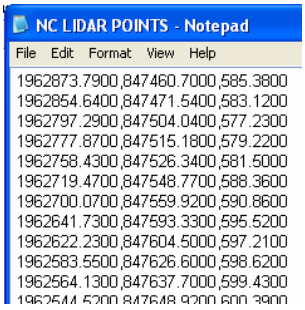
Building Surfaces from Large Point Files

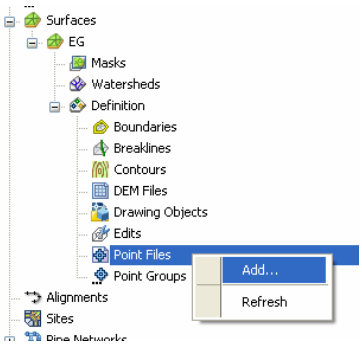


The example point file is a North Carolina Flood Mapping LIDAR .txt download. The file is in NEZ format and is over 8 meg.

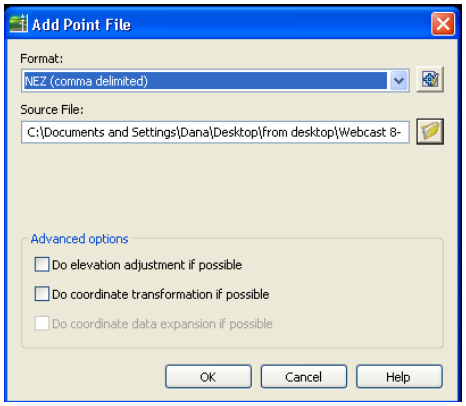
When dealing with a file this large, DO NOT import the points as Civil 3D cogo points. Importing this data as cogo points would make the drawing size larger than necessary while not adding any additional quality to the drawing. It is not likely that you will need to study any one point, you simply want to build a surface from this information.

Procedure: Building a Surface from Large Point Files

1. Create a new drawing from your Civil 3D template.
2. Surfaces>Create New Surface
3. In the Create Surface dialog, give your surface a name and select an initial style (probably a “no visibility” style for reasons discussed earlier in this paper.)
4. In Prospector, expand your surface definition and right-click on **Point Files**. Choose **Add…**



5. In the Add Point File dialog, choose the appropriate format. Choose your file. Press OK.

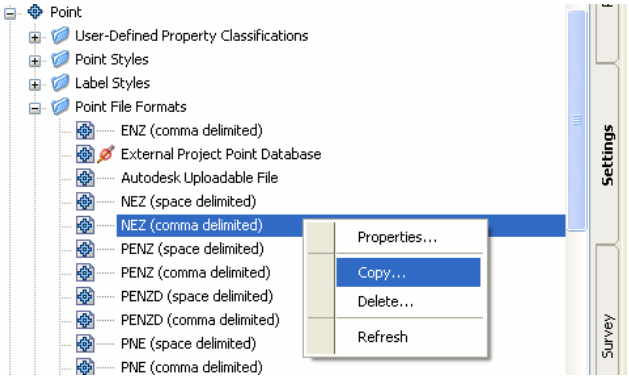


6. Your surface will build. Depending on the size of your point file and your individual machine specifications, this could take several minutes.

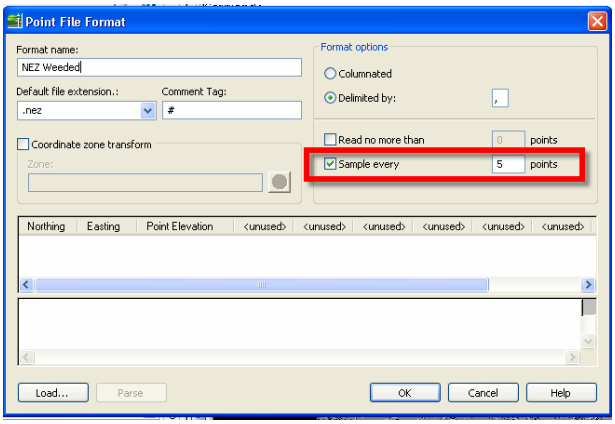
If you are faced with a very large point file, you might want to consider only using a portion of the file. There are several methods for weeding data. The following procedure leads you through creating a new point format that will use every fifth point in surface creation. Other techniques will be discussed later.

Procedure: Creating a Point Format to Weed Large Point Files

1. Switch to the Settings Tab of the Prospector.
2. Select Point File Formats and right-click. Choose **New…** OR select a file format that is close to what you'd like to create and choose **Copy…**



3. In the Point Format dialog, name your format appropriately, such as **NEZ Weeded** or similar.
4. In the Point Format dialog, check the **Sample every** box. In the **Sample every** field, enter a weeding factor. In this example, I've created a format that will sample every 5 points.



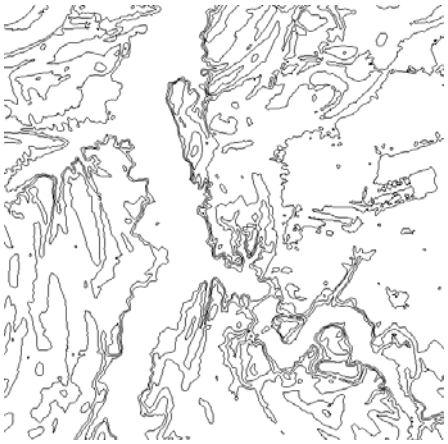
5. Press OK to exit the Point File Format dialog.

6. Your file format will now be an available choice when importing points through the first procedure in this section.

✓ Points cannot be weeded by location using this method. For another approach to importing LIDAR point files, check out this article by Chris Gountanis of ImaginIT. http://imaginit.rand.com/files/Workin%20with%20Lidar%20Data-White_Paper.pdf

Building Surfaces from LIDAR Contours

LIDAR contours are often publically available.

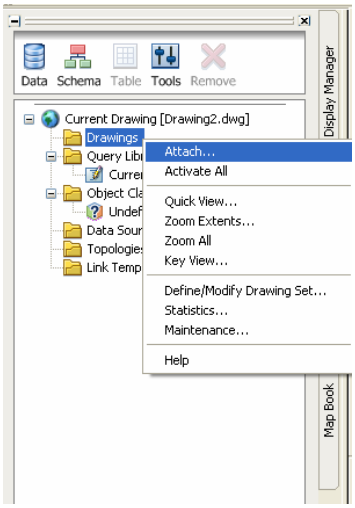


An example of LIDAR contours.

Contours are probably the least desirable type of data for surface creation. By definition, contours are the end product of a terrain model, not the raw materials. However, there are some times where the only data you have is contour data. When contours are your only option, follow the procedure below to create a surface.

Procedure: Building a Surface from LIDAR Contours (or any polyline contours)

1. Make sure the contours in your warehouse drawings are polylines and not Land Desktop contours, lines or other objects. Save and close your warehouse drawing.
2. Create a new drawing from your Civil 3D template.
3. Attach your warehouse drawing in the Map Task Pane (see Map tutorials, or the recorded session of this class for step by step how-to)



4. Create a location query to import appropriate data in the target location. (see Map tutorials, or the recorded session of this class for step by step how-to).
5. Surfaces>Create New Surface
6. In the Create Surface dialog, give your surface a name and select an initial style (probably a “no visibility” style for reasons discussed earlier in this paper.)
7. In Prospector, expand your surface definition and right-click on **Contours**. Choose **Add…**
8. In the Add Contour Data dialog, give your contour set a meaningful name. Press OK.
9. Make a crossing window to choose all of the contours you would like to add. Right click to end the command.
10. Your surface will build. Depending on the size of your point file and your individual machine specifications, this could take several minutes.

✓ Map queries are a great way to bring forward only the “good stuff” and leave behind the junk. For example, if you only wanted the polylines from a drawing. This is especially important with large files that may not be easy to open and are often impossible to “block in”.

Depending on your project needs, you may be able to greatly reduce the size of your surface and your drawing without sacrificing accuracy. LIDAR contours are often present as polylines with many closely spaced vertices. These closely spaced vertices often do not provide any additional meaningful data and can be weeded resulting in a more manageable surface. Investigate Map Cleanup tools to simplify polyline contours before using them for surface creation.

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Building Surfaces from Aerial Topographic Data

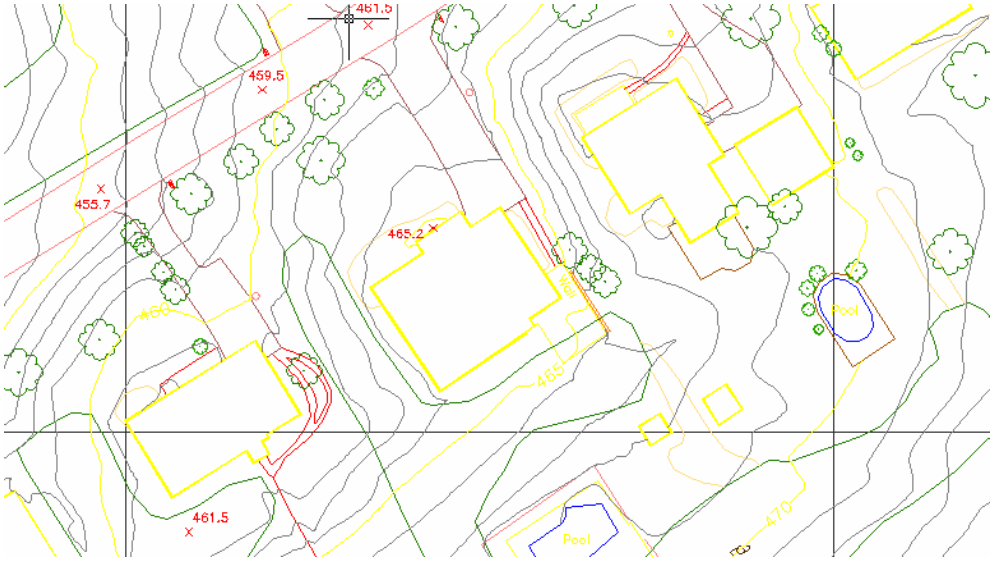
Many firms will have a site "flown" by an aerial topography company in lieu of sending a crew out in the field. Typically, the aerial company will provide you with two .dwgs. The first contains features and the second contains DTM data.

When hiring an aerial topography company, be sure to ask what formats are available for the final data. Many firms are capable of providing data formats such as LandXML, DEM or a .TIN file that might be more useful to you than the traditional .dwg information.

The Features or Topography Drawing

The features drawing usually contains contours at elevation, blocks representing trees, linework for roads, houses, tree lines and other notable features which are also often at elevation. This drawing is typically VERY large. Many engineering firms use this drawing to create their surface.

If you have a choice- **DO NOT** USE THIS DRAWING TO CREATE YOUR SURFACE.



A close look at an example features drawing
Entire drawing covers 2400 acres, drawing file size 130 megabytes.

The DTM (Digital Terrain Model) Drawing

The DTM drawing typically contains AutoCAD points at elevation, and polylines (either 3D or 2D) at elevation. This drawing will have a file size that is 50-75% smaller than the features drawing. Many engineering offices overlook this data for surface creation.

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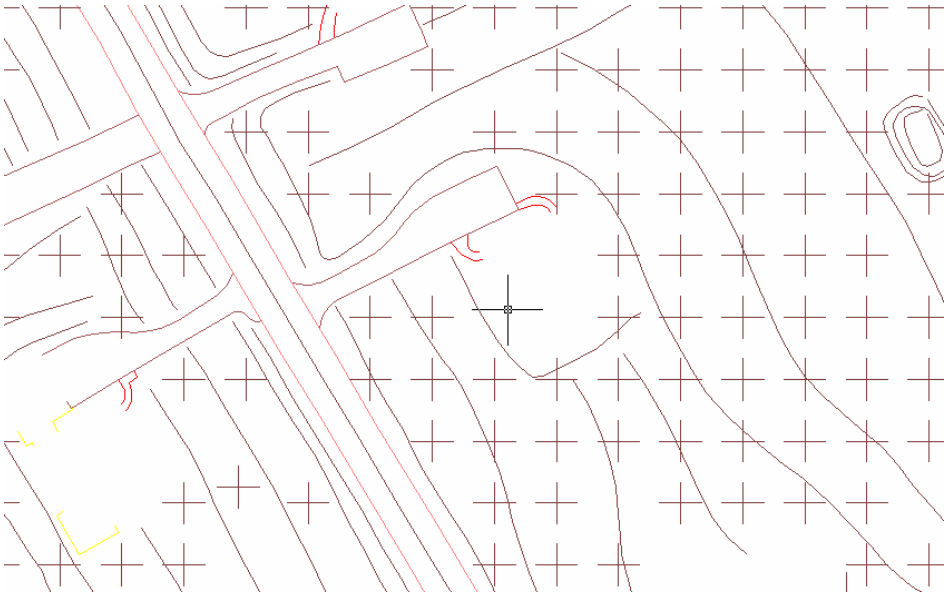
✓ Chances are good that you receive this drawing from your aerial topo company whether you realize it or not. Many firms have sworn up and down that they don't get a DTM drawing. When I make them dig out the original CD from the aerial company, we find the drawing on the CD. Usually, someone opened a DTM drawing once and didn't know what to do with it. From that point forward, the topo drawing was dumped on the network and the DTM drawing forgotten. If you check the CD and you aren't getting the DTM drawing from your aerial topo company, give them a call and ask for it.

If you have a choice- **DO** USE THIS DRAWING TO CREATE YOUR SURFACE.

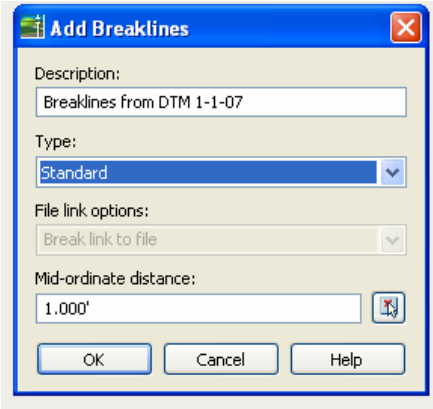


A close look at the DTM drawing for the same project.
Entire drawing covers 2400 acres, drawing file size 28.8 megabytes.

✓ If you cannot see your AutoCAD points, change PDMODE to 2 and adjust PDSIZE.

Procedure: Creating a Surface from Aerial Breaklines and Mass Points

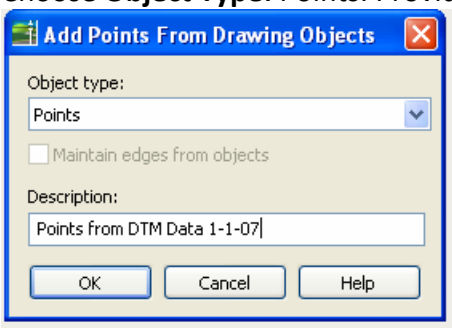
1. Create a new drawing from your Civil 3D template.
2. Surfaces>Create New Surface
3. In the Create Surface dialog, give your surface a name and select an initial style (probably a "no visibility" style for reasons discussed earlier in this paper.)
4. In Prospector, expand your surface definition and right-click on **Breaklines**. Choose **Add…**
5. In the Add Breaklines dialog, provide a description for your breaklines. Choose **Type:** Standard. Press OK.



6. The Command Line will ask you to Select Objects. Go into the drawing and make a large crossing window that includes all of your polylines, then right click to exit the command.

> ✓ It is OK if this crossing window includes those AutoCAD point objects. Civil 3D will filter those out since it is seeking polylines in this case. However, be sure that you do not have any other polylines visible in the drawing (such as the topographic linework) because zero elevation polylines will add a zero elevation to your surface data.

7. Your surface will build. Depending on the size of your drawing and your individual machine specifications, this could take several minutes.
8. In Prospector, expand your surface definition and right-click on **Drawing Objects**. Choose **Add…**
9. Choose **Object Type:** Points. Provide a meaningful description. Press OK.



10. The Command Line will ask you to Select Objects. Go into the drawing and make a large crossing window that includes all of your points, then right click to exit the command.

> ✓ It is OK if the window includes those polylines or even the Surface you may already see. Civil 3D will filter those out since it is seeking points.

11. Your surface will build. Depending on the size of your drawing and your individual machine specifications, this could take several minutes.

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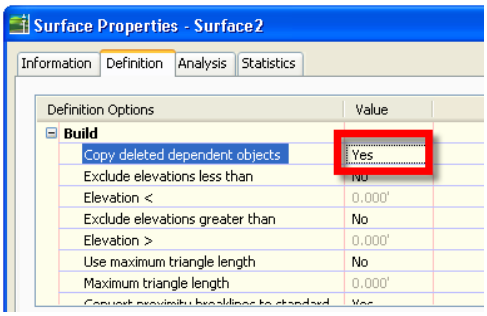
Should I Erase the Linework That Created the Surface?

By default, surfaces are dependent upon the objects that created them. For example, if a surface was created from polyline objects and those polylines were erased, the surface would disappear upon rebuild.

You can change this setting using the following procedure:

Procedure: Change the Copy Dependant Objects Setting

1. Select your surface in Prospector, right click and choose **Properties**.
2. In the Surface Properties dialog, switch to the definition tab.
3. On the Definition tab, note under **Build** that the **Copy Deleted Dependant Objects** field says **YES**. This setting makes a "copy" of the linework and absorbs it into the surface definition itself.



Since the DTM drawing can be very large before a surface is even built, it is tempting to erase those breaklines and mass points in an attempt to reduce file size.

I haven't found much drawing performance improvement in erasing this linework, but it might be worth experimenting.

> ✓ A Surface Snapshot can also be used to "freeze" the surface definition.

What About the Features?

Legally speaking, you probably have to show the aerial topography company's contours exactly. The only way to ensure this is to use that features drawing as an underlay through some kind of XREF. Since the features drawing can be quite large, you will need to find some other way to show this information. Here are two ideas:

1. Thoroughly weed, clean, flatten, purge and audit the features drawing, then attach to sheet drawings as an overlay XREF. If the drawing is simply too large to handle, use Map Queries to break it into logical chunks before XREFing.
2. Convert features drawing into DWF and attach through the XREF manager.

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Bringing It All Together

Once you have created all of the required Surface Only drawings, you can bring it all together by making data references. Use either Vault or Data Shortcuts to reference only the surfaces you need.

Resources

Books

American Society of Civil Engineers. **Topographic Surveying**. 2000.

Robert C. Steele. **Modern Topographic Drawing.** 1980.

Online Materials

Best Practices for Working with Large Data Sets White Paper from Autodesk
http://images.autodesk.com/adsk/files/large_data_best_practice.pdf

Working with LIDAR data in Civil 3D from Chris Gountanis of Imaginit

http://imaginit.rand.com/files/Workin%20with%20Lidar%20Data-White_Paper.pdf

Manage Surfaces by Mike Choquette of Imaginit

http://aec.cadalyst.com/aec/Column:+CAD+Clinic/Manage-Surfaces-Part-1-CAD-Clinic-Civil-3D-Tutoria/ArticleStandard/Article/detail/470059

Blog Resources for Using Map Tools and Dealing with Large Surfaces:

www.civil3d.com

Map 3D and Murph's Law at http://map3d.wordpress.com/