# WisDOT Use of Civil 3D: Concepts and Realities

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**CV5796** Wisconsin Department of Transportation (WisDOT) began using AutoCAD Civil 3D software with the 2010 release. Since that time, more of the department's internal users have switched over and WisDOT has switched platforms to 2012 and, more recently, to 2014. As WisDOT's use and user base have grown, the department has learned many lessons that have effected how it has moved forward. We will explore these lessons, specifically those that come from the development of standard concepts for use of AutoCAD Civil 3D software and the ways in which those concepts are put into practice in project workflows.

## Learning Objectives

At the end of this class, you will be able to:

- understand the importance of a coherent project structure
- understand the concept of the end result design
- understand the importance and efficiency of the single point of truth structure
- understand the capabilities of dividing larger projects

## About the Speaker

Russ Nicloy is a Civil Applications Technician for MasterGraphics in the upper mid-west. For 10 years he has provided training, consulting, and support for users of Civil 3D. Russ is an Autodesk Certified Trainer, as well as a Wisconsin DOT certified trainer. Before joining a reseller Russ worked for 10 years in a production role for gas, water, and site design. Through his training and mentoring role he has worked through many of the issues that users experience on every project. Russ has spoken at Autodesk University as well as many conferences for surveyors, road designers, municipalities, and GIS professionals.
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# Concept of a Consistent Project Structure

## Project Folder Structure

The project folder structure is critical to the maintenance of the project. Having a standardized structure allows for the project to be moved as a unit, both in-house or to external consultants (and returned). Part of the concern for transportation of the project folder structure are that the references can maintain their connectivity with a minimum of attention by the users. Both data shortcut references and external (XREF) references are important here since both will be used in large numbers.
One of the side benefits to the standardized folder structures is the ability for users to join a project, or take it over from previous users, and be able to find all of the necessary parts quickly. While references in particular can be found using “Open Source” options from within Civil 3D, other files and object definitions can be found based on standard locations. This reduces the time and effort of team member searching for design data, and of adding new users to a project.

### *The folders and their contents*

The data shortcut references are tracked in the _Shortcuts folder. This is created through standard data shortcut project creation methods, using the WisDOTProjectTemplate folder structure.

The BaseData folder holds all existing conditions data, including Survey data, mapping data, and any other captured data.

The Design folder holds all of the proposed data, including alignments and profiles, corridor designs, proposed surfaces and project design edgelines.

The ConstData folder is for all of the design data in a format used by the contractor.

The Metadata folder is for the project reports associated with the sheets.

The RW folder is for right-of-way and plat development data.

The Sheets Plan is for the plan and profile, plan only, section sheets, and any other sheets typically included in the project (Title, Details, etc.). This folder also includes a PDF folder for all of the final PDF sheets for output.

The SheetsOther folder is for miscellaneous sheets, exhibits, or sheets for Public Information Meetings. In other words, sheets that wouldn’t normally be part of the normal sheet set.

### File and Object Naming Structure

Similar to the folders, the files and objects have naming conventions that require standardization. This is so that the files spell out exactly what is in them, expediting the search for needed information. The object naming is important since there are so many similar objects in the course of a large project. As an example, the project alignments include the centerline, pavement edges, edge of gravel, right-of-ways, and beam guards, just to name a few. It had to be considered that some of the places the object names could appear would be dialogs that were either not fully expanded, or just not wide enough to display some of the longer names. So the naming conventions place the most important data to the front of the name, and attempt to shorten the name in the most appropriate ways possible. An example of this would be the STH 18 left edge of shoulder would be named 18-L-EOS. The Facilities Development Manual (FDM) spells out these options and gives extensive examples to clarify the many options. This should also help when names for unexpected needs arise.

## The Concept of a Single Source of Data

### As a Concept

*Dynamic Updating of Design Data*

The “single source of data” concept is one of the bedrock concepts used in developing the standards and workflows. The idea is to use the interactive dynamic ability at the core of Civil 3D, as well as the data sharing aspects of the critical objects, so that changes will update the project. This becomes even more important later in the development of a project when even small changes would require extensive attention. Certain rules are in place specifically so that Civil 3D can track and update those updates and ensure accuracies on calculations, labeling and sheet production.

#### *Unification of the Project Pieces*

Projects of any size will be divided up for access and file-size purposes. The single-source alignments and profiles become the unifying factors for this divided data.

#### *Exceptions*

There are exceptions to this concept in the project, but they are very specific. It was decided that project data that is going to the Right-of-Way (RW) developers would not be dynamic. This serves two purposes. First, design changes continue without changing the right-of-way files automatically. There are no surprises when the RW files are accessed later. Second, since by design the changes are not effecting the RW files the designers HAVE to ALWAYS report changes to the RW staff. There is no question - its standard and understood. There MUST be communication.

## Use of References

Because projects become large very quickly the use of references are critical. They allow the files to stay smaller than if all of the design was in one file. Also, they allow multiple users to access data and make changes at the same time. This concurrent use of data is critical as designs near completion. References take the form of AutoCAD's External References and Civil 3D Data Shortcuts.

### *Data Reference Shortcuts*

As mentioned regarding the project folder structure, data references are maintained through the _Shortcuts folder. Wherever a data shortcut could be useful it is used to unify the project. This has the combined effect of keeping data up to date, allows for concurrent use of important data, and also allows the critical definitions of objects to be in their own files, somewhat protected from accidental editing. The separating of data is taken to what some might think is an extreme level where one object is defined per file. This allows other users to work on other objects at the same time, while still allowing for data to be shared extensively. Some objects are in shared files, where necessary, such as alignments that have offset alignments. Also, profiles are almost always included in the host alignment's file. The one exception is for intersection files that need primary and secondary profile locking and interaction.

### *External References (XREFs)*

External references can be from any file to any file, but they must use "Relative Path" options. This is so that inside the project folder structure, no matter where the project is moved to, the XREFs can still be properly linked. The other option that is generally mandated is that the attachment type be "Overlay" rather than "Attach." This prevents circular references from being an issue, and generally makes the references slightly smaller on the file size. There are allowances for using the "Attach" option when a circular reference isn't an issue, and having to recreate an overwhelming number of individual attachments would not be reasonable. An example of this would be the plan sheets or section sheets.

## Data Integrity

The only way that the single-source of data can work is if that data is trustworthy, and truly the only source. Users may be tempted to explode, or copy, or…well, cheat with the data. If this happens the data integrity is lost, the single-source is no longer affecting the project data, and you have to start finding which file is up-to-date and which is static.

### *No Exploding*

While exploding any Civil 3D object is generally discouraged due to the destruction of intelligent object data, for WisDOT's workflow it is *highly* discouraged. Since exploding objects results in the intelligent information being lost, this also means the single source of data is broken. There are very few exceptions, and most times an alternative workflow can be found so that exploding is not necessary.

### *No Making Polylines out of Civil 3D Objects*

This is very similar to exploding, where the method results in a "dumbed-down" copy of an object that is no longer linked to the original. This also means that what appears to be a fully functioning design is really a non-updating picture-in-time of the design that is not updating with the design. Again, there are exceptions where polylines are acceptable, but they are few and far between. One such case is the road design edge lines. This is at the end of the design and is known that if changes occur the proposed edgelines will need to be recreated. This exception is a case where the loss of data is consistent and expected, therefore, reasonable to the workflow.

### *No promoting of data shortcuts*

Promotion of data shortcuts has the same effect as creating polylines from objects. It creates a non-connected copy of the object, that may be assumed to be still attached and updating, but is not staying up to date.

### *Exception to promoting data shortcuts*

Here is where a significant exception occurs. Use of the data by the right-of-way developers requires the data shortcuts to be promoted so that dynamic changes do not affect their legally binding documents. These are rare and very specific circumstances, and should not be the norm for other portions of the data. This is another occasion where consistently broken data is expected, therefore, reasonable to the workflow.

## Concept of the End Result Design

### The Surface is the Ultimate Result

One of the end goals for the WisDOT project design is to provide automated machine grading (AMG) with a more perfect surface data to work with. This may often mean the corridor is not the final authority on the design. It's a GREAT base for the data, and takes care of much of the design, but other methods need to be employed to finish the surfaces. Things like grading objects, or editing individual surface triangles are regular functions.

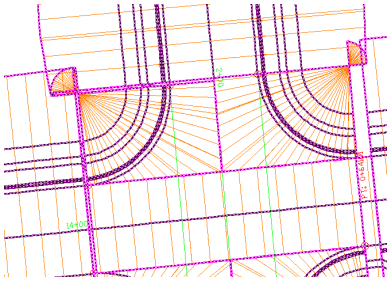
### *Editing and cleaning the surface*

There are places where the corridor surface can be expected to not be triangulated correctly. Where frequency lines are long, the surface triangulation will find it easier to go the wrong way. Normally this would require the surface edit "Swap Edge," but in this case adding a surface line here or there will be a more efficient method.

This manually editing can be useful in other areas as well. In particular check where curbs transition to shoulders, or other transitions. The idea here is to make sure that the corridor's surface triangles are correct.

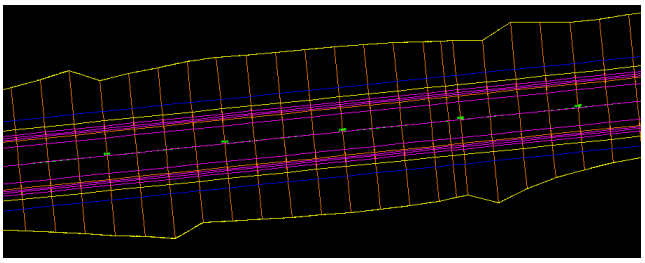
### *Grading in curb return areas*

Due to the high likelihood of corridor sections crossing over one another (a condition known as "bowties") the decision was made that it is better to always use grading in the curb return areas. This is discussed later in this document.



### *Grading in slope transition areas*

Due to design constraints some daylight slope transitions occur too quickly to satisfy construction constraints. In these areas special grading workflows have been created to smooth out the transitions. These grading areas are discussed later in this document.



## The "Refinement" Surface

The refinement surface is a surface separate from the corridor surface that other surface parts can be pasted together into. Think "final proposed" surfaces. The WisDOT standard is to have the refinement surface to be its own file, so that multiple users can edit the parts that contribute to the refinement surface and update it through data shortcuts.

### *Pasting in the surface parts*

The refinement surface is the perfect place to combine the curb return grading surfaces, any slope transition grading that may have been necessary, and other miscellaneous gradings.

### *Combining separate corridor parts*

Generally, longer projects will be broken into 2-mile sections, with a maximum of 5 intersections on any one given file. This means parts of the corridor design that are intentionally in other files will need to be joined up at the end. The refinement surface is where this will happen. Data shortcut referencing of these separated surfaces will bring them together in a single file, and model.

### *Every surface*

In the course of the project several surfaces are going to be needed. Especially where these surfaces need to be kept separate for the machine grade control equipment. There will be a refinement surface for the top, the subgrade (datum), base course, and others depending on the project. Each of these final refinement surfaces will have its own DWG file. Later these final refined surface files will be exported to an AutoCAD (non-Civil 3D) file, a format that is common to the machine grade control equipment.

## Corridor Surface Creation

Although the corridor is not the final critical model, the surfaces that come from it should make full use of its design ability. For this reason certain rules should be followed for creating the corridor's surfaces.

### *From Feature Lines*

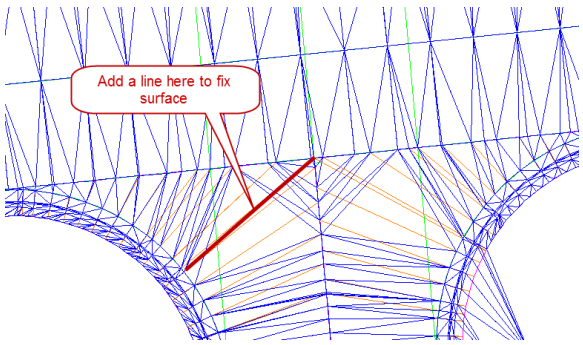
Technically, surfaces that are made by breaklines have the ability to be more correct. WisDOT has mandated all corridor surfaces to be created by Feature Lines rather than the link codes. There are exceptions that a link surface can be added, but only to augment the feature line surfaces. If a link surface is used the overhang correction cannot be used on it. This has an opportunity to be "too perfect," and gloss over where the surface needs attention.

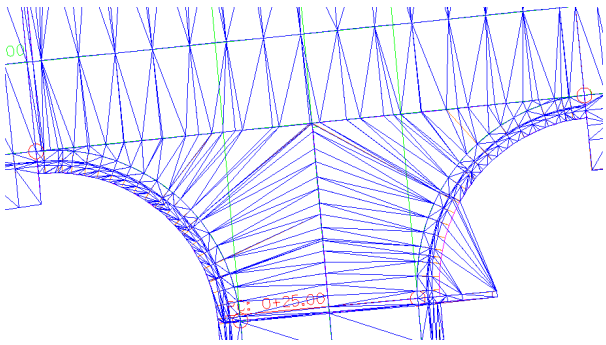
## Grading and Special Surface Additions

Since the surface is the ultimate design goal, sometimes the design surfaces will need to be adjusted differently than the corridor has created them. The designer can edit the surface directly, as they would any other surface, or by using grading functions.

### *Direct Surface Editing*

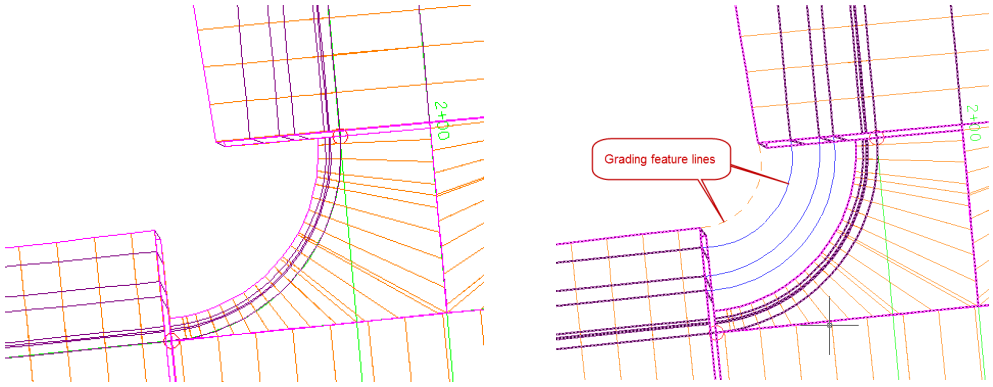
There are areas in a corridor that the surface will generally not create the way the designer intended. Likely this will occur in areas where the corridor frequency widths get very wide. An example would be in intersections, where crown points are much closer together than the road edge points, so the surface will attempt to cut across the intersection. This creates a flat spot that was not intended. In areas such as these, Using the surface Edit tools can add one or a few extra surface triangle lines that force the corridor surface to be shaped correctly.



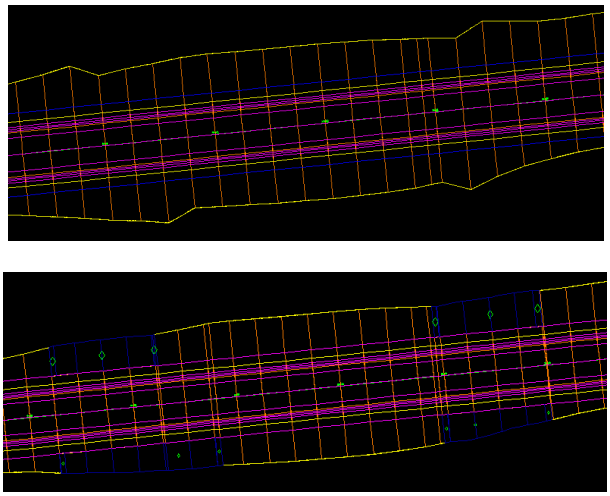
### *Grading in the Curb-Returns*

It was discovered early on that curb return areas in particular tend to be such a tight radius, and that the daylight slopes and elevations end up further out than in most areas, that the chance of overlaps (“bowties”) was very likely. For this reason it was decided that all curb returns should not use daylight subassemblies. These areas are graded using feature lines. The feature lines are attached to the end of one set of daylight’s feature lines, and then connected to the other daylight feature lines – setting the elevations on both sides. Then, the connecting feature lines can be edited to appropriately model the curb return area. The surface is created from these breaklines, and referenced into the refinement surface where they are pasted with the corridor surface.




### *Special Daylight Area Grading*

Because corridor definition is created at frequency stations some slope transitions are created much too quickly. For example a 4:1 daylight slope may need to transition to 2.5:1 in certain conditions. The corridor will do this in the 5’, or 10’ or whatever the frequency is. However, the WisDOT standard is at least 100’ for such a transition. In these areas the daylight is removed and grading replaces it. The surface from this grading is referenced into the refinement surface where it is pasted into the final surface.



#### *Grading for Corridor surface editing*

In some situations you may need to create grading over the corridor itself. Remember that the resulting surface can be data shortcut referenced into a “refinement” surface and pasted in. If it is pasted in after the corridor surface it will take priority and change the overall surface. This priority order is true of the other surface edits and pastings as well, but this will be more obvious if it is in the middle of the corridor.

## The Concept of Dividing the Project

### Unity through Alignment and Profile

As mentioned before, projects will generally be broken into parts. This keeps large projects manageable, and allows for concurrent user access to the design. As long as the alignments and profiles are single-source data they easily unify the project in later files.

#### *Roughly 2 Mile Sections*

It was decided that roughly 2 mile sections was long enough for dividing a project. This is a rough estimate, but a decent measurement to follow.

#### *Five Intersections per File*

Because intersections are so much more complex than normal corridor sections it was decided fewer intersections per file were a prudent idea. Reasonably, there will need to be intersections in close proximity to each other, and it will be useful to keep them in the same file. Generally, less than five would be best.

#### *Intersection Proposed Profile Exception*

Further, because of the profile locking mechanism in the intersection tools it is allowable to create proposed profiles for secondary roads in the intersection file instead of the normal alignment/profile files. This is only if the Intersection tool is being used. If the designer has chosen to do the intersections manually, then the secondary profiles should only be in the secondary alignment file.

### Surface Combination through the Refinement Surface

The key to dividing a project into parts in this way is the ability to combine it at the end. As discussed above, a refinement surface file is created and finished surfaces are referenced into it. First, the corridor surface is pasted in, and then any of the graded surfaces. Since the alignment and profile are the unifying parts the individual surfaces, the surfaces end and begin at very accurate station and elevation locations. They then paste together smoothly, and should show no sign of having been separately developed entities.