Using Autodesk Map® Capabilities in Autodesk® Civil 3D®

Neil Brooker - Autodesk

CV33-3  This class is designed to show civil engineers using Civil 3D the power of Autodesk Map. Used in combination with Autodesk Map, Civil 3D becomes much more than the engineering tool the majority of users experience. The class will show the power of data integration, database connectivity, data cleanup, data queries, and more in a civil engineering context.

About the Speaker:
Neil has worked for Autodesk for 5 years as a presales technical engineer for the Infrastructure Solutions division. The work involves presales consultancy, training, technical benchmarking and application specification, product demonstration, GIS industry presentations and post-implementation consultancy, and technical support. The products he has supported include Autodesk Map, MapGuide, Land Desktop, Civil Design, Civil Survey, Civil 3D, Envision, Raster Design and OnSite Enterprise. Previously, Neil worked in a GIS research team at the Scottish office exploring environmental data integration techniques using ESRI, MapInfo, SmallWorld, and SPANS products. Neil holds both BA and Master of Science degrees.

neil.brooker@autodesk.com
1. Introduction

Many in the Civil Engineering industry are by now familiar with the power of Autodesk Civil 3D® and the dynamic model approach to Civil design. Autodesk Civil 3D® helps increase profitability, and provide better service to customers by improving conceptual and detailed design and drafting services. It also offers dramatic efficiencies through the planning, design, and documentation phases of engineering projects. But it may not be so commonly known that within this powerful AutoCAD and model based design software there is a complete geospatial design, integration and analysis tool, Autodesk Map 3D®. Further, it may not be commonly known how to utilize these features to further enhance the accuracy, efficiency and integrity of their designs.

The purpose of this class is to introduce and explore the most powerful features of Autodesk Map 3D® in a Civil Engineering context, to give overviews of each feature and to demonstrate their use. The philosophy behind this class is that no Civil Engineering undertaking exists in isolation from matters of environmental, infrastructural, cultural or geographic importance. With Autodesk Map 3D® under the bonnet of Autodesk Civil 3D®, users have the tools at their disposal to integrate, analyze and present such data in the design process. The features also enable the management of assets in the post-construction phase of any project.

2. Overview

2.1 What is Autodesk Map 3D®?

Autodesk Map 3D® delivers the power and precision of AutoCAD plus an integrated toolset for infusing your data with geospatial intelligence. In short, Map 3D connects civil engineering, CAD and GIS (Geographic Information Systems).

Autodesk Map 3D® 2006 software is a powerful 2D and 3D precision mapping and GIS analysis tool for mapping technicians, planners, utility managers and designers, and cartographers. With Autodesk Map 3D®, you can create, maintain, and produce maps; integrate data from various sources and formats, including Oracle® Spatial; perform data analysis; and produce thematic maps. Users can work with multiple drawings, and multiple users can edit the same map simultaneously. Built on the AutoCAD® 2006 foundation, with a new and enhanced application programming interface (API), Autodesk Map 3D® is the foundation of a complete infrastructure solution.

Autodesk Map 3D® software is intended for GIS managers, GIS specialists, mapping technicians, planners, facilities/infrastructure management designers and managers, and others who create, maintain, and produce maps, design infrastructure, use their map data for analysis and planning, and/or integrate data in varying types and file formats. Their data may include vector or raster data in a variety of mapping file formats, as well as database (both geometry with Oracle Spatial and attribute data) information from different sources.

Users typically work with multiple drawings and large data sets. The industries that benefit most from Autodesk Map 3D® are utilities (electric, gas, water), communications, government agencies, environmental engineering, oil & gas, agriculture, and natural resources. Autodesk Map 3D® is suitable for any application that requires management or design of resources or infrastructure in a precision graphical environment.

2.2 Autodesk Map 3D® Key Features and benefits

With Autodesk Map 3D® embedded within Autodesk Civil 3D® the user not only has a complete AutoCAD environment and a powerful best of breed model based design tool but also a comprehensive GIS platform. With this, the user can add other data formats, compile links to multiple project components, support multiple user editing and querying, create and define real world features, connect design objects to spatial and non spatial databases, use real world coordinate systems and publish data to the internet.
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The main features of Autodesk Map 3D® are:

- A multi-user environment that manages multiple GIS files or CAD drawings across a seamless spatial extent for data creation, editing, query and analysis
- Native support for several industry-standard GIS and CAD data formats.
- Native support for hundreds of worldwide projections and coordinate systems
- Native support for GIS data stored in a relational database like Oracle® Spatial and Autodesk® GIS Design Server.
- Flexible, user-definable attribute data embedding through object data tables.
- Powerful thematic and property display tools
- GIS spatial analysis tool such as network tracing, buffer and polygon overlay
- Data management tools to coordinate project specific data.

3. Overview of Autodesk Map 3D® Tools

Before we look at the individual features of Autodesk Map 3D® that can benefit a Civil Engineering project, let's take a quick tour of the main Map menus and tools. In Autodesk Civil 3D®, mapping capabilities are found in two main areas: the Map menu and the Project Manager Task Pane.

3.1 The Map Menu

The Map menu on the main Autodesk Civil 3D® menu bar contains most of the commands needed for data integration, spatial analysis, project management, editing of spatial data, database connectivity, real world feature creation and more. The main menu is shown in Figure 1.

![Figure 1: The Map Menu](image1.png)

The features of the Map menu that will be covered in this class are: Drawings, Query, Feature Classification, Object Data, Database, Image and Tools for import and export.
3.2 The Task Pane

The Autodesk Map 3D® Task Pane is similar to the Autodesk Civil 3D® Tool space that contains the Prospector and Setting, but contains very different data management and presentation capabilities.

By default the Task Pane will not be active in Autodesk Civil 3D®. To show the Task Pane go to the main menu and select: **Map > Utilities > Task Pane**

You can activate the Task Pane automatically by changing the Map Options. Go to the main menu and select: **Map > Options**. In the Map Options dialog make sure you check the ‘Show Task Pane on startup’ checkbox (Figure 2). You should also check the ‘Show Display Manager on startup’ checkbox (Figure 2). This will give you the tools to graphically display your data by attribute thematic or properties. Note you may also choose to disable any of the data management capabilities in the Task Pane.

![Figure 2: Setting up the Map Task Pane](image)

The Task Pane consists of three tab panels: Map Explorer, Display and Map Book.

- **Map Explorer**: allows you to manage data in a multi-user environment. This includes using other drawing files in your current project, creating data queries, attaching databases and drawing objects from spatial databases, creating topologies (the description of relationships between objects) and creating real world features using feature classes (Figure 3a).

- **Display Manager**: provides tools to control the visibility and display of data layers in your project. This can be done on a CAD layer, on the basis of a query, on a Feature class, Raster image or a topology. The layers can also be classified according to chosen criteria to provide powerful data representation and thematics (Figure 3b).

- **Map Book**: provides the capability to create and control sheet sets containing spatial data. These sheets are navigable within the Map Book and can be plotted as jobs or to digital format (Design Web Format – DWF) for data lifecycle management (Figure 3c).
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4. Using Autodesk Map 3D® capabilities in Autodesk Civil 3D®

4.1 Example Project

To display the capabilities of Autodesk Map 3D® in Autodesk Civil 3D® the majority of the class follows a Civil Engineering road project. The project centers on a road relief scheme to the south of the town of Beverley in northern England. The by-pass will consist of 1.5 miles of a newly constructed 2 lane highway through pre-dominantly arable land. The engineers already have detailed survey data across the proposed route and could already begin the design process using Autodesk Civil 3D®'s powerful dynamic model. However there are other factors to consider before the exact routing can be finalized; factors that the Map capabilities can help incorporate and integrate.

4.2 Using Raster Imagery to Analyze Site Information

Raster images (data represented by squares or pixels of a uniform size or resolution) are often displayed as a backdrop to GIS or mapping data. In their simplest form raster images, such as aerial photographs or satellite imagery give spatial context to a project. Further they can be used as reference to create new vector data. Of great importance to any engineering project is the added value they give to site analysis. Trained operators can interpret form and luminance of imagery to indicate such environmental factors as soil type, rock type, slope, drainage, land use and human habitation. Such factors can have a very large bearing on the design of construction projects.

While AutoCAD can be used to insert such imagery it does not support all of the geospatial industry’s major raster file formats. Further, the Image capabilities in Map 3D allow you to use georeferenced imagery: that is, imagery that knows its insertion point and orientation in real world coordinates. This means that as long as the project design is being coordinated using real world coordinates.
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coordinates, additional data such as imagery will appear in the correct place. The Map 3D capabilities in Civil 3D allow the use of hundreds of national and local coordinate systems.

In the context of this example project, aerial photography can be used to analyze the proposed route of the relief road. To import an image simply go to the Map menu on the main menu bar and select **Image > Insert**. After selecting the required image the Image Correlation dialog appears (Figure 4). This shows georeferencing information for the image (normally held in a supplementary header file for the image). You may choose to change the insertion point and scale and rotation in the Insertion tab panel.

Selecting the ‘OK’ or ‘Apply’ button will import the image into the drawing in the specified location. Figure 5 shows an aerial photograph for the Beverley area. The survey data is overlain to show the general proposed route of the road. Within this zone, engineers can rapidly pick out obstacles such as other roads, houses or water features from the imagery.

**Figure 4: Image Correlation Dialog**

**Figure 5: Aerial Photograph of Relief Road Project Site**

4.3 Data Acquisition: spatial data exchange

Common with most mapping and GIS projects, the design phase of Civil Engineering projects involves a common first step; acquiring the correct data. This can involve more than just ground survey data. Very often data about the environment, soil types, climate, flood risk, drainage and population is required for optimum, cost effective design. Engineers and draftsmen could create this data (using such sources as the imagery used above), but it is very likely that it already exists in some digital format. Further, engineers may have to exchange such information with contractors who use a preferred data standard. While it is calculated that 70% of the world’s spatial data has been captured in DWG format there are several other widely used GIS data formats.

Autodesk Map 3D® uses the GIS industry’s accepted standard for data support and exchange. Safe Software’s Feature Manipulation Engine (FME) powers data support for several data formats such as:
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- ESRI SHP, Coverage and e00
- Microstation® DGN®
- MapInfo® TAB and MIF/MID
- GML v2
- Federal data transfer standards SDTS and VPF
- Digital elevation models (DEM)
- Triangulated irregular networks (TIN)

Autodesk Map 3D® data exchange capabilities not only supports double-precision vector geometry and thousands of coordinate systems but also drawing object properties, object data and associated database information so that drawing intelligence is not lost in the import/export process.

4.3.1 Spatial Data Import

In this example, land parcel data already exists for the project area, available from the National Mapping Agency. This data is stored in MapInfo TAB format and includes attribute data reflecting land use, parcel area, change information and unique identifiers. For the project this data can be used to:

- Add spatial reference data for the construction phase
- View the land use for the proposed site
- View areas of parcels and analyze parcel fragmentation and size changes during design
- Attach ownership information if available in a database

The import process for spatial data in Autodesk Map 3D® provides common options regardless of data format. In this case we will import a MapInfo TAB file with associated spatial intelligence. To start a data import, on the main menu bar select **Map > Tools > Import**. This will open the Import Location dialog. In this dialog the user has the option of selecting the data format they will be using as well as the data file itself (Figure 6). Once selected the Import dialog enables the selection of import options (Figure 7).

If there is more than one layer of information in the import file the user can select which ones to import. They can then choose the drawing layer or layers to place the imported geometries on. All geometries can go on one layer, either existing or new, or geometries can be split onto unique layers according to attribute or properties (Figure 8). Intelligent attribute data can be imported as well. The user can select which object data table to place this information in as well as which fields (or columns) of information to use (Figure 9).
In this project we will import land parcels onto one layer in the drawing file, with intelligent attribute data created in one object
data table. The data being imported are Polygon geometries. We can choose to view these as closed polylines instead. This
means that we can use the data proactively in the design process later as Civil 3D Parcel objects. Figure 10 shows the imported
land parcels objects. It also shows intelligent attribute data from the object data table for the selected parcel.

4.3.2 Using spatial data in the Civil 3D design phase

While such spatial data import capability provides useful context information for an engineering project it can also be
incorporated into the Civil 3D model itself. In this case, the imported land use parcels can be converted into Civil 3D parcel
objects and used to examine the impact of the road design on existing conditions.

As we have imported the spatial data as closed polylines they can be converted to Civil 3D parcels immediately simply by using
the **Parcels > Create from Objects** menu command. Depending on the Parcel Style chosen to represent the parcels we can
view area, perimeter and parcel segment information as well as any custom information contained in the Style. Figure 11 shows
some parcels that cross the project area transformed into Civil 3D Parcel objects. The survey data has been used to create a Surface, displayed as contours. Any interaction with the design model will now also affect the parcels. In this example, we can draft an alignment to represent the road center line. As the alignment is created the Parcels dynamically update and fragment, giving us new Parcel objects and dimensions (Figure 12).

Figure 11: Transforming spatial data to Civil 3D Parcel objects  Figure 12: Dynamically updating Parcel Objects

As the alignment is drafted, the existing parcel objects split automatically and new parcels are created, each with new properties. This will be important of course to notify any land owners. There may be other considerations too, such as drainage changes, or site access.

Of course we could take the design further in this scenario to create a highway boundary. We could also export these parcels to a supported data format using the Map 3D export capabilities to share with interested parties (see the exporting design objects section later in the class). Finally, we are not limited just to parcel objects. Imported vector data using the Map 3D capabilities could be the basis for creating Civil 3D alignments, points, surfaces or grading as objects.

4.4 Presenting design data using the Display Manager and object data

Presenting designs and drawings in a straightforward and compelling way can help deliver complex information effectively. The Autodesk Map 3D® Display Manager provides a visual tool for symbolization and cartography. Users can define display elements using spatial, property or data criteria and one or more symbolization properties.

Figure 13 shows the imported land parcels classified according to land use type. Such thematics are easy to produce and give powerful insights into the intelligent spatial data and spatial patterns.
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You can rapidly create as many thematic representations of your data according to underlying attributes or more complex data queries using Display Manager. Here we can also display the land parcels according to ranges of areas. In Display Manager select the arrow next to the ‘New’ button and choose ‘Layer’ (Figure 14a). In the layer selection dialog select the layer you wish to represent, in this case the layer containing the parcels (Figure 14b).

The new layer appears in the Display Manager panel. To specify the display criteria you add stylization. In this case, select the ‘Add’ button in Display Manager and select ‘Theme’. The Thematic Mapping dialog allows you to specify the type of theme: individual or ranges of values (ranges in this case, as we are dealing with numbers). You can then select where the values are obtained from. In this case the values are stored in an object data table called ‘TopographicArea’ (created during the import process) in a column called ‘CalculatedAreaValue’. Once selected you read the values and select the type and number of ranges required. Map 3D then divides the values into the ranges specified (Figure 15a). Finally you select the color schemes to use to represent the data (Figure 15b). Figure 16 shows the result of the new data classification.
4.5 Attaching drawings and creating queries

During the design phase, data relevant to the project may already be stored in other DWG files. Autodesk Map 3D® supports a multidrawing environment where users interact with a collection of drawing files called a drawing set. You can run queries against this drawing set to extract required objects into the current project where they are available for editing. This is very different from the XREF capability in AutoCAD because users can actually import the objects into their current drawing without locking the source drawing. In Map 3D locking is performed at the individual object level, not the file or drawing level. As a result, multiple users can edit objects from the same file at the same time! Users can additionally save modified objects back to their original drawings.
In this example, Engineers need to know where existing services, such as pipes and cables, are located within the proposed development site. They will also need to add services such as drainage pipes to the existing infrastructure. A drawing containing the location of water pipes already exists as a DWG. To incorporate these objects into the design phase Map 3D enables the user to query the pipes in from the original drawing. All objects can be queried, or a set of criteria can be set to filter the objects. In this case, the engineers need to see all pipes within 200 meters of the proposed road alignment. At this stage, the class assumes that the Engineers have already used the Civil 3D model tools to create a Corridor object from a design profile, alignment and assembly.

To attach a DWG file to the current project you use the Map Explorer panel on the Map Task Pane. Select the 'Attach' button and select drawing (Figure 17a). Navigate to the DWG and select it. The DWG will appear as an icon underneath the Drawings folder in Map Explorer (Figure 17b).

At this stage the data in the attached drawing can be viewed by right clicking on the icon and selecting quick view. At this stage however the objects are not editable and object data not viewable. To do this we need to perform a Query. Queries can be very simple, such as 'read all objects'. They can be more complex as you refine your criteria. For example you can query in objects based on location, on an attribute (for example only 8mm pipes), on a property such as a layer or line width and color. Further, you can change the appearance of objects as they are queried. Queries can also be saved in libraries or in external files for others to use.

In this example project we wish to query in all pipes within 200 meters of the proposed alignment. In Map Explorer, under the Query Library we click on 'Current Query' to display the Query Dialog box. Here we define our specific criteria based on location, properties, data, database information, or combinations of those. In this case we could select the location criteria and select 'Buffer Fence' and 'Crossing'. We could then trace the alignment and specify a width of 200 for the buffer when prompted.

A better, more accurate way to perform the query in this case would be to use the Corridor design as a reference. To do this, export the Crown feature line of the corridor to a Polyline using the Corridor tools in Civil 3D. Now we can use this line as the center of a query buffer. In the Query dialog we can now specify a location query, based on a Polyline crossing Buffer fence with a width of 200 meters (Figure 18a).

The Query Dialog box displays the query and gives options to Preview the selection or Draw the selection. By selecting 'Draw' and then 'Execute Query' all those objects within 200 meters of the road are brought into our project for analysis and editing (Figure 18b). The result is shown in Figure 19, with existing pipes in red.
It is also worth noting that the same result can be achieved using the display manager and creating a new layer based on a query of attached drawings. That layer could then be classified, according to pipe width or depth for example.

### 4.6 Creating Real World Features using Feature Classes

Autodesk Map 3D® incorporates a new property called a feature class. The feature class object property is used to identify drawing objects as real-world features such as roads, parcels, or pipes. Feature class definitions are derived from standard geometry objects but can incorporate object properties such as layer, color, linetype, and associated or embedded data fields. Associated data can include valid data ranges and values. For example, Figure 20a depicts a waste water pipe with a data range that represents the condition of the pipe.
A major benefit of feature classification is that drafting is controlled to standards, and attribution is controlled to set ranges or values. This means that throughout an organization drafting is undertaken to set standards, eliminating error or confusion: for example, a road is a road of set color and line weight and can only have 2 or 4 lanes.

Feature classes are stored in XML files and can only be created by administrators. Users attach the feature classes to their project (Figure 20b) and can classify existing objects or create new ones. They can add feature attributes, but only to set values.

In this project we could classify the existing service pipes we just queried into the design. We could also create new services to reflect drainage for example. In Civil 3D we can also use Civil 3D objects. For example if the engineers draft a Civil 3D pipe network to capture run-off, they could also classify the pipes as features. Figure 21 shows a Civil 3D pipe design classified as a pipe feature. The pipe is then automatically assigned properties and attributes as shown. The engineer could then change the attributes accordingly, but only within set values.

Taking this further, the feature class could be added as a layer in Display Manger and classified according to its attributes (pipe type or width for example).

Feature classes can be created by anyone with the administrative rights. There is also an increasing stock of industry standard classes available on the internet.
4.7 Using Databases

We have already seen how object data tables in Autodesk Map 3D® can be used to add intelligence to engineering design projects. However, as the amount of information grows in these tables the file size also increases. Further it may be a requirement to share this information with other applications that do not require a graphical component. And of course a wealth of information may already exist in databases that can provide value to the design model objects.

With Autodesk Map 3D® you can export object and feature data tables to external ODBC databases, such as Oracle®, Sql Server, Access or Excel. This information can then be used in other applications within the organization. You can also establish links between objects and features in your project and an existing database. These relationships can then be used to analyze spatial relationships, query and filter information, navigate the design or edit and add to the database information. The power of the latter capability lies in the fact that any change to the database information will be automatically reflected in the design objects and all other applications viewing the database: everybody has access to the most accurate, up to date information. This also makes databases a powerful tool in the post-design management phase of any project, to find and maintain assets.

Using the Map 3D database capabilities in Civil 3D it is very easy to utilize the power of databases. In this project example an Access database has been created to store additional information about the recently created Civil 3D pipe network junctions. First, we can define the junctions as features, using a Junction feature class. This will automatically assign feature data to set standards and values. Using this feature data table we can link to a database using a unique identifier column that exists in both the feature data table and the database table.
To use database information we first attach the database to our project. On the Map Explorer panel of the Map Task Pane select the 'Attach' button and select 'Data Source' (Figure 22a). We can then navigate to and select the appropriate database. The database tables will appear in the Map Explorer (Figure 22a). At this point we can open and view the database information, but we have yet to establish the relationship between the tables and the design objects. To do this we define a Link Template. By right clicking on the Link Templates folder in Map Explorer we can define the database table, feature table and unique data column that will define the relationship (in this case a column called ‘datalink’). Figure 22b).

All that remains now is to process the links. On the Map menu go to Tools > Convert Object Data to Database Links. The dialog box allows us to choose the Object or Feature data table to link to the database, whether we are writing new data to a database or linking to existing data, the unique identifier to use, and which objects and layers to process (Figure 23a).

The result in this case are pipe network junctions linked to an external database. By selecting the database table or link template we can view the associated data in the Data View window. The Data View allows spatial query and navigation: by selecting a record in the database the drawing navigates to that object (Figure 23b). Further the database records can be filtered, for example, to view only those records containing a certain attribute, such as depth to rim or junction material. The user can also select an object in his design and the associated record will be shown in the Data View.

Figure 22a: Attaching a Database                              Figure 22b: Defining a Link Template

Figure 22a: Establishing a Database Link  Figure 23b: Using Data View to navigate and query design objects
4.8 Exporting and Sharing Engineering Design Data.

The final section of this class provides a brief overview of the capabilities of Autodesk Map 3D® to share design data with other interested parties. Many Civil Engineering projects need to share data with contractors, managers, public planning bodies or the public. Using the Map capabilities in Civil 3D there are a wealth of ways to share design data whilst maintaining data integrity and accuracy.

As with the import capabilities, Map allows you to export data to the format of choice, whether it is DGN for Microstation users or ESRI SHP files for analysis by public bodies. Not only are geometries maintained to double precision but any associated attributes or feature data can be exported.

Further, while AutoCAD supports the generation of light weight Design Web Format (DWF) files for digital distribution, Map extends this capability by enabling the creation of multi-sheet Map Books in DWF format. These are navigable representations of the project design in defined plot sheets, exported to DWF.

Finally, Map allows the design data to be shared to a wider audience using Autodesk’s MapGuide technology. This allows interested parties to view, navigate, query and view reports and other documentation about the project using nothing more than a modern Web Browser. Figure 24 shows our completed road design in a MapGuide application on the web.

![Figure 24: Distributing Project Design Information Using Autodesk MapGuide](image-url)
5. Summary

This class has introduced some of the powerful data creation, management and spatial analysis capabilities provided by Autodesk Map 3D® within Autodesk Civil 3D®. Using these capabilities Civil Engineers can use the powerful model based design tools within Civil 3D in conjunction with intelligent, spatially enabled capabilities. Using Autodesk Map 3D® engineers and drafters can:

- Use other environmental, topographic, geological, cultural or political data in the design process to increase context, accuracy and efficiency.
- Share data accurately with interested parties without losing intelligence.
- Use the power of visual data representation to study pattern or provide reports.
- Create real world objects to set data standards
- Create Civil 3D design objects from GIS data
- Attach and use a wealth of information held in databases
- Incorporate and filter existing DWG design data to provide supplementary information
- Manage assets and share information to a wider audience