Using CAD in ArcGIS®

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Using CAD in ArcGIS

About This Document

The following is a discussion of the computer-aided design (CAD) technology in ESRI® ArcGIS® and how it can be used for editing and bidirectional interchange of CAD and GIS data. Included is an overview of CAD-related technology in ArcGIS and a section describing the functionality needed for various users and their common tasks.

ArcGIS CAD Technology

ArcGIS CAD Feature Layers and CAD Drawing Layers

As much as 80 percent of the CAD functionality needs of most GIS users can be accomplished using the native capabilities of ArcGIS. CAD files can be read as a single background layer (CAD Drawing Layer) or as a collection of point, line, polygon, and annotation feature classes (CAD Feature Layer).

There are accommodations that need to be made in the construction of the feature classes of the CAD Feature Layers that some CAD users may be reluctant to make, and there are some subtleties of the CAD Drawing Layer that ArcGIS does not expose. However, for most GIS users' applications, the CAD Feature Layer and CAD Drawing Layer will be a suitable means of working with CAD drawing file data.

The CAD Drawing Layer functionality is only meaningful in ArcMap™ (the map query and display application within ArcGIS Desktop) and ArcScene™, the viewing application in ArcGIS 3D Analyst™, and allows an entire CAD drawing and all its various objects to be displayed as a single map layer. The CAD Drawing Layer is depicted by the white drawing icon when browsing for data in ArcGIS. The vector objects in the CAD Drawing Layer can be selected and their graphic properties displayed with the Identify tool. The CAD Drawing Layer is most useful when all you need is to display a CAD drawing in ArcMap as a backdrop or drape the CAD data over a three-dimensional terrain in ArcScene. The CAD Drawing Layer is often compared to an "image" of the CAD file. The CAD Drawing Layer differs from an image in that the data is still vector data; it is more analogous to a group layer in ArcMap. If you wish to use the CAD data as GIS features for query, for analysis, or to change symbology, then you can use the built-in CAD Feature Layer option of opening CAD files.

The CAD Feature Layer opens a CAD drawing and treats the CAD file as a source of GIS features. The icon for CAD Feature Layers is the expandable blue folder, which contains point, line, polygon, and annotation feature classes. Breaking the drawing up into these distinct feature class types allows ArcGIS to interpret the CAD geometry as ArcGIS geometry and the CAD graphic properties as a virtual table of attributes. In memory the CAD Feature Layers are treated no differently from other ArcGIS data sources for query, display, and analysis. (Technically, this is handled like an ArcInfo™

coverage, which is most important when you consider that the annotation must be converted to get geodatabase annotation.)

When working with CAD Feature Layers on typical CAD drawings, it is often useful to define a feature layer that limits the contents of a drawing file to display a single system of data. For example, a CAD drawing may include many types of lines, and the user may only be interested in the road lines. In such a case, one would typically limit the visibility of a map layer in ArcMap to just include line entities on a specific CAD layer, effectively ignoring the rest of the lines in that CAD drawing. A separate ArcMap layer pointing at the same CAD file would need to be added to a map with a different set of defining parameters if the water lines in the same drawing were to be another map layer. It is not uncommon to add the same CAD file to ArcMap multiple times to expose what would be considered different data sets in ArcMap that live in the same CAD file.

CAD Feature Layers are supported in ArcCatalog™, ArcMap, and the ArcGIS geoprocessing framework of ArcToolbox™, all core components of ArcGIS Desktop. Using CAD Feature Layers in the geoprocessing framework is a simple way to expose CAD drawing data as input for various conversion or data analysis processes. In addition to the CAD Feature Layer capability, ArcGIS provides several CAD-specific geoprocessing tools. The CAD-specific tools include Import CAD, Export CAD, Add CAD Fields, Assign CAD Alias, and Create CAD Xdata. These special geoprocessing tools are intended to provide the necessary flexibility to perform complex translation processes. These tools do not rely on CAD Feature Layer functionality, but rather have their own method of opening a CAD drawing and saving it as a "staging" geodatabase, whereas the CAD Feature Layer performs its conversion only in memory. These CAD-specific geoprocessing tools are used as the building blocks in models and scripts assembled to perform common translation tasks. Sample scripts and models are provided to the user in a special CAD Translation Toolbox shipped with ArcGIS. Users can also build their own custom CAD translation models or scripts with these CAD-specific geoprocessing tools.

Deciding whether or not to use CAD Feature Layer functionality to open CAD files or to use the CAD-specific Import CAD tool in geoprocessing is determined by the requirements of the translation or geoprocessing operation. It is far simpler to use the CAD Feature Layer for a single CAD file in which there is no need to treat attributes as entities or annotation, extract AutoCAD extended entity data, or make extensive use of MicroStation user data. The geoprocessing Import CAD tool will provide better geometric support for splines, three-dimensional features, annotation, and CAD-based imagery. The geoprocessing Import CAD tool is also designed to accommodate multiple files as input to a translation operation.

It is useful to remember that CAD Feature Layers are a valid data source for the geoprocessing environment without the need to use any geoprocessing tools such as Import from CAD. When a CAD file is used as a data source, the CAD reader functionality of ArcGIS makes intelligent assumptions about the data. Using a CAD file as a data source is the preferred and more straightforward approach for dealing with single file CAD data translation.

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ArcGIS—Geoprocessing CAD Translation Tools

Different from the CAD Feature Layer, which is supported in all aspects of the ArcGIS Desktop applications, the geoprocessing CAD translation tools work exclusively within the ArcGIS toolbox geoprocessing framework. These tools are accessed and executed as geoprocessing tools in the geoprocessing framework from the command line, in a default tool dialog box, within a ModelBuilder™ model, or within a script. You need not translate CAD data to use the CAD Feature Layer or CAD Drawing Layer in ArcGIS, but if you need to perform complex translation tasks you should consider using the geoprocessing CAD translation tools.

If you need to create a CAD drawing from a shapefile, coverage, or geodatabase, the task is accomplished in ArcGIS using the Export CAD tool, or some form of it, from the geoprocessing framework.

The geoprocessing tools are exposed to the user at two different levels. There is a series of sample scripts and model tools that ESRI has created to perform common CAD translation tasks. In addition, there are the CAD-specific geoprocessing tools that are used to build these sample models and scripts and from which you can create your own tools to perform your own CAD translation tasks. You can think of the sample scripts as useful tools in their own right that you can use, combine, or modify to build your own custom tools.

Another distinction within the geoprocessing CAD translation tools is that some of the tools are designed to aid in the conversion of CAD files into GIS data while others are designed to export GIS information to CAD files. Generally, these tools are either the first or last tool chained along with other tools in a series to perform a translation in a model or script.

Within the geoprocessing tool sets, there are many tools to manage, modify, and move GIS data. By having tools that turn CAD files into GIS data and GIS data into CAD files as geoprocessing functions, one can use the other geoprocessing tools to perform processes to transform data from one schema and data model to another. Therefore, the Import From CAD tool or opening a CAD file as a CAD Feature Layer inside the geoprocessing framework generates GIS data from the CAD file. At this point the rich functionality available in ArcGIS Desktop can be used to manipulate this transformed CAD data. Likewise, by using geoprocessing tools to manipulate GIS data from one form to another, the user can output GIS data as a well-formatted CAD file when geoprocessing of the data is complete.

The Import From CAD geoprocessing tool exposes the various standard and extended attribute schemas used in CAD drawings as highly normalized tabular information. This is important because in CAD drawings, data relationships are often not explicitly defined but instead are spatially inferred on a map or coded by some "clever" combination of CAD symbolic properties in combination. For instance, a text object may be placed inside a group of lines that are supposed to denote polygon features with some descriptive attribute such as a parcel identification number.

Geoprocessing models and scripts can be used to establish rules for building spatial relationships between multiple CAD objects to aggregate data or break single objects into

multiple objects. A common translation task might be to take CAD boundary lines and generate closed polygons from them and then associate a text value inside the inferred polygons as an attribute of the same newly formed inferred polygons. This type of operation could be assembled in a geoprocessing model using the Import From CAD tool because the default CAD Feature Layer view of the CAD files would not expose the text as point features from which a spatial relationship could be established.

Choosing Between Using CAD Feature Layers or CAD Geoprocessing Tools

Remember that the decision to use the CAD Feature Layer technology or the Import CAD geoprocessing tool depends on the complexity of the translation task. The Import From CAD geoprocessing tool in this case is the correct choice to perform the task because it does not make the assumption that text should be used as annotation instead of a spatial point feature with the text value as an attribute. In general, the Import From CAD tool exposes more drawing attributes and types of geometry, so consequently, its use requires more steps.

The CAD Feature Layers are much simpler to use, and they expose most of the common CAD graphic properties, including block attributes, without a need to create a scratch file geodatabase or join tables. Assuming it is necessary to translate a CAD drawing into a geodatabase at all, it would be easier in most situations to use the CAD Feature Layers technique to import a single CAD file. One need not use the more powerful Import CAD strategy of the Import From CAD tool unless one needs access to the layer properties of the CAD drawing or extended entity data, alternative geometry representations (such as text as points), or other CAD document properties not exposed by the CAD Feature Layer.

The CAD user can automate the tasks of bidirectional CAD translation between a well-defined GIS schema and a strict CAD standard. The task of exporting CAD data can be streamlined by coding standard database lookup tables in such a manner that explicit CAD graphic properties can be associated with various attributes managed in geodatabase feature classes. By creating lookup tables with CAD properties and joining these tables with existing GIS feature classes or feature classes modified for the purpose of translation, one can create high-quality CAD drawings according to exacting and predefined CAD drawing standards.

For the infrequent or casual user who only needs to express some GIS data in a CAD file format without the above exacting standards, any feature class can be sent to the Export to CAD geoprocessing tool and an acceptable CAD file can be created with no user intervention. For example, if 10 different feature classes were input to the Export to CAD tool with a single output drawing name and no other provisions are made to control the output of the CAD file, a CAD file with each feature class on its own layer (named after the feature class) would be generated according to its appropriate geometric type. Linear features would be generated as polylines, points as points, polygons as closed polylines, and annotation as text.

ArcSDE CAD Client

The ArcSDE® enterprise geodatabase relies on an enhanced version of the ArcSDE simple feature layer to store additional tables and relationships required to support versioning and other advanced functionality of ArcGIS. By providing a CAD interface to ArcSDE databases, all the data stored in ArcSDE can become accessible to CAD

operators without leaving the CAD environment. This access includes read-only access to ArcInfo coverages and ArcSDE versioned geodatabases. By storing CAD information in ArcSDE managed spatial layers, the CAD user can create a huge seamless database of CAD objects. Storing CAD data in ArcSDE enables spatial databases to be created that greatly exceed the practical size limits of a CAD file.

The CAD functionality in ArcSDE CAD Client is separate from that exposed in the ArcGIS Desktop applications. CAD Client provides exclusive access to ArcGIS geodatabase information and ArcSDE simple feature layer data from within the AutoCAD or MicroStation environments.

ArcSDE CAD Client editing technology is built on the ArcSDE simple feature layer model. The simple feature layer model stores geometry and tabular attributes in a database that is managed by ArcSDE. The ArcGIS Desktop applications are read-only software clients to the simple feature layers of ArcSDE in which users can view and query the layers but cannot edit them. ArcSDE CAD Client is available in AutoCAD or MicroStation versions and allows either AutoCAD or MicroStation to become full editing software clients of ArcSDE simple feature layers.

CAD Client runs within the CAD software application as a MicroStation or AutoCAD extension. CAD users can access ArcSDE databases through the standard CAD Client interface or build CAD-based applications using the extensible CAD Client application program interface (API). When pulling information into a CAD drawing from an ArcSDE spatial database, new CAD entities are created in the drawing session based on the ArcSDE feature representation in the spatial database. Conversely, CAD entities are used to generate ArcSDE features in ArcSDE simple feature layers. In addition to generating ArcSDE features in simple feature layers, CAD Client can store a binary copy of the CAD object that can in turn be retrieved by CAD Client. It is important to note that CAD drawing files are not stored as a unit but are stored as ArcSDE feature records of the objects that make up CAD drawing files.

ArcGIS CAD User Profiles

The Infrequent CAD User

Typical tasks of the infrequent user focus on simply viewing CAD data.

Viewing

- Using CAD data as background to a map in ArcMap
- Identifying the properties of CAD objects, including cells and blocks, in ArcGIS.

The infrequent user simply wants to view a CAD drawing within ArcMap, ArcScene, or ArcCatalog. This viewing functionality is provided in ArcGIS in the form of CAD Drawing Layers. CAD files are recognized in ArcGIS as valid GIS data sets and as a special CAD Drawing Layer when viewing of the CAD files is all that the user requires. The CAD Drawing Layer attempts to mimic the symbology of the original CAD drawing. All the drawing's contents are included in a single layer in ArcGIS. Visibility of the CAD layer is controlled by a single entry in the table of contents.

The graphic properties of CAD drawings are exposed as tabular attributes and can be queried using the standard identify tools of ArcGIS. Often the graphic properties of CAD files are used as attributes. Properties such as layer name, line style, and color are often used to denote real-world attributes such as material type, roadway classification, or some other descriptive characteristic of objects in the CAD file. CAD data lacks the inherent database attribute tables common to GIS data, and therefore CAD users have taken to coding the attribution of objects based on symbolic graphic properties. In addition to the standard CAD graphic properties, block and cell attributes are included in the attribute tables of the CAD objects. Block attributes values appear in the records of both the point feature that represents the insertion point of the cell or block and the geometry of the block or cell symbology (the geometry that makes up the block or cell symbol in the CAD file).

Typical ArcGIS Technology Accessed by the Infrequent CAD User

- CAD Drawing Layers—ArcCatalog, ArcMap, and ArcScene
- CAD Feature Layers—ArcCatalog, ArcMap, and ArcScene

The Average CAD User

In addition to the tasks performed by the infrequent CAD user, the average CAD user performs both viewing of CAD files and the integration of CAD data as a GIS feature source.

Viewing

- Resymbolizing CAD objects in ArcMap
- Filtering the contents of a CAD drawing to isolate a particular group of entities

Analysis

- Using CAD features in spatial queries and analysis
- Querying the drawing by block attributes and graphic properties

Data Conversion

- Outputting a feature class to a CAD file
- Converting a CAD file to a shapefile
- Converting a shapefile to a CAD file
- Using a CAD layer to make a feature class

Typical ArcGIS Technology Accessed by the Average CAD User

- CAD Drawing Layers—ArcCatalog, ArcMap, and ArcScene
- CAD Feature Layers—ArcCatalog, ArcMap, and ArcGIS geoprocessing
- CAD Translation "Sample" Tools—ArcGIS geoprocessing

The Advanced CAD User

The primary distinction between the advanced user and the average CAD user involves the additional requirements necessary to expose some of CAD files' custom schemas or simply the volume of CAD data in question. In addition to the viewing and integrating of CAD data that the average user undertakes, the advanced user needs to perform complex data conversion tasks and reorganize CAD data for use in ArcGIS.

Viewing

- Modifying a CAD file's spatial reference to fit with other GIS features

Analysis

- Performing overlay operations with CAD files

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Data Conversion

- Creating CAD files with specific entity properties from ArcGIS data
- Batch conversion of many CAD drawings to simple ArcGIS feature classes
- Reestablishing database file links to CAD files
- Making use of extended CAD attribution in the form of Xdata, MSLink, and user data

Typical ArcGIS Technology Accessed by the Advanced CAD User

- CAD Drawing Layers—ArcCatalog, ArcMap, and ArcScene
- CAD Feature Layers—ArcCatalog, ArcMap, and ArcGIS geoprocessing
- CAD Translation "Sample" Tools—ArcGIS geoprocessing

The Expert CAD User

The primary distinction between the expert user and the advanced CAD user includes the additional requirements of exposing some of a CAD file's nonstandard and more complex schemas. In addition to viewing and integrating CAD data, the advanced user needs to perform complex data conversion tasks and support a mixed editing environment of CAD and GIS as well as updates and requests for CAD output of data in an automated or semiautomated fashion.

Viewing

- Creating a centralized spatial data repository for both CAD and GIS data

Analysis

- Using CAD files as GIS data to perform any operation possible on a feature class without conversion using the CAD feature data objects layers functionality built into ArcGIS

Data Conversion

- Supporting automated or semiautomated updating of ArcGIS feature classes and their attribute schemas with CAD drawings that adhere to certain CAD drawing standards
- Supporting automated/semiautomated export of ArcGIS geodatabase information into CAD drawings according to established CAD standards
- Large custom batch conversion of complicated CAD schemas to existing or well-defined ArcGIS geodatabase schemas
- Large custom batch conversion of ArcGIS geodatabase data to well-formatted CAD drawings
- Manipulating CAD drawing data with ArcGIS geoprocessing tools to extract inferred meaning of drawings, including geometric data modification, and complex tabular join operations
- Building ArcGIS geodatabases from various CAD drawings in different coordinate systems, from different sources, using a variety of database models and loose or strict drawing standards

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- Creating ad hoc CAD drawings from geodatabase information with various forms of extended CAD attribution including Xdata, MSLink, blocks with attributes, and user data

- Using the powerful editing tools, auditing, and quality control aspects of ArcGIS to perfect CAD drawings

Typical ArcGIS Technology Accessed by the Expert CAD User

- CAD Drawing Layers—ArcCatalog, ArcMap, and ArcScene
- CAD Feature Layers—ArcCatalog, ArcMap, and ArcGIS geoprocessing
- CAD Translation "Sample" Tools—ArcGIS geoprocessing
- CAD-Specific Geoprocessing Tools—ArcGIS geoprocessing (scripts, models, tools)
- ArcSDE Simple Feature Layers—ArcSDE CAD Client