Integrating CAD Into an Enterprise GIS

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Abstract

The PUD in Truckee, California maintains Electric and Water facilities. Although Electric facilities are designed in-house, more than 85 percent of new Water facilities are designed by Engineering firms using CAD software. Historically, as-built information was often delivered without a coordinate system, not to scale, and unstructured. Using tools from ArcScripts, internal development, and as-built standards, the TDPUD has created a scenario that allows Engineers quick access to the Enterprise GIS in CAD format, which in turn puts designs in the proper Coordinate system, to scale, and with proper structure to quickly and easily load new designs into the GIS.

Introduction

Truckee is a community located in the central Sierra Nevada mountain range, just north of Lake Tahoe. It is a rapidly expanding mountain hamlet with several unique characteristics. First of all, our service territory spans an 11 by 4-mile area, and ranges in elevation from 5,000 to nearly 8,000 feet. The rapidly expanding community requires an efficient design process if Truckee Donner is to have any hope of keeping up. Electric system design work is completed in-house using ESRI Business Partner Miner & Miner's Designer software. Most of our water system design is conducted by outside engineering firms working closely with District engineering staff. Both the electric and water design paradigms rely on data generated by outside Architectural and engineering firms, which work mainly in a CAD environment. CAD integration became essential to streamlining our design process.

At Truckee Donner, we have decided to use a GIS Geodatabase as our central spatial data repository. The geodatabase model presents several advantages: it provides version control allowing multiple users to edit the data at once; advanced analytical and modeling functionality; and the flexibility to incorporate other data formats and systems within our enterprise. The GIS allows data spanning the entire District to be represented in the same, georeferenced space. Most engineering and design work is completed in an arbitrary, project-specific space. Incorporating CAD data into our GIS has been one of the crucial steps in getting the GIS to function as our central spatial data repository. The nature of our business at Truckee Donner requires GIS staff to communicate with engineering staff both within our organization as well as consulting engineers and project developers, all of which work mainly in a CAD-based environment. In order for the GIS to become a functional tool for the engineering community it was necessary to integrate CAD with our GIS. CAD has also proven to be an excellent data exchange format, facilitating data sharing between our organization and other private and municipal organizations in the Truckee area.

Before we implemented an enterprise GIS, spatial data was stored in individual CAD files, referenced only to an arbitrary project-based coordinate system, or ancient decaying paper maps. Integrating CAD with our GIS has also allowed us to leverage this legacy data by incorporating it into our enterprise GIS.

The First Step: Overlaying CAD data

The first step in our CAD integration involves incorporating CAD data into our Geodatabase. This is accomplished using standard, out-of-the-box GIS and CAD functionality as well as ArcScrpits from the GIS development community. There are several problems with the as built and design information coming in from CAD. First of all, CAD practitioners work in an arbitrary, project-based coordinate system. CAD data are often not drawn to scale. And secondly, CAD files are delivered with a cryptically named or arbitrary layer structure. Overcoming these problems requires extensive time and effort on the part of District GIS staff.

The Truckee Donner PUD developed an as-built policy to address these concerns. The goal of the policy is to minimize the amount of District staff time required to load the CAD data into our Enterprise GIS. The framework of our policy dictates CAD drawing standards and layer naming conventions to address the above concerns. The policy is enforceable through a deposit required prior to construction. The deposit is refunded after successful submission of the as-built drawings. Successful completion is defined by the District and requires project proponents to submit hard copy as well as electronic versions of the as-built electric, water, landbase, and other utility information. Electronic data files are required in either a CAD or ESRI compatible format and have rigid layering conventions and coordinate system requirements. Drawings that do not meet the District's standards are returned to the project proponent for adjustment. Any staff time required to bring the drawings into compliance with District standards is deducted from the initial deposit.

The As-built Policy

The policy requires two pieces of information from the project proponent, a hard copy plot and an electronic file depicting the as-built information. The hard copy submission must be drawn to scale. The scale must be clearly noted and a north arrow must be provided. Electronic files can be submitted in either a CAD format or an ESRI compatible format. Most submissions are made in a CAD format due to the engineering community's reliance on that platform.

Electronic data files must conform to the District's base datum. As-Built drawings shall be referenced to at least three points on the drawing that have noted horizontal and vertical datum information. These three points may be existing control points, new control points, or parcel corners. The District uses these three points for location and rotation of the project coordinates. The coordinate system for all as-built drawings shall be California State Plane Coordinates, NAD 83 Zone 2 in US Survey feet. All elevations shall be referenced to the NGVD 88 datum with elevations given in US Survey feet.

The policy also defines a strict layer-naming convention. CAD layer names correspond with geodatabase feature class names. This simplifies the process of loading data from the proper CAD layer into the proper GIS feature class.

Engineering Community's Reaction

Initial reaction to the as-built policy was a mix of fear over loss of control over positional accuracy of survey data, and increased time and money on the part of engineering staff. The fear of lost accuracy is valid and points to a general division between the survey community and the GIS community. Licensed surveyors were concerned that their data would be moved from its original location during the process. These concerns were addressed through discussion. The District's mapping program is based on a "mapping grade" landbase with a lower accuracy than surveyed data. This level of accuracy is acceptable for our purposes. It is extremely important to understand the end use goal of the data when considering a coordinate system and rectification scheme.

Time and money concerns were addressed on two fronts. First of all, the engineering community was concerned that increased time and effort on their part would translate to higher fees for their clients. In practice, some of these increased costs are offset by the decrease in District staff time, which is also billed to the same client. The second approach that the District takes is to simplify its as-built policy and make compliance as easy as possible for the engineering community.

Easing the Transition

Truckee Donner PUD recognized the additional burden that the as-built policy placed on the engineering community. The District realized the need to provide the engineering community with our GIS data to provide a base in the proper coordinate system, set-up with the correct layer naming convention. These data are provided for exploratory purposes and are not intended to substitute for surveyed data. Discovery data is only intended to aide the developer in collecting this information quickly and cheaply. Discovery data is provided as a "shell" CAD file containing base data for the project area as well as all of the layers required by our layering convention. Existing facilities are placed on layers with the "EXIST" prefix. New facilities and base data are placed on layers with the "New" prefix by the developer. This approach simplifies compliance with our layering convention and provides a base for designs, in the proper coordinate system.

To facilitate the dissemination of our Enterprise GIS data in a CAD format, we found it necessary to develop a custom CAD export utility. This tool allows District GIS staff to quickly and easily export geodatabase data to a CAD file. The export utility supports many aspects of the GIS data including symbology and annotation. Edge feature classes are exported with color and line type properties as well as annotation generated in the GIS. Point features are exported with an associated CAD block as well as color and annotation properties. All geodatabase feature classes are exported to the corresponding CAD layer. The output of the CAD export utility is a CAD file with a very similar appearance to the original GIS data.

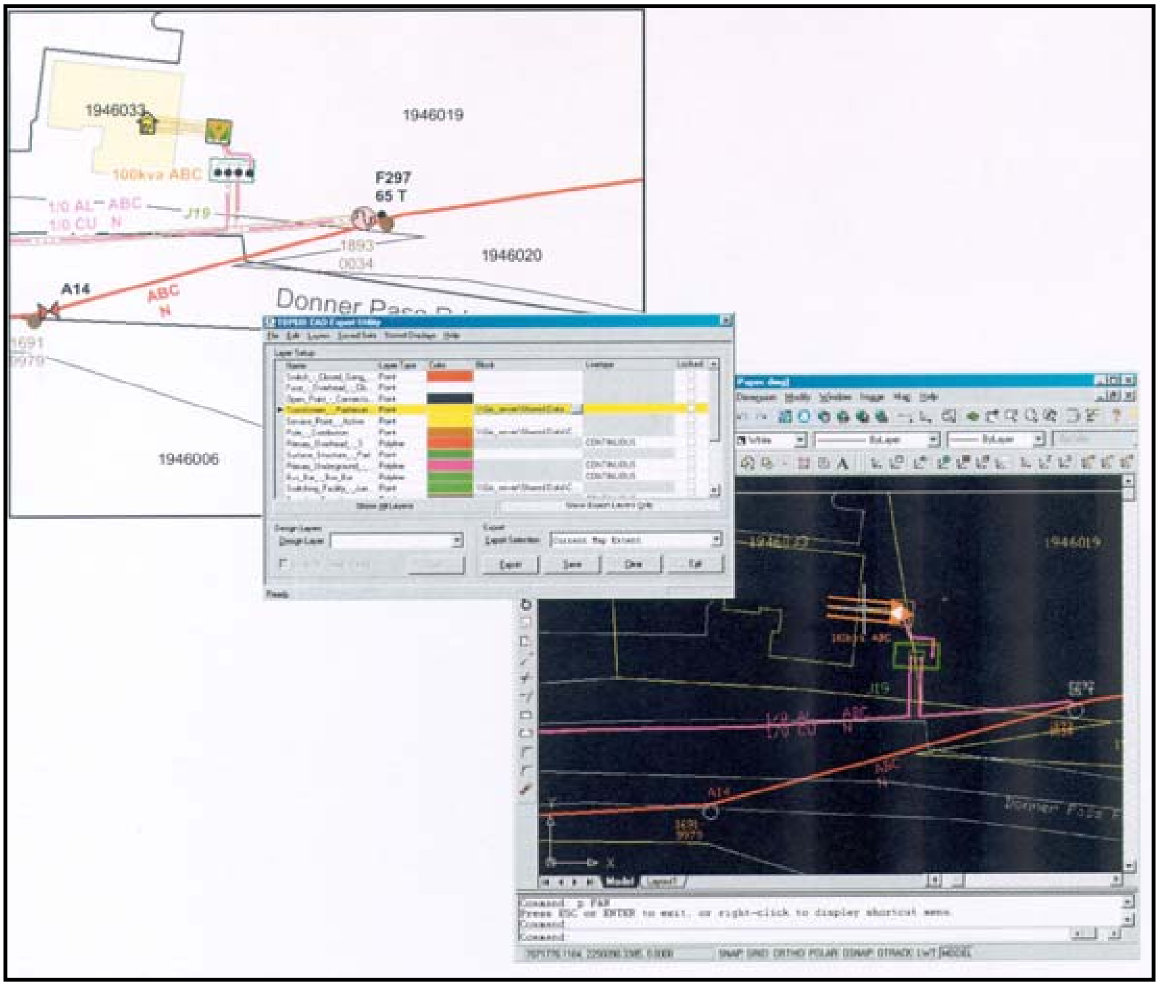

Figure 1. CAD Export Utility in action

Step 2: Loading the Data into Feature Classes

Once CAD data are rectified to the GIS base, features must be extracted and loaded into geodatabase feature classes. At Truckee Donner this is accomplished in one of two main ways. GIS features can be drawn using standard ESRI editing tools by either tracing the CAD data or snapping to CAD vertices. Alternatively, CAD objects can be loaded directly into geodatabase feature classes using ESRI's Object Loader utility.

Currently, District staff use a manual process to load CAD objects into geodatabase feature classes. Electric and water facility data exist as point and line objects in CAD. Since these data are organized onto CAD layers that correspond to geodatabase feature classes, it is a simple process to manually select the CAD layer and feature class and run the Object Loader utility. Once features have been loaded into the geodatabase, District staff must manually edit attribute values based on text in the CAD file, and run a rigorous QA/QC process. QA/QC is especially important to the PUD since electric and water network models rely on complex relationships between objects.

Step 3: The Future and Beyond

Thus far, the District has developed an as-built policy and a CAD export utility with the goal of increasing communication with the CAD community and reducing staff time required to rectify CAD data with GIS base data. While these tools have greatly improved this process and allowed us to realized great time savings, we still rely on a manual process to load the data into feature classes. It is our goal to expand the functionality of our CAD utility to automatically load data from CAD directly into the appropriate geodatabase feature class. Currently, the process involves manually selecting the target feature class and manually selecting the input CAD layer. We intend to automate this process using SQL queries to define the relationship between the feature class and its corresponding CAD layer. A mapping table whose function is to assign the appropriate query to each feature class would manage these queries. The data import would still be handled through ESRI's Object Loader utility. The goal of this development would be a "one-click" CAD import function. District staff will still have to manually edit attribute values and perform a QA/QC routine, but we expect that this automation will yield tangible staff time savings.

Closing: Implications Beyond the Enterprise

As Geographic Information Science grows and expands into greater and farther flung industries and disciplines, it is important to consider interdisciplinary cooperation as a goal. Our experience at Truckee Donner has been that CAD integration provides a useful communication tool for sharing data with geographic professionals within and outside of our organization. Thus the enterprise GIS model can be expanded beyond the confines of one organization. The enterprise model is best viewed as a solution to a problem. The interdisciplinary team that makes up the solution to the problem can be viewed as an enterprise. The advantage of this viewpoint is that it allows the GIS professional to cooperate with professionals in other disciplines and visualize a greater role in the enterprise as a whole.

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