World Academy of Science, Engineering and Technology
International Journal of Civil and Environmental Engineering
Vol:6, No:9, 2012

The Digital Filing Cabinet–A GIS Based Management Solution Tool for the Land Surveyor and Engineer

A. Giraldo, A. Lapatka, A. Namyslak, S. Pilny, J. B. Miima

Open Science Index, Civil and Environmental Engineering Vol:6, No:9, 2012 publications.waset.org/17233/pdf

***Abstract*—**This paper explains how the New Jersey Institute of Technology surveying student team members designed and created an interactive GIS map, the purpose of which is to be useful to the land surveyor and engineer for project management. This was achieved by building a research and storage database that can be easily integrated into any land surveyor's current operations through the use of ArcGIS 10, Arc Catalog, and AutoCAD. This GIS database allows for visual representation and information querying for multiple job sites, and simple access to uploaded data, which is geospatially referenced to each individual job site or project. It can also be utilized by engineers to determine design criteria, or to store important files. This cost-effective approach to a surveying map not only saves time, but saves physical storage space and paper resources.

***Keywords*—**Data Storage, GIS, Land Surveying, Mapping.

I. Introduction

GEOGRAPHIC Information Systems, or GIS, has become a widespread multifaceted tool utilized by a variety of professions and fields. In its early stages, government agencies were some of the first to adapt to this mapping aide. Currently, the advantages of GIS are becoming more renowned – this software, especially the ArcGIS platform by ESRI, Inc., has been found to be applicable to multiple types of mapping and imagery endeavors, and is "now accepted internationally as an umbrella term for all digital systems designed to process geographical data" [1]. Cartographers are not the only users of GIS–the applications extend to architects, planners, biologists, IT professionals, and statisticians, along with the department of public works for municipalities, counties, and states. In civil engineering GIS provides spatial solutions to many fields such as transportation, water resources, facilities management, urban planning, construction and E-business. Its applications in construction industry are discussed in [2]. However, the land surveyor has been slow to stand behind GIS, mainly due to the reduction of spatial accuracy in GIS data and inconsistencies between GIS and actual survey data [3]. Other reasons for this include lack of opportunities and the "lack of understanding by surveyors of the role of GIS in their surveying business" [4].

A. Giraldo, A. Lapatka ,A. Namyslak, and S. Pilny are with New Jersey Institute of Technology, Newark, NJ 07102 USA (e-mail: ag383@ njit.edu al69@njit.edu, an243@njit.edu, smp33@njit.edu, respectively).

J. B. Miima is with New Jersey Institute of Technology as an Asst. Professor in Engineering Technology, Newark (NJIT), NJ 07102 USA (phone: 973-596-3249; e-mail: miima@ njit.edu).

The term GIS has become synonymous not only with computer-based imagery mapping, but also with the storage and analysis of geographical data. Geographical information is linked through coordinates to a specific location, and attaches a variety of physical characteristics and classification qualities to these geographical locations, such as soil types or land ownership [1]. All of the data within a GIS database are organized into layers, where each layer has its own specific attribute. These layers are spatially linked through a common georeferencing system, thereby creating a relationship between each feature. These features and attributes allow for this information to be readily available to each user's individual needs.

GIS became pertinent to multiple disciplines with the advent of faster computer technology and larger quantities of data storage. For surveyors, there has been a rapid change in technology for total stations, GPS, EDMs, and laser scanners. With more robust mobile computer hardware and the availability of large amounts of online and network centralized data storage, the ability to access such a database from the field would greatly increase the efficiency and productivity of a land surveyor, who normally would need to return to the office in order to complete the research that he may require on site. While in the office, a land surveyor would still have access to this database, allowing him to efficiently plan for site visits without having to rely on the availability of wireless data streams on site.

II. Project Conceptualization

While discussing the advantages and disadvantages of GIS, the group determined that a records database would be the most appropriate application for land surveying and engineering, and would act as a launch pad to other possible products for GIS analysis. This interactive GIS mapping tool would be a quickly accessible project management database, which allows the user to upload project data, and then graphically interact with any project with uploaded information. Each project would be geospatially referenced to a specific coordinate system, so that they are all interconnected within one framework. This would create one standardized geospatial database that is available to an entire land surveyor's office. This entire system could be easily integrated into any land surveyor's current business operations.

By using this GIS database, the land surveyor can upload

Open Science Index, Civil and Environmental Engineering Vol:6, No:9, 2012 publications.waset.org/17233/pdf

individual attributes, or extract required data from CAD files, as he sees fit, for each specific property. The data could be as simple as property boundaries, monuments, traverse location, and horizontal and vertical positioning for benchmarks; this would provide the surveyor with useful information quickly. A relatable example is as follows:

Fred, a land surveyor, is hired to do a topographic survey on Lot 7, Block 8010 in Newark, New Jersey. Fred remembers that he had done work in that area a few years before, but does not remember the exact lot or project ID. Instead of going through old files, he opens his GIS database. When he zooms to Lot 7, he notices that information has been uploaded for Lot 5, which is two lots away. Upon further examination, Fred notices that there were two stone monuments and three capped rebar found in the area, along with traverse with horizontal and vertical data. When Fred prepares the work order for his field crew, he includes this information, instructing them to look for the stone monuments and rebar. He also tells them to tie into the old traverse points, if possible, to establish vertical and horizontal datum for the new job. By doing this, Fred saved time, money, and effort for himself, his crew, and his client. This tool can also be used to help determine the cost of a survey, based on the proximity of control points or vertical datum, or the topographical conditions and geographical location.

Depending on how much effort the surveyor would be willing to put into his GIS database, numerous different layers could be added, with varying benefits and results. The user of the database must decide what information is entered, and how it should be used. Papers such as deeds, notices, filed maps, and government agency letters could be uploaded as PDF files into the GIS database. When the parcel is identified, a table would appear containing links to these files. Sensitive areas such as wetlands, highlands, and floodways could be uploaded into the map as visual layers, permitting a rapid positional orientation in comparison to project sites. All of this information could be consolidated into one GIS map, reducing the amount of time allocated to researching areas (as long as the information in the GIS database is kept current and up-to-date).

The main purpose of this project is that it would be a cost-effective, time-saving research and storage assistant to the land surveyor. Records could be stored digitally, reducing the need for filing cabinets and storage space. All files would be georeferenced to their specific geographical locations. The GIS database would also contain visually represented layer information. With the onset of the regular use of laser scanning to collect point cloud data, the GIS database provides a platform for the data visualization and display. If 3D point cloud data was available, it could be attached to the database, which would allow for information to be extracted without the need for a field visit (or a return to the office). The final aspect of the GIS database would be to develop query, or search, strings, so that certain attributes can be searched for and listed. All of this data would be readily available to the land surveyor in the office, aiding in most aspects of surveying.

The secondary purpose of this project would be to ensure that the database is useable by others – namely, others who work with the land surveyor. This would allow for civil engineers to have improved design capabilities in roadway design, pipe networks, building location, and utility locations, to name a few. For example, pipe slopes and sizes could be determined from drainage tables and used for flow calculations; utility locations could be better known prior to excavation, reducing the possibility of accidents during construction. For an analysis perspective, queries could be developed to determine impervious and pervious coverage.

A final entry point for this GIS database would be metadata. Metadata is defined as "data about data" [1]. This data is a tool to link the producer with the user by identifying the data set. The main purpose of including metadata would be to establish who obtained, analyzed, calculated, uploaded, and maintained the data. For example, the field crew collected all of the data, which was then analyzed by the professional land surveyor. The civil engineer calculated certain quantities, and then a drafter uploaded and maintained the available information. By including all of this metadata, the user would be able to determine if the data is reliable and relevant to the project.

III. Learning Objectives

A. To learn GIS software, namely ArcGIS 10 by ESRI, Inc
B. To determine how to extract previously drawn layers from AutoCAD into ArcGIS
C. To develop a GIS database, containing information and data relevant to land surveying, as well as other professions, such as engineering
D. To develop query strings within the database
E. To learn how to successfully integrate data from multiple sources, and present it in a useful and visually appealing manner

IV. Software

For the project, a number of software packages were used. ESRI's ArcGIS 10 Suite was used for map creation. AutoDesk 2010 was used to isolate and extract shape files. Microsoft Access and Excel were used to store and manage attribute data.

V. Methodology

The major considerations and purpose of this GIS database, which were discussed in the previous section, determined how exactly to build the map. The approach to create the map was generally simple:

1. The different necessary layers were determined. The layers were divided into two groups: primary layers, and secondary layers. The primary layers are directly applicable to land surveying, while the secondary layers apply to civil engineering. These are displayed, in no particular order, in Table I below.

TABLE I
PRIMARY AND SECONDARY LAYERS FOR A GIS DATABASE

Primary Layers	Secondary Layers
Georeference – Country, State, County, Town, Parcels	Permanent Structures
Contours/Topography	Water bodies
Property Boundaries	Trees
Right of Way	Utilities
Easements	Street Signs
Monuments	Street Lights
Deeds	Storm and Sanitary Sewers – location, inverts
Previous surveys	Floodway/Wetlands lines
Benchmarks (horizontal/vertical)	NJDEP/FEMA approvals

2. Once the layers were determined, data needed to be obtained.
a. The group gathered an existing AutoCAD file from Omland Engineering Associates, Inc. This file contained a multiphase subdivision plan. The first phase of the project, which contained 18 lots, was used as the basis for the map.
b. The second data set that was required was deed information. Since this was a recent subdivision, there was only one deed per lot, and the original deed for the entire subdivision.
c. The final required data set was the shape files for georeferencing. These were obtained from the U.S. Census Bureau website, in the Topologically Integrated Geographic Encoding and Referencing (TIGER) database [5]. This database contains shapefiles, which are a single feature class, or a "geospatial vector data format for GIS software" [6]. These shapefiles describe geometry, points, polylines, and polygons for a specific area. In other words, the boundaries and geographical attributes for the nation, state, and county are contained within these shape files.
d. Municipal and parcel boundaries were obtained from the NJGIN database website.
3. A new geodatabase was created with ArcCatalog. ArcCatalog is used to manage geographic data, and "it gives you more information about spatial data than you can get from…file browsers" [6]. This geodatabase was enabled to accept data, which creates a toolbox, or "builds a warehouse" to store data. Any data that is uploaded into this database is mapped in one geographical system, based on the database characteristics.
4. The shapefiles were converted through ArcCatalog. These shapefiles already included the metadata.
5. The previous steps began the initial phases of creating a GIS database – the next step was to verify that the AutoCAD geometry was correctly georeferenced. The data needs to be in state plane coordinates to accurately be inserted into the database. The previously obtained AutoCAD file was already in state plane coordinates (SPC83), and so there was no need for alterations.
6. Next, the layers (as previously described) were extracted from the AutoCAD file as shape files. Since GIS assigns specific attributes and properties to each layer, the CAD file had to be manipulated for their specific properties, such as lot lines, roadways, and buildings. These layers were assigned feature class characteristics depending on what they represented (point, line, polyline, polygon). This established coordinate properties and defined the georeferencing geometry. The layers that were extracted were:
a. Buildings
b. Impervious cover–patios, driveways, curbs, and sidewalks
c. Road centerline
d. Utilities
   i. Gas lines
   ii. Water mains
   iii. Electric/telecomm lines
   iv. Sanitary sewers
   v. Storm sewers
e. Property setback lines
f. Spot grades (for slope determination)
7. The CAD layers were projected to fit to NAD83-NJ.
8. The metadata for the CAD layers was added to each layer. This was an explanation of the data–it included a summary and description of each layer.
9. The CAD layers were converted, using ArcCatalog, to the geodatabase.
10. The deeds, in PDF file format, were uploaded into the database. A Microsoft Excel TM file, containing storm sewer information, was also uploaded into the database. All were linked to their appropriate layers.
11. Once the toolbox or "warehouse" was filled with all necessary materials, a new project was created in ArcMap. ArcMap is "an application for displaying maps and investigating them, for analyzing maps to answer geographic questions and producing maps that make analysis persuasive" [6]. All of the layers that were imported through ArcCatalog were readily available for use in ArcMap, and were inserted into the new project. The first layer inserted was the United States shape file, since the first layer added defines the geometry for everything else; this is the base map for the area.
12. Satellite imagery from Microsoft Bing™ was uploaded into the map to enhance the graphical visualization of the area.
13. The geodatabase was now ready to view in ArcInfo, which allows the user to query data, analyze spatial relationships, and data editing tools.
14. All of the layer attributes, such as line type, weight, and color, were then altered to best represent the map. The layers were ordered so that they could be viewed over or under other layers.
15. Queries were developed within ArcInfo to enable the user to search for specific items. These steps finalized the geodatabase for this project's purpose.
16. The final step of this process was to publish the map using ArcMap. Once this was accomplished, ArcReader, which is free reader software from Esri, allows anyone within a network to view and use the map and database,

Open Science Index, Civil and Environmental Engineering Vol:6, No:9, 2012 publications.waset.org/17233/pdf

without permitting them to edit it.

VI. Results

This GIS endeavor proved to be an extremely useful tool for the surveyor. Although it lacks the functionality required in the field, it does allow for quick project referencing. In the office the ability to view different project data greatly aides the surveyor when preparing field work, since previously found information can be immediately located and displayed. This data depository allows each individual parcel to be selected, and all available information for that parcel will be displayed in its own window. The drainage table that was uploaded allowed for individual pipe lengths to be highlighted–for example, if you queried '24" pipe', every 24" diameter pipe was listed.

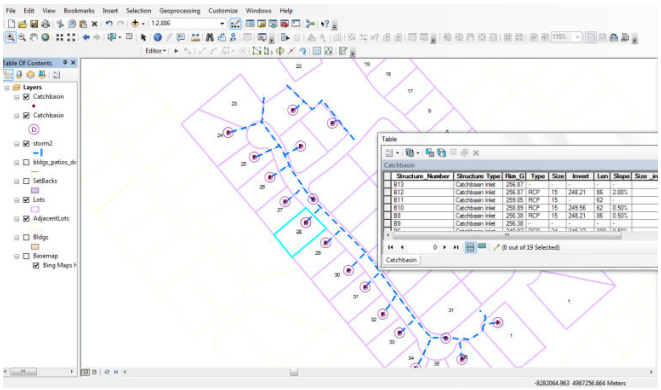


Fig. 1 Storm sewer network with associated drainage table, as viewed in the database

Buildings could be selected to obtain their footprint area – an exceptional tool when creating a zoning requirement table. Monuments and property corners, with proper metadata (such as the date they were set, descriptions, and condition updates) are readily available with a mouse click. In addition, images of this evidence can be linked to the geodatabase, which aides the surveyor when searching for property corner markers. Horizontal and vertical benchmarks are able to be accessed, and their metadata can be edited based on their existing conditions. Previous surveys, such as as-builts or real estate transaction surveys, can be shown quickly.

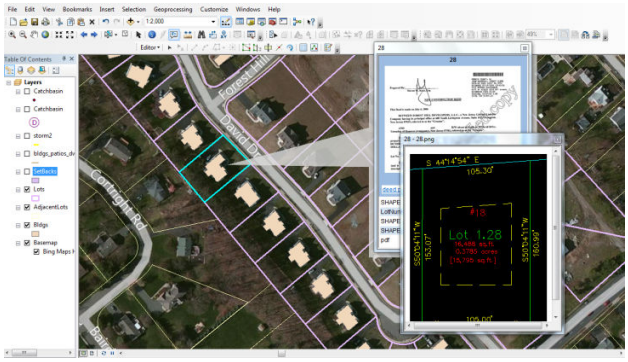


Fig. 2 Individual lot selection, with links to Deed and CAD file

For this particular subdivision, we did not have any flood information, but it must be noted that floodway information and elevations can be input and used as references for Federal Emergency Management Agency (FEMA) Flood Certificates and Letter of Map Amendment (LOMA) requests. Spatial analysis calculations, such as obtaining lengths and areas, are easily performed. We felt that even though there were imperfections in the map, due to the available data sets, that the project was a great success.

VII. Conclusion

The possible information and data that can be uploaded into a GIS database are practically endless–one can upload and link to an individual parcel many different file types, from simple text files to AutoCAD files. The tools, as they are now, are exceedingly useful to the land surveyor and civil engineer. Like anything else, these databases are a work in progress, but only in the respect that you can use them for as little or as much as you want. This type of database lets the user choose their level of involvement. The database that the surveyor or engineer would create can be as detailed as their needs require it to be. The most rewarding outcome of this project was learning that the final product and the possible applications are heavily influenced by how much data one is willing to put into it.

Since this database is designed to run with a well-known GIS software application, it is much easier for surveying and engineering companies to adapt to using it in a minimal amount of time. The software and database is not solely limited to one user-it is available to anyone within a network with the ArcReader software. The time normally spent learning to use new software, in this instance, would be time spent uploading data. The time spent today updating parcel data in this software could save days of rediscovering research that has already been completed in the past. Imagine a future where what would normally take days of research might only take minutes with a few clicks of the mouse, or where one would have the ability to access an entire project geodatabase through a hand held system while in the field.

Although this is a rudimentary GIS database, this is the very first step a land surveyor would require to prepare surveying data for GIS analysis, which would enable the expansion of surveying products that a land surveyor could offer. In the future, the surveyor will be tasked to provide more products, and GIS easily allows for this, thereby giving surveying companies the opportunity to cultivate their capabilities to meet public demand. This GIS database for land surveyors presents GIS software as a means of accessing and storing this information in a more secure, graphically enticing, environmentally friendly, and efficient way.

Acknowledgment

The authors thank New Jersey Society of Professional Land Surveyors, Leica Geosystems, Omland Engineering Associates, Inc., and Mingolo Precision Products, Inc.

Open Science Index, Civil and Environmental Engineering Vol:6, No:9, 2012 publications.waset.org/17233/pdf

REFERENCES

[1] T. Bernhardsen, *Geographic Information Systems: An introduction.* 3rd Ed. New York: John Wiley & Sons, 2002.
[2] V. K. Bansal "Potential of GIS to Find Solutions to Space Related Problems in Construction Industry" *World Academy of Science, Engineering and Technology* 8 (2007): 307-10
[3] J. Greenfeld, "Geospatially Connected." *Point Of Beginning*. February 26, 2008. http://www.pobonline.com/Articles/
[4] J. Greenfeld, "GIS Education for Professional Land Surveyors." (Accessed February 9, 2012). http://proceedings.esri.com/ library/userconf/survey04/docs/JoshuaGreenfeldPAP.pdf
[5] "2010 Census TIGER/Line® Shapefiles." U.S. Census Bureau. http://www.census.gov/geo/www/tiger/tgrshp2010/tgrshp2010.html.
[6] T. Ormsby, E. Napoleon, R. Burke, C. Groessl, and L. Bowden. *Getting to Know ArcGIS desktop.* Redlands, California: ESRI PRESS, 2009. Article_Rotation/BNP_GUID_9-5-2006_A_10000000000000270211.

Open Science Index, Civil and Environmental Engineering Vol:6, No:9, 2012 publications.waset.org/17233/pdf