Enterprise Wide Access and Editing Via ArcIMS and the Geodatabase

Trevor W. Feagin, AICP and John Marchetti

Trevor W. Feagin, BA 1991 University of Texas, MS 1994 Texas A&M University has worked in the GIS field since the late 1980s and currently is the GIS Manager for the City of Tamarac, Florida.

John Marchetti, BA 1965 Columbia College MS, 1968 University of Oklahoma has over 30 years of mapping experience and nine years using GIS. He is currently Manager of GIS Technologies for BAE SYSTEMS ADR, Pennsauken NJ.

Abstract

The City of Tamarac, population 58,500, has a goal of an enterprise GIS with a broad user base. Initial planimetric and utility mapping employed a coverage data model. The geodatabase has now been adopted as the standard data model. The geometric network is an ideal environment for the water and wastewater utility systems, providing many built-in applications. The geodatabase is also being used for non-utility data. Using ArcSDE, the geodatabases with their domains and rule base architecture enable quality control for enterprise data management and maintenance. ArcIMS deploys GIS data and applications throughout the City.

Introduction

The City of Tamarac is a suburban City of about 12 square miles with about 58,500 people in Broward County Florida. The City began a GIS program in early 1995, with the hiring of Trevor Feagin as the City's GIS project manager. The GIS Project was designed with the purpose of meeting the needs of all departments. The Public Works and Utilities Departments need an accurate and complete inventory of water, sewer and stormwater lines in the City. The City contracted with Aerial Data Reduction Associates (Now BAE SYSTEMS ADR) of Pennsauken, New Jersey to develop digital orthophotography and digital planimetric mapping for the City. This process has continued to the present day with the delivery of all public utilities and an update to the planimetric map.

The City of Tamarac is a planned community founded in 1963, with portions constructed as a private development. During the first 20 years, the City was designed and constructed under a single developer. Like most communities in South Florida, the City has substantial areas that now have 30 or more year old utilities, and some areas have utilities that are over 40 years old. Some areas showing signs of a future that may have higher than average leak and breakage rates as well as inflow and infiltration and under-capacity problems in variety of pipes, lines and drainage systems. Several neighborhoods report occasional water discoloration and other minor flaws with the water that indicate problems with joints and seals. About _ of the utilities do not have complete paper plans and an additional _ have plans that are not considered to be reliable.

In the early 1990's the Utilities Department began an AutoCAD-based inventory, but the project only covered 1/5th of the City and did not have any tabular data. In 1995-1996 the City's GIS Committee developed a standard for an AutoCAD delivery and a coverage delivery with a detailed descriptive database design. In 1997, the City contracted with BAE SYSTEMS ADR to develop City-wide planimetric data and a one square mile pilot project for the utility lines. The pilot project was used to test the utility data against the City's ongoing need for utility location. The main lessons were learned from using the pilot data include the need for a complete dataset, rules for controlling the data entry process, and smarter features: a way for the pipes to know that they connect to a similar size pipe, or a tee or a reducer.

The lessons pointed to either a series of ranges set up with Arc Macro Language scripts that would smooth portions of the data entry and long-term maintenance process, or convert all of the utilities data into the geodatabase format. The AML approach would not fix all of the shortcomings and the coverage database or shapefile did not allow for all of the improvements in data entry automation that the geodatabase would provide.

As a part of the recent utility conversion, the City determined that the geodatabase offered a more structured way to enter in descriptive data, reducing the chances of errors in the utility lines database. The practical result is that the contractor was able to develop a series of rules for data entry as well as improving the Quality Control and Quality Assurance processes. The City determined that several utility packages that are under review do use the geodatabase and that the geodatabase will over time become the preferred data format.

Use of the Geodatabase in Florida
The Geodatabase is a relatively new database format that has yet to be widely adopted by county or municipal governments in Florida. In summer of 2002, the author conducted a phone survey of known GIS projects that use ESRI's products in the three counties in Southeast Florida. The three counties encompass 3 million people living in 90 cities, several dozen distinct incorporated areas, a handful of quasi-governmental jurisdictions and several tribal governments.

The respondents indicated that less than 5% of the governments were using the Geodatabase and or the Spatial Database Engine (SDE) to store, share or serve enterprise wide and only the largest users had both softwares and the capability to use them. About half of the respondents saw the benefits of the Geodatabase and Spatial Database Engine, but indicated that the time, knowledge and experience needed to convert and the cost of SDE and a Relational Database Software limited the ability of most respondents to set up and implement such a system. The majority of private sector companies surveyed indicated that they did not have the capability, and were not recommending using the geodatabase. Several companies mentioned that third party software developers were making applications that would use the geodatabase format.

As a part of the consultant selection process in the early summer of 2002, the City issued a Request for Proposals specifying six major tasks with the Geodatabase design, migration and implementation as one. Once a short list of potential contractors was created, the City thoroughly reviewed the potential contractor's past clients' experience. In addition each potential contractor received a series of written questions to gauge their depth of experience with the relatively new data model. After a verbal examination, the City selected a contractor that had demonstrable experience with the Geodatabase and SDE.

Migration From Coverages to the Geodatabase

The City and the contractor developed a specification based from the City's earlier coverage database design and incorporated updates and improvements in to the current Geodatabase design. As of the summer of 2002, the City's primary GIS data sets consisted of:

- Citywide planimetric data in coverage format
- Pilot area with water, sewer and Stormwater data in coverage format

To meet the goal of an enterprise solution using the Geodatabase data model and ArcSDE, a strategic plan was developed that would accomplish four principal tasks:

1. Migrate the coverage data model to the geodatabase.
2. Convert the remainder of the City's underground utility data using the geodatabase data model.
3. Implement ArcSDE to store all of the GIS data in an enterprise database.
4. Distribute all of the City's GIS data and meaningful applications using ArcIMS.

The Strategic Plan was developed in stages. As each stage was completed, it was incorporated into a comprehensive Procedures Manual.

Geodatabase Design and Migration of the Planimetric Data
The planimetric data consisted of 26 coverages. The aerial photography was captured with a negative scale of 1" = 300' enabling the compilation of a suite of detailed map features with a positional accuracy of ± six inches. A new geodatabase data model was designed for the planimetric features. A total of 32 feature classes were designed, which, in turn, were divided into seven feature datasets:

Transportation
Vegetation
Hydrology
Structures
Utilities
Parks
Topography

A schema was developed to map the data from the coverages into the new feature classes that preserved the rich attribution that had already been captured. The design allows for easy integration of future data sets.

A special tool was developed that migrated the Citywide planimetric data from the coverages to the new geodatabase. This was followed by a series of quality assurance tests designed to detect errors or discrepancies in the migration. The necessary edits were performed.

Geodatabase Design and Migration of the Pilot Utility Data
The process was more complex for the utility data. The City wanted to structure the design of the utility geodatabases based on the two standard data models that had been developed by the ESRI team of software developers and industry professionals. We were aware that the use of such a standard would promote interoperability with other formats and also would support third-party applications (e.g. WOMS, CIS, hydraulic modeling) that were already being developed against the standard model.

The first step was to download the standard models (one for water and the second for sewer and storm water). We then made a detailed comparison between the data dictionary developed for the coverage and the schema of the standard model. This resulted in a "gap analysis" that determined which features and attributes were unique to the City's needs

and not included in the standard data models. Wherever possible we using the same field names and data types that were present in the models. There would be differences between the way the pilot data was developed and the data in the remainder of the City. The pilot coverages were developed using a data model similar to the "Glendale Model" using arc/node topology. This resulted in a break in the water mains at each valve. Using the complex edge feature in the geometric networks of the geodatabase, such breaks are unnecessary.

A new schema was developed for the addition of facility IDs primarily for the gravity systems of the sewer and storm water utilities. The schema incorporated a system to reference the downstream sink (lift stations and outfalls) in the facility IDs of the upstream structures (manholes and inlets).

The data entries in the pilot coverages provided a baseline for domains (valid values) that were assigned to the appropriate feature classes.

When the data schema was completed, a tool was developed that would migrate the map features and their attributes in the pilot coverages to the feature classes of the new geodatabases. When the data migration was completed, a series of quality assurance tests were applied. This step enabled us to detect and correct minor errors that were present in the pilot coverage data. These were more apparent in the geodatabase format with its data validation capabilities. Finally, we built geometric networks for all three utility geodatabases.

Utility Data Conversion of the Remainder of the City

The pilot data was developed by spatially orienting the source documents on table digitizers because the georeferencing capabilities of ArcMap were not available at that time. The conversion plan for the geodatabase software environment included the following preliminary steps:

- Develop a naming convention for scans of the source documents.
- Scan paper prints (or originals in some cases) of the source documents.
- Name the scanned images according to the naming convention.
- Georeference the scans relative to the planimetric data.

All of the surface utility features had already been mapped either photogrammetrically or by subsequent field edit. The conversion was therefore reduced to establishing the proper underground alignments between the surface features. This process was frustrated by discrepancies among numerous overlapping (or missing) source documents. To address this issue, a systematic process called Problem Resolution Reports (PRR) was developed to efficiently convey (by Internet) source problems to City personnel in the Utilities and Public Works Departments who would then determine the solution and transmit it back to the contractor. The maximum turnaround time for each PRR was 5 days and the majority of them were accomplished in much less time.

Software Tools
In order to expedite the conversion process, a series of software tools were developed. All of the tools were coded in Visual Basic macros in ArcMap. A partial list of the tools follows:

- Roping Tool – populates SourceDocName and InstallDate fields following the conversion of features and attributes on each source scan.
- Fittings Tool – populates the Daimater1, 2, 3 and 4 fields of fittings based on the Diameter of the connecting mains.
- Water Tool – adds water service laterals between water meters and mains, adds a tap fitting at the junction and populates the Diameter 1and 2 fields based on the Diameter of the connecting main.
- Storm Water Tool – assigns structure numbers to all structures upstream of the outfall for each basin, assigns FacilityIDs to the structure and intervening gravity mains and calculates the distance from the outfall to each structure (to be used in a planned hydraulic modeling application).
- Sewer Tool - assigns manhole numbers to all manholes upstream of the lift station for each lift station basin, assigns FacilityIDs to the manholes (referencing the FacilityID of the lift station) and intervening gravity mains. The tool also automatically adds a lateral between mapped cleanouts and the gravity mains and places a wye fitting at the junction. The tool adds a dogleg in the downstream direction with the geometry controlled by the operator and it populates the Diameter 1 and 2 fields of the wye based on the NominalDiameter of the connecting main.

Although the software tools were developed to facilitate (and reduce the cost of) the data conversion, the City plans to make use of them during data maintenance operations.

Finally, a special tool is being developed that will enable Utilities and Public Works users to quickly access scanned images of the as-built plans either georeferenced in ArcMap or unreferenced in a custom viewer that includes a full suite of pan, zoom and printing tools.

Quality Assurance
A Quality Plan was developed to assure the City that it is receiving data of the highest quality. The utility data conversion project is divided into five delivery areas. At the conclusion of each delivery area, a systematic series of quality assurance procedures are executed that are designed to detect errors or omissions for each of the three utilities. This is followed by a City review period where City personnel examine the data in each delivery area for adherence to the project specifications.

Enterprise Solution – ArcSDE and ArcIMS
When all of the utility data has been converted and accepted by the City, the data will be loaded into ArcSDE, which has already been implemented on the City's GIS server. This will also include natural color digital orthophotography developed from new 1" = 300' photography with a 3-inch pixel.

Arc SDE was installed to allow multiple users to access the GIS and the digital orthophotos data via the City's network. The three (3) power users are located in three (3) different buildings that are several miles apart. The approximately dozen mid-level users are located in five buildings separated by up to five miles. The City has the potential for several hundred casual Intranet GIS users in nine (9) buildings and several parks and trailers linked to the City's network. Given the number of layers and the size of the data involved, the City has the choice of having a dozen or so sets of two square mile pieces of GIS data stored on multiple computers with different edited versions, or one Citywide SDE layer supplied by a server with access rights granted to various levels of users. The City's recently delivered color digital orthophotography can not be served without the lossless compression of SDE.

A custom ArcIMS application has been developed that will be used to distribute both data and limited GIS applications to all City workers on our computer network. The application is designed with web pages that are specific to each of the major user departments (Community Development, Utilities, Public Works, Fire/Rescue, etc.) Initially the websites will only be available on the City's Intranet, but there are future plans for public access websites that will publish more limited, but highly useful data. The Internet websites are expected to not only promote public awareness of the City's use of technology, but also enable them to access information they require without a trip to City Hall.

Conclusion

We believe that the true measure of success of GIS is establishing a large user base. Our focus on data quality means that City workers will likely trust the quality and integrity of the GIS data. The ArcSDE implementation is expected to provide acceptable levels of system response and the ArcIMS application will bring GIS data and functionality to City workers through the familiar browser interface with minimal training.

The Procedures Manual developed by the contractor will serve as a guide for database maintenance after the conversion is completed by the end of 2003.

Trevor W. Feagin, AICP
GIS Manager
City of Tamarac Florida
7525 N.W. 88th Ave.
Tamarac, FL 33321
(954) 724-1295
(954) 724-2453 FAX
Trevorf@tamarac.org

John Marchettii
GIS Manager
BAE Systems ADR

9285 Commerce Highway
Pennsauken, NJ 08110
1-800-257-7960
(856) 486-7778