Paving the Way for GIS

by Helen Ireland, SR/WA

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Geographic Information System (GIS) applications can be a powerful tool in the right-of-way field, providing access to accurate, timely and consistent data. Typically, these systems have a foundation in a national database and are fine-tuned at the local level. GIS tools have been used in infrastructure management, superfund cleanup, transportation engineering and interstate utility projects. On a daily basis, GIS provides the field agent with maps and fact sheets, and benefits the public with one-stop permit processing.

A GIS is a means to link graphic data with land data maintained in spreadsheet format. A graphic link is the obvious structure for tying together land data. Queries on a particular location can access data from various files as well as relate the graphic area to other maps. There are many advantages to having a file of maps related this way. Each map can be treated as a thematic layer, allowing selective viewing of as little or as much information required. Automated maps can be easily scaled. The use of the common graphic link eliminates redundant mapping as various departments are able to share maps electronically. Information related to the map can be transferred quickly, providing complete and current information.

GIS technologies have a wide range of uses in the right-of-way field. Facilities management is a popular application. Highways, utilities, waste disposal and water systems all benefit from an efficient method for maintaining, improving and linking the systems and facilities. System components inventoried through a database can be easily identified and updated to reflect factors such as history, condition and location. Planning for expansion and the preparation of Environmental Impact Statements is simplified with the ability to overlay maps of historical sites, old landfills, storage tanks, soil data and drainage patterns. Routing and scheduling applications is another area where GIS is useful for tasks such as transportation scheduling, sanitation pick up and meter reading.

With such useful widespread applications, why aren't more individuals using a GIS? The main obstacles are cost and time of cost recovery. From user requirements to implementation, costs can run into millions of dollars. To be cost-effective, it should serve a large number of users over a wide range of applications. The primary candidates for GIS are currently government, utilities and big business. Installation must be customized to the users' system. Analyzing user needs and data stores; evaluating software and hardware requirements; defining a plan to incorporate this into a GIS; implementing, testing and revision—this is a lengthy process. It may take from four to 10 years before costs can be recovered. Still, faced with problems of increasing work loads and aging systems in a tightening economy, there is a rapidly growing demand for GIS tools to produce greater efficiencies of management.

Getting Involved

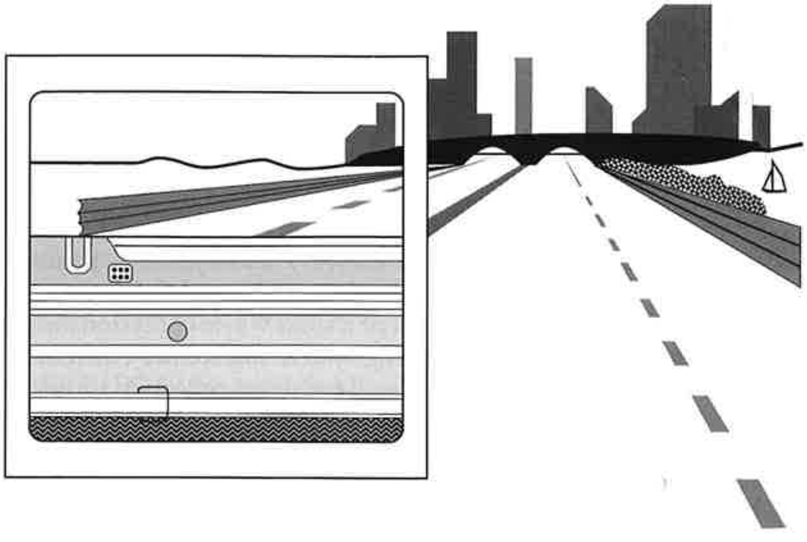
The right-of-way agent is one of the elite who may be involved in the maverick operations which will pave the road for others. For those who are fortunate enough to be within an organization which is developing a GIS, there are certain steps you might take to become an active participant. The costliest and most time-consuming aspect of a GIS is data conversion. You can mitigate this by planning now for the system you would like to develop. Anticipate the data and formats other departments might require to facilitate data sharing. Taking the initiative could qualify you for inclusion in a pilot project. Getting involved in the early stages of system development will help uncover oversights in system analysis and user needs. A GIS can, and should, be functional even in the early stages of development. A good integration can be expected when the system and the user develop at the same time.

This author became involved with GIS initially through work as a right-of-way agent for Pima County's Property Management Division. Pima County's IMAGIN project in Tucson, Arizona, is supervised by the county manager's office through a project manager. During development, only a few of the departments were expected to participate. Some divisions became included through their own initiative. One, of course, was Property Management. Another was the Pima County Health Department's (PCHD) Division of Disease Control. Both were able to do this by devising a workable database.

Property Management Application

Pima County's Property Management Division is responsible for the acquisition and disposal of county property, administration of improvement districts, and review of rezoning and subdivision requests. Although project information was maintained primarily in reports and files, the division planned to reorganize this information using a Dbase database. The Dbase system would link information maintained in the appraisal and acquisition sections.

The initial system was designed to



track the acquisition of land. Each acquisition project would be defined by a fund number and each parcel would be identified by a record within that file. As the project progressed, the sections would update the files using Dbase on a computer network. The entry of the recording data of the title of conveyance would signify completion of the project. At this time, all the records of the parcels for that project would be assigned a unique identifier and be included in the county land inventory.

The GIS program developed for Property Management was designed to allow them to view their property in relation to geographical layers, such as road networks, floodplain and district boundaries. The software used for this project is ARC/INFO, a popular geographic relational database. Under the proposed system, each parcel in the Dbase database would be represented in the ARC/INFO database by a point. This point would be associated with items describing the parcel. ARC/INFO would automatically generate an x,y coordinate, an internal identification number, and a user ID number. These items are fields describing a record. Although it would be possible to include all the information known about a parcel in one record, it was decided that it would be more efficient in terms of performance and storage to maintain information in smaller blocks, which could be linked together by common fields. By maintaining a minimum of information in the ARC/INFO database, most of the work of updating information could be done in Dbase. The related files would then be those maintained by the divisions of Appraisal, Acquisition and Administration.

With this simple system, a user could enter the ID numbers of any county property under review and view them in relation to the county property point map as well as the maps already online, such as major road networks, washes and zoning districts. The advantage of this system is the early functionality within the IMAGIN project development. Later, when the parcel boundaries were digitized, the parcel boundary (polygon) and parcel point layers would be joined, completing the property map.

Health Department Application

Pima County's Health Department was also included in an early applications. The PCHD Division of Disease Control performs disease surveillance throughout the country, monitoring the distribution of communicable diseases in different areas, and identifying unusual patterns of health disorders. Case reports are submitted by physicians and hospitals who are required by state law to report any cases of communicable diseases or disease conditions. The Health Department also maintains a database of annual birth and death records. These are analyzed to identify high risk groups for hazards such as heart disease, cancer, lung disease, diabetes, motor vehicle accidents, strokes and suicides. Additionally, data on community health indicators such as infant mortality, low birth weight and teenage pregnancies are maintained in the database.

Reportable diseases were tagged with a census track number, allowing analysis by age, sex, ethnic group and community of residence. This created a link to the Census Bureau DIME file, a commercially available digital map. This was enough to allow a graphic portrayal of the health statistics. PCHD is one of 10 county health departments selected by the Center for Disease Control (CDC) for participation in a national project on community health planning. The ability to produce maps showing the levels of risk added impact to the reports submitted to the CDC.

Considering the large volume of maps that needed to be generated, ARC/INFO's programming capabilities made it a logical choice to create the maps with a minimum of effort. The system that was devised for this project was designed so that a user with little or no computer background could generate the map by entering choices from a menu system. The user need only select the health statistic of their choice; establish a range of values, colors and title lines; and zoom in to the specific area of Pima County under analysis. In a typical session, the user might ask for incidences of motor vehicle accidents within the range of 0-25, 25-50, 50-75, and 75-100 percent per census tract population. The areas are then divided into these four classes and shaded by user-defined color values. The screen display can be saved as a plot file with appropriate title lines and plotted on a pen plotter to create a letter size map for the report.

The principles used to generate maps displaying statistics could be applied anywhere. The map format could be used to show population density for emergency routing or project siting. Environmental Impact Statements are clearer with the inclusion of statistical maps. Market value

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and neighborhood analysis is facilitated by depicting the assessors' data on land use. The only inputs required would be a digital map and related files of statistics, the area of the map to zoom in to, and the range of values or number of classes.

Through planning and initiative, these divisions were able to use the mapping facilities of a GIS in the early stages of system development. These applications only begin to demonstrate the power of a Geographic Information System. Its analytical capabilities are the strength of a GIS. Long Island's town of Oyster Bay is an example of such a system. They are using a graphics package to link the sanitation database with routing software to generate maps for the recycling crew. The graphics system calculates distances and retrieves information from the sanitation database. The routing system uses this information to generate efficient routes. After the routes are generated, the graphics system is used to display the results.

Routing Application

Oyster Bay's Sanitation Division was responsible for service to 64,000 homes and businesses scattered over 100 square miles. Through an agreement between the town and the Sanitation Union, the measure of work for the crews was determined by a task completion agreement. Due to the uneven distribution of population, vehicles and crew spent a good deal of time in deadhead travel. Oyster Bay needed a way to improve system performance, reduce operating costs, and create an equitable work load for each collection crew.

In 1989, Oyster Bay and its Sanitation Division proposed the development of a solid waste collection and routing system to produce efficient and well-balanced collection routes. This was a major undertaking, considering the scope of the project and the difficulties in estimating task completion in an urban environment. The routing of sanitation vehicles required a street network database at the block level complete with reliable data on load, stops and travel time between all intersections. The town worked with the consultants of Bowne Management Systems to develop the system.

The software used to develop the system was INFORMAP, a VAX-based GIS package designed by Synercom. The system was designed as four modules. One module would be the data housekeeper—storing, accessing and updating data. The second module would extract and assemble data files. The street segment network would be created from the GFB/DIME file and other sources, such as the County Parcel Coordinate File, the town's Assessment File, and the Long Island Lighting Company's Master Billing File. The third module would perform the routing and scheduling. This module was the link to the routing software. The routing software was a series of FORTRAN programs that applied mathematical algorithms to determine the best path. These programs would "handshake" with INFORMAP by passing data through files. The fourth module was the designated report generator, producing reports such as Driver's Daily Route Report, the Area Route Report and Map, and the Route Collection Statistics Report.

The success of the project far exceeded expectations—the first year's savings to the town were triple the development costs. A large part of the success of this system can be attributed to the involvement of the sanitation crew in every phase of system design. The street network within the collection area was checked by the crew to verify the accuracy of the street network, provide details on missing and extraneous streets, identify incorrect street names, identify one way streets, and streets presenting special collection requirements such as constraints on collection time due to schools, traffic, etc.

Up and Running

The new routes generated through this system improved performance, reduced operating costs and created an equitable work load for the collection crew. The completeness and accuracy of the data has attracted the attention of other departments. Departments such as the Department of Planning and Development and the Highway Division of the Department of Public Works are using the Sanitation Division's system as a model for planning and implementing their own systems. The smooth integration of these departments and the resulting efficiency of data exchange would not have been possible without the initiative of the employees of the Sanitation Division, who were willing to take those first steps. IRWA