

## BIOGRAPHICAL INFORMATION

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### Education

M.S., Landscape Architecture, Graduate School of Design, Harvard University, 1969.  
M.S., Urban Planning, Institute of Technology, University of Minnesota, 1968.  
B.S., Landscape Architecture, California Polytechnic College–Pomona, 1967.

### Honorary Doctorates

City University of London, 2002  
University of Redlands, 1999  
Ferris State University, 1993

### Selected Awards

Distinguished Public Service Award for outstanding contributions to national and international affairs, U.S. Department of State, The Secretary's Open Forum, 2002  
LaGasse Medal for Excellence in the Management of Public Lands and Natural Resources in the Public Interest, American Society of Landscape Architects, 2000  
Brock Gold Medal for Outstanding Achievements in the Evolution of Spatial Information Sciences, International Society for Photogrammetry and Remote Sensing, 2000  
Cullum Geographical Medal of Distinction for the advancement of geographical science, American Geographical Society, 1999  
EDUCAUSE Medal for developing outstanding, technology-based teaching and learning programs in geography, EDUCAUSE in partnership with the Association of American Geographers, 1999  
James R. Anderson Medal of Honor in Applied Geography, Association of American Geographers, 1998  
Ed Forrest Award for Excellence in Design/Construction Design Automation, A/E/C Systems International, 1997  
John Wesley Powell Award, U.S. Geological Survey, 1996

### Professional Organizations

GITA  
Earth System Science and Applications Advisory Committee, NASA  
Science and Technology Advisory Committee, NASA  
National Steering Committee, Task Force on National Digital Cartographic Standards Role, International Eurasian Academy of Sciences  
Executive Board, National Center for Geographic Information and Analysis (NCGIA)  
National Advisory Council for Environmental Policy and Technology (NACEPT)  
Information Impacts Committee, U.S. Environmental Protection Agency  
Board of NCGIA—University of California at Santa Barbara  
National Science Foundation: SBE Advisory Committee and AC-ERE Advisory Council  
Committee on Social Science Association (COSSA)  
Committee on Geography, National Academy of Science  
President's Engineering Advisory Council, University of California at Berkeley  
Editorial Advisory Board, *GIS World*  
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# THE ROLE OF GEOSPATIAL INFORMATION - ITS FUTURE FOR UTILITIES

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## ABSTRACT

The ability to provide geospatial content and access within corporate information systems has become increasingly important for day-to-day utility operations. Geospatial systems are now becoming more a part of mainstream information technology. Technology maturity is one reason. However, utilities are now recognizing the strategic value of geographic information from a business, operating and engineering perspective. The future of spatial data usage within utilities will continue to grow. Developments in hardware, GIS software and access methodologies will change the way spatial information is disseminated and processed.

Advancements and growth in three major areas of technology contribute to this shift in GIS usage. The first is mobile access. Wireless technologies will allow unprecedented field GIS usage. The second is the use of embedded GIS applications. Corporate and operational systems continue to add mapping components to allow geographic data queries. Third is the advent of Web services. Web services allow users to perform sophisticated analysis or data manipulation without the need to buy and install applications locally. This paper describes how these technologies will have a profound effect on utility operations.

## PROCESS ISSUES

### In the Beginning

In the days before GIS and computers, maps had been used extensively at utilities. Workers needed to find their way to customers, underground structures, poles, and equipment. The maps served at least these functions:

- 1) Documentation for what had been built – a “visual facilities inventory”
- 2) Basis for engineering upgrades and new customer connections
- 3) Representation of the network for analysis of electric or gas flow
- 4) Basis for storm or outage restoration or leak analysis
- 5) Guiding documents for maintenance and compliance activities

The responsibility for the creation and maintenance of utility maps was with the engineering department and mapping groups within engineering. Engineers and technicians created new work orders. After the new facilities were built, drafters would copy the work order data along with field notes and as built changes back onto the maps. Copies were marked up by field office people and sent back to the mapping group for inclusion on the official maps. Then map sheets were sent to the field offices and trouble centers.

Crews reported to work at the various field offices or service centers. There, they received their work orders, loaded up their trucks with material from the storeroom or warehouse and drove to the various job sites during the day. As crews replaced blown transformers and

fuses, corroded and leaky gas pipes, downed wires and damaged poles, handwritten notes were sent by the crews to the mapping groups. Sometimes they were legible and accurate. Frequently, they were not. Sometimes no record was ever recorded of changes to the electric or gas distribution system.

Often the mapping groups were located at the corporate office. So the mapping group had to print map books and deliver the maps to the field office. Field people would often make notes, called redlines, on the maps to indicate recent changes and mapping errors. In the meantime, the mapping groups were making changes to the maps. Then they would send the new map sheets to the field office. There, someone would have to replace the old sheet with the new one, compare the new to the old and transcribe all the redline notes to the new sheets. Too often the original redlines were lost or incorrectly translated. In many cases, the person transcribing the data had very little knowledge of the meaning of the field notes.

This process produced plenty of problems for utilities. Getting an updated map in the hands of field workers took a long time. Sometimes it took longer than a year to document a change in the utility infrastructure on the official maps. Often utilities reported backlogs that ranged from several months to a few years. There was no real process assurance that the information once displayed on the maps was correct or even relevant anymore. Even if the information on the corporate map sheet was up to date, that information might not reach the right people. Utilities either had to rely on incomplete or inaccurate information to base their decisions on or would be forced to travel to the job location to verify the information.

The negative implications on efficiency were obvious. All kinds of workarounds were invented including special job categories called inspectors. Multiple sets of maps were created for the higher voltage or higher-pressure systems, adding to the map maintenance workload and increasing the chances for inconsistent and uncoordinated data.

Inaccurate data created a host of problems. Utilities that did not maintain good records (in the form of maps or tables) took longer to restore customers. They made upgrade decisions based on out of date data. Their financial records were often incomplete. Utilities had inaccurate records of meters, streetlights and foreign attachments, such as telephone lines and later cable television boxes and wires thus potentially losing revenue or paying too much property tax. Crews lacking good information could show up at the wrong location or have the wrong material for the job.

Another less obvious issue was the lack of recognition of the strategic value of the data that was contained on the maps. The maps were in effect buried within the engineering and operating departments, hidden from strategic planning, rate design, customer service, financial reporting, marketing, environmental and business groups.

While all these process issues seem obvious to us today, this was best business practice for utilities at the time. As loads and revenues grew during the 1950's and 1960's, utilities added more people to the engineering departments in an attempt to keep up with the workload. Operating departments added more inspectors and clerks to keep up with the information flow.

Investor-owned utilities in the United States enjoyed steady growth and prosperity, with little significant regulatory interference from the 1930's breakup of the utility holding companies

(with the passage of the Public Utility Holding Company Act of 1938) until the 1965 Northeast Blackout. Following on the heels of the Blackout and the associated reliability regulations, 1970 Clean Air Act, the 1973 oil embargo, the Clean Water Act of 1977, Three Mile Island, the 1978 Natural Gas Policy Act and the Public Utility Regulatory Policies Act (PURPA) of 1978 continued to put increasing pressure on operational costs. The resultant investments in plant and equipment didn't generate one additional kW-hr or BTU of additional demand for electric and gas utilities. Staffs were cut without making process improvements. The results were predictable. Backlogs increased, making the mapping system less and less dependable.

### Automation Appears

In the 1970's and early 1980's, computer graphics systems began to be deployed in utility companies. They were designed to replace the manual maps. More often than not, those early computer generated maps were created to look *exactly* like the old maps they were intended to automate. Early implementations of these systems typically had two completely separate components – a graphics “engine” and tabular records file. Like the maps that they replace, they were typically deployed solely in the engineering or mapping department. These early systems were based on a computer-aided drafting (CAD) platform that was linked to a separate database of textual or attribute (non-graphical) information. Eventually, the name of these specialized computer graphics systems came to be known as Automated Mapping / Facilities Management (AM/FM) systems.

Since AM/FM systems were typically CAD-based, their graphic primitives contained the mathematical expression to create each line and symbol along with their geographic location. Because of these expressions, entities could be programmatically “connected” to one another, using a parent-child relationship or other network model. Therefore, these systems modeled the electrical or pipe network of the utilities well. What they did not do well was handle areas or polygons because there was typically no support for graphic entities other than network elements. Those systems that did provide primitive support for polygons had to create them from the lines representing edges or boundaries.

Did these automated mapping systems help improve the process problems for utilities?  
Probably not much.

They didn't shorten design times very much nor did they result in any significantly new or innovative solutions to utility problems. The following process issues remained:

- Loss of data in the long journey from the field crews into the information system (whether manual or automated)
- No single source of “official” data communicated to all the decision makers
- Lack of control on the quality of the data
- Long cycle times from work order inception to work closeout
- Lack of intelligent scheduling of work based on geographics
- Lack of integration and reconciliation to corporate data
- No linkage to the supply chain, human resources or customer care processes
- Lack of coordinated data from multiple data sources
- Lack of coordination of data from sources outside the utility

AM/FM systems improved the performance of the existing process, similar to adding additional people. Few utilities actually changed in a fundamental way, because they did not look at their digital data in a new way, despite the technological enhancement. Jobs stayed pretty much the same, only the drafting tools changed.

The non-standard, closed, proprietary platforms further limited the value of AM/FM. In most cases, these systems were not maintained by the corporate Information Technology Departments. The mainstream IT systems of the 1970's and 1980's, like the customer billing systems and financial systems were mostly home grown. Integration to these systems was difficult as well. So integration of early AM/FM to utility corporate systems was nearly impossible.

### GIS is Not AM/FM

During these years, another type of computer graphic system was emerging which handled geographic areas as its primary component. It also linked graphic entities to non-graphic information stored in flat files or databases. GIS differed from AM/FM systems in that it dealt directly with the underlying geography, rather than as simply a means to display facilities.

AM/FM based on CAD attempted to replicate the map sheets, much like a word processor replicates the written word. No new knowledge is created. A GIS, on the other hand, produces a map that is the result of mining geographic and tabular data. A map created by GIS is capable of producing new knowledge. A GIS is capable of answering the question: show me a map that displays all transformers that are within 80% of their nameplate data displayed as red triangles. Or a GIS could answer the question: show me a map that displays areas of rapid population growth where the substation capacity is 90%.

One recent example of the problem solving ability of GIS in an electric utility application occurred during the recent California wild fires. The fires were rapidly engulfing a larger portion of a highly populated mountain community. The electric transmission was severely threatened, but it was not clear where to deploy crews to minimize the threat. The GIS was able to analyze the terrain, weather patterns and utility structure data to provide a prediction of what part of the system was in danger the most. Maps were created that directed utility crews and firefighters to utility locations that were most at risk. Unlike the CAD based maps, the GIS maps created new knowledge. Because GIS works directly with the database, multiple databases were accessible for supporting a community response effort.

GIS can organize existing information and effectively communicate that information throughout the enterprise. GIS can be used as a strategic tool to transform the business. Stated differently, the GIS can be an effective tool to see things differently, to garner new knowledge and to solve serious process problems.

While GIS had a natural advantage for solving business problems (not just improving existing processes), many utilities used GIS in the same way as AM/FM: to simply automate the mapping process.

### IT and GIS Advance Together

Things are changing rapidly. Utilities are driven to improve processes, reduce costs and improve service. They recognize that just implementing a new technology alone is not enough: technology must be coupled with serious process improvements.

The good news is that the technology of both GIS and mainstream IT within utilities has converged.

- Modern GIS design is based upon industry standard computing standards
- IT departments have adopted more off the shelf systems. Homegrown custom mainframe are rapidly being phased out.
- A number of utilities are adopting Enterprise Resource Planning (ERP) systems which integrate well with GIS
- Most of the proprietary databases of the 1980's and 1990's have been replaced with industry standard DBMS
- Wireless communication has blossomed, allowing computing to be deploy in the hand, to the truck and to the utility devices
- The Internet and Web have become accepted tools within utility environments
- Utilities include GIS within their IT framework

Has all this new technology solved the old process problems within utilities? Surprisingly, many of the legacy processes are still present within utilities. While GIS has made some significant improvements at many utilities, there is much more improvement that can occur.

#### MOBILE GIS – DECENTRALIZING DECISION MAKING

Even with automated systems with centralized databases, the challenge and the struggle is to get data into and out of the hands of the field crews quickly and accurately. Many utilities still struggle with the quality of the data within their automated systems. That is because the basic process of collecting data from the field has not changed and they are still straddled with data that was converted from the old manual maps. Mobile GIS creates a new venue for information technology.

As stated earlier, data from the field traveled a long journey from the gas repairperson or electric troubleshooter or the line worker to the corporate GIS. In that journey, there were a number of hands touching, copying and interpreting the data. In this revolving workflow, field crews and engineering workers had to work with out of date and incomplete information, requiring more data correction to the mapping groups.

Mobile GIS allows:

- Data to be captured directly in the field with no unnecessary interpretation.. Reconciliation and QA can occur immediately. The journey of field data to the corporate office is immediate.
- Access to the single source of data. Everyone involved in all steps of the process are working from the same data.
- Data to be validated visually and programmatically. Data quality will improve rapidly with mobile GIS.

- Helps to dramatically reduce cycle time for designs and new construction.
- Intelligent routing and rerouting to occur immediately and dynamically as field conditions vary.

By fully expanding the use of mobile technology, utility managers may be able to rethink the entire business process.

For example, utilities may create virtual service centers, in which workers rarely report to field office at all. With mobile work designs, information can be immediately forwarded to vendors, allowing for the elimination of service center warehouses. By fully deploying mobile technology, utilities could completely shift the way they handle nearly all aspects of their field force workflows.

Three key process improvements can occur:

- Data about infrastructure are captured immediately from the geographic location where the facilities are located and made available everywhere in the organization
- Decisions are based on current data.
- Workflows and crew routing can be optimized

The results of process improvement using mobile and routing technology can have a dramatic impact on the bottom line.

### EMBEDDING GIS – VISUALIZING THE ENTERPRISE

While GIS is often associated with stand alone systems, like the early AM/FM systems, it is now possible to embed GIS functionality directly into other non-GIS corporate applications. Not only can the functions be embedded, but the data accessing ability is embedded as well. This allows utilities to access and leverage the investment in the GIS database but not have to integrate a GIS system to the corporate system to benefit from the data. Embedding gives general corporate system users the ability to spatially enable their work. Customer, collection, service dispatch, work management, outage and financial systems all have spatial components and could benefit greatly from having deeply embedded GIS capability.

Some things that utilities could do include:

- Drawing relationships between reliability issues and crew productivity
- Comparing crew productivity across multiple divisions
- Fully integrating work requests and designs
- Measuring the impact of vegetation control on operations
- Providing high level asset management – being able to visualize where the money is being spent
- Seeing financial data and infrastructure data geographically
- Electronically taking simple new connection and street light orders, scheduling projects, and reserving material on the spot

### WEB SERVICES – BROADCASTING KNOWLEDGE

Utilities cannot afford to recreate and maintain information that already exists and is being maintained outside the company. Examples include new subdivision, environmental, zoning, weather, crime, demographics, vacant land use and planning council data. Yet this data is important to utilities. After 9/11, utilities more than ever need rapid access to information and services that are currently not maintained internally, such as security information.

Utilities also cannot afford to have large overhead staffs of experts in local planning, environmental and weather.

GIS based Web services provide the means to access geographic data from outside the utility and to coordinate with the GIS data that exists within the utility. These services provide the means to reconcile different projections and scales effectively. In addition, Web services can provide expertise that operates on the data that the utility does not have.

Geo-coding is a simple example of a Web service. A fire dispatcher receives a call that a building is on fire and is threatening other structures in the area. That dispatcher electronically notifies the gas company of the address via the Web. The utility, via a geo-coding service (both data and functionality lie outside the utility), receives the coordinates of the location; then coordinates the location with the customer locations within the GIS; identifies the nearby shutoff valve; and dispatches a service person using an optimal routing algorithm to the exact location. The routing algorithm could also be a Web service.

Environmental validation is another example of a Web service. Botanists delineate vegetated wetlands. Utilities typically do not have the expertise or the data to maintain wetland delineation. Yet disturbing a delineated wetland by a utility can be expensive, can cause a public relations issue and can shut down an important project. A utility could subscribe to a Web service that provides immediate notification when a project is within an specified distance from a delineated wetland from within the internal utility's GIS design process. The data and intelligence are maintained by a service outside the utility.

Utilities can create their own GIS web services for use within the utility or for contractors and customers use.

Utilities could use Web services for:

- Automated work order creation every time an electrician is issued a wiring permit by the local wiring inspection agency
- Utilities with multiple street light ownership can create an automated Web service that checks the ownership of the street light in the case of a lights out call
- A service that checks the tax districts for automatic creation of property tax, where there may be multiple and overlapping jurisdictions
- A service that alerts the utility of recent seismic activity near transmission towers or natural gas pipeline
- A service that notifies pipeline operators of building permits of structures that would result in a change of regulatory classification (such as day care centers, nursing homes)

A Web service saves utilities from maintaining data that they don't have control over (such as zoning or environmental overlays) and provide expertise outside the utility's core competency (such as botany).

## MAKING THE BUSINESS CASE

The application of new technology and thorough rethinking of the fundamental processes has the potential of dramatically improving the performance of a utility. Following are some specific examples,

A southwestern United States natural gas distribution company implemented mobile GIS coupled with routing technology to provide gas technician service to its customers. Unlike telephone and electric service, which can be switched on and off from a central location, the nature of gas service dictates that technicians must go where the gas is being delivered. More than 1,000 employees work as customer service technicians and receive thousands of requests for service each day. The nature of the requests range from having the gas turned on when someone moves into a new home to turning off the gas when someone moves out, to requests for gas appliance repairs and adjustments, to requests to have pilots turned on. Using mobile GIS and routing capabilities, technicians are optimally directed to their customers using advanced GIS and geo-network processing algorithms to minimize the number of miles traveled and ensure that appointments are made on time. In addition, technicians have access to all the data about the gas distribution system. Further, if technicians find conflicting or bad data in the field, they can update the information immediately using a handheld device. The company estimated that it reduced 2 million miles of travel in the first year of implementation. Savings result from fuel to vehicle maintenance to reduced overtime.

Two electric utilities in the southwestern United States made detailed studies of backlog reduction using GIS, by rethinking their process. One company, posting more than 12,000 work orders per year, has seen a decrease of more than 35 percent in backlog since the GIS production application was deployed. Work order posting costs were reduced from more than \$13 each to approximately \$6 each. The second company reduced the time required to post backlogged work orders from more than six months to less than one and one-half months, with critical operational network changes posted overnight.

A Scandinavian utility uses an integrated schematic generation tool within the GIS design environment to allow all designers to view data in schematic form. As a part of the work order process, each proposed improvement requires a switching diagram, a large-scale schematic of the area and feeder affected by the proposed change. This utility has estimated that it saves three to five hours per design by generating the schematic, rather than redrawing a switching diagram each time.

A major urban/suburban utility expected to reduce its service crew overtime by 24 percent by improving the numbers of crews it had to hold "on-shift" to meet demands during storms. Throughout its service territory, this utility was able to save more than million dollars per year through better prediction of service restoration requirements.

An urban utility in the United States made a detailed study of the cost of complaints including those leading to settlement for damages. Implementation of an GIS that integrated

with an outage management system allowed it to reduce the number of complaints that resulted in a repeated call, sometimes for a second or third time. The overall cost reduction was more than \$890,000 per year. In addition, claims for damages were reduced by more than \$50,000 per year, by improved information and response time.

## SUMMARY

The challenge for utilities implementing true enterprise GIS is to fully understand that a GIS is not an automation of the former mapping business process but a foundation for many business processes, many of them new. The justification for the GIS is not in the improvement of the mapping process, but as one of the enablers for fundamental and perhaps radical process improvement and its associated savings in cycle time, asset utilization and productivity. Putting the data and functionality directly into the hands of the field force at the job site has the potential for providing quantum increases in crew effectiveness and data quality. Embedding GIS functionality and data directly into corporate systems gives utilities a strategic view of how the utility is functioning. Finally, Web services have the potential to revolutionize how utilities think about internal and external knowledge and expertise.