Enterprise GIS for Utilities—Transforming Insights into Results

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An ESRI White Paper

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Enterprise GIS for Utilities—Transforming Insights into Results

A geographic information system (GIS) is a language for communicating content and processes for the utility business. People working in the utility industry need a better understanding of the context of change, what it means, and how they can manage their present and their future. They need better information and a framework for understanding and collaboration. As utilities merge and staff shrink, sharing workflows in an automated and systematic way is vital. The enterprise GIS platform facilitates collaboration by unifying the underlying data infrastructure and workflows with other key utility information system (IS) platforms such as SCADA; enterprise resource planning (ERP); asset, work, and outage management; and field force automation.

GIS is used to apply geospatial information to a host of utility applications. As a result, GIS is helping utilities unify by integrating information from many sources, both internal and external, into a common framework. By using this common geographic language, utility managers discover new insights that they can transform into tangible business results such as lower costs, improved asset utilization, and quicker customer hookup.

New technology such as Web services, location-based services, geoprocessing, loosely connected distributed spatial databases, smart clients, and intelligent GIS unifies information for utility executives, managers, and operators. Decision making, communication, and asset management can be based on the same information throughout the organization. This white paper discusses some of the ongoing issues still facing utilities and GIS technology's impact on utility management, operations, and engineering.

Introduction

What went wrong? The utility spent millions of dollars on the automated mapping/ facilities management (AM/FM) system in the mid-1990s. It converted its old operating drawings to beautiful crisp, clear computer-generated plots. And yet when one of the distribution operating managers asked that the new GPS tracking system installed in their trouble trucks be interfaced with the AM/FM system, the operating manager was told it couldn't be done. Huh? The AM/FM manager sheepishly had to confess that the old maps were converted "as is" based on the old mapping standards, before GPS was invented. The next obvious question was, Can the AM/FM system be adjusted to conform to the new GPS standard? The answer was that anything was possible, but it would take a major effort to reconstruct the locations of all facilities to a new consistent land base.

The operating manager opted for an independent vehicle tracking system based on a commercially available land data source with no interface or links to the AM/FM system. Opportunity was lost.

Another utility decided to interface its newly converted distribution mapping system with a brand-new commercially available outage management system. While the distribution maps looked fine, there was no quality assurance of the proper connectivity of the electrical network, nor were there any relationships built between the conductors, the poles, the transformers, the streets, or, most important, the customers. Could the digital mapping system be fixed? Anything was possible, with enough money.

The utility decided to maintain the operating network separately in the outage management system. Opportunity was lost.

The CFO of a major gas utility had just closed a deal on a new ERP system, which included a plant accounting module. She asked that ERP be integrated with the distribution mapping system. Sadly, the mapping system was a file-based CAD system. None of the gas service pipes were mapped. The cathodic protection system was maintained separately in a different set of CAD files that didn't coordinate with the main system. It would take a major overhaul to link to the ERP system.

The CFO abandoned the idea. Opportunity was lost.

A medium-sized electric utility discovered in an embarrassing audit by the public utility commission that it had been overstating the number of poles it owned for the last 10 years. The only real record of the pole inventory existed on paper maps that had a spotty history of maintenance. The company was forced to do an expensive field audit. After the audit, though, the company had no comprehensive system in place to maintain the audit data other than by hand. Opportunity was lost.

An electric utility decided to diversify into the telecommunications business. It rushed to install fiber optics, coax, and twisted pair on its distribution poles. Yet in its haste to build out the system, it abandoned the use of accurate electric GIS and instead opted for an inexpensive CAD drawing tool for construction work orders. The tool had no particular regard for scale, location, or consistency. The system was then turned over to the GIS department. The telecommunications GIS project required rebuilding the data from scratch and resulted in a major backlog of work for the mapping group. The telecommunications system existed undocumented. Opportunity was lost.

Today, most utilities recognize the strategic value of good data. It's hard to imagine operating a complex infrastructure without an up-to-the-minute understanding of its condition and configuration. Yet it happens all the time.

A digital mapping system is not an enterprise GIS. However, a properly designed enterprise GIS coupled with good processes can produce fabulous and useful utility maps. Utilities run into problems using their digital mapping systems because they have viewed the systems as applications to solve a specific utility problem such as needing a system to keep track of cast iron gas mains, solving a streetlight maintenance problem, improving the design process for distribution engineering, holding inspection data, or viewing the results of a voltage drop study. An enterprise GIS is not a series of spatially enabled or map-based utility applications. While a properly designed enterprise GIS can, in fact, be used to solve all the problems raised above, it should rather be viewed as a critical information technology infrastructure: a spatial information platform.

The Utility Enterprise Architecture

So what did each of the utilities in the above examples lack? The answer seems simple enough: a comprehensive enterprise GIS architecture. The connection of servers, networks, and PCs is certainly part of the architecture. The database management system

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is a critical component. The application programs, user interfaces, and interapplication interfaces play a role. Data is critical. These are all important and all of the above utilities had these things. Yet the data was incomplete or redundant, the applications didn't work together, and the workflows were disconnected. One department would end up maintaining similar data as another. Lots of opportunities were lost. Precious labor resources were wasted. The utility processes were not unified.

The architecture for the utility must have at least the following interrelated components:

- **Workflow and process models:** This is the identification of the master process and subprocesses that drive business for major stakeholders in the utility: the customer, the shareholder, the community, and the employee.
- **Data models:** Utility data models describe the data, data relationships, and behaviors that are needed for the workflows in a logical and disciplined way.
- **Data:** This is the actual data that details the utility land base, customer locations, and infrastructure.
- **Output products:** These products are tools that people use to make decisions, do work, and communicate.
- **Integration framework:** This allows corporate systems to be visualized along with location, often in the form of a map.
- **Physical architecture:** This includes all the hardware, operating systems, processes, tools, DBMSs, and networks that make the whole thing work.

Workflow and Process Models

It's difficult to look at enterprise architecture without considering a handful of enterprise processes. While they may seem obvious at first, these processes drive much of the business. Examples of master processes include restoring customers after a storm, rendering an accurate bill and collecting the payment for gas, paying property taxes, complying with a regulatory reporting requirement, hooking up a new gas customer, or filing an annual statement with the security and exchange commission. Every process contains a workflow.

The problem for many utilities (and other businesses) is that work gets organized into functions for practical purposes of management. When the functions were created, they may have made perfect sense in the context of the business process and requirements that drove the process. Further technology may have been created to support the functions. New business requirements (like liberalization), demands (like lack of tolerance for intermittent power interruptions), and technology (like Web services) may have rendered the functions ineffective, obsolete, or counterproductive. Introducing enterprise GIS into a business without making sure the process models and workflows make sense in the current business context is risky.

Mapping groups can fall into a trap where they believe the production of accurate as-built maps is a critical business process. Map production is really only a service to one or more business processes. Yet some utilities spend an enormous amount of time detailing the critical requirements of the mapping process, including the look, color, line weights, annotation placement, and level of detail contained on the maps, while minimizing the more strategic service that GIS (not the maps) provides to outage management, new customer connection, and asset management processes, thus elevating the importance of the maps and devaluing the importance of the service. In the first example that appears at the beginning of this paper, the computerized mapping system perfectly met the needs of replacing the old hand-drawn maps with easy-to-maintain maps that look like the old ones. Yet the new mapping system didn't provide even a rudimentary service to the critical business processes of the utility.

Functions and functional departments can become introspective. Work rules are often hard to change, especially in a union represented utility. Managers of functional units can be threatened to preserve the status quo. Change is always painful; people avoid change and so do organizations. Massive business process reengineering reorganization initiatives can be very disruptive and get "into the weeds" very quickly. Nonetheless, if GIS is really going to be enterprise-wide, some degree of overall process modeling needs to occur to make sure that the GIS is in fact meeting the needs of the utility. At the very minimum, process in relationship to the data sources should be modeled.

It's the Data Model

Once the workflows have been established and process models built, the data models need to be constructed. In its simplest form, a data model is nothing more than a structured way of describing the data needed in a workflow. Today, most data models are described in a standard format called Unified Modeling Language (UML). When described by UML, the data model presents the data in a structured, object-oriented way. The purpose of the data model is to capture in one document three essential components of data used in the workflows and process models:

1. Attributes—For example, the rating in kilovolt-amperes (kVA), phase, and manufacturer of a transformer

2. Relationship—For example, the relationship of a pole to a wire

3. Behavior—For example, what material type values are valid for a gas main

Some of the data needed in a workflow may come from outside the utility like street opening permit data, indigenous population protected areas, vegetated wetlands, or zoning overlays. The complete data model includes all types of data generated internally and used externally. Data models are developed around major elements of industries that generate or use the data. There will be a data model for land information, gas and electric distribution, electric transmission, pipeline systems, customer information, and many others, depending on the workflow and process models that are created.

Web services can be an effective way of extending the data model from external providers and government agencies. Utilities have a hard time keeping up with their own data, never mind having to keep track of someone else's. So if, for example, a transmission department needs to know the current status of vegetated wetlands surrounding a proposed site for a transmission line, it would be far better for the utility to subscribe to a service from an organization who is responsible for keeping that data up-to-date. That service could be a Web service that seamlessly integrates into the utility's enterprise GIS.

Geodata Sets

Obtaining or creating good data often represents the largest cost of a comprehensive enterprise GIS project. Usually data conversion/migration falls into these categories:

- Direct conversion from paper sources—While most utilities have converted much of their facility data into a digital format, there still remains much data in raw hand-drawn form. This would include those drawings and maps that have been digitally scanned.
- Building the data from field inventory—Some utilities have made an assessment that their paper (or digital) data sources are too out of date, incomplete, or inaccurate to convert. So they rely on a process of direct field data collection. Today, that usually involves collecting the GPS location of critical network devices. This process is most often used for overhead electrical systems.
- Digital data migration—This involves converting CAD, AM/FM, or legacy GIS data to a more modern platform. Often this process requires considerable manual data correction.

Many projects will use a combination of all three processes.

Data Quality

Although many utilities have data in electronic form, they need to create internal processes for data quality improvement. Many utilities that have used CAD, or even GIS, alone for mapping have found that they do not have sufficient quality within their data for enterprise applications. Maps rely mostly on how well they look. GIS applications rely on the proper database design including connectivity of the data.

One common problem in gas distribution utilities is the time and internal effort required to build an accurate gas network model for their gas network analysis. Utilities that have used CAD systems have found that creating a gas network model requires weeks of work even though the data is in electronic form. A properly designed GIS data model with good data maintenance tools will allow gas utilities to directly utilize the GIS gas connectivity model for network analysis. However, there will be a cost associated with fixing the network connectivity data from the legacy CAD, AM/FM, or even an older GIS dataset.

Many utilities have been disappointed when they have used GIS data for their outage management algorithms. Inconsistent phase data, tiny discontinuities in the connectivity data, and lack of consistent links between network data and customer data have plagued utilities that have assumed that their electronic mapping data has the quality needed for outage management. These inconsistencies and data quality issues must be addressed before the data can be used for advanced applications. Like the gas model, electric connectivity has to be outstanding for it to be used for outage prediction. In fact, no connectivity is probably better than bad connectivity for outage management. Lack of enforcement of connectivity rules during the creation of the CAD drawings and the edgematching issues can create a nightmare for a utility.

Many utilities created their own mapping coordinate systems. For convenience, they created mapping grids. These grid designations are often found in the databases of related systems such as unit of property accounting systems, customer systems, and trouble call systems. Internally, these grid systems worked well, creating graphic reference systems.

For example, some utilities would number their poles according to the company's grid numbering system so that a pole contained within a certain grid would have a pole number starting with the grid number. The grid numbering system became embedded into a whole host of processes.

Over time, these nonstandard mapping systems become inaccurate and not easily coordinated with government systems based on standard coordinate systems or land projection systems. In this case, the use of external data sources is of diminished value because the facilities do not lie in the proper orientation with the external data sources. As in the example at the beginning of the paper, this mapping either precludes the use of GPS or requires constant correction.

If a utility based its old manual mapping systems on an arbitrary grid coordinate system, it should seriously consider adopting the standard land base system used throughout the region by government agencies that conforms to GPS standards. If they don't, there will be an additional cost to adjust the electric and gas facilities to this standard land base system. There will also be additional costs to change other corporate systems that buried these grids within their systems. Without consistent land references, utilities will not have the ability to share critical data when serious events occur such as the recent hurricanes that ravaged the U.S. Gulf Coast.

Output Products: Maps

The point of GIS is not to replicate existing maps; it is to create new knowledge and awareness so that utility employees can make better decisions, communicate those decisions more clearly, and be able to deploy resources in a more coordinated way. That means the output products need to effectively communicate in an outstanding way.

Attention to cartography is essential. Early AM/FM systems were devoted to the replication of existing hand-drawn maps to the point that employees found the digital maps to be less useful than the old hand-drawn maps. There are very practical constraints of making a map. For instance, if a map is created at a scale of 1 inch equals 400 feet (as with the old maps), it becomes impossible to clearly represent much detail.

As an example, most utilities install distribution poles, on average, 150 feet apart. Assume that the pole symbol is a circle. For clarity, assume that the pole symbol circle has a diameter of about one-fourth of an inch. If there is a transformer on one pole, a switch on an adjacent pole, and a lateral tap on the next adjacent pole (each of these symbols measuring ¼ to ½ inch) with appropriate annotation of the equipment, the symbols will likely overlap each other. In the old days of manual mapping, drafters used great discretion in scale and accuracy with liberal use of arrows and insets, match lines, and all kinds of drafting tricks.

As process models and workflow and data models are designed, utilities must face the need to change the presentation of the maps. Strict adherence to legacy mapping standards could impact the overall performance of the system. Since we now know that GIS is about process improvement, if utilities overly complicate the map production process with complex mapping algorithms and annotation rules, which in and of itself is not strategic, the utility may fail to see the potential improvement in strategic business processes. As mapping data is published on the Internet and made available to wireless and handheld devices, the presentation of the mapping data should be optimized for the

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specific media. Therefore, maps on the Internet and on mobile devices should not be encumbered by old-fashioned mapping conventions that applied to hand-drawn maps.

Integration Framework

To really unify a utility, the enterprise GIS needs to become part of the utility's overall IT framework. Since GIS can apply to nearly all aspects of the utility, it makes sense that the spatial information be readily available to all IT systems throughout the enterprise. Today, there are many examples of utilities integrating their GIS through common integration frameworks. Utilities have the ability to publish Web services of their GIS data coupled with other corporate data to outside agencies. They can also consume Web services. They can use their GIS as a location-based service framework for locating employees or equipment using standard field devices.

The Physical System

Servers, desktop PCs, enterprise application integration (EAI) buses and software, networks, routers, operating systems, storage devices, wireless devices, and DBMSs play a huge role in the effective deployment of enterprise GIS. The physical system must be coordinated with process models and workflows. Utilities need to decide how employees are deployed and where data needs to be accessed.

If a utility is spread over hundreds of miles of territory and there is only weak, low performance, or high-risk telecommunication between where the data resides and where the people need the data, then the physical system needs to be constructed to alleviate this. A physical system must be constructed to account for workflows, not the other way around. Poor response time, network outages, and lost work will quickly frustrate workers already wary of the new system if utilities construct physical GIS projects that are too weak or lack computing, network, or storage capabilities.

GIS Enterprise Architecture: Unifying the Utility

Building an enterprise GIS is not about converting maps to digital form or even about creating mapping applications. It's about improving critical business processes that have a spatial component, which most utility processes have. Workflows and process models really must be examined in the context of the core IT systems like the back-office billing, customer, financial, supply chain, work management, outage management, and SCADA systems that underpin the business processes. Enterprise GIS, such as those systems, is not an application but one of the underpinnings of the total utility IT infrastructure. GIS viewed as a spatial information architecture has the potential to unify the processes within a utility and recapture those lost opportunities.

Learn more about how utilities are using GIS to transform their business practices at www.esri.com/electric.

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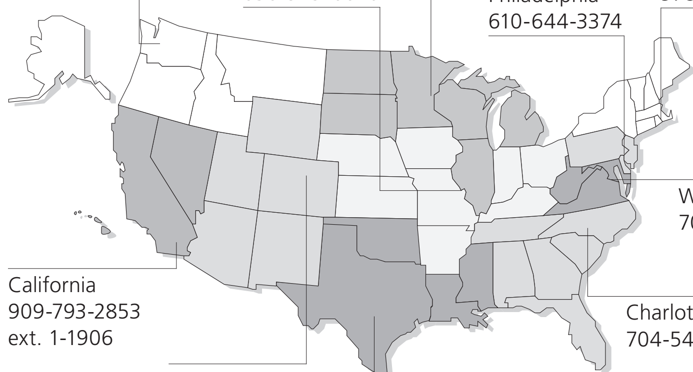

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