Integrating SCADA Systems with AM/FM-GIS Technology

by Mark G. Wehmeyer

Utilities throughout the country are implementing computer-based technologies in an integrated manner to help streamline many design, planning, maintenance, and analysis applications. And the acronyms AM/FM-GIS (automated mapping/facilities management) and SCADA (supervisory control and data acquisition) are appearing at an increasing rate in the language of the water and wastewater community.

Today's open system computer architecture allows for this multi-application integration. Of course, cost savings and maximizing use of resources are primary driving forces. Utilities, vendors, and consultants must take time to plan systems integration based on a thorough study of needs and a clear organizational consensus prior to implementation of solutions. Preparation of a detailed strategic automation master plan document followed by an implementation plan document is the first step. Involvement of users and teamwork among all participants is a must that requires priority attention during the entire systems integration project. Complex integration projects can yield real benefits, but time for sufficient planning must be allocated.

Much has been written about integration of computer systems. However, the tendency to discuss the characteristics and virtues of the myriad of computer industry standards perhaps has been too common. There is a confusing array of standards for all aspects of hardware and software. Different standards are being sponsored and supported by different groups in the computer industry. What they have in common is their goal to provide improved interoperability between different manufacturers of hardware and software. To a large extent this interoperability has been successful and vendors are now producing systems that can be considered open.

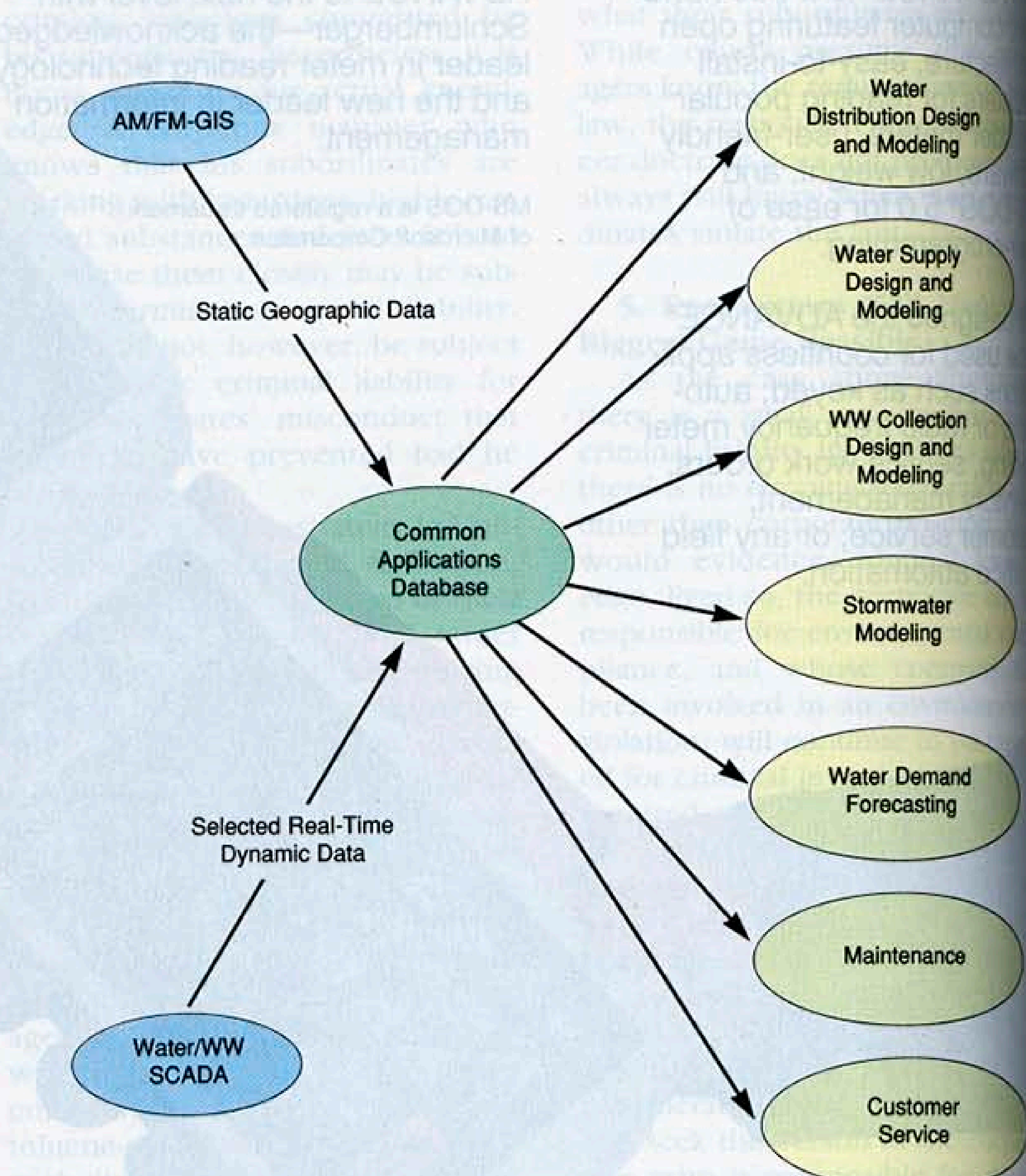


Fig. 1: GeoSCADA Model

An open system is one in which the user does not know or care precisely which computer he or she may be accessing, or just what software is running. The user is just concerned with the application. No emphasis is placed here on how interoperability is accomplished. Rather the focus will be on

- Forces driving system integration and the characteristics of an integrated system
- Different computing applications being used by utilities with integrated SCADA and AM/FM-GIS
- Techniques for, and expectations of, a systems integration project

SCADA Evolution

In the 1970s and into the early '80s, SCADA vendors built many of their own system components. This was because commercially available man-machine interface (MMI), networking, and telemetry hardware were not available to provide data acquisition, display and control tasks. Because of the revolutionary increase in the cost-to-performance ratio of personal and minicomputers, and the maturation of a number of broadly-accepted local area network (LAN) and wide area network (WAN) products, vendors have migrated from proprietary hardware to the use of industry-standard equipment. Consequently, today's

SCADA host computer and its associated MMI are suitable for integration with other computer applications

SCADA vendors also are moving toward providing products with open systems compliant software. From the user's point of view, the degree to which the various software modules contribute to overall interoperability is an important aspect of a vendor's offering. Oftentimes it is also the most difficult to determine. For many years SCADA vendors have been using industry (but not necessarily open systems compliant) standard operating systems. Today systems are being sold with a variety of proprietary and nonproprietary modules including

- Operating systems
- Database structures
- Communication protocol
- MMI (graphic) software
- Networking
- Reporting software

The software layer that does the input/output (I/O) scanning, trending, alarming, and closed or open loop control can be thought of as the SCADA applications layer. This layer is typically proprietary and may remain so for some time since this software is what distinguishes one vendor from another. In the electrical distribution and energy management industry, many basic control algorithms are standard from one vendor to the other. To-date there has been some work to attempt to standardize typical water system control functioning, but nothing has been successfully commercialized.

Characteristics of Integrated Systems

A primary characteristic of most successful implementations is that they were preceded by a careful analysis of the organization's needs and capabilities. Following the needs analysis phase detailed master plans were prepared.

SCADA and AM/FM-GIS integration differs with each organization. That is why a master plan is critical. But, to varying degrees, many organizations have emphasized all or part of the GeoSCADA model illustrated in Fig. 1.

This model allows for the information in an existing computer environment to be left in its native system. For example, the SCADA data would reside in the format originally designed by its system supplier. Access to data through a variety of system integration techniques can build a comprehensive system that most effectively meets the needs of the total user base. By taking advantage of advances in relational database management systems (RDBMS), utilities are implementing systems that maintain data on the AM/FM-GIS database while maintaining other applications on separate databases. Spatially-related data links are used to tie the various data together. Using this technique results in computer system solutions that emulate, as well as complement, the way organizations operate. For example, integrated systems should

- Allow each department to perform its individual functions and maintain its own information independently of other departments.
- Allow all departments to access and use common data.
- Allow each department to communicate with all other departments or computer systems.
- Control and manage the organization's data through effective database management.
- Be easy to use so people throughout the organization will be able to take advantage of the system's capabilities.
- Protect the organization against loss or corruption of data.

There are pros and cons to integrating computer applications. The handling of information within a utility is a process. As with any process, there are multiple alternative designs, each with advantages and disadvantages. Advantages of integrated systems include

- Reduced or eliminated duplicate data entry
- More consistent and accurate information because updates are input only once
- More timely information
- Increased productivity
- Lower data maintenance costs

Some disadvantages are

- Increased implementation time
- Not all software products work on a variety of hardware platforms therefore limiting product choices
- Computer personnel must be skilled in the use of more than one computer system, as well as networking and distributed processing

If a user wants to obtain (or upgrade to) an open systems-compliant SCADA system, suppliers who can meet the need are available.

Why Should SCADA and AM/FM-GIS Be Integrated?

Both SCADA and AM/FM-GIS applications are geographically referenced database sets. Many vendors and consultants present the argument that it is instinctively obvious that data from closely related applications should be integrated. Without a thorough study of specific needs, the costs and benefits of coupling two or more applications will not be known. However, we do know that the cost of labor, energy, regulatory compliance, construction, employee benefits, and just about everything else a utility uses is rising, except for the cost of applied technology. A few examples serve to illustrate this:

- Water quality regulations imposed by the Safe Drinking Water Act will cause a ten-fold increase in the number of regulated contaminants by the year 2000.
- The public expects to receive excellent service from all organizations they deal with, including water and wastewater utilities. According to a study done by Training Magazine, we are responding to this expectation by a dramatic increase in training expenditures, The number of programs has more than doubled from 1985 to 1990.
- Labor costs continue to increase and health care costs are skyrocketing while actual pay increases have been modest. This means that attempting to meet the demands for quality water and customer service by proportional increases in staffing will create disproportionate increases in cost.
- Other water treatment and production costs such as energy and chemicals are rising at or above the inflation rate.

The driving forces for integration of SCADA with AM/FM-GIS are cost containment, improved service to customers, and better protection of our environment. These are the same forces that drive virtually any project that a utility pursues. A distinguishing factor that the implementation of technology has is its effect on the people and the organization from the perspective of training necessary to use and accept the technology, and also the potential to redefine job roles and responsibilities. This "re-engineering" of the organization's way of doing business has real efficiency and cost benefits.

Application Trends

The types of data provided by AM/FM-GIS and SCADA systems are quite different. AM/FM-GIS systems contain massive amounts of data, all referenced geographically and all relatively static in nature. SCADA systems, on the other hand, generate large quantities of data that are dynamic in nature since the systems they monitor and control are always changing. The nature of SCADA's data acquisition and control functions fit into the category of "real time." Since the system's database is constantly being updated, its structure is tailored for fast access and is typically hierarchical in nature.

The typical AM/FM-GIS system provides a seamless interface to Structured Query Language (SQL)-compliant database products. Most SCADA vendors also have the ability to map data to SQL databases, which is depicted in the center oval of our GeoSCADA model. From this location, near real-time and historical data from the SCADA, plus the facility-related information from the AM/FM-GIS system, is available to the utility's various data users. Today these types of applications may include

- *Water Distribution Design and Modeling*—The ability to combine graphical representation of treated water pipelines, hydraulic modeling software, and real-time operations data provides the utility with a powerful design/modeling tool. Actual operations data can be used to calibrate the model so that accurate "what if" scenarios can be played out, Theoretical energy consumption calculations can be performed using different operating parameters to help determine the best mode of operation for different conditions.
- *Water Supply Design and Modeling*—SCADA systems are being used more and more to monitor raw water supply information such as aquifer or reservoir levels. Combining this information with hydraulic models and geographic information on water supply networks allows for determining the best wire-to-water efficiencies of wells and pump stations. In response to increasingly stringent water management regulations, graphical presentation of the effects of raw water consumption (such as aquifer level changes) are being made using SCADA date and AM/FM-GIS mapping capabilities.
- *Wastewater Collection Design and Modeling*—Two important applications are being undertaken by many utilities. First, the combination of monitoring sewer flow in various areas of the collection system, superimposed on weather conditions, is used to plan inflow and infiltration (I/I) strategies and to measure the effectiveness of corrective systems performed. Secondly, modeling software coupled with collection system maps and historical SCADA information is used to plan wet weather operation of lift station systems to utilize the storage capacity in the sewer system and to minimize hydraulic fluctuation at the treatment plant.
- *Stormwater Modeling*—Historically, hydraulic models and mapping applications have combined to provide pictures of storm events. Recent permitting regulations have moved utilities to monitor their stormwater discharges with SCADA technology. This increased data availability leads to better predictive tools.
- *Water Demand Forecasting*—This application is, again, a combination of real-time data, historical data, geographic presentation of distribution system and hydraulic modeling software that utilities are using to help predict water consumption during different times of day, types of weather, and different seasons.
- *Maintenance*—Some applications utilities are using include automatic triggering of preventive maintenance work orders based on run times, analysis of maintenance on a geographical area basis, and capability for SCADA operators to electronically enter work order requests and trouble descriptions.
- *Customer Service*—Utilities are implementing systems that have the ability to obtain information rapidly on customer status, requests, or complaints from the customer service computer system by using the AM/FM-GIS system. Such requests might include water pressure problems, sewage overflows, and the like. The SCADA operator is able to access land-based information plus the operating data and dispatch maintenance crews to correct problems. This data is typically not real-time, but improves the effectiveness of service to the customer and, consequently, their satisfaction.

Information As An Asset

Some utilities have taken the approach that information, particularly AM/FM-GIS type data, is a tangible asset, and updating that information involves a capital expenditure. The same logic could be applied to historical SCADA-acquired information. The useful life span of such data is generally considered to be 20 years or more. Mapping-related data may have a life of 50 years or more.

Many examples exist of utilities forced to use outdated and/or inaccurate maps, as-built drawings, or water consumption data. Virtually every AM/FM-GIS project implementation involves some technique for correcting the existing data set. The time and, therefore, the costs of updating can be very high. However, costs associated with using inaccurate data for planning or design work can be many times higher. If data is not up-to-date or accurately maintained, then every tine a design project is started, the information must be validated. Worse yet, costly field construction corrections may need to be made. And without complete information a utility cannot monitor and report the environmental impacts of its actions properly.

Establishment of an integrated AM/FM-GIS SCADA system should be considered a capital expenditure. As such, projects involving complex information systems don't have to compete with operating expanse budget line items that may be based on a tight tax base and revenue stream.

Techniques and Expectations

Open Systems Compliant Specifications

Numerous published and accepted computer systems standards exist. These come in many forms

Fig. 2: Top 10 Contributors to Applied Technology Success

Characteristics	% of Respondents
Good planning	67
Clearly defined needs	63
Sufficient staff to operate and maintain	56
Reliable equipment	55
Good vendor training and support	51
Operator assistance	50
System maintainability	50
Management backing	48
Field instrumentation	48
Realistic expectations	48

mapping, networking, electrical interface specifications, mechanical packaging specifications, communication protocol specifications, etc. Some standards are "official," others are "de facto." If a utility wants to upgrade an existing computer system or implement a new one, its written specifications should call for open system compliant hardware and software. If staff do not have the time, experience, or knowledge to prepare such specifications, a qualified consultant should be engaged. The standards are confusing and some vendors have self-serving interpretations.

Obstacles To Implementation

A recent survey by the Association of Metropolitan Water Agencies indicated that seven out of ten key factors influencing the success of applied technology are human, not technical. Figure 2 summarizes the survey results.

The following obstacles to success have been identified by utility staffs from their experiences in planning and implementing AM/FM-GIS and SCADA projects.

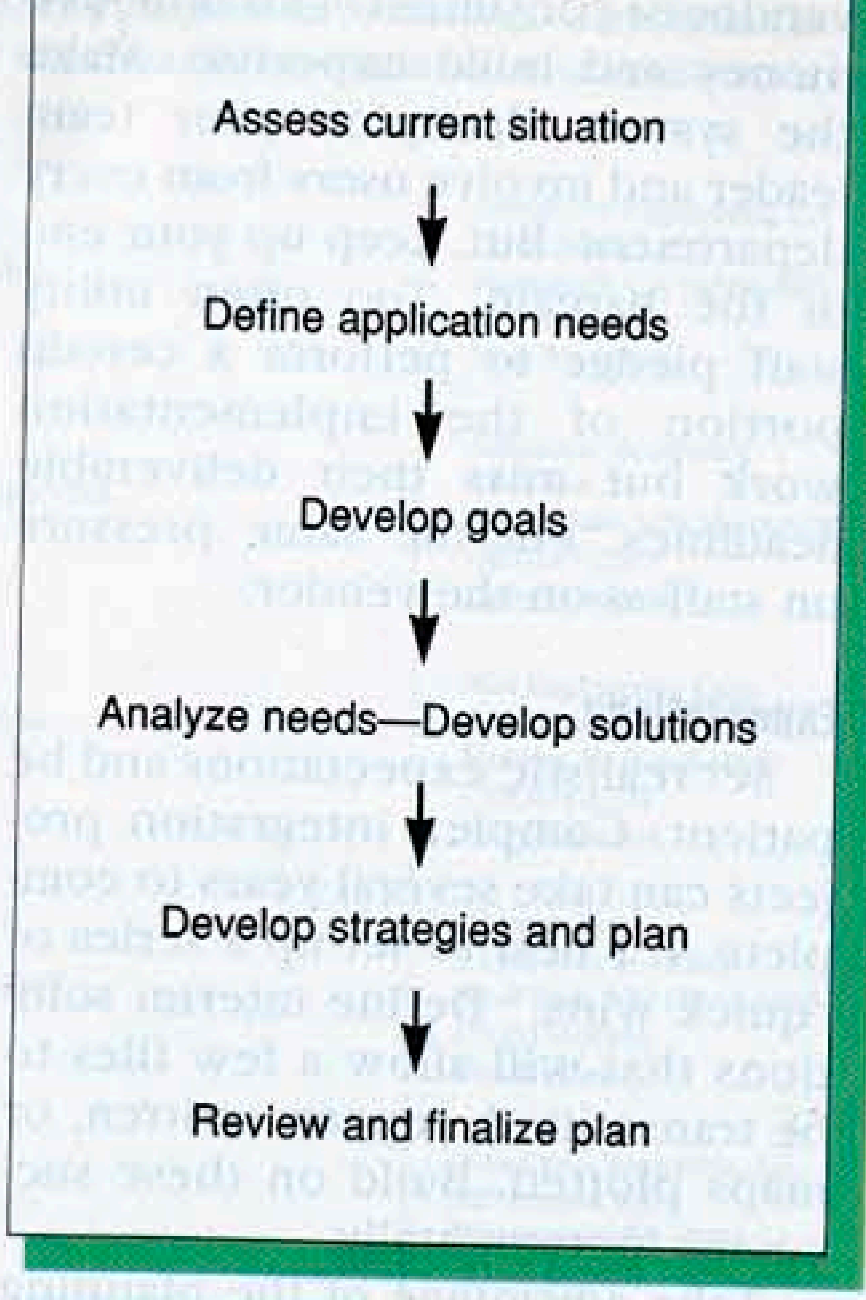
- Interdepartmental or interagency lack of cooperation because of inadequate senior management agreement or commitment.
- Department "turf" battles over the possession and distribution of information.
- Adequate training and access to computer hardware early in the implementation phase.
- Each department has different priorities.
- Information integration projects are often so long-term that they are hard to sell in a politically motivated budget environment.
- Facilities are changing so fast that implementing an information system that consists of accurate data is difficult.
- Organizational structures are not set up for interdepartmental data transfer. They are too hierarchical.

- A defensible cost benefit analysis is difficult.
- Timeliness of data—if accurate data is not available departments may strike out on their own and acquire what they need.
- Lack of agreed-upon standards.
- Inability of technical people to agree on details.

Implementation Techniques

An integrated information system of any type, by definition and function, crosses departmental lines. The list of obstacles suggests this is an important factor. That is why the first step in any implementation scenario is to prepare a strategic plan. Many techniques are used in automation planning, but any planning process should be designed to gain consensus across departmental boundaries involved. In general, the first planning phase should include six steps (Fig. 3).

Fig. 3: Integrated Information System



Each project is different because each utility has different needs, goals, and constraints. However, certain specifics always should be addressed:

- Diagnose before you prescribe—Some say to "answer the five Ws," i.e., what's needed, who needs it, why is it needed, when is it needed, and where is it needed. Do this on an application-by-application basis. Define the problem first, then the technical solution. Every project team has a tendency to jump to describing solutions before it has described the problems—sometimes resulting in undiagnosed problems.
- Find a "system champion"—Results can be achieved with technology from a vendor or consultant during implementation. But, after they leave, overwhelming evidence indicates that if you don't have a system champion, continuous improvement does not take place. The champion must be a utility employee dedicated to the system's success. The person must be knowledgeable, but equally sensitive to the needs of the users.
- Don't skip on mapping—Assess your mapping needs critically. Mapping can be a very expensive effort, but keep in mind the concept of the maps as a long-term asset.
- Do a cost/benefit analysis—But beware of canned approaches.

The cost of keeping current data up-to-date can be determined quickly and easily. Don't forget the intangible benefits associated with improved customer relations and perceptions.

■ Agree on standards—Set up policies, standards, and procedures between departments. Be sure to address security, naming schemes, back-up procedures, training procedures, testing procedures, data accuracy requirements and funding responsibilities.

■ Consider doing a script—When evaluating different software suppliers, don't simply do an evaluation based on a vendor's presentation. Prepare a document that tells the prospective supplier exactly what to demonstrate. This will customize the demonstrations to your specific application, cut the time spent on non-essential aspects of the vendor's product, and put all vendors on a level playing field.

■ Implement the team approach. During the project implementation phase, use as many staff members as possible to augment those of the vendor or consultant. This will save money and build expertise. Make the system champion your team leader and involve users from every department. But, keep up your end of the bargain. Too often utility staff pledge to perform a certain portion of the implementation work but miss their deliverable deadlines. Put the same pressure on staff as on the vendor.

Expectations

Set realistic expectations and be patient. Complex integration projects can take several years to complete. It's best to set up a series of "quick wins." Define interim solutions that will allow a few files to be transmitted, reports written, or maps plotted. Build on these successes incrementally.

Take advantage of the planning and implementation phases of the project as opportunities to rethink the way the organization works. Often departmental and individual roles and responsibilities are set up based on the information they have. With more information available to more people, more possibilities are available to the organization.

REFERENCES

1. DiSera, D., et al, 1991, "Palm Beach County Needs Assessment," Section 4 and Appendix A.
2. Manning, A., et al, 1991, "Developing a Strategic Computerization Plan—How and Why." WPCF Annual Conference, Toronto, Ontario, Canada.
3. Shaw, W., 1992, "Flexible Systems Using Open Architectures."
4. Sciulli, A., 1991, "Pittsburgh's AM/FM-GIS Strategies, Geo Info Systems," March, pp. 38–42.
5. Quinn, T., et al, 1991, "Applied Technology Controls The Rising Resource Costs at Indianapolis: How To Do More with Less," Proceedings of Water Environment Federation.
6. Walls, R., et al, 1991, "Systems Integration Offers Proactive Approach to AM/FM-GIS, SCADA, and CSS," AM/FM-GIS Networks.

About the Author:
Mark G. Wehmeyer, P.E., is regional vice president, Southeast region, based in the Orlando, Florida, office of EMA Services, Inc. The firm is headquartered in St. Paul, Minnesota.