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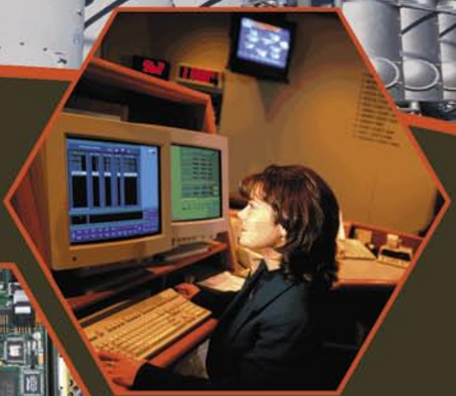

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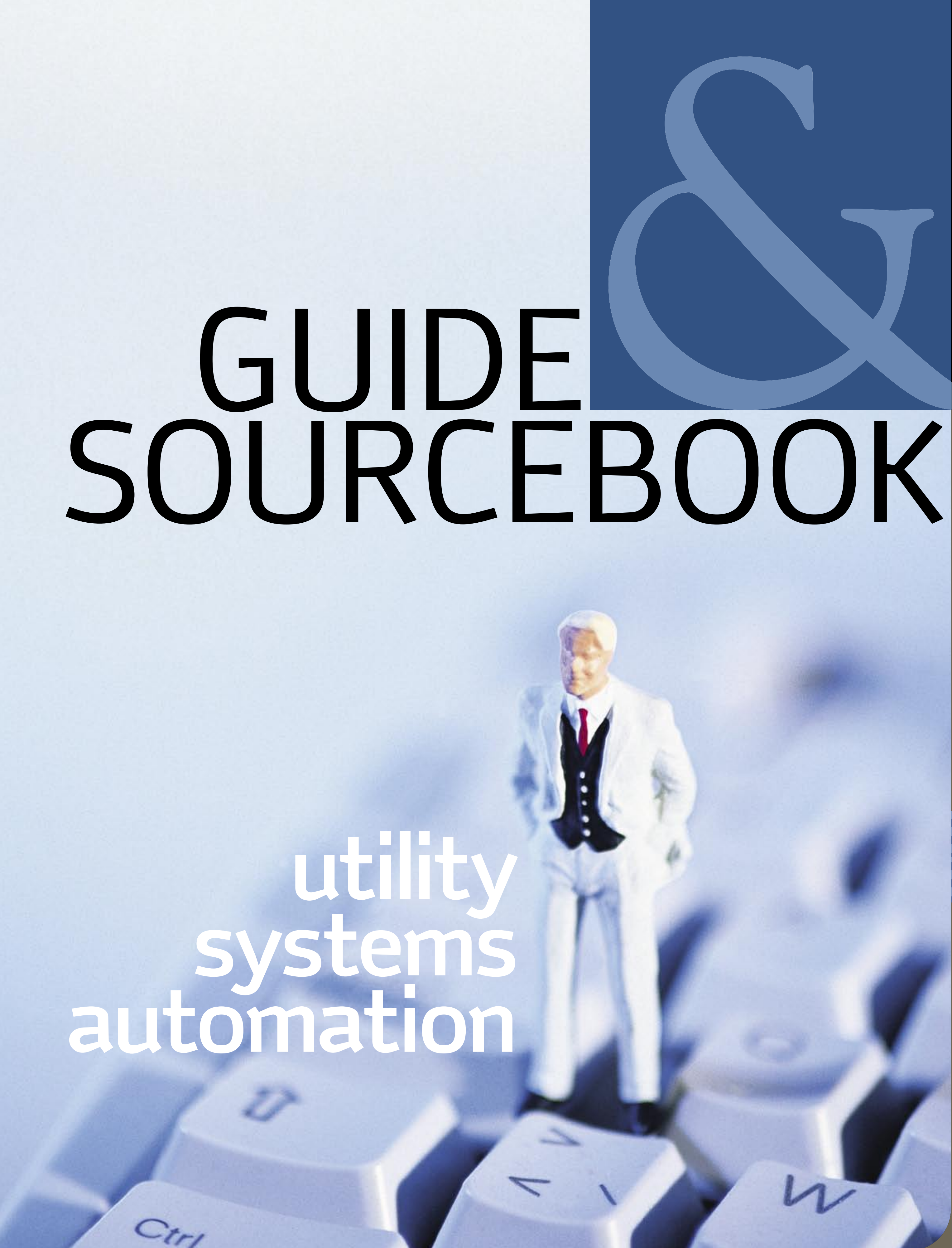

The Growing Power of Automation

By Michael A. Marullo

GUIDE & SOURCEBOOK

For two decades, utility systems automation has been undergoing a slow but steady transformation. Whereas in the 1980s and 1990s, the most pervasive issues and trends affecting markets were generally rooted in technological changes (e.g., the shift from minicomputers to distributed workstations and a few years later, to ever more powerful desktop personal computers), the most visible drivers today center primarily on business issues.

Once considered to be an acceptable justification for upgrading or replacing automation equipment, technological improvement has more recently taken a back seat to keeping the utility on a solid financial footing. That means that projects without a well-defined and measurable return on investment usually don't get funded. Gone are the days when flashy displays and a dash of techno-glitz were sufficient to justify what might otherwise be considered progressive projects.

Markets & Applications

The electric utility systems automation market falls into two main business areas:

- Real-Time Automation & Controls (RTAC) including, but not limited to, real-time data acquisition and control products, systems and services for:
  - T&D Automation (Transmission and Distribution Management Solutions);
  - Substation Automation (Intelligent Electronic Devices & Systems); and,
  - Field Data Devices (FDDs) for T&D Automation and Substation Automation, above.

- Geospatial & Field Automation Solutions (GFAS) including, but not necessarily limited to:
  - Traditional AM/FM/GIS (Automated Mapping, Facilities Management, Geographic Information Systems) products, systems and services; and,
  - Outage Management, Work Management, Work Force Management & Mobile Computing Solutions.

RTAC and GFAS cut across substantially all utility T&D (as well as a nominal portion of generation) infrastructure. Total expenditures across these two important market/application areas are projected to approach $700 million this year, as depicted in ***FIGURE 1***, on page 37.

The year 2005 is looking good for several reasons, including the return to stable economic growth now that the country has seen several quarters of good to excellent economic performance. Coupled with improved economic news is the widespread return to core business by the utilities and a renewed focus on infrastructure improvements now that the restructuring process has slowed.

Annual expenditures for both RTAC and GFAS are projected to increase steadily for several years at a higher rate than has been observed for some time. Generally strong compounded annual growth rates ranging from nearly 20 percent for RTAC to about 30 percent for GFAS are anticipated, but these rates will vary extensively within each segment.

RTAC & GFAS Suppliers

Large supplier organizations enjoy the largest shares of RTAC and GFAS markets. Among the top RTAC suppliers, only Open Systems International rivals major players such as ABB, Areva, GE-Energy and Siemens for total market volume in the Systems segment. This is mainly due to the high average selling prices typical of Energy Management, Generation Management and Transmission Management Systems (EMS/GMS/TMS), which represent the highest average selling price components of RTAC system procurements.

At the distribution level, the profile is reversed with GE-Energy the only large company that is a significant player. Other key participants in Distribution Management Systems (DMS) include Advanced Control Systems, DAQ Electronics, Survalent Technology (among the fastest growing RTAC suppliers), and Telvent USA Inc. (NASDAQ:TLVT), the only publicly held company dedicated exclusively to energy and utility automation/IT markets.

Large supplier organizations also dominate in the Geospatial Systems portion of GFAS. All four top suppliers – AutoDesk, ESRI, Intergraph and GE-Energy – are large companies with a global business focus and resources they can bring to bear on any project. However, smaller suppliers – many of which are active in one or more segments of the Field Automation Solutions portion of GFAS – are numerous and address a vast array of segments and applications ranging from Outage Management to Mobile Computing.

Because of the relatively large number of participants, it is difficult to identify leaders, although several suppliers enjoy a significant position in one or more areas. However, recent mergers and consolidations such as the acquisition of CES International by SPL-WorldGroup and Enspiria Solutions are beginning to narrow the field, a trend that is expected to continue throughout 2005 and beyond.

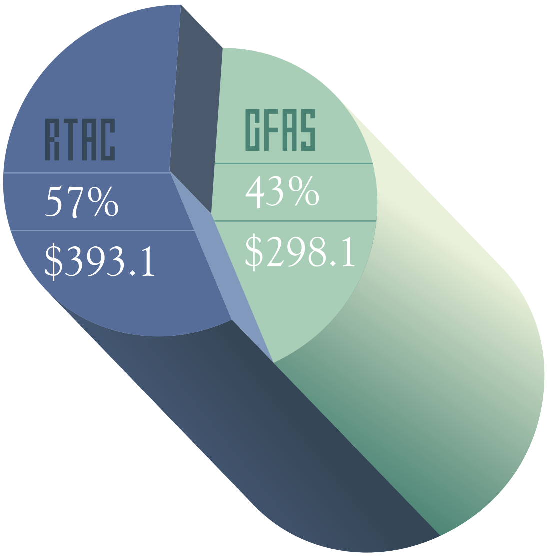

FIGURE 1

Projected 2005 Electric Utility RTAC & GFAS Expenditures (in $ millions)

RTAC= REAL-TIME AUTOMATION AND CONTROLS; GFAS= GEOSPATIAL AND FIELD AUTOMATION SOLUTIONS

RTAC Market Outlook: 2005-2007

The RTAC sector will perform well overall, but some RTAC market/application segments will grow rapidly while others experience modest growth. For example, expenditures for RTAC Systems targeting applications in T&D management and substation automation will see strong double-digit growth, fueled in part by a steady increase in the number of projects among smaller utilities. (See ***FIGURE 2.***)

By contrast, Field Data Devices (e.g., remote terminal units, substation controllers, etc.) will experience less aggressive spending patterns as standardization trends, increased use of commercial off-the-shelf (COTS) equipment and downward pressure on average selling prices continue to offset strong gains in the total number of FDDs being sold annually.

RTAC application segments where the most significant spending growth is expected are in T&D supervisory control and data acquisition (SCADA) and in substation controllers and gateways. Declining spending is expected for traditional remote terminal units (RTUs) in substations and high-end RTUs in general, many of which are being displaced by substation controllers and to a somewhat lesser degree, programmable logic controllers (PLCs) and protective relays.

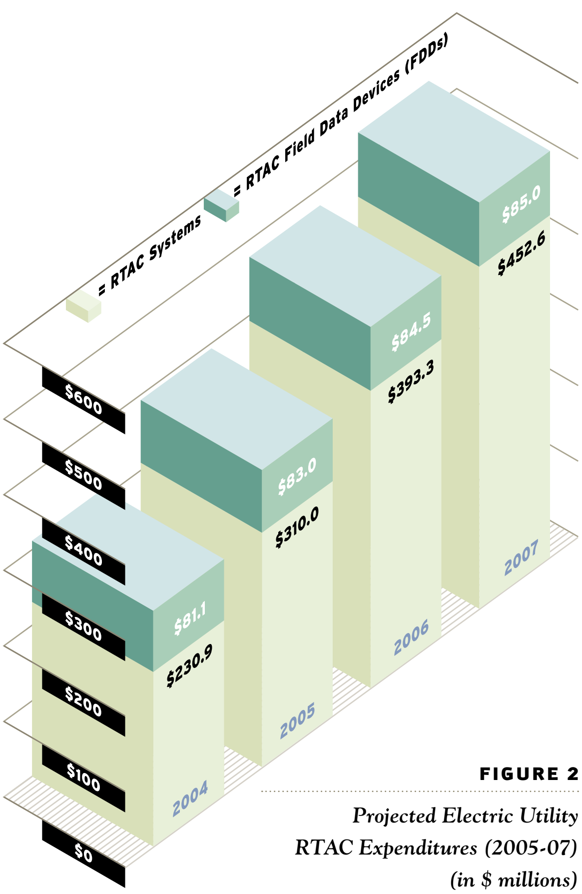

FIGURE 2

Projected Electric Utility RTAC Expenditures (2005-07) (in $ millions)

GFAS Market Outlook (2005-2007)

Expenditures in 2005 for geospatial products, systems and services (i.e., traditional AM/FM/GIS Systems and Technical & Integration Services including engineering consulting, conversion/mapping, and system integration) will see gains as utility Information Technology (IT) spending continues to rebound. With most large and even many smaller utilities now into their second- and third-generation systems, geospatial platforms are increasingly viewed as enterprise information platforms rather than simply mapping and GIS tools.

Spending for AM/FM/GIS is expected to jump in 2005 by 25 percent or more over 2004 levels (i.e., from about $107 million in 2004 to more than $135 million in 2005). Even stronger gains are indicated for the Technical & Integration Services segment where spending increases could approach 65 percent, led by spending for System Integration Services. Even conversion is showing signs of a modest rebound despite the fact that most large conversion projects have already been concluded. (See ***FIGURE 3*** on page 38.)

Field Automation Solutions (FAS), which includes Outage Management Systems (OMS), Work Management Systems (WMS), Work Force Management (WFM) and Mobile Computing Solutions (MCS) will rapidly grow as blanket deployments replace earlier concentrations on pilot projects. Within these areas, OMS will probably continue to show the fastest growth as utility managers zero in on productivity and operational efficiency improvements.

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As **FIGURE 4** illustrates, geospatial system purchases represented about half of all GFAS expenditures in 2004, but that dominance is expected to decline in comparison with surging FAS project activity between 2005 and 2007. The influx of more modest projects by municipal and rural electric utilities will shape the market mix going forward.

Tales from the Dark Side

Just as the Utility System Automation markets have evolved, utilities have been undergoing a transformation that has had a profound impact. Whether defined as restructuring or deregulation, utilities remain in a quandary. While the industry has been struggling to get its arms around the changes and implications by experimenting with new ventures, the basic culture of utilities still has not really changed much.

Following the recent period of corporate crises, financial scandals and other debacles, utilities have been returning to their core business.

The blackout of August 2003 left more than 50 million people in the northeastern United States and Canada in the dark for up to 38 hours. This event had both immediate and far-reaching implications for investments in utility automation and IT products, systems and services.

The Past is Prologue

Among other things, the August 2003 blackout – the largest in North American history – underlined the Achilles heel in the longstanding practice of minimizing investments in power transmission and distribution facilities, along with the associated automation systems, generally in favor of investments in generation. The blackout reminded the industry that a network of highly coordinated real-time operations and information management systems are vitally needed to oversee the already heavily interconnected grid.

Moreover, population shifts over the past 30 to 40 years have fundamentally changed the balance and demographics of power supply and demand. Moving power across the grid efficiently, reliably and profitably are now substantive issues. These new challenges come at a time when the grid is not fully able to meet new demands. Many critical components of the T&D infrastructure are nearing the end of their estimated life expectancies. However, new infrastructure deployment is often opposed by environmentalists, special interest groups or ratepayers.

As a result, a substantial percentage of long-anticipated T&D spending – and associated automation spending – failed to materialize. Until recently, most spending for infrastructure, though in many cases quite substantial, has concentrated on routine upgrades and occasional system replacements. Although much of the problem-solving emphasis has been placed on preventing future outages, the answers are inextricably linked to infrastructure improvements with long deliveries and huge price tags that will take decades to fund, plan, design, permit and implement even under the best of circumstances.

A Road Paved with Good Intentions

In recent years there has been a shift toward more investments in T&D in order to alleviate grid bottlenecks, which is a principal area of need for automation and IT investment. However, although most new infrastructure will take years to upgrade or replace, automation allows better management of the grid. Moreover, new automation technology might be better targeted toward faster service restoration, rather than focusing exclusively on outage prevention.

Although billions — or by some accounts, trillions — in infrastructure investment are needed to bring the grid up to 21st century demands, automation currently accounts for only a tiny fraction of the investments that will be needed to modernize infrastructure. Hence, utilities should be looking toward automation as a means of preserving and enhancing the operational integrity of their asset base while the determination of how to best modernize the aging T&D infrastructure is studied and deployed.

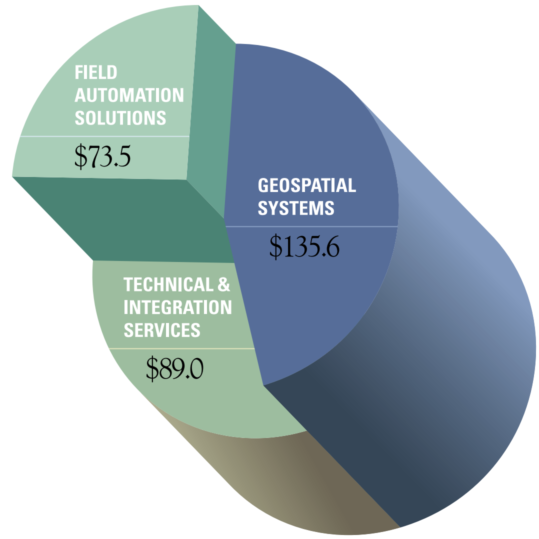

FIGURE 3

Projected 2005 Electric Utility GFAS Expenditures (in $ millions)

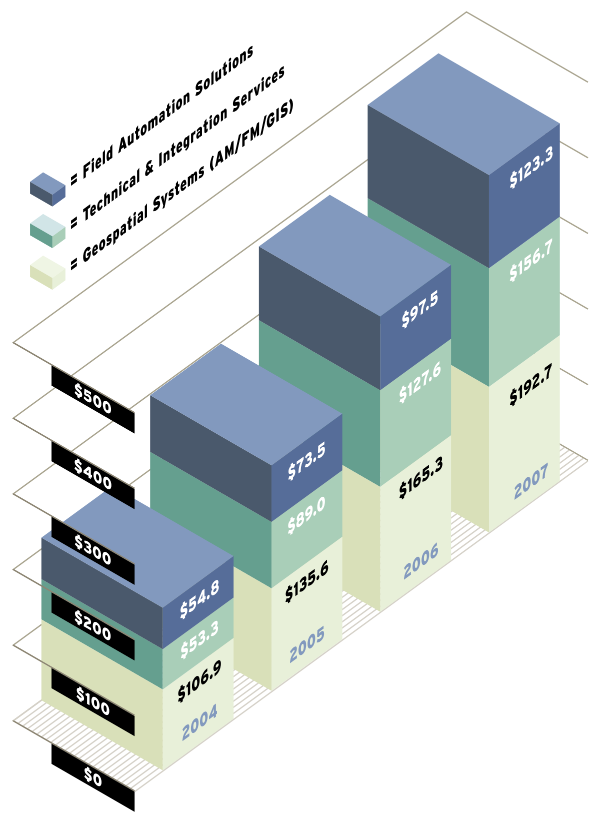

FIGURE 4

Projected Electric Utility GFAS Expenditures (2005-07) in $ millions

Another important factor driving the trend toward more automation in the utility industry is the growing impact of retiring baby boomers. As this huge block of workers leaves the workforce, utilities are losing key individuals with irreplaceable knowledge and experience.

The only feasible solution to this growing problem will be to transfer that crucial knowledge and experience to some type of conventional storage medium and/or knowledge-based system. Information systems used to gather the primary data and provide the mechanisms for converting ever-increasing amounts of such data into useful information must be quickly upgraded.

Same Game – New Rules

Two other important Utility System Automation market drivers will be regulatory and security compliance issues. With Sarbanes-Oxley legislation, GASB-34 implementation and new security mandates looming like dark clouds on the horizon, three things have become apparent:

- Compliance measures will require unprecedented levels of documentation, accuracy and validation, especially with respect to revenue-producing assets;
- Substantial portions of the data needed to satisfy compliance guidelines rely on real-time data acquisition systems and their associated databases;
- The political and regulatory bodies imposing these or other mandates will not appropriate the money needed for compliance. Funding must come from utility resources.

Critical infrastructure security issues have taken on new urgency. In order to protect critical infrastructure assets against terrorist attacks, real-time systems to monitor and control those assets must also be put in place. Moreover, the systems must also be able to fend off any physical or cyber attacks that could cause them to cripple the infrastructure they are designed to protect. While many systems are already secure, many more are not and will have to be upgraded or replaced in the years ahead.

Looking Ahead

Utility automation systems including primary SCADA (supervisory control and data acquisition) and T&D management systems as well as geospatial and secondary field automation systems offer smart, cost-efficient ways to bridge the chasm between long-term infrastructure improvements and the immediate need for system reliability and operational integrity. Today, as the industry faces unprecedented challenges brought about by a constantly changing business and technological environment, there is light at the end of the tunnel – but it will take a new kind of power to turn it on.

Michael A. Marullo is a principal of InfoNetrix LLC in New Orleans.

on topic

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Piecing Together the Interactive Utility

By Arthur O'Donnell

Automation has long been an integral part of the electric power industry. Shortly after the start of the 20th century, the *Journal of Electricity, Power and Gas* described an early innovation by California hydroelectric engineers, who combined several remote hydrogenerating stations "to be operated in union as a single station as easily as if they were combined under a single roof."

Today's advances in utility system automation go far beyond combining and coordinating generation output, by building on such modern technologies as computers, satellites, fiber optics and superconductors. Yet the goals of employing automation remain the same: to improve the efficiency and reliability of the electric power system, to affect cost savings, and to streamline business processes for greater productivity and improved customer service.

Utilities as a whole still lag in the use of automation and new technologies compared to other industries, said Clark Gellings, vice president of innovation for the Electric Power Research Institute (EPRI). "Sensors, communications and computational ability have transformed every industry except the electric utility industry," Gellings said. Unless investments in research and implementation are greatly accelerated, he warned, "It will come to a point where the existing electric distribution system is a relic of the Industrial Age."

It's not that utilities aren't investing in systems improvements. EPRI estimates that utilities spend $3.5 billion each year on telecommunications and $12 billion on digitizing their information technologies and business processes. The problem is that these systems are based on proprietary technologies or customized software that can't integrate with other systems. This frustrates the goal of having a "smart" power delivery network that employs automation to recognize problems, find solutions and optimize the performance of the network.

EPRI's answer to this quandary is to promote a unified vision of an interactive utility that links communications and electricity into an integrated, self-healing and electronically controlled network. The vehicle for this "smart grid" design is the Intelligrid Architecture project spearheaded by EPRI, the U.S. Department of Energy and GE Global Research.

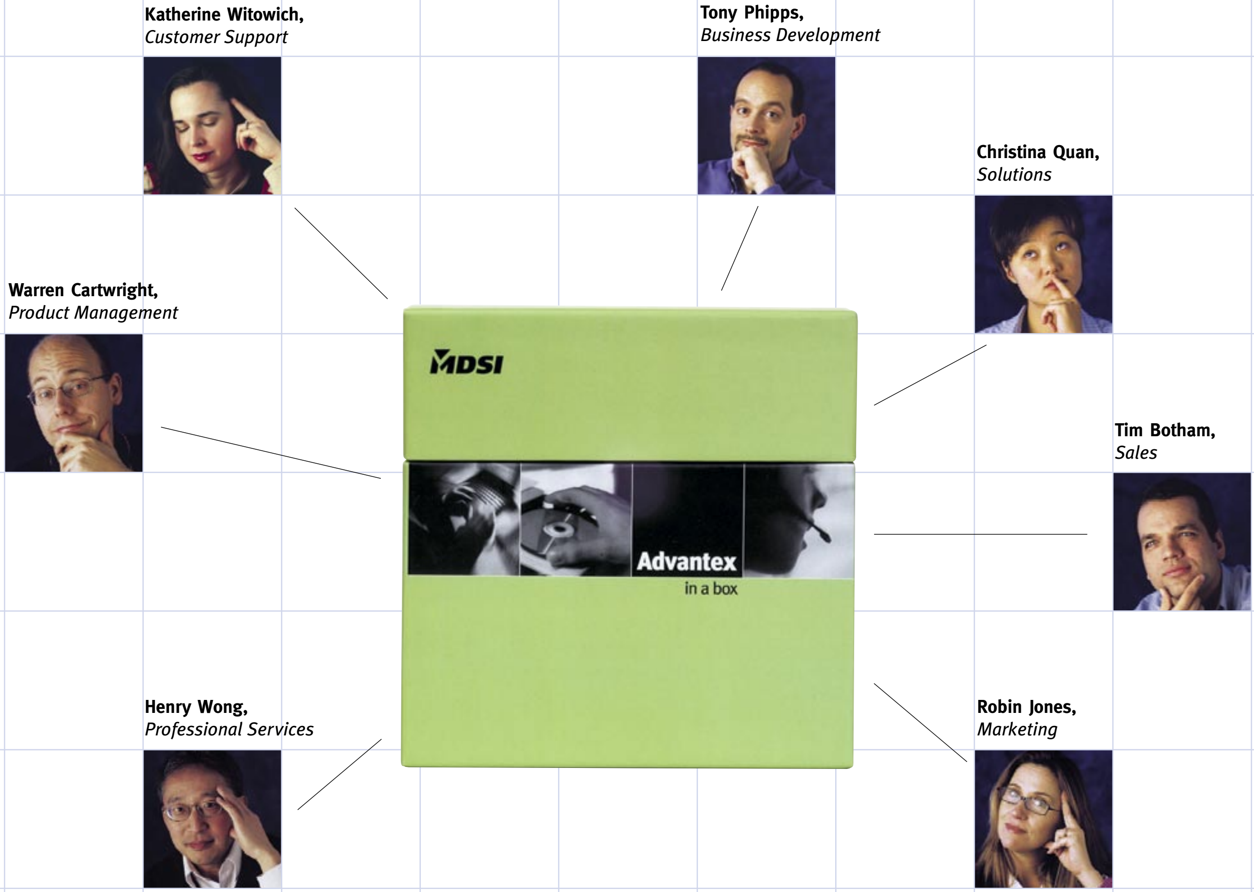
According to Joe Hughes, program manager with the EPRI effort, implementing this vision requires construction of a common language of communications standards, — establishing "open systems" rather than the hundreds of individualized and proprietary systems now in place.

A Self-Managed Grid

To the outside observer, the daily operations of the nation's transmission network are a marvel of computer technologies and integration. Behind the scenes, the operation of the grid requires multiple tasks, including scheduling and logging systems to forecast demand and secure supplies; market systems to set a price for power; and settlements systems to provide the accounting and payment functions.

All of the various functions of grid control appear to be working together, observed Dan Yee, chief information officer for the California Independent System Operator. "In reality, these systems are individually passing batons to each other. They are coordinated today, but a next generation of automation is needed for real-time enterprises to move from asynchronous operations to more real-time, synchronous operations."

For the past several years, California ISO has been trying to redesign its markets, in response to deficiencies that were uncovered during the California market failures in 2000 and 2001.



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Manual systems had been embedded in many of the business processes, which were, in turn, embedded in proprietary systems. As a result, even a simple change in market rules meant going back into the core computer software programs and altering code to match the new requirements.

"Our focus is taking the opportunity to enhance IT systems using market design, replacing some things that had been in place since start-up," Yee said. That also includes taking some functions that have already been automated and changing them so they interact with other systems. "If automation is taking something manual and using computers to do it, we've achieved most of the automation necessary," he explained. "Now we're in transformation."

Examples of these changes include automating both the real-time economic dispatch of generation and the process of making sure that generators follow the dispatch orders.

Additionally, the complex structure for financial settlements are more fully automated. Finally, when changes to market rules become effective, they can be implemented without having to alter the basic algorithms built into the software systems.

The hoped for results are lower wholesale energy costs, improved coordination and management of resources and improved grid reliability.

Building the Self-Correcting Grid

Grid reliability is, of course, job number one for ISOs, and many current trends in automation are geared toward improving system reliability and security. Terry Winter, recently named a vice president of American Superconductor, was a transmission controller for decades — first at San Diego Gas & Electric and then as chief executive officer of the California ISO. "Automation is going to be our only solution as we move to bigger and more complex grids," Winter said.

He identified three major areas in which automation is improving the system:

- Gathering information for operators to act upon;
- Automating controls to better run the system; and
- Protection schemes in the event of system faults or severe voltage frequency fluctuations.

Utilities and grid operators have long been able to collect data from key power transfer points at substations and switchyards. One of the most important sets of data provide a picture of the physical state of the system — not just the balance of demand and supply, but rather voltage levels, phase angles and the flow of current.

There are many different pilots and demonstration projects meant to improve operators' ability to see what's going on, he added. He cited the use of "state estimators" or systems that offer a comprehensive view of the network at a particular point in time. The current trend of automation is to connect the systems that gather various system metrics into the state estimators.

One of the granddaddy systems for monitoring the health of the grid has been in place at the New York Power Authority for more than a decade. It is known as Phasor Measurement Unit (PMU), explained Shalom Zelingher, NYPA's director of research and technology development. "Back in the early 1990s, we looked at a common hardware platform that could provide information on a number of functions, dynamic monitoring of the system, harmonic measurements over a wide area and levels of geomagnetic current," he said.

One of the key features of the PMU project is combining various functions into a common system. "If we went to do each one of the functions, it would have required three sets of hardware and software systems," he said.

Measurement of phase angles is "the window to everything else," Zelingher said. As with other types of energy management systems (EMS), the project relies on monitors—in this case a phasor measurement unit or PMU—located strategically on the system. But an early problem was detected in synchronizing the internal clocks of the remote units. Even a tiny shift in the display of frequencies would render the entire exercise useless. That led to an early innovation in using the Global Positioning System (GPS) of satellites run by the Department of Defense, which vastly improved accuracy.

> ***"Automation is going to be our only solution as we move to bigger and more complex grids."***

Right now, there are six PMUs installed at substations on the New York State grid that have been in place since 1992. Currently, the project is moving away from dial-up connections to a local-area network (LAN) to provide a live stream of data flow and allow for multiple user access. Connecting the system to the state estimator run by the New York Independent System Operator is another project that's underway. Full integration is expected a year from now, Zelingher said.

"It's not to the point of using it for a self-healing grid, but that's where we're heading," Zelingher said.

A somewhat different take on monitoring the health of the grid has been developed by the Bonneville Power Administration for use in the Western Interconnect. The Wide-Area Measurement System (WAMS) was conceived after a massive blackout in August 1996 cascaded throughout the Western grid, cutting power to about 7 million people.

More advanced than a dedicated SCADA system that takes measurements every two to four seconds, WAMS' sensors monitor the transmission network 30 times per second and report real-time data that's been synchronized via GPS.

Phase shifts and loop flow are also problems in the West, said Bill Mittelstadt, a former BPA engineer who helped develop WAMS, but it incorporates other measurements as well.

There are three steps on the ladder of WAMS' usefulness, he explained.

- After-the-fact check of computer models and validation of information;

(Continued on page 45)

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- Using the information in control room and dispatch operations to take preventive actions;
- Incorporating the measurement in taking actions automatically.

BPA and its partners in the project primarily view WAMS as a diagnostic tool. This next step is to link network measurements into system controllers. BPA's name for this project is Wide-Area Stability and Voltage Control System (WACS).

Carson Taylor, BPA's principal engineer for transmission, is heading up the WACS development. In BPA materials describing these innovations, Taylor indicated that together WAMS and WACS would change the nature of grid control. "Even the best operator can't react quickly enough. This is where high-speed controls could take over, instantly analyzing troublesome trends, projecting their possible outcomes and initiating protection schemes to offset the problems."

Growing Interest

WACS testing is expected to last for another year. Many of the principles developed by BPA's WAMS and NYPA's PMU projects are finding applications around the country. This past summer, for instance, the Eastern Interconnection Phasor Project (EIPP) went into effect, providing the first real-time, system-wide measurement of phase data for utilities throughout the Eastern Interconnect. Five control centers, located in or near St. Louis, Columbus, Ohio, Chattanooga, Tenn., New Orleans and Schenectady, N.Y., began sharing information via the EIPP network in August. The project will expand throughout the eastern system by the end of 2005.

NYPA Research Chief Zelingher is watching the EIPP with great interest. "If we had all that kind of information available during the August 2003 blackout, people in control rooms would have had a much better idea of what was happening and could have acted on it," he said.

The eventual goal for wide-area systems is to be able to sense and correct for a variety of problems anywhere they might occur. In the meantime, engineers at the Salt River Project in Arizona are following a more specific grid strategy. According to John Blevins, SRP's manager of engineering and planning, the sudden loss of two 1,200 MW units at the Palo Verde nuclear complex near Phoenix has the potential to ripple through the Western system, leading to an overload on the Pacific AC Intertie between California and Oregon. The California/Oregon Intertie is the major 500-kilovolt route for power transfers in the West. Palo Verde power is transferred into California via the 500-kilovolt Devers/Palo Verde Interties into Southern California.

It's not an unlikely scenario. Just this past summer, the Palo Verde nuclear plants tripped after a transmission line near Phoenix experienced a short-circuit. Utility customers as far away as Santa Clara, Calif., lost power as a result, although the COI remained intact.

SRP has created a remedial action scheme (RAS) that would correct for a severe disturbance on the COI/Palo Verde corridors by automatically reducing load in the Phoenix area—thus reducing the chances of an overload in California. A network of 15 sensors is installed at the Palo Verde Generating Stations and 14 Phoenix-area locations. "They can sense a trip signal from one end of the system to another, all the way from California to Four Corners," in New Mexico, Blevins said.

The COI/Palo Verde RAS cost about $2 million in hardware and software, a bargain compared to constructing another high-voltage transmission line to reduce system stress. The next-step in this development will be to expand the sensor network to the territories of other Palo Verde plant owners in California and New Mexico, providing more flexibility in load-shedding responses.

"This would not have been possible five years ago," Blevins said. "This is one of the building blocks of a self-healing grid."

Distribution Visions

Although much of the research and investment in "smart grid" technologies is being devoted to the high-voltage network, many of the same concepts are finding application at the utility distribution level. One such project is called Distribution Vision 2010 (DV 2010), a project conceived by WE Energies in Wisconsin and now has a dozen participants.

Bob Huber, senior manager of research and development for WE Energies, noted that even though distribution substation automation is quite common in the industry, "There was a wall there; systems weren't talking to each other."

The goal of DV 2010 is to develop a "plug and play" system that will be able to monitor localized networks for potential problems and correct them, without human intervention.

The idea is to tie the separate functions of feeder network automation, dynamic voltage control and substation automation into a coordinated system. This novel approach involves identifying a premium operating district (POD) that can be isolated from the rest of the network automatically when a fault occurs. By localizing and isolating the problem, utility crews can respond and correct the fault much more quickly.

Success can be measured by reductions in the frequency and duration of outages. Customer benefits come in the form of improved reliability and power quality. Currently, there are three sites being tested by DV 2010 participants: a residential area near Milwaukee, an older industrial park at New Berlin in southeast Wisconsin, and at a commercial park in British Columbia.

Although the "smart grid," as conceived by EPRI and DOE, remains a goal to strive for, it's clear to see how the many pieces of this "very large machine" are being tested and implemented throughout the nation and at all levels of the power delivery business.

"The technology is mature and can be applied; it's the application programs that need to be worked on," Zelingher said. "The future is here. We need to make it happen now."

Arthur O'Donnell, AOD@energycentral.com, is senior editor of **EnergyBiz.**

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