
**THE TENNESSEE VALLEY AUTHORITY
NUCLEAR DIVISION (TVAN)
DECATUR, ALABAMA**

NORTH AMERICAN EXCELLENCE AWARDS: WORKFLOW, SILVER

EXECUTIVE SUMMARY

TVAN uses state-of-the art workflow technology to reduce and maintain production expenses *below the nuclear utility industry average*.

The Tennessee Valley Authority (TVA) is the largest power producer in the country, generating more than 123 billion kilowatt-hours of electricity a year. Serving eight million customers, TVA operates and maintains 29 hydroelectric dams, as well as 11 coal-fired and three nuclear-powered plants. The utility also maintains more than 15,000 miles of transmission lines and manages more than 650 miles of the Tennessee River.

Its mission to be “the very best electric utility in North America and the most productive and effective agency in the federal government” is supported by the fact that quality teams focus on reducing utility costs for customers, and one of the three phases of its total quality management process is ‘process improvement.’ (TVA is a government corporation that is 98.2 percent self-funded, with the remaining funds coming from government appropriations, allowing TVA to build cash reserves and surpluses generated from quality improvements that can be reinvested back into TVA.)

All organizations at TVA’s Nuclear plant rely heavily on its Procedures Control Process for the performance of maintenance and operation of the plant. Inherently paper-intensive, this process used to cost more than \$4.8 million a year, so TVAN embarked on a major business process redesign in order to reduce electrical production costs and maintain low rates to its customers.

By implementing workflow electronically, TVAN realized a 42 percent cost reduction and 53 percent cycle time savings (reduced from 26.5 hours to 12.3 hours). Annual savings of more than \$2.2 million for the labor, equipment, and supplies to support the Procedure Control and Maintenance Work Order processes have also been measured. Redesign to the Maintenance Work Order Process represents a 33 percent cost reduction and 41.7 percent cycle time savings in the initiation, planning, scheduling, and performance of maintenance. The total savings from implementation of the redesigned processes is a reduction of approximately 52,693 man-hours and \$2.2 million a year.

With 850 users of workflow and electronic routing at Browns Ferry and a total of around 3,500 users on the system across three sites, TVAN has demonstrated a true commitment to

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continuous quality improvement, while already achieving significant results in the areas of work elimination, reduction, and process improvement.

THE SYSTEM APPLICATION.

In April 1994, the TVA Nuclear Group initiated an effort to focus on improving business processes. Two key processes selected for improvement were the Procedures Control Process and the Maintenance Work Order Process. These processes were selected based on their costs, perceived process problems, and integration potential.

Historically, at Browns Ferry, more than 14,000 work orders and approximately 5,000 procedure changes are processed annually. Consequently, any reduction in the time it takes to write one work order or process one procedure change results in significant total labor reduction and, in turn, reduced production costs.

For the Maintenance Work Order Process, these labor staff hours were measured from the time the maintenance work item is identified to the completion of the work. For the Procedures Control Process, labor staff hours were measured from the identification of a needed change to a site procedure to the time a revised procedure is issued.

The redesigned Procedures Control Process utilizes information technology to store all procedures on site on magnetic disk storage accessed by a powerful routing software package known as "Curator" (TSW's electronic document management system developed using Identitech's FYI toolkit). Utilizing this software, all procedures are electronically accessed directly by users, and changes or markups are made at the users' desks (including any redlines, highlights, lineouts, and parallel routing). The proposed procedure change is then automatically routed via a pre-established workflow for independent review and approval.

All approvals are made utilizing electronic signature with passwords to ensure proper security and approval authorizations. Once approved, the procedure is automatically updated as the latest revision and stored in an electronic "In Use" database. Thus, all manual routing and approval of hard copy procedures, copying, and distribution are eliminated.

Now, a planner can completely assemble a plant work order electronically, including processing work instructions, associated surveillance instructions, technical guidance, and other references. The package is then in electronic storage for retrieval for review by other reviewers or reference reviews by other work order planners.

Because Browns Ferry has already enjoyed measurable success with the implementation of these new electronic processes, plant drawings and vendor manuals have been entered into the Curator system to realize even greater efficiencies.

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THE KEY MOTIVATIONS BEHIND THIS SYSTEM

The TVA Nuclear Group supplies 20 percent of TVA's generation and can best demonstrate its commitment to customer satisfaction by supplying competitive, low-cost power. A major contributor to this competitiveness is the implementation of major business process redesign efforts at Browns Ferry Nuclear Plant.

Throughout the years, due to increased regulations, identified problems, and other issues, additions were made to procedures processes with little regard for the overall effect on their efficiency. Additionally, time was seldom available to re-examine the entire process for inefficiencies. Consequently, an average of \$4.8 million was spent annually to support the revision, approval, and distribution of procedures and \$48.7 million per year on generating, planning and performing maintenance work orders (more than \$14 million of this cost was aggressively attacked by process improvement).

From April to June of 1994, all business processes at TVAN were reviewed for appropriate process improvement. The methods of evaluating these processes included:

- Standardization—standardizing processes on best TVAN practices (internal benchmarking);
- Work elimination—eliminating unnecessary work tasks performed within a process;
- Process redesign—including radical process change of high strategic importance to the business.

The Maintenance Work Order and Procedure Control processes were selected for redesign for the labor costs associated with Corrective and Preventive Maintenance, which formerly comprised 25.6 percent of Brown Ferry Nuclear's total labor costs.

THE CURRENT SYSTEM CONFIGURATION

With 850 users of workflow and electronic routing at Browns Ferry and a total of around 3,500 users on the system across three sites, TVAN at Browns Ferry uses TSW International's Enterprise Maintenance Planning and Control (EMPAC) application, which runs on an Oracle7 relational database. Additionally, TVAN is standardizing both hardware and software among sites.

Currently, the Browns Ferry site is set up using an integrated client/server infrastructure composed of Ethernet subnetworks, optical FDDI ring, SUN, Novell, and PC servers, with more than 800 PC clients. TVAN upgraded hardware to Sun servers, while PC-based workstations will use PowerSoft's event-driven Graphic User Interface (GUI) client layer, PowerBuilder development tools. The database engine utilizes Oracle 7 Release 7.3. Within this three-tier local area network (LAN) and wide area network (WAN) environment, extensive use of stored procedures will ensure TVAN's data integrity and performance.

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IMPACT TO THE COMPANY.

One of the key measures of TVAN performance is how inexpensively electricity is produced. This is typically measured in Mills/kWh (one-tenth cent per kilowatt-hour) and is calculated by dividing production cost by electricity produced. The only way to significantly reduce Mills/kWh is to reduce production cost (since there is a license limit on the amount of electricity a nuclear plant can produce).

COST SAVINGS

The Browns Ferry system alone has already achieved a proven savings of more than \$2.2 million with the promise of considerably more in the future. By implementing workflow electronically, TVAN realized a 42 percent cost reduction and 53 percent cycle time savings. The maintenance work order process redesign represents a 33 percent cost reduction and a 41.7 percent cycle time savings in the initiation, planning, scheduling, and performance of maintenance.

The total savings from implementation of the redesigned processes is a reduction of approximately 52,693 man-hours and more than \$2 million a year.

Electronic routing has yielded the following additional benefits for the work order and procedure processes:

- Lost work documents reduced to near zero.
- Integrated scheduling improved adherence to the work schedule by 33 percent.
- Duplicate work order preparation was eliminated.
- The number of standalone databases was significantly reduced.
- Support work hours were reduced via improved job coordination.
- Duplicate word processing was eliminated.

PRODUCTIVITY IMPROVEMENTS

In the old revision process, hard copy procedures were manually marked up by a worker, who began the long process of hard copy review by supervision, other departments, and other experts for things such as technical adequacy, impact on safety, etc. A procedure revision took an average of 24.6 hours to accomplish because of the required technical reviews, management reviews, filing, documentation, and comment resolution. With associated materials cost, this was a net annual cost to the site of \$4.8 million.

To reduce costs and enhance customer satisfaction, the redesigned processes resulted in

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major changes to the ways maintenance work is performed and procedures are revised and distributed. This includes:

Routing Documents Electronically (including retrieval of work orders and procedures)

- reduced lost work documents to zero
- resulted in instantaneous routings
- resulted in no need for manual revision verification
- resulted in parallel routing of procedures
- resulted in no manual tracking of documents required
- and resulted in no longer filing and distributing 40,000 procedures

Eliminating Unnecessary Work

Supervisory reviews consolidated:

- manual ordering of materials replaced by automated process
- duplicate work order preparation eliminated by automated check for duplicates
- reduced number of stand-alone databases

Reducing Work

- craft efforts in coordinating work
- documentation of consumables
- support work hours reduced via improved job communication
- duplicate word processing eliminated

Improving Work Processes

- integrated scheduling improved adherence to work schedule by 33 percent
- accurate cross referencing provided through full text search capabilities
- work orders and procedures no longer have to be reprinted when a change is made because documents are not printed until just before they are used

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COMPETITIVE ADVANTAGE GAINED.

Browns Ferry Nuclear Plant is the first within the nuclear utility industry to implement a completely electronic work order process that includes electronic approval. Internally, the implementation of the reengineered maintenance work order and procedures processes at Browns Ferry is being duplicated at all TVAN sites. Additionally, Browns Ferry has hosted more than 45 national and international companies, both nuclear power and other industries, to review the process for consideration for use by their own organizations.

The use of this system has been so successful at Brown's Ferry, in fact, that it now serves as the nuclear model for maintenance systems for other TSW power-generation clients, including the New York Power Authority, Maine Yankee Atomic Power Company, Vermont Yankee, and Niagara Mohawk.

Current and potential beneficiaries of the new workflow processes at TVAN include the eight million people served by TVA through 160 distributors, as well as 67 directly served industrial customers who have directly benefited from process improvements in work management and procedure handling. Improvements in these processes have reduced costs, have helped to ensure that power rates are competitive, and have contributed to holding rates stable for 10 years.

Since TVAN began holding rates constant in 1986, approximately 7,800 companies have announced plans to expand or relocate in the Tennessee Valley, creating more than 315,000 new jobs. In addition, as the deregulated electrical industry becomes more competitive, TVAN's efforts to maintain competitive electrical rates will benefit all electrical customers in the Southeast United States.

"TVA Nuclear's operational and maintenance costs have dropped 15 percent in the past four years," says Donnie Martin, TVAN's EMPAC project manager, "and the savings we've achieved through implementation of TSW's Best Practices approach to maintenance are passed on to our customers, who now enjoy one of the country's lowest residential rates."

THE IMPLEMENTATION PROCESS AND METHODOLOGY

When conducting business process redesigns, TVAN Nuclear forms dedicated teams whose members are selected from line organizations. The redesign teams are trained in and use TVA's six-step redesign process. The teams are empowered to take a "clean sheet of paper" approach to design new, radically improved business processes. As part of these redesigns, the teams:

- analyzed existing processes using flow charts;
- conducted more than 350 hours of interviews with process customers;
- benchmarked 15 utilities and six other companies;
- investigated available information system technology;

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- and developed new processes using data flow diagramming techniques (an enhanced flow charting methodology).

Using a method known as “data flow diagramming,” each process under consideration was carefully studied by TVAN groups to identify inefficiencies in order to remove them from newly redesigned processes.

Browns Ferry teams went through painstaking research and review, including:

I. Identifying Reason for Improvement—One of the major paper-based processes at a nuclear plant is the revision, routing, approval, and performance of maintenance or operation of equipment with hard copy plant procedures. In 1992 and 1993, Browns Ferry expended approximately 235,000 man-hours per year in this process. (Thanks to redesigned processes and workflow, they have since achieved a reduction of an estimated 52,693 man-hours.)

Also, since an average of \$48.7 million per year was spent on generating, planning, and performing maintenance work orders (more than \$14 million of this cost was aggressively attacked by process improvement) and an additional \$4.8 million annually spent to support the revision, approval, and distribution of procedures, a redesign of the Maintenance Work Order and Procedure Control processes was justified.

II. Analyzing—The project team conducted approximately 350 hours of interviews with actual customers of both processes to study the workflows and receive input from users on potential improvements. The major factor determined to contribute to process inefficiencies was the total reliance on manual routing of hard copy procedures for review, approval, and actual use in the plant. In fact, total cycle time from initial procedure change to final distribution ranged from days for simple revisions to weeks for revisions on administrative or upper tier procedures. The team’s findings included the need to fully integrate the maintenance management (work order) system with the procedures management and document workflow system. The findings also identified the need to consolidate numerous software tools.

III. Researching New Paradigms or Ideas—For the Procedures Control Process redesign, the team had two objectives:

- to convert all hard copy procedures to electronic media; and
- to provide the ability to electronically revise, approve, and automatically route procedures to multiple users at any given time.

The team benchmarked 15 utilities and six other companies to learn about their maintenance and procedures management processes. The team also investigated available information system technologies, specifically maintenance work management and procedures management software tools. The principal finding was that an integrated maintenance management, procedures management, and workflow system did not exist at any of the benchmarked utilities or companies, but that such a system could significantly improve maintenance and procedure management processes.

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A powerful routing software package (Curator) from TSW was chosen to electronically access and route all procedures. TVA licensed Curator, which was developed using Identitech's powerful electronic document management system toolkit—FYI.

IV. Redesigning the Process—The new process was designed using Data Flow Diagramming to extensively map transfers of data in support of the process workflow. After the redesign, all procedures can be directly accessed by the user electronically and changes or markups made at that person's desk, including any redlines, highlights, or lineouts. The proposed procedure change can then be automatically routed via pre-established workflow for independent review and approval.

The team redesigned the maintenance and procedures management processes using data flow diagramming techniques (enhanced flowcharting methodology). During this step, the team examined the intricate details of the process and allowed for investigation of every possible opportunity for improvement.

V. Piloting the Redesigned Process—The team established a test laboratory to verify software functionality and compatibility with necessary systems and databases. This way, innumerable problems were identified and resolved before implementation.

Weeks of testing retrieval times, routing efficiencies, and data transmission rates of Curator on a test network at Browns Ferry produced exciting results. Testing involved continuous demands on Curator for document routing from multiple workstations. In one test conducted over an 11-hour time span, Curator successfully handled the heavy, simultaneous network demands, retrieving more than 11,720 documents (approximately 1MB each) from the object server and routing them to the users.

Currently, the Browns Ferry site is set up using an integrated client/server infrastructure composed of Ethernet subnetworks, optical FDDI ring, SUN, Novell, and PC servers, with more than 500 PC clients.

VI. Implementing the Redesigned Process—Implementation of the Procedure Control Process redesign was completed in phases for approximately 5,000 site procedures. Each phase was chosen to ensure maximum benefits were realized in a timely manner.

The team developed detailed implementation plans, including hardware installation, document conversion to electronic format, data migration from mainframe, user training, and procedure revisions.

THE OVERALL TECHNOLOGICAL INNOVATION

In 1986, TVAN was using an in-house maintenance management system that lacked interconnectivity between functions and was unable to keep pace with TVAN's growing need to control and cut maintenance costs. This system was unable to provide complete planning functions or track costs and work histories on components. With more than 2,000

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workers at 14 sites handling \$140 million in spare parts annually, TVAN recognized the need to change its maintenance-related work practices and acquire a more comprehensive maintenance management solution.

Today, TVAN is standardizing both hardware and software between sites. Upgrading hardware to Sun servers, TVAN will use PC-based workstations for PowerSoft's event-driven graphic user interfaces (GUI) client layer, PowerBuilder development tools. The database engine will utilize Oracle7 Release 7.1. Within this three-tier local area network and wide area network environment, extensive use of stored procedures will ensure TVAN's data integrity and performance.

Also, TVAN piloted procedure conversion from exiting products (Eastman Software and Interleaf) to Microsoft Word; developed a new infrastructure with TVA's IS department; and in conjunction with TSW and TVA IS, conducted extensive product testing in a laboratory environment.

Implementing Curator, TSW's electronic document management system, TVAN has expedited the work order process by electronically routing drawings, procedures, vendor manuals, and other retrievals. Its anticipated annual savings of \$30 million will result from the elimination of at least 735 databases with the addition of Curator.

By early 1997, TVAN had reduced the number of stand-alone databases to 505 (originally 862). These are used for information management and storage at three sites—Sequoyah, Watts Bar, and Browns Ferry. Under TVAN's plan to switch to the Curator system, all but about 20 of the databases will be eliminated and the information transferred to Curator.

Additionally, TVAN is scanning 2,000 vendor manuals and 80,000 engineering drawings for eventual transfer into Curator.

The Curator system was tested extensively to ensure that its software routing capabilities could handle the highest potential electronic traffic generated by site users. In one test conducted over an 11-hour time span, Curator successfully handled the heavy, simultaneous network demands, retrieving more than 11,720 documents (approximately one megabyte each) from the object server and routing them to users.

TVAN's Browns Ferry Nuclear Plant has phased out Wang and continues to phase out IBM and Prime systems to integrate TSW's Curator and EMPAC solutions. As part of TSW's EMPAC asset care solution, Curator enables organizations to optimize their maintenance and operations budgets. Curator offers imaging for electronic mass storage and display of equipment manuals, engineering drawings, parts catalogs, and other documents.

THE OVERALL BUSINESS INNOVATION.

Because off-the-shelf software was not available to support the redesigned processes, Browns Ferry Nuclear entered into an alliance partnership with a key software supplier (TSW

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International). The team contracted the software supplier to develop the necessary software and supplied detailed process functional specifications. The software vendor then developed an integrated maintenance work management, document management, and workflow software system.

One aspect of the redesign that made the alliance partnership possible was the detailed functional specifications developed using the data flow diagramming techniques. These detailed functional specifications graphically show how data flow, provided detailed written descriptions of each process step, and provided a detailed written definition for each piece of data.

The alliance was an innovative approach to software development between a public entity and a private company. The alliance was a win-win situation. TVA received state-of-the-art software designed specifically to support TVA Nuclear's redesigned business processes. The software vendor was able to utilize TVA Nuclear's expertise in maintenance and document management functional requirements to develop a software product with strong market potential.

It should also be noted that these improvements were made at Browns Ferry while maintaining high capacity factors on the operating unit, adding a second unit to the grid after operating as a single unit plant for 11 years, setting a record for shortest maintenance outage and improving regulatory performance.

Moreover, enhanced with Curator, TVAN is assisted in complying with the dynamic regulations of the Occupational Safety and Health Administration (OSHA. *See* Occupational Safety and Health Administration), the Nuclear Regulatory Commission, and the Institute of Nuclear Power Operations, as well as the regulations of additional environmental organizations.