DCS RETROFIT AT GERALD GENTLEMAN

The Nebraska Public Power District (the District) Gerald Gentleman Station has found itself in a unique situation. Combined, its two 680 MW PC-fired drum units are the system's largest. The system's daily load cycle is severe. In fact, the load swings are very large, occasionally requiring Gerald Gentleman to serve as a peaking unit with the stability and efficiency of a base loaded unit.

The District and Burns & McDonnell had just completed a thorough reconfiguration (when necessary) and retuning of the Unit Two controls (an L&N DEB-300 analog system) to significantly improve high load stability, low load stability, and load ramp capability. The program was successful, but limited by the existing control system. The labor-intensive task of analog control revision and the difficulty of obtaining extra parts from the control system manufacturer made the program quite time consuming and costly. The District found it very difficult to maintain this "high performance" state of tune with analog components that drift or fail. One three-man crew was assigned to methodically work its way through the system, replacing failed components and retuning as necessary.

With Unit 2 performance improved, attention was directed to Unit 1 for a similar program. The initiation of this effort, along with ever-increasing difficulty in obtaining control system parts, caused the District to authorize a Justification Study to see if total control system replacement was cost-effective.

JUSTIFICATION

In September 1987, a task force consisting of general office engineering, plant engineering, plant operations, and I&C personnel was created to evaluate all the major control systems at Gerald Gentleman and develop a comprehensive plan. One of the first actions of the task force was to retain a consultant, Burns & McDonnell Engineering Company, to conduct a Justification Study. The study determined that total control system replacement was justified, based primarily on the following cost items, per unit:

- Defer an increase in maintenance staff $473,533/yr
- Eliminate two unit rips per year $119,398/yr
- Improve heat rate by .5% $188,895/yr

The task force accepted the justification and the District management directed the task force to proceed with plans to replace the combustion controls, the DAS, the annunciator, and provide soft interface to the burner management and motor control logic systems for both units. The $6.7 million budget (two units) provided a 5-year return on investment.

TEAMWORK

The District's Project Manager had recently completed a similar project at the Sheldon Station and was very much aware of the many difficulties to expect and of the importance of cooperative teamwork. The task force intentionally included operations personnel and I&C personnel from the plant. The success of a DCS replacement project is very dependent upon the involvement of those persons who will be using the new system. Operations personnel were on the task force providing positive input related to operating the units, the operators complaints about the old control system, and their preferences, expectations, uncertainties, and fears about the new system. Operations participated in graphics design, control system improvement, operator interface, logs, etc., and control room/console layout. The I&C staff was similarly involved with the complete system configuration. Teamwork and coordination was stressed, and the task force met frequently to coordinate activities, encourage new ideas and report on progress.

BID SPECIFICATION

It was the task force's intention to identify features to be required of the new system and to technically evaluate the variety of available DCS options and features prior to writing the bid specifications.

The technical learning and evaluation process included a task force cross country tour to visit numerous DCS installations. The objective was to identify advantages and disadvantages of the major manufacturer's current systems and to identify features that the District might want to specifically include or exclude in the new system. The District's consultant, now functioning as par of the task force, participated in the site visits. Most major system manufacturers also brought a formal presentation of their current system capabilities to the District's offices. All this, combined with the District's experience at Sheldon and Burns & McDonnell's experience with numerous DCS replacements, provided the basis for bid specification development.

Technical features which the District felt to be of prime importance included:

- Unit 1 and Unit 2 systems must each totally stand alone, but be capable of controlling or monitoring the other unit when required.
- Total CRT control.
- Touch screen control on lower-tier CRTs.
- Trackball cursor control.
- 8 control CRTs per unit.
- Dedicated 33-inch alarm CRT per unit.
- Multi-screen function capability.
- Windowing capability.
- Screen call-up time of 3 seconds or less.
- Closed loop round trip time of 3 seconds or less.

- Loop processing time of 0.5 second or 1 second, depending upon type of loop.
- Dynamic data updates at least once per second.
- SOE time-tag at 1 msec resolution and coordinated with control system clock.
- Maintain integrity of present District-developed SAMA logic (i.e., not manufacturer's standard).
- Four sets of 50 programmable push buttons.
- Color printers, or video copier for graphics.
- Three engineer programming terminals.
- One stand-alone simulator using the same hardware and applications program as the control system.
- All system upgrades & Beta versions to be included for the first two years from award of contract.
- In-depth training.
- Fixed discount on spare parts for 12 years from award of contract.
- Guaranteed 48-hour delivery of spare parts when required.
- The District had specific requirements for a high level of redundancy.
- The District had specific requirements for very flexible and tunable control drive interfaces.
- Console floor plan as specified.

EIGHT CONTROL CRTS/UNIT

The decision was made to totally remove all existing benchboards. Unit operation would require multiple CRTs and after numerous site visits, it was agreed to specify eight CRTs plus a large overhead alarm monitor per unit. The console layout was designed to provide functional access of eight CRTs by one operator but allow an additional operator access during start-ups and emergencies. The console is laid out in a horseshoe arraignment with two groups of four CRTs. The NFPA-required dedicated trend recording is accomplished via a sub panel of Yokogawa pen records.

MULTI-SCREENING

One operating feature inherent to conventional benchboards is familiarity with the board layout. Every switch, light, indicator and hand/auto station is always in the same place. Operators can get so used to the layout that they don't really have to read the nameplates. This feature is lost during the transfer from benchboard to CRT control. While the CRT is always in the same place, the function it serves may change from moment to moment. This works well during normal operation. The District was concerned however, that this loss of familiarity with a physical layout might also result in a loss of reaction time. Operators may have to pull up one or several graphics, indicators, or operating stations before taking any action in confidence.

As a solution to this problem, multi-screening was included in the technical specifications. Multi-screening utilizes the reconfigured push buttons to automatically call up as many as eight different graphics on eight CRTs. If for example, the operator is faced with a drum level problem, one keystroke can instantly bring up all drum level-related indications and controls in an arrangement that operations has learned to be familiar with. The operator may then act quickly and in confidence, as all necessary instrumentation is before him. Once multi-screening has been activated, the operator may change any CRT image at any time.

WINDOWING

Doing everything with windows is quite the fad today, but was not so in 1987 or 1988. Windowing was a feature that, at that time, was relatively unavailable in DCS systems. The District indicated however that this flexibility was necessary. It was one thing to have eight CRTs available for startup or emergencies, but quite another to force the operator to actively use them all during normal operation. Windows would allow the operator to place multiple graphics (normally on multiple CRTs) all on one CRT. One manufacturer was found technically incapable of true windowing, but instead offered "windows" in fixed quarter or half screens.

SCREEN CALL-UP TIME

During the task force DCS tour, several systems were visited which displayed extremely long screen call-up times. To assure rapid call-up times, specifications required screen call-up time for any graphic to not exceed 3 seconds for "100 dynamic variables for any mix of I/O from any of the controllers in the system".

ROUND TRIP TIME

"Round trip time" was defined in the specifications as the elapsed time "from operator initiation of any field output command, to the CRT update of the resultant field status input...excluding any delays in response external to the control and I/O hardware". Specifications required round trip time to be less than 3 seconds.

LOOP PROCESSING TIME

Loop processing time was specified at 0.5 second for most control loops and 1 second for the slow loops. To help assure rapid loop processing, the District specified 80 percent or less loading of the controllers and did their own partitioning. These three items are the keys to obtaining rapid loop processing.

Establishing a specified loop processing time was actually quite controversial within the task force. The recent extensive tuning on Unit 2 had resulted in several very fast loops. In order to tune and configure fast loops properly, a high speed Gould eight pen test recorder was used. Resolution in milliseconds was often necessary to determine which variable changed first, etc. If the DCS were to be tuned just as "hot", then loop processing time would have to be very short, possibly 0.25 second or less. The system's ability to process inputs and indicate them however, would have to be even quicker. Extremely fast processing could be achieved by very lightly-load controllers. All this proved to be cost prohibitive. Eventually a compromise was reached with 0.50-seconds and 1-second loops as discussed above.

MAINTAIN EXISTING SAMAS

Following such a comprehensive reconfiguration and tuning efforts on Unit 2, the plant I&C specialists knew exactly how they wanted the new system configured. Detailed SAMA logic and digital logic diagrams were prepared and included with the technical specifications. The biggest fear was that previous efforts would be wasted when the successful bidder began to implement his own "standard" SAMA logic. During a factory tour one manufacturer's engineer actually told the task force he would throw the District's SAMA drawings in the trash and configure his own logic! This was exactly what we did not want to hear.

GRAPHICS

Operator familiarity and comfort level are of prime importance. The graphics were developed by a team effort of the operators and District engineering. Graphics layout is a P&ID format with pop-up sub graphics of switches and hand auto stations. This provides a very user-friendly environment for the operators.

STAND-ALONE SIMULATOR

Operator training was considered to be an essential ingredient in making a successful swap to total CRT control. A considerable amount of training and a loop tie-back control simulator were purchased with the system.

The simulator was specified to be completely stand-alone with no dependence upon the control system. Simulator hardware was to be identical to the control system hardware, however. Operator functions are simulated, with Unit 1 and Unit 2's control system software loaded into the controllers such that manual conversion of addresses is not required. The Unit 1 or Unit 2 system and tuning parameters can be read from the control systems and down-loaded directly to the simulator.

The simulator includes three initialization macros to allow the trainer to set up the simulation without going through a startup procedure. Shipping the simulator three months prior to the outage gave the operators sufficient time for familiarization.

BID EVALUATION CRITERIA

Nineteen items were identified in the technical specifications as evaluation factors. Many items were routine, such as bid price, ability to meet schedule, conformance to the specifications, and completeness of data requested with the proposal. Others however, identified the new system's life cycle cost including repair parts over 10 years, electrical power requirements, and training. Most had some stated method of assigning a dollar value to the factor. Included were:

- Cost of maintenance.
- Cost of spare parts.
- Cost of replacement parts.
- Field Service.
- Training.
- District's engineering costs.
- Electrical power requirements.
- Vendors "after sales service record."
- Past record of the Bidder in meeting his commitments.

Evaluation factors which proved to be surprisingly influential were electrical power requirements and cost of spare parts and replacement parts.

Thus, the successful bidder was the low responsive bid as adjusted according to these evaluation factors. Honeywell's TDC 3000 was selected.

THE CONTROL ROOM

The District meticulously specified and evaluated the control system to get exactly what they wanted, functionally. The control room was approached in a similar fashion. The room had to be a quiet, comfortable place to work. The traditional utilitarian look was rejected in favor of carpet, ceramic tile, and oak, all completed in soft coordinating blues and grays.

The District engineers worked closely with Burns & McDonnell to develop the basic concepts of console shape, the vaulted ceiling, raised floor, etc. Burns & McDonnell made some initial recommendations on types of floor and wall coverings, and the District completed the design, including all color schemes, lighting, and final selection of materials.

The consoles are Honeywell's standard gray. A painter was hired to repaint the existing vertical panels (formerly gold) to the same color and texture as the Honeywell equipment. Various pieces of hardware throughout the room were also touched p or repainted with the matching paint. The District's attention to detail is evident.

The consoles are placed on a very solid raised computer floor with a vaulted ceiling above, trimmed in oak. The vaulted ceiling houses speakers connected to a sound system that automatically cuts out during paging from the Gaitronics or the two-way radio. Also in the vaulted ceiling is a grid of bronze parabolic lighting with dimmer control to adjust background lighting for each operator's needs.

Vertical panels behind the consoles are washed in fluorescent light housed above in an oak valance. Perimeter room walls are covered in a sound-absorbent corduroy-looking blue/gray carpet with an oak chair rail and theater-style sconce lighting in Honeywell gray. Floor covering in the operating area is a coordinating blue carpet tile. The high traffic areas are covered with light gray ceramic tile.

High quality acoustic tiles were selected to replace the drop-in type tiles. One architectural design criteria was to eliminate ceiling penetrations. In an effort to abide by the design criteria, the HVAC supply and returns are hidden. The supply enters via slots around the vaulted ceiling. The returns are housed at opposite ends of the room in what appears to be a large oak crown molding. Only the fire detector sensors and Halon nozzles penetrate the ceiling tiles.

One feature of the original conceptual design which was later deleted is the use of theater-type traffic control ropes. Now that the systems are installed, operations has found a need to control traffic between the vertical panels and the consoles, and traffic control ropes are on order.

The control room sounds expensive, but the District found that there was minimal increase in cost and a very large benefit in providing a quiet appealing environment for the control room operators.

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