DCS in a pc: Your father would be 'blown away' by today's simulators

It wasn't long ago that "training" of a new powerplant hire consisted of working alongside one or more veterans until they thought you were competent enough to stand watch or do maintenance work on your own. Not a very sophisticated approach. But "hands-on" was a great way to learn—provided the person doing the teaching really knew the right way to do what you needed to know.

Hands-on still is a great way to learn, but now you can do it in air-conditioned comfort. Simulators allow you to operate *your* powerplant in virtual space, with both the look and feel of the actual control room and immediate response to your actions. Computer-based training also enables you to learn process fundamentals and procedures developed by true experts, so you can be sure what you're doing is correct.

Today, there's no reason that the entire powerplant staff cannot be taught from "the same book" and be "on the same page." Breakroom chatter on "how Mel does it, how Harry does it, etc, and what's the best way," should be a thing of the past. Everyone should be doing everything correctly from the "get-go." Near-error-free operation is as attainable as near-zero defects is in manufacturing. If gas turbines (GTs) can be built to "six sigma" standards, why can't they be operated to the same criteria?

They can, given the availability of state-of-the-art tools and capable management. Most industry greybeards probably recall their first experiences with simulators. It was new technology in the 1970s and a big step in the right direction.

But they were rudimentary training tools compared to today's offerings, typically programmed to general criteria and not representative of your plant. Often an instructor would be pushing buttons to simulate off-normal operating conditions—such as over-firing. If you didn't react quickly enough you heard safety valves pop. If this sounds prehistoric, you're young and probably never played 1970s video games.

Motivation for researching the state of simulator development came from Dave Ulozas, generation manager for Nebraska Public Power District and chairman of the 7EA Users Group (access www.combinedcyclejournal.com/archives.html, click 3Q/2007, click "Experience in using simulators for operator training" on the issue cover).


Kessler

During a presentation last year, Ulozas mentioned the difficult time operations people can have trying to "sell" the value of simulators up through the executive offices. He was looking for a million dollars (round numbers) and got *only* a couple of hundred thousand. That sounded generous to editors who clearly were out of touch.

The real story: While top-of-the-line simulators may be the ultimate training tool, their value extends well beyond training to problem-solving, faster commissioning, etc. The capital investment in them almost surely will be paid back before a new unit is declared commercial. Your sales pitch to the executive corps should reflect this fact. Adding a million or so to the capital budget for a 2 × 1 combined cycle (a half billion dollars or more) is, excuse the phrase, "chump change."

To come up to speed on the state of simulator technology, the editors visited Emerson Process Management Power & Water Solutions in Pittsburgh where they were "indoctrinated" by Gene Abruzere, manager of simulation business development, whose career began before the availability of 1970s simulators. They also witnessed the design review of a scrubber retrofit project by a major utility which was facilitated by the latest simulator technology.

Next, Bill Kessler, operations manager for Consolidated Edison Co of NY Inc's East River Station and member of the 7F Users Group steering committee, invited the editors to see first-hand the value of "high-fidelity" simulation in the design, commissioning, and operation of a 7FA-powered combined-cycle plant. The simulator for East River was provided by Emerson in conjunction with GSE Systems Inc, Sykesville, Md.

Simulators: The family tree

Looking back, Abruzere recalled the evolution of the technology—from simulators requiring extensive hardware in the 1960s and 1970s to today's simulators based primarily on software and virtual technology.

He then reviewed the various solutions that can be tailored to meet the unique operational challenges and budget for a given plant, using as an example Emerson's simulation suite—branded Scenario®. Its virtual technology replicates the full functionality of your control system without the need for full-size cabinets and controller components. Control strategies are executed within Windows®-based workstations, making the plant simulation portable for use throughout the facility.

Low fidelity. At the bottom of the "food chain," Abruzere said, is tie-back simulation, which includes DCS graphics and control logic (Figure). This relatively low-cost tool works well for (1) practicing control-system navigation, and (2) familiarizing new hires with critical power-generation fundamentals. It also is widely applied for control-logic checkout prior to its loading on the actual control system.

Tie-back simulation relies on

control-system algorithms for power generation that model key processes simplistically and accurately. Here's how it works: A subset of the process inputs and outputs from the control system used in factory testing are connected to the simulated logic. This then produces the inputs to the control system, thereby closing the control loops in the virtual controllers.

Medium fidelity. Algorithmic models allow more detailed modeling of plant systems, Abruzere continued. They can simulate any piece of equipment or subsystem you designate, or the entire power-generation unit. These models are created with the same powerful, advanced software programs used to create and maintain expert control-system strategies, process graphics, I/O placement, etc.

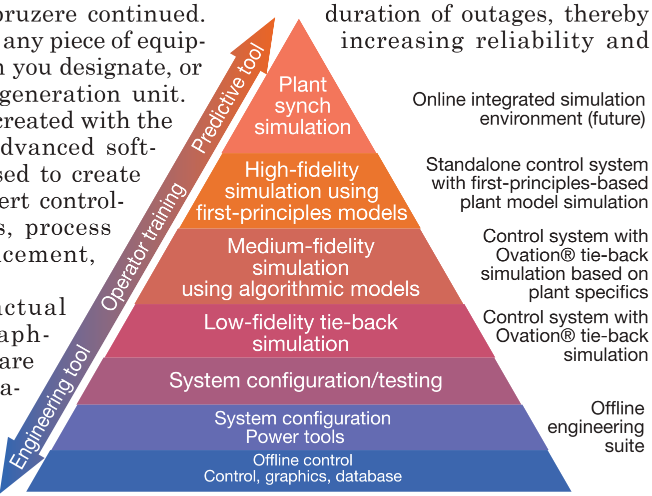
Your plant's actual control logic, graphics, and database are used as the foundation for medium-fidelity simulation, he said, which offers a realistic view of plant activities both during steady-state operation and during periods of dynamic response to equipment operation, control actions, and malfunctions.

Medium-fidelity simulators are configured to train operators on information acquisition and diagnostic skills—including practice in (1) the recognition of, and response to, equipment malfunctions, and (2) the use of emergency procedures to isolate failures. Other benefits include the capability to demonstrate existing operating procedures, to validate new procedures, and to show the affect of equipment malfunctions.

High fidelity. When a high degree of realism is desired, Abruzere told the editors, first-principle models are used to simulate individual systems or the entire generating unit. "First-principle" is not a term you'll find in the plant lexicon. It refers to the use of complex two-phase thermodynamic and other mathematical models to reflect, with the highest degree of accuracy possible, the operation and interaction of plant equipment and systems.

Abruzere gave an indication of how sophisticated the graphics-based software tools used for thermohydraulic modeling truly are with this statement: "They use conservation equations in a complex matrix solver for mass, energy, and momentum balances to provide fast and stable responses for pressures and flows." As the saying goes, "You get what you pay for."

Plant personnel use Hi-Fi simulation to efficiently perform fast-paced operating activities with confidence. Applying its capabilities as a decision-support tool, they can gain a higher level of process familiarity and develop best-practices procedures to help reduce the number and duration of outages, thereby increasing reliability and availability.



A wide range of simulation solutions is available to meet training and engineering needs within available budgets

One of Hi-Fi's greatest attributes is its ability to capture and retain the wealth of plant-specific process knowledge acquired by personnel over the years and to easily transfer it to new employees. This way the facility owner/operator doesn't have to pay a second, third, or fourth time to acquire the same experience. Dr Robert Mayfield offers valuable insights into the emerging world of knowledge management in "Maximizing and retaining the value of human, physical, and digital assets" (p 84).

As an engineering-analysis tool, first-principle simulation can be used to tune system parameters, validate new or changed control strategies, optimize alarm management, and test various "what-if" ideas to establish the validity of new procedures. When specified as part of a new plant purchase or major retrofit, Hi-Fi helps reduce startup costs—often substantially—because of its ability to fine-tune control schemes and to verify that all operational aspects of the plant are ready for commercial operation well in advance of commissioning. It also is used to train new operators and upgrade the skills of existing staff.

Abruzere summed up the compelling benefits of today's simulators this way: They reduce,

- Plant startup times through enhanced operational readiness and tested control strategies;
- Forced outages by providing tools for effective operator guidance;
- Project risk by decreasing human error; and
- O&M costs through improved operator effectiveness.

Plus, they improve,

- The bottom line by doing more with less, and
- Safety by preparing operators for correct and rapid reaction to equipment malfunctions and uncharacteristic plant situations.

Looking ahead, he said the next step in the evolution of simulation solutions is to overlay the model on the actual plant control system to provide meaningful online diagnostics as well as to simulate operational actions under real-time conditions.

In wrapping up the interview, Abruzere focused on two critical aspects of project success: proper integration of the simulator into overall new-plant or retrofit project scope and adequate resources to maintain the simulator throughout its lifetime.

A Hi-Fi simulator typically takes from 12 to 14 months to design and "build," he said, requiring that its development proceed in parallel with plant design to achieve training and logic check-out goals, etc, prior to commissioning. More pointedly, a high-fidelity simulator must be available three months prior to the commencement of plant startup activities to achieve the rapid ROI (return on investment) it is capable of delivering.

Working backwards, the plant controls design effort must be finalized nine months to a year before commissioning, suggesting that the DCS team be the lead group on projects involving Hi-Fi simulation. Timelines for the less sophisticated medium- and low-fidelity simulators are two to three months and six to eight weeks, respectively, allowing flexibility in project design workflow.

A follow-up conversation with GSE Systems offered two lessons learned:

- Typically the owner provides plant design details to the simulator developer for retrofit projects, the EPC contractor for new plants. Early in negotiations, the owner and/or EPC contractor should agree to participate in the development of procedures for the transfer of design data required for simulation and to make the necessary information available on a schedule compatible with the final objectives.

- Consider having the DCS startup engineer assigned to work alongside the modeler during critical phases of simulator development. This allows pretuning of the DCS, adjustment of set points, and systematic "debugging" while not under the pressure of a commissioning schedule.

Finally, Abruzere referred to simulators as "living things." As such, they must be "nourished" regularly to maintain their functionality and value. Plant I&E technicians can update the simulator by incorporating logic changes, system upgrades, etc. However, when equipment mods are implemented in the plant—such as the installation of new piping circuits, new valves, etc—the plant model itself must be updated.

The East River experience

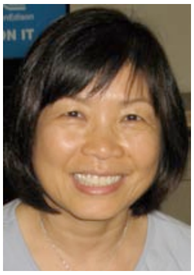
Kessler has a demanding job at a unique plant in a city that holds its utility under a microscope. A turbine trip at an inopportune time could put you on the front page of four newspapers that are among the 11 largest in the US in terms of circulation. Frank Sinatra meant it when he sang, "If I can make it there, I'll make it anywhere."

The East River Repowering Project, which began commercial service in April 2005, was a huge undertaking given its waterfront location at East 14th St in Manhattan. The two GE Energy (Atlanta) 7FA gas turbine/generators and heat-recovery steam generators (HRSGs) installed as part of the project, produce up to 360 MW of electric power and 3.2-million lb/hr of steam for the city's thermal grid—largest in the US by a wide margin. Many buildings south of about 96th St in Manhattan rely on ConEd steam for heat in winter and air conditioning in summer.

The total project encompassed far more than just installing two GTs and HRSGs, which were shoehorned into a landmark building. A new 10-ft-diam concrete-lined tunnel under city streets was required to deliver steam to the existing ConEd network, a new pipeline was run to deliver gas to the plant, etc.

Kessler's staff had to be thoroughly prepared to bring the new units into operation before the summer peak and run them hiccup-free through the warm months; transmission constraints limited the amount of power that could be delivered to the load center.

The East River team achieved that objective and has accomplished much more since. Highly commendable is that since first fire in March 2005, there have been no—*zero*—trips of either GT attributed to control-room operator error. By the end of 2008, each of the engines had logged more than 28,000 actual fired hours.


Wang


Mansell

A significant part of the utility's solution was a high-fidelity simulator to (1) facilitate training and commissioning in the near term and (2) enable operators to maintain their skills over the long term through an ongoing retraining/recertification program. Getting operations personnel "on the same page" was important because of the diversity in staff experience and general unfamiliarity with GT-based plants: Some employees were very experienced operators from conventional steam plants, some served on navy nuclear vessels, some were new hires.

Two of the leaders on the simulator decision-making team, Kessler told the editors, are Jon Mansell, shift supervisor, and Hsiu-Chen Wang, a senior engineer in corporate Control Systems Engineering. Present tense is used because both still are very much involved in maintaining the simulator as a viable diagnostic and training tool: Mansell, who has expert knowledge of the Mark V control system for the GTs, participates in the day-to-day management of DCS and simulator logic; Wang is responsible for simulator upgrades.

Other team members include Shift Supervisor Jan Van Daatselaar, who has a major involvement in operator training and recertification; John Giamarino and Steve Kurtz, project/HRSG specialists; and James Brennan, GT specialist.

The East River simulator uses actual plant control software and duplicate workstations to mimic the real control room. It incorporates the functionality of the turbine control system, programmable logic controllers for the burner management system, gas compressor, water treatment system, etc.

The training program included 10 weeks of classroom instruction—system by system. Practice on the simulator was part of this. It enabled operators to (1) become proficient in "screen navigation," (2) gain confidence, knowing how the plant would behave in real time during startups, shutdowns, ramps, etc, and (3) learn how to handle off-normal conditions—such as low drum level, high steam temperature, duct-burner runback, etc.

Such rigorous training was not for everyone; about half a dozen candidates left the program before it ended. For those completing the classroom sessions, there were "finals"—a two-week-long formal assessment. Each candidate had to score at least 80% to meet the requirements for an "operator" rating. Testing included "deck plates" drills using the simulator to verify the candidate's ability to operate under fire. Example: How did the prospective operator respond when one GT tripped?

Training never stops at East River. Annually, one week during the planned maintenance outage is devoted to review of system upgrades, logic changes, abnormal events experienced, etc. Some of the abnormal events are replicated on the simulator as part of the recertification program. Anyone who has operated a powerplant knows that if something happened once it can happen again. Having a simulator means you don't have to relearn lessons; you practice how to deal with specific operational situations quickly and effectively.

Training aside, a simulator pays for itself by identifying oversights in design *before* commissioning begins, thereby reducing the time required to achieve commercial operation. Also, the less time spent in commissioning means fewer stops, starts, and transients on the GTs which reduces the number of factored starts and factored hours that determine when the first maintenance inspection is required.

At East River, the simulator was the primary reason commissioning was completed three months earlier than forecasted—the first unit in 26 days, the second in 24. It identified several inadequacies that were addressed before the startup process was initiated. For example, the deaerator drain valve was switched out to a motor-operated valve, and valves were changed in the raw-water system supplying the reverse-osmosis system—both to enable operation the way designers intended.

Since commercial operation was declared, the simulator has been used to verify and validate any new controls and interfaces to third-party systems prior to "live" plant operation. CCJ