Simulator Digital Controls Installation Methodologies

SCS Conference, January 2020
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Introduction

Early Approaches
Manual Operation (Admiral Rickover’s legacy)

• Plant Process Computers
  • Usually simulated due to high computer costs

• Large DCS Systems
  • Usually stimulated due to fidelity desires

Later Developments
Automatic Operation Comes to Nuclear Plants

• Plant Process Computers
  • Usually stimulated – lower computer costs

• Large DCS Systems
  • Usually simulated – training needs
Methodologies

DCS Vendor Early Approaches

Early emphasis on hardware solutions for DCS

- “hardware-in-the-loop” - Bailey “Red Box” at VC Summer.
- GE “suitcase” design – Corys did interface to models.
- Westinghouse PC board addition to simulator host computer for FW and Recirculation controls.
  - Problems when upgrading to new computers and new operating systems.

CORYS Approach

Simulation software to support classroom training on multiple stand-alone simulators and development systems for simulator engineers and instructors

- First auto generated DCS models developed for Millstone 3, Foxboro IA for MSR, Gland Steam, and Bearing Temperatures.
- Second auto generated for Davis Besse hosted B&W Owners Group testing of new ICS using Foxboro IA.
- Applied same approach to Foxboro IA at TVA’s Browns Ferry, Sequoyah, and Watts Bar.
Methodologies (Continued)

CORYS Approach (Continued)

- First auto generated HMI graphics on the Watts Bar Foxboro IA system.
- Continued auto generated HMI on Perry and Hope Creek.
- Developed auto generator for GE Mark V, VI, and Vle DCS and HMI on several DEHC systems, and AVR Exciter systems.

(The photo shows Calvert Cliff’s GE Mark VI applied to their Unit 1 Turbine Control System.)
Methodologies (Continued)

CORYS Approach (Continued)

(The photo shows the same Turbine Control system in “Monitor” mode.)
Methodologies (Continued)

CORYS Approach (Continued)

• Applied auto generator of DCD and HMI on full fossil plant simulators using GE Mark VI, including Meag and Sabiya.
• Developed auto generator for Bailey (ABB) system at VC Summer to replace “Red Box” hardware. Graphics done manually in ThunderView.

(The photo shows C FW PUMP CONTROL of the Bailey DCS from VC Summer.)
Methodologies (Continued)

CORYS Approach (Continued)

(The photo shows FW HEATER EXTRACTION STEAM AND DRAIN of the Bailey DCS from VC Summer.)
Methodologies (Continued)

CORYS Approach (Continued)

(The photo shows FW HEATER EXTRACTION STEAM AND DRAIN of the Bailey DCS from VC Summer. Popups are shown for level transmitter selection and the M/A station for the drain valve, 3783A.)
Methodologies (Continued)

CORYS Approach (Continued)

Then came a blend of early and new approaches on big project, first at First Energy plants Davis Besse and Perry. (This was a past Corys presentation at SCS.) GE Mark VI DEHC was tested on a simulator test bed provided by Corys prior to plant installation. Then a second DEHC system was purchased to use with the test bed as an engineer and technician part task hardware trainer for the plant.

- Incorporated “hardware-in-the-loop” by building a test bed that created the signals the DEHC expects in the plant as inputs, and took the DEHC outputs to feed back to the simulator model.
- The test bed is interfaced to the simulator by Corys CAN I/O.

(The photo shows the front of the test bed panels.)
Methodologies (Continued)

CORYS Approach (Continued)

• The model is the training simulator running on a PC.
• The plant DEHC system was completely tested through all plant operations prior to installation, including calibration activities.
• The Corys GE Mark VI auto model generation utility was applied later to provide the simulation of the DEHC on the paneled simulator.

Utilizing both the early concept of “hardware-in-the-loop” and the present software simulation approaches, Corys completed these projects to meet First Energy’s training needs.

(The photo shows the rear side of the test bed panels.)
Methodologies (Continued)

DCS Vendors Present Approaches

The hardware approach has largely been abandoned. It has been replaced by the development of emulation software. An example is:

• The Bailey “Red Box” at VC Summer, discussed in the early approaches, is now fully emulated on the paneled simulator host computer using licensed software developed by ABB, the present owner of Bailey Controls. There is no hardware control system.

• The HMI stations are the same as those in the plant, and the emulation software drives them directly.

• Corys provided the interface effort to tie the DCS signals to the host simulator models.

• The glass simulators and all other desktop simulations for development engineers and instructor lesson plan development still use the simulated system supplied by Corys, discussed in the Corys approach. The control systems are auto generated from plant configuration files derived from the plant systems. The HMIs are manually coded in ThunderView, the Corys TRex Instructor Station Graphics platform.
Methodologies (Continued)

DCS Vendors Present Approaches (Continued)

Another example is:

- Westinghouse now supplies a fully emulated software package for their Ovation applications.
- The HMI stations are also emulated, and both emulations run on the simulator host PC.
- Corys provided the interface effort to tie the Ovation signals to the host PC simulator models and participated in all acceptance testing.

(The photo shows Westinghouse Ovation applied to the Calvert Cliffs Feedwater System.)
DCS Vendors Present Approaches (Continued)

• The glass simulators and all other desktop simulations for development engineers and instructor lesson plan development can use the same emulated system supplied by Westinghouse.

• Plant updates can be brought over from the plant system and dropped in the proper simulator folder.

(The photo shows a popup of the Main FW valve controller, 1FIC 1111.)
Methodologies (Continued)

DCS Vendors Present Approaches (Continued)

(The photo shows the Ovation alarm screen for the Calver Cliffs FW Control System.)
Methodologies (Continued)

DCS Vendors Present Approaches (Continued)

(The photo shows an interesting benefit from emulation – the same live wiring drawings are available on the simulator.)
Smaller Digital Control Systems

The approaches to smaller instruments, such as controllers, radiation monitors, and dedicated control systems can vary according to simulation requirements. We will tie in some instruments discussed in previous SCS conferences.

Radiation monitors lend themselves to full simulation.

• High Voltage sections for radiation transducers require large capacitors and are prone to failure and are not needed in simulation.
• Maintenance is expensive and frequent.
• Overrides of panel instrumentation and internal failure modes are not included in the real monitors. Training may require malfunction capabilities not present in the plant instrument.

(The photo shows the simulated Victoreen Model 942A, the subject of a previous SCS presentation.)
Methodologies (Continued)

Smaller Digital Control Systems (Continued)

PID controllers are much more efficiently stimulated.

• The hardware is usually quite complex, using LCD displays, and containing computers.

• Internal programming is easily accessible.

• Remove process coding supplied for the plant and replace it with interfaces to model parameters in the simulation database.

• Create a software module to calculate the control algorithms in the host computer.

(The photo shows a Yokogawa 1700 controller on the Point Beach simulator for Steam Generator level control.)
Methodologies (Continued)

Smaller Digital Control Systems (Continued)

Most special purpose control systems lend themselves to full simulation.

A previous SCS presentation covered the Siemens VFD, Variable Frequency Drive for Recirculation Pumps. The project was done for Hope Creek.
Methodologies (Continued)

Smaller Digital Control Systems (Continued)

- The VFD physical hardware on the MCB is just an LCD screen.
- Corys implemented the graphic screens.
- The VFD replaces the motor generator set with hydraulic drive.
- The VFD synthesizes the power source for the Recirculation Pump Motors.

(The photo shows the main screen of the Siemens VFD for Hope Creek, the subject of a previous SCS presentation.)
Future Work

Plant Computers

The approach to implementing large scale plant computers has changed from simulation to stimulation due to decreasing computer hardware cost. This is likely to continue in the future.

DCS

The early concept of “hardware-in-the-loop”, discussed for VC Summer, Davis Besse, and Perry, has remained a viable approach depending on site training needs. When maintenance technician training is an issue, it remains the demanded solution.

Specialized hardware made for simulators, such as the GE “suitcase” design and the Westinghouse PC board addition, have been abandoned and mostly replaced by software emulations.
Future Work

Small Digital Control Systems

Digital Control Systems for smaller limited scope applications will remain a mix of simulation or stimulation depending on the nature of the plant hardware.

For example, radiation monitors are likely to be simulated when the plant hardware includes power to the radiation detectors (such as Victoreen 942A) or complex interfaces to other hardware performing database operations (such as General Atomic). But the later Mirion models will likely be stimulated since the monitor hardware is relatively inexpensive and easily accessible with standard interface design.

PID controllers will continue to be stimulated for the same hardware reasons – inexpensive and easily accessible with standard interfaces.

VFDs, AVR/Exciters, and DEHCs on simulators will likely remain simulated devices since the software is much more manageable in the simulator host regarding simulator unique features (reset, run, freeze, etc.), and the hardware in the MCR is very limited – usually just an LCD, or hidden altogether.
More Challenges On The Way

With the advent of extended operation licenses for nuclear plants of up to 80 years, we will face bigger challenges.

The plants will demand more new control systems to support extended life. DCS and simulator vendors will need to support their customers in new and different ways.

Corys is looking forward to playing a viable role in the training goals of its customers in the future.
Conclusion

Thank You

For Your Kind Attention. I hope this presentation is helpful.

Special thanks to Yves Lacombe, for his help providing background material.

Any Questions or Comments?