7ICMSNSE-52

Application of Classroom Simulators in the Training of Managers at CANDU Plants

G. Bereznai and K. Rizk
University of Ontario Institute of Technology, Oshawa, Ontario, Canada
george.bereznai@uoit.ca, khalid.rizk@uoit.ca

Abstract

Technical managers of Canada's nuclear power plants are required to have in-depth knowledge of the normal and abnormal integrated unit operations typical of the plant at which they work. The Advanced Operations Overview for Managers (AOOM) training program was developed by Ontario Power Generation to fulfil this need for many of its managers. The program makes extensive use of "classroom" simulators that have the same software models as the full-scope training simulators, but use graphical user interface to replicate the control room devices. For the last several years the AOOM program has been delivered by the University of Ontario Institute of Technology.

Keywords: Real-Time Simulator, Operations Support

1. Introduction

The CANDU nuclear-electric generating stations operated by Ontario Power Generation (OPG) and Bruce Power produced over 60% of the electricity generated in Ontario in 2014. There were eight units operated by Bruce Power, and 14 units (6 at Pickering and 4 at Darlington) operated by OPG.

The managers responsible for technical aspects of operating and maintaining these nuclear units typically have an educational background of a university degree in engineering or science. While some of these university programs have significant content specific to nuclear power plant technology, notably in Ontario at McMaster University and at the University of Ontario Institute of Technology, typically well over 90% of the engineers and scientists working at the above two nuclear utilities graduated from undergraduate degree programs that contain little if any knowledge specific to the nuclear aspects of power plants. Traditionally such specialized knowledge was gained via on-the-job training and professional development courses, as well as graduate degree studies. The University Network of Excellence in Nuclear Engineering (UNENE) was established in 2001 and has been successfully operating a Master of Nuclear Engineering program to address the industry's need for such nuclear-specific post-graduate education [1].

One of the key technical manager roles at nuclear utilities is that of the manager responsible for one of the “shifts”, which collectively operate the plant on a continuous basis. The “shift managers” at each nuclear utility are “authorized” by the Canadian Nuclear Safety Commission (CNSC). The highly specialized training program is conducted by the utility operating the nuclear units, and the program itself, as well as the qualifications of the authorized shift managers, is overseen by the CNSC. A key component of the authorization training program is the use of full-scope replica training simulators, each simulator being unique to the power plant for which the manager has authorization [2].

The shift manager authorization training program is lengthy, requires specialized resources, and is typically followed by several years of managing “shifts” at the respective power plant. The knowledge and experience gained in the process of gaining authorization and managing the “shift” is highly valued for the many technical jobs that support the operation and maintenance of the plant, as well as to conduct periodic updates, upgrades and refurbishments of key plant components. However, the authorization training program followed by lengthy assignment as shift manager has proven to be inefficient to impart the range of knowledge and skills that typical managers in technical roles need at a nuclear utility. Instead, Ontario Power Generation developed a program that includes most of the classroom components of authorization training, and has used this “Advanced Operations Overview for Managers” (AOOM) program to provide its technical managers with the desired level of nuclear plant design and operating knowledge [3]. Bruce Power has adopted this program for its purposes, and New Brunswick Power has also recently commenced a similar program for the technical staff at Point Lepreau.

2. Classroom simulator user features

An essential prerequisite for the conduct of the AOOM program is the availability of a “graphical user interface” or GUI for the plant’s full-scope simulator. These “classroom” simulators use the same software as the replica simulators, i.e. they are “full-scope” in terms of the range of events that the simulator can perform [4], but instead of replicating in hardware the operator-machine interface of the control panels, the panels are displayed as graphical representations of the actual equipment.

Figure 1 shows an example of representing a section of the main control room panel, in this case instruments, hand-switches and a controller associated with pressurizer level and solid mode pressure control. While this GUI was constructed using graphics software, other implementations use photographs of the panel section. In either case, there is a high level of reality in viewing the displayed devices. The operator is able to manipulate the control panel devices with a mouse that allows “pointing” and “clicking” to change the state of a specific GUI that represents the panel hardware. The simulation software has been changed from using a hardware interface generated signal to one generated by the GUI software.

An obvious limitation of the GUI approach, particularly if it uses a single computer display screen, is that only selected portions of the control panel can be viewed and operated at any given time. Selection of a panel section can be done via a pull-down menu, via a stylized representation of the control panel as shown in Figure 2, or via a small mimicry of the panel hardware displayed on each panel section GUI.

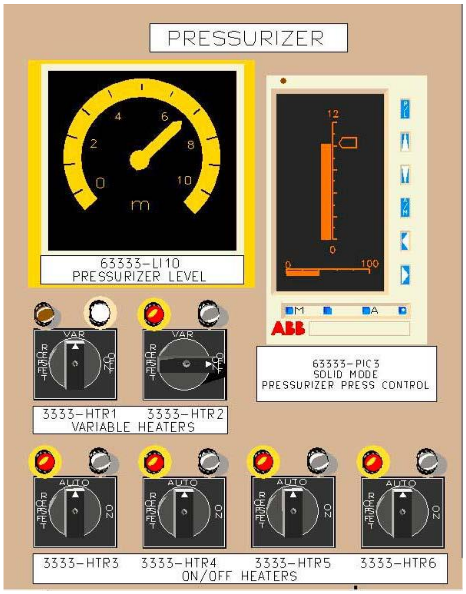

Figure 1 Example of a GUI representation of a section of the main control room panel

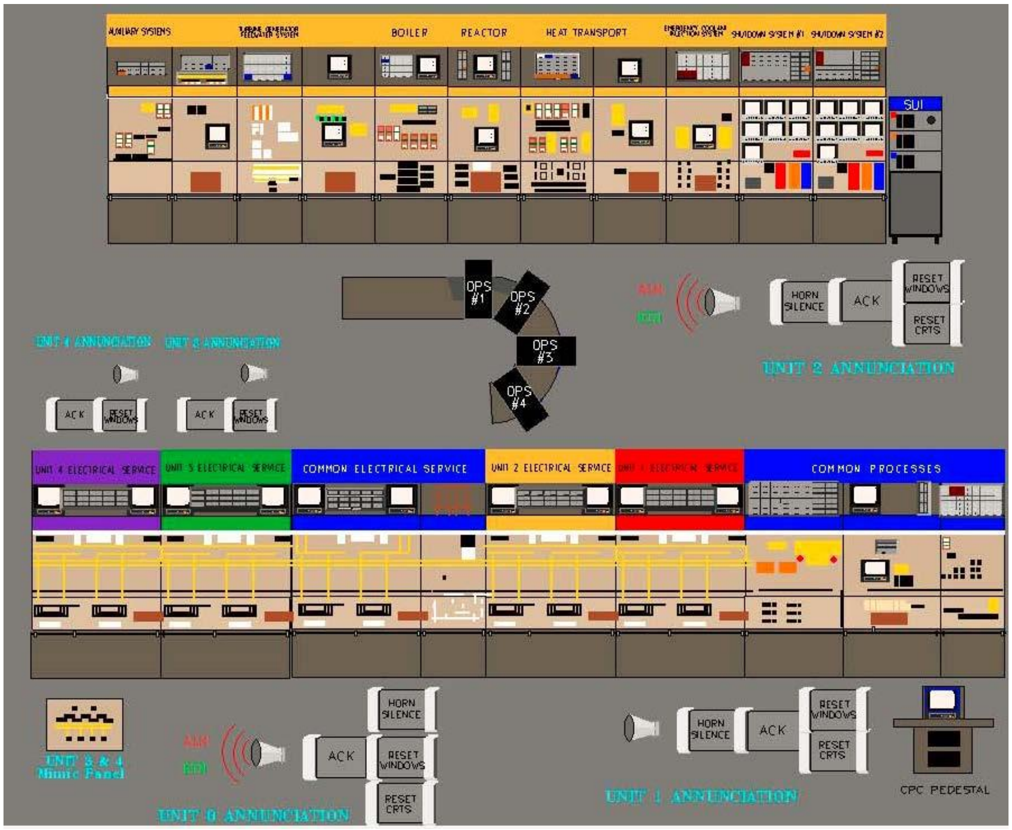

Figure 2 Representation of the main control panels of the simulated unit

The classroom simulator uses the same software representation of the simulated unit as for the replica simulator, and has all the usual features of a full-scope simulator. These include: freeze and run, a wide choice of initialization points and the ability to create new ones, the introduction of malfunctions that are representative of typical equipment failures at the power plant, including multiple malfunctions, and the ability to perform all normal and abnormal operations that are included in the authorization training program. However, since the participants in the AOOM program are not expected to operate or to supervise the operation of a unit via the control room, the simulator is used to support the knowledge aspects of how a nuclear unit operates, and not how to operate such a unit. In other words, in the AOOM application and as used in a number of UOIT degree and diploma courses, the simulator is an educational tool that helps the understanding of the physical processes and engineering principles that are essential knowledge for technical personnel working at a power plant to apply so as to ensure the safe and reliable operation of all the equipment that comprises these very complex systems. The simulator is unique in being able to present the operation of each piece of equipment, subsystem and system within the context of an integrated unit, operating in real time.

3. Simulator configurations used at UOIT

The effectiveness of the classroom simulators are greatly enhanced by being able to display multiple screens simultaneously. These displays may show more than a control room panel section, or some combination of panel equipment, control room display monitor, a stylized representation of the circuit diagram for a given system, as well as parameter values that are not measurable at the real plant, but are computed as part of the simulated process. One such classroom display setup used at UOIT to enhance the learning benefits of using a simulator is shown in Figure 3. The display equipment comprises six back-projection screens that can be configured to show a multitude of views, in this illustration eight different representations are shown that combine panel equipment and computer displays. In particular, all CANDU units use digital computer control for all major control loops, as well as for displaying alarms, annunciations and key plant parameters. While Figure 3 illustrates the flexibility of the display system used, this particular example was taken from a presentation on the procedure to manage the unit’s response to an abnormal event, made by a senior undergraduate student as part of the capstone presentation for the B.A.Sc. in Nuclear Power program.

The more typical use of the display system that shows the use of the simulator in the AOOM program is shown in Figure 4. The arrangement of three front projection screens is also typical of the configuration used in the industry delivery of the AOOM training program for utility managers. The three display screens provide the necessary flexibility for the instructor, who are all former authorized shift managers, to demonstrate the design and performance of the system or integrated plant under the full range of operating conditions expected to be encountered in the operation of the given nuclear-electric generating unit.

Figure 3 Use of six back-projection units showing multiple control room displays

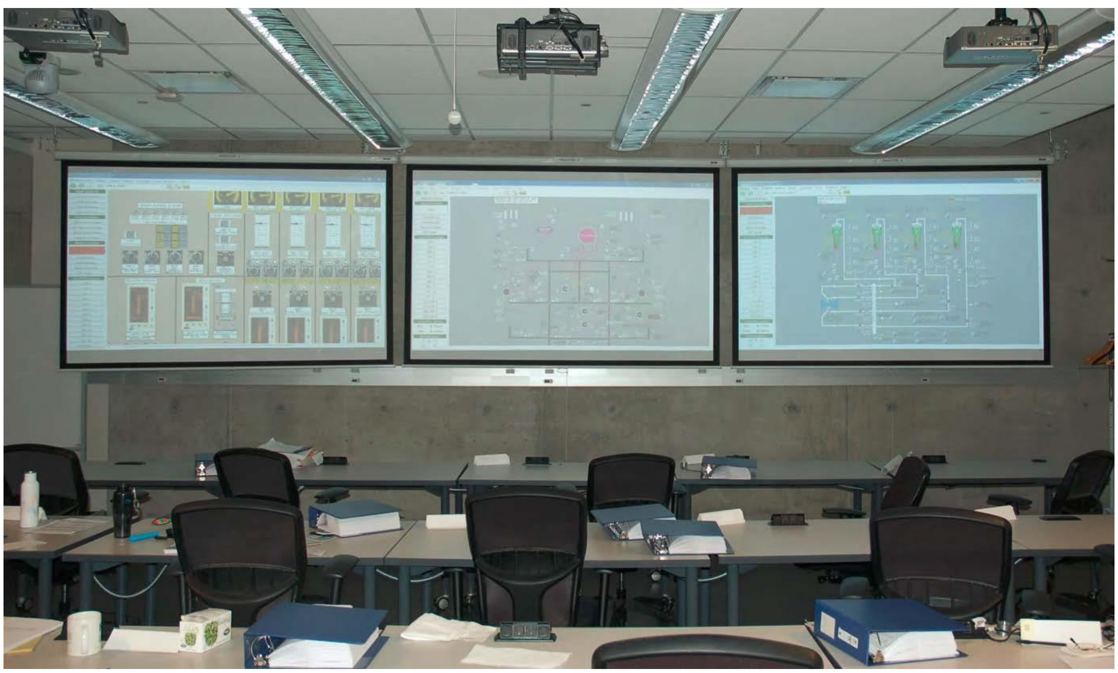

Figure 4 Use of three front-projection units that support current delivery of AOOM program

4. Overview of technologies used in the AOOM classrooms

There are several features that make the classroom environments shown in Figure 3 and Figure 4 unique and optimal for delivering course material. The “video wall” shown in Figure 3 consists of six high definition rear projection screens that are arranged in a 3 x 2 matrix which is effectively seamless and behaves as one integrated display. Each screen can display a maximum resolution of 2048 x 1536 pixels which makes the entire video wall capable of displaying a combined resolution of 6144 x 3072 pixels. This allows detailed graphics and text on the simulator panels as well as parameters on the process simulation diagrams to be more clearly visible than on a standard video projector. The images that appear on the video wall originate from 16 input sources and are fed through a Jupiter Video Wall processor which is responsible for arranging the video inputs according to predefined configurations. These configurations are fully customizable and are selected from a touch panel by the instructor such that any one video source can be projected onto the entire video wall or multiple video sources can be simultaneously displayed in various arrangements. The video inputs in the classroom include two laptops (for instructor presentations), six inputs from a simulation computer, one input from a VCR or DVD player and six inputs from student laptops in the classroom which are connected to the network. The display inputs from the student laptops communicate with the video wall using UltraVNC in combination with the ControlPoint Client Software that comes with the Jupiter Video Wall processor and the instructor has the option of displaying each laptop individually or all of them simultaneously.

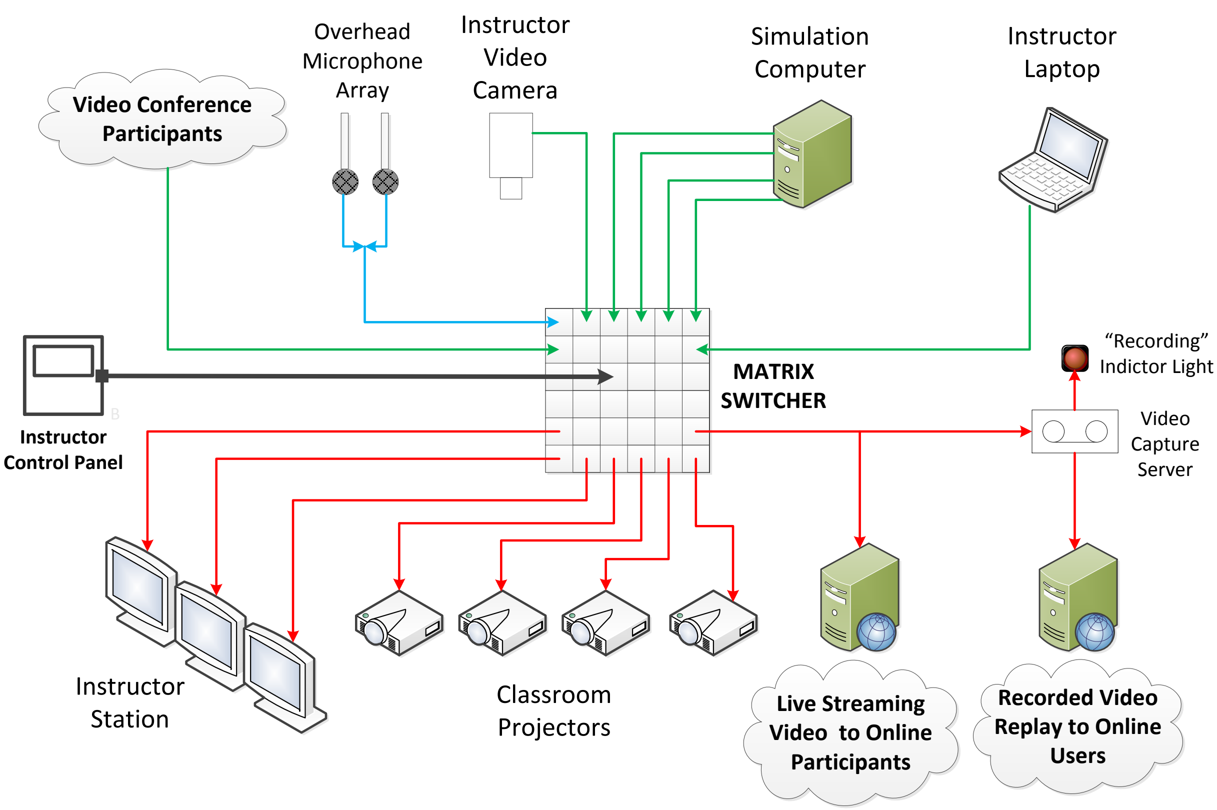

Figure 5 A system device map of all the I/O components used in the AOOM classroom

The hardware architecture of the classroom which is used to deliver the AOOM program at UOIT is more complex in terms of its configuration but offers additional functionality for distance learning and video recording. Figure 5 shows all of the I/O devices which are connected to a Crestron DigitalMedia Matrix Switcher that manages all of the video and audio routing from their origins to their destinations. As depicted using green lines in Figure 5 there are seven possible video inputs for the system, namely; four inputs from a simulation computer, one from an instructor laptop, one from a video camera located in the classroom that records the instructor and an input from a video feed that shows all of the participants in the group video conference call. An array of overhead microphones are installed in the classroom to capture audio from the instructor and the students. The outputs for the system are three LCD screens which are located at the instructor station for manipulating the simulator displays, four high definition projectors which can display resolutions of 1080p (three of the projectors are shown in Figure 4), one media server which streams live video from the classroom to distance users and finally a webserver that takes captured video and archives it for future playback. As can be seen in Figure 6, the Instructor Control Panel was designed to allow for full flexibility in the selection of the desired video input to be displayed on the

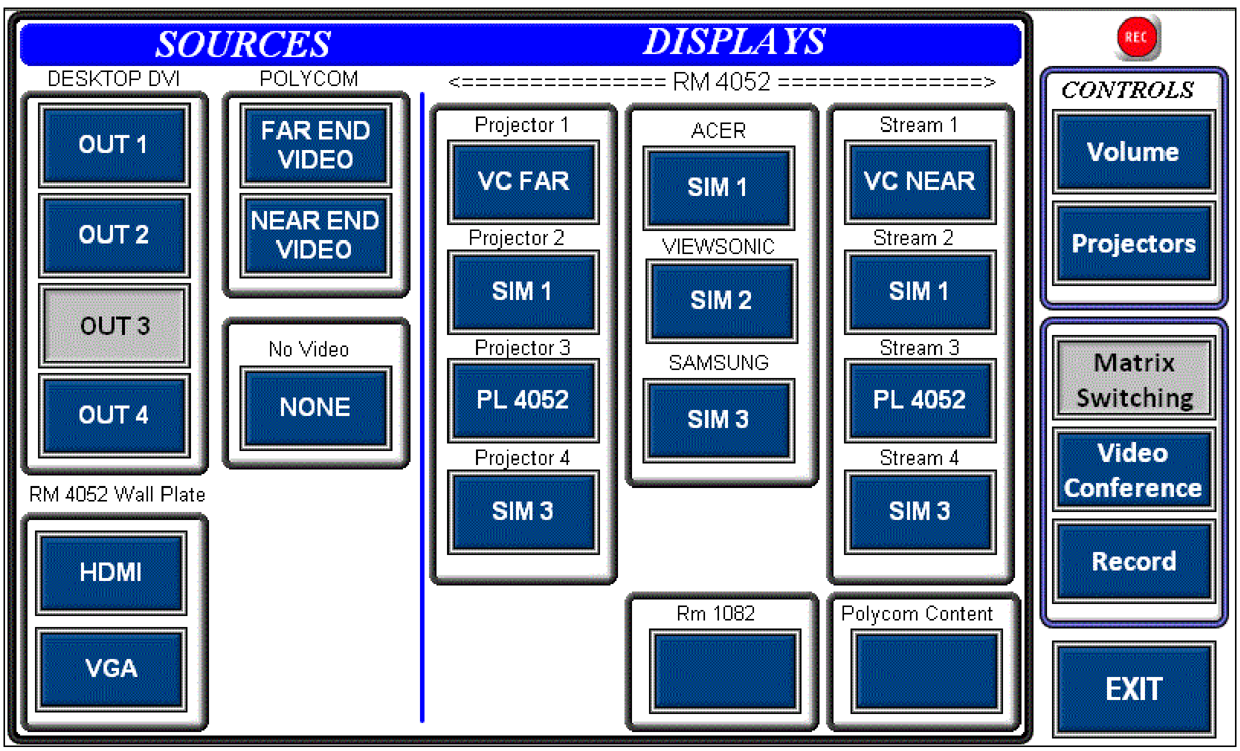

Figure 6 The Control Panel allows any input source to be displayed on any output device

projectors or LCD screens. The instructor panel also has a “Record” button that, when selected, causes a “REC” light to appear in the top right hand corner of the panel and also illuminates a large red light in the classroom to indicate to the students that are present that the session is being recorded. This recording is automatically uploaded to a webserver which reconciles the time of the recording with a schedule of the topics and a script auto-generates descriptive links on a website that students access to view the recordings.

The video conferencing system used in the classroom is a Polycom HDX 8000HD unit in combination with an Eagle Eye Director camera. This system allows up to 16 distance users to dial into the classroom and interact with the classroom using an application called Polycom m100 on their laptops or by using the Polycom RealPresence Mobile app on their mobile devices. Corporate users and partners in the industry that have access to an .H323 compliant video conferencing system can also dial in and participate in the video call. If the distance users do not need to interact with the classroom they can login to the live video streaming feed and view the instructor as well as what is being displayed on the three presentation screens at the front of the classroom. Figure 7 shows a screen capture of a live session that was recorded and then played back at a later time using the webserver. As can be seen the video stream is split up into four quadrants and can be paused and scrolled to any point in time during the session and also maximized to take up the full screen. A minimum resolution of 1600 x 900 pixels using a 21” or large LCD screen is required for the best viewing experience and so that details of the simulator process parameters are clearly visible. The close-up views of the instructor as he moves around the classroom are handled automatically by the Eagle Eye Director camera which uses Polycom’s proprietary voice and facial recognition technology.

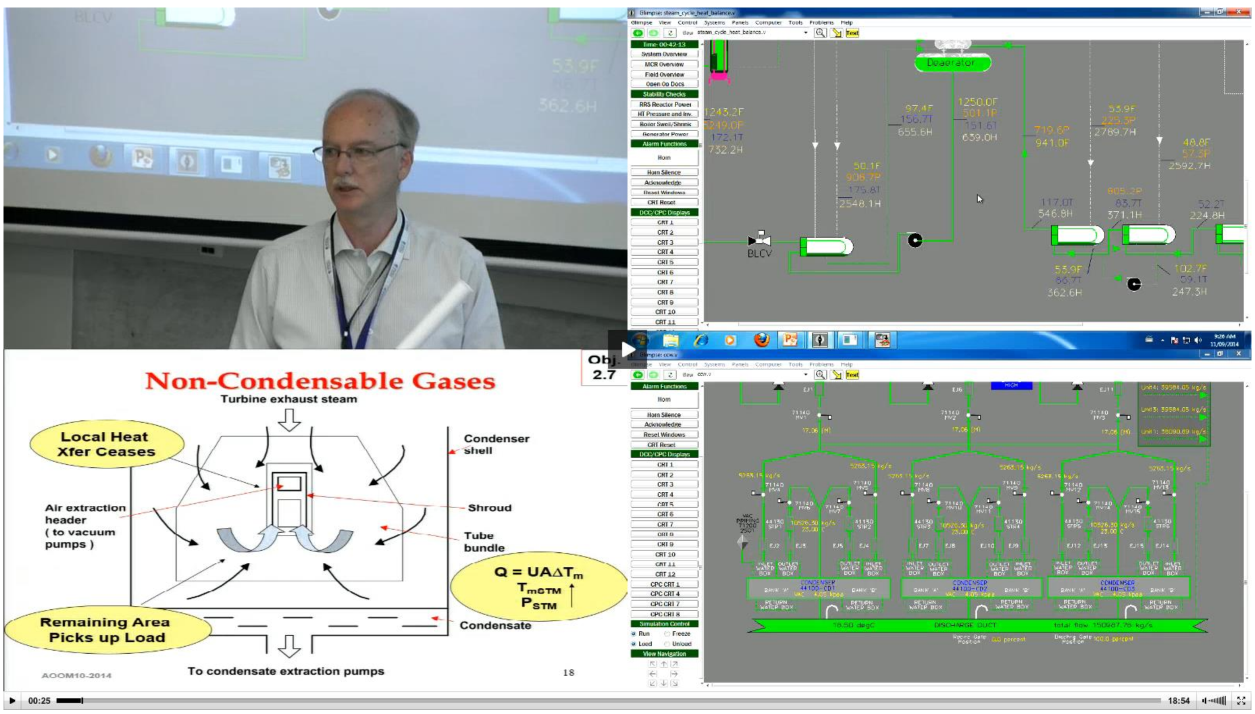

Figure 7 A sample screen capture of a recorded video being replayed by the webserver

5. Conclusion

The use of class-room simulators with GUI and full-scope process models has been found to be key to the successful conduct of a training program that delivers the essential classroom components of authorization training to shift managers at Ontario Power Generation’s nuclear power plants. The delivery of the program at a university that is located close to the power plants has been found to enhance the learning experience.

6. References

[1] V.G. Snell, “UNENE and Nuclear Human Resource Development in Canada”, International Conference on Nuclear Human Resource Development in Asia and Pacific, Tokyo, Japan, 2011 March 14–16.

[2] G. Bereznai, W. Burns, and G. Hancock, G., “Technical Requirements for Simulator-Based Testing of Candidates for Authorization”, Proceedings of the 14th Annual Conference of the Canadian Nuclear Society, Saint John, New Brunswick, Canada, 1992 June.

[3] G. Bereznai, G. Cornett, and H. Nivi, “Advanced Operations Overview for Managers Training Program”, Proceedings of the American Nuclear Society Conference on Nuclear Training and Education (CONTE 2013), Jacksonville, Florida, 2013 February 3-6.

[4] G. Bereznai, “Ontario Hydro’s Training Simulator Program for Nuclear Generating Stations”, Proceedings of the 10th IMACS World Congress on System Simulation and Scientific Computation, Montréal, Canada, 1982 August 8-13