ICS Specialist
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Study

Training Alternatives

Instrumentation and Control System (ICS)

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ALTERNATIVES FOR TRAINING ICS PROCESS OPERATORS

PREFACE/OVERVIEW

Computer technology today provides tools for producing presentations and training programs that are colorful, effective and comprehensive. For example, the Microsoft package of **Word**, **Excel**, **Powerpoint**, and **Visual Basic** can be used to produce a *multimedia presentation* for training WETF ICS operators. This presentation would be segmented into a series of lessons which would lead the prospective operator from a cursory view of facility operations to a detailed knowledge of ICS, process, control room and other systems operations. Using a suitably equipped Personal Computer (PC), a person would be ready for advanced, hands-on experience at the conclusion of such a training sequence.

On-the-job training is another viable alternative. In this scenario, the prospective operator would be required, through hands-on experience, to learn how to respond to existing conditions during actual facility operations. A trained, experienced operator would be the "mentor" who would provide such knowledge. This method has the advantage of direct interaction with existing facility equipment as well as having a "knowledge person" available for help during all phases of the training.

Existing equipment and configurations suggest another alternative. The WETF Facility is configured not only with the main process console, but also with a software development system which is used as a backup in case of failure of the main console. This system could provide experience with actual equipment without need for real-time plant operation. Trained, experienced operators could provide as-needed assistance to augment this training without undue impact on WETF operations.

REQUIREMENTS

In order to provide meaningful training, certain minimum requirements should be met. The training should be directly related to the desired results; the equipment and other materials should be as relevant as possible; and the impact on WETF operations should be minimal.

Existing facility, equipment and software constraints

The specialized nature of the WETF Facility, and the tasks performed therein, require a direct familiarity with the facility itself, the equipment used in performing process operations, and an understanding of the software used.

Desired outcome

The result of training should be a knowledgeable, competent operator, capable of responding to both normal and abnormal situations as they occur.

Each of the alternatives identified above are discussed in the following pages, showing both advantages and disadvantages as well as how well each meets these requirements.

ALTERNATIVES

PC-based multimedia

Today's modern Personal Computers (PCs) have a plethora of software and hardware tools available with which to produce multimedia applications. An IBM-compatible PC equipped

with a sound card, a video card, a CD-ROM, suitable speakers, a large hard disk and a large color monitor can be used to simulate the OPCON at WETF. The applications software package would be written using such tools as Microsoft **Word**, **Excel**, **Powerpoint**, and **Visual Basic**, and others directly suited to particular hardware (e.g., sound and video interface packages).

An operator training course designed around a PC would consist of a series of lessons similar to the following:

Introduction: General overview of WETF [Guided Tour (GT) and/or Video and Sound (VS)]

ICS Software Familiarization: Operating system software (AOS/VS, FLIC) --- Applications software (TGH, TWT, TGC, ETC, FAC) --- System point descriptions (Analog and Digital, Input and output) [VS]

Use of the PC as the OPCON: How to use the PC keyboard to simulate the OPCON keyboard --- Calling up displays --- Use of the mouse to control the simulated function buttons --- Use of color in the displays [Sound and directed help screens (SH)]

Basic Console (OPCON) Operations: Display organization --- Function buttons -- Display navigation [VS and SH]

Alarm Acknowledgment: Levels of alarms --- Operator actions --- Printer functions [VS and SH]

Process Control: Analog point setting --- Alarm limit setting --- Device control [VS and SH]

Facility Monitoring and Control: Preparing for operations --- Safety checks --- Normal and abnormal conditions --- Processing --- Shutting down [VS and SH]

Video segments would have to be prepared in separate sessions, utilizing the existing WET Facility hardware. Extensive editing would then be necessary to integrate each video session with the proper training information pertinent to each lesson. Playback, over the simulated OPCON screen, would be accomplished through use of the video board and associated software. Synchronization of video, text, and in some cases on-line-help would be accomplished through an overall control program designed to provide for interrupted viewing (e.g., viewing lessons out of sequence, repeating lessons, starting in the middle of a lesson, etc.).

Video would be shown through the use of a VCR, as the frame storage requirements are prohibitive for direct viewing from PC storage¹. The VCR output would be directed to the

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¹To produce full-color (16 million colors), full-motion (30 frames per second) video on a 640x480 pixel VGA screen, a computer must process 27MB of video data per second. No processor can currently process this much data fast enough to update the image; no hard disk is large enough to hold more than a minute of video; and the transfer rates are too slow. By reducing the image size to 320x240 pixels, using only 256 colors and reducing the

video card and the image displayed in a corner of the simulated OPCON screen. Sound would be directed through the sound card to the speakers. Alternatively, a standard TV (with VCR attached) could be used, but synchronization of activity (e.g., directing the trainee to call up a display) would be difficult.

The OPCON function buttons would also be shown in a corner of the simulated OPCON screen. This display would be integrated with the use of the PC pointing device (typically a mouse)². A button would be chosen through use of the mouse. Careful programming would allow the mouse to serve this additional role ("pushing" a function button or controlling the PC software). Similarly, the PC keyboard would have to be re-programmed during OPCON simulation to disable certain keys (most notably the ENTER key...). Interfacing a spare function button unit to the PC can be done through use of various interface boards, thereby saving the cost of a large (or second) monitor but at the expense of having a customized hardware setup. Programming requirements, though different, would be similar in cost and complexity. Use of a single monitor is recommended, although the size should be 21" or larger for ease of use.

The primary advantages of a PC-based multimedia setup for WETF operator training include convenience and ease-of-use. The training can be conducted "off-line", away from the site, at any time, and requires no knowledge person as assistant. PCs and VCRs are somewhat ubiquitous, so minimal training in their use is required.

The disadvantages include heavy hardware requirements and specialized software development. A PC equipped with a video card, sound card, 21" monitor, speakers, CD-ROM, a large hard disk, along with the necessary keyboard, system box and floppy drives costs approximately \$7000.00 --- not exactly a typical home (or office!) PC. VCRs are about \$500.00. The software as outlined above is mostly custom software, and will take considerable time to develop, even with the modern tools available today. For instance, a function button simulation using **Visual Basic** was written in approximately four hours, but interfacing to a control program written in **C** could not be completed in less than a week³.

Use of a PC does not bring about a direct familiarity with the WETF facility, either. Some hands-on training would be required.

Meeting the requirements: PC-based multimedia training can provide a direct familiarity with WETF through video presentations filmed at the facility. This isn't as good as "being there", but is acceptable. Impact on WETF operations is definitely minimal, as this training is conducted "off-line", and no knowledge persons are required. The ability to respond to real-life situations is probably not very strong after this type of training, so a certain amount of on-the-job training will be necessary. My overall assessment: satisfactory.

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frames-per-second to 15, the data rate may be reduced to just over 1MB per second. This is still prohibitively high. Similarly, CD-quality sound with its 16-bit resolution and 44.1 kHz sampling rate can demand 10MB of disk space per stereo minute. Data compression techniques can substantially reduce these requirements, but the cost, in terms of processing power and storage, is still too high for a WETF Training Program.

² The function buttons could also be simulated through use of a second monitor which would display the function button array.

³**Visual C/C++** holds promise of improving this effort, but the package has not been received yet.

On-the-job direct training

On-the-job training has been used effectively in many situations. Operators trained under this scenario would be able to directly operate the WETF upon conclusion of the training; certification as an operator could be part of the training itself. Familiarity with all aspects of the facility are "built in" to the training, so additional familiarization is not necessary.

Knowledge of the software can be obtained through use of the existing FLIC video training tapes⁴. These tapes were made during an actual training course presented by Quadrex, the developer of FLIC. The questions raised during the course come from people who actually built WETF, so the course is very focussed on WETF.

An operator training course based on hands-on operation would consist of a series of lessons similar to the following:

Introduction: General overview of WETF [Guided Tour (GT)]

ICS Software Familiarization: Operating system software (AOS/VS, FLIC) --- Applications software (TGH, TWT, TGC, ETC, FAC) --- System point descriptions (Analog and Digital, Input and output) [Video Tapes (VT)]

Basic Console (OPCON) Operations: Display organization --- Function buttons --- Display navigation [GT and Hands-On (HO)]

Alarm Acknowledgment: Levels of alarms --- Operator actions --- Printer functions [GT and HO]

Process Control: Analog point setting --- Alarm limit setting --- Device control [GT and HO]

Facility Monitoring and Control: Preparing for operations --- Safety checks --- Normal and abnormal conditions --- Processing --- Shutting down [GT and HO]

Additional video tapes would have to be prepared which would discuss each of the application software packages - TGH, TWT, TGC, ETC, and FAC. Alternatively, existing Vu-Grafs could be used, but these would probably need a "presenter" to provide reasonable understanding.

The primary advantage to on-the-job training is that a person who completes such a course of instruction can immediately control the facility (with proper certification). No additional cross training or familiarization training would be necessary. Also, no extra expenditure for additional hardware would be necessary.

There are two disadvantages, however. A "mentor" (a skilled, certified operator) must provide the training at (nearly) every phase. And while such training is underway, the facility cannot be effectively used for any other purpose. While on-the-job training may be desirable, it does not lend itself to cost-effective utilization of either manpower or equipment!

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⁴Additional tapes would have to be made. See text.

Meeting the requirements: On-the-job training is ideally suited for providing direct familiarity not only with the facility itself but also for providing directly applicable operations knowledge, as well as familiarity with existing equipment. Operators who complete this training should be completely familiar with almost all aspects of WETF. However, the impact on WETF operations is high. My overall assessment: highly satisfactory.

Utilization of existing equipment

As mentioned in the Overview, the WET Facility is configured not only with the main process console, but also with a software development system which is used as a backup in case of failure of the main console. This system could be effectively used for training WETF operators.

An operator training course utilizing the WETF backup system would consist of a series of lessons similar to the following:

Introduction: General overview of WETF [Guided Tour (GT)]

ICS Software Familiarization: Operating system software (AOS/VS, FLIC) --- Applications software (TGH, TWT, TGC, ETC, FAC) --- System point descriptions (Analog and Digital, Input and output) [Video Tapes (VT)]⁵

Basic Console (OPCON) Operations: Display organization --- Function buttons - -- Display navigation [Hands-On (HO)]

Alarm Acknowledgment: Levels of alarms --- Operator actions --- Printer functions [HO]

Process Control: Analog point setting --- Alarm limit setting --- Device control [HO]

Facility Monitoring and Control: Preparing for operations --- Safety checks --- Normal and abnormal conditions --- Processing --- Shutting down [GT and HO]

Because the WET Facility is configured with a backup system, this system can be utilized as a training setup without shutting down main plant operations. Additionally, because it contains the same hardware as the WETF OPCON, it provides direct, hands-on experience with actual equipment. Finally, the backup system uses the same software as does the on-line system, so familiarity with the actual process control programs is built-in.

While use of the backup system seems to obviate many of the disadvantages of the preceding alternatives, certain "extras" will still be required. The existing simulation software package, though adequate for software development, is not comprehensive enough for training, and will

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⁵As noted under on-the-job training, additional tapes would be necessary to describe the application software.

have to be augmented. Additionally, a "snapshot" program, used to obtain actual plant values, should be integrated into the training package⁶.

As with the PC alternative, video segments would have to be prepared in separate sessions, utilizing the existing WET Facility hardware. Some editing would then be necessary to integrate each video session with the proper training information pertinent to each lesson. Playback would be through a standard TV/VCR setup, however, rather than through the OPCON display. Synchronization of activity is also a problem here.

Primary advantages to use of the backup system as a WETF operator training facility include:

- *The only additional equipment necessary is a TV/VCR.*
- *Direct, hands-on experience with actual hardware and software.*
- *The ability to respond (through snapshots) to real situations without jeopardizing actual plant operations.*
- *A "mentor" is not necessary except during final checkout/certification.*
- *Training can be conducted "off-line" while still utilizing actual plant conditions.*

There are at least two disadvantages: the backup system is used as the software development system. As such, whenever additional software must be developed, or whenever existing software must be modified, the system cannot be used for training⁷. Additionally, there is still the need for a mentor during the later stages of training.

Meeting the requirements: Because existing equipment is used during this training, intimate familiarity with it is a direct result. And because "snapshots" of actual plant values can be used, direct understanding of normal and many abnormal situations is quickly acquired. Operators who complete this training should be competent and quite knowledgeable about WETF. The impact on WETF operations should be minimal; the occasional use of knowledge persons would seem to be all that is required. My assessment: excellent.

COSTS

PC-based multimedia

A properly equipped PC hardware setup will cost approximately \$7000.00. To this needs to be added the (commercially available) support software, which may cost upwards of \$3000.00. Also, the custom software, written either by in-house personnel or contracted out, will take anywhere from six months to a year (depending upon complexity) and cost in the range of \$100K - \$300K. The video taping is an additional cost, probably requiring two to four months' effort in addition to equipment, for an additional \$30K - \$70K⁸.

On-the-job direct training

By far the cheapest solution is on-the-job training, at least in terms of out-of-pocket costs - virtually nil (actual costs would include a TV/VCR (\$700.00). But because of the impact on

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⁶Such a program would be used to provide a starting point for training. It would preset the training software with actual plant conditions, including all alarms, valve positions, pressure vessel conditions, etc., thereby allowing near-real-time "responses" to both normal and abnormal conditions.

⁷A spare system will be available, however, when the switch to the new computers is made.

⁸HRD is quoting about \$2K/minute for a training video without animation, and about \$1K/minute for CBT's.

operations and the need for experienced operators to act as instructors, this is potentially the most costly, and therefore not recommended.

Utilization of existing equipment

A reasonable compromise is the use of the existing backup/software development system. Minimal hardware expenditure is required, the demands on operator personnel are less than in either of the other alternatives, and more real benefits accrue from its use. Actual costs would include a TV/VCR (\$700.00), video taping (somewhat less than the PC alternative --- \$10K to \$30K), and software development to improve the simulation package and the snapshot package (\$50K --- \$100K).

RECOMMENDATIONS

Utilization of existing equipment

Cost Effective

The use of the backup/software development system is potentially the most cost-effective approach. Costs for implementing this alternative can be contained by careful determination of course content, thereby limiting the amount of video instruction that should be produced⁹. Use of in-house personnel to write the necessary software (a better simulation package and a better snapshot program) will also prove to be economical.

Cleanup/Fixup for effectiveness

The only real deterrent to immediate use of the backup/software development system is its current configuration. I recommend that a new console be built to house the Aydin, the keyboard and the function buttons, making it similar in configuration to the main OPCON. A desktop large enough for the necessary texts and writing tablets should be included.

CONSIDERATIONS FOR THE FUTURE

Hands-off video/multimedia presentation

While I think the PC-based multimedia approach to operator training is exciting, I believe that it is not currently feasible. There is just too much custom software that would have to be developed to simulate the existing WET Facility. If it is decided to change hardware/software during an upgrade of the Facility, however, then consideration should be given to developing this kind of training system in conjunction with that upgrade.

Upgrade of the WET Facility

I do not know what the operational lifetime of the WET Facility is projected to be, but I would anticipate that one or more major upgrades will occur during that time. I would use the time between now and then to investigate current and projected SCADA system developments in the commercial sectors, with the thought of utilizing both new hardware and software if it is deemed appropriate.

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⁹For instance, a short course on the applications software could be presented, using the existing Vu-Grafs. This could then be video-taped and used for subsequent training.