



PROTOTYPE EQUIPMENT STATUS MONITOR FOR PLANT OPERATIONAL CONFIGURATION MANAGEMENT

M. DeVERNO*, S. GROOM**, D. TRASK*

*Atomic Energy of Canada Limited,
Centre for New Energy Research,
University of New Brunswick,
Fredericton, New Brunswick

**New Brunswick Power,
Point Lepreau Generating Station,
Lepreau, New Brunswick

Canada

Abstract

CANDU plants, such as the Point Lepreau GS, have tens of thousands of operable devices. The status of each operable device must be immediately available to plan and execute future changes to the plant. Historically, changes to the plant's operational configuration have been controlled using manual and administrative methods where the status of each operable device is maintained on operational flowsheets located in the work control area of the main control room. The operational flowsheets are used to plan and develop Operating Orders (OOs) or Orders-to-Operate (OTOs) and the control centre work processes are used to manage their execution. After performing each OO procedure, the operational flowsheets are updated to reflect the new plant configuration. This process can be very time consuming, and due to the manual processes, can lead to the potential for time lags and errors in the recording of the current plant configuration. Through a cooperative research and development program, Canadian CANDU utilities and Atomic Energy of Canada Limited, the design organization, have applied modern information technologies to develop a prototype Equipment Status Monitor (ESM) to address processes and information flow for efficient operational configuration management. The ESM integrates electronic operational flowsheets, equipment databases, engineering and work management systems, and computerized procedures to assess, plan, execute, track, and record changes to the plant's operational configuration. This directly leads to improved change control, more timely and accurate plant status information, fewer errors, and better decision making regarding future changes. These improvements to managing the plant's operational configuration are essential to increasing plant safety, achieving a high plant availability, and maintaining high capability and capacity factors.

INTRODUCTION

Successful management of the plant operational configuration is a key component of station operations and is essential to enhancing safety, achieving a high plant availability, and maintaining a high plant capacity factor. CANDU¹ nuclear plants, such as the Point Lepreau GS, include tens of thousands of manually operated devices besides those operated through automated control and reactor protection systems. Multi-unit CANDU stations may have up to 160,000 operable devices. The operation of these devices on a daily basis requires strict controls and procedures to ensure safety, procedural compliance, and to provide correct up-to-date status information for future decision making. Efficient yet comprehensive work

¹ CANadian Deuterium Uranium

processes and information flow are needed to plan, execute, track, and record changes to the plant configuration and an up-to-date status of each operable device must be available to plan and execute future operational activities.

Historically, these activities are controlled using a combination of manual and administrative methods centered around the use of operational flowsheets and Operating Orders (OOs) or Orders-to-Operate (OTO)² procedures. Operational flowsheets, located in the work control area of the main control room, use coloured pins, dots, labels, and other markups to indicate the current operational status. This includes device and equipment status, jumpers, and work protection tags. As many as 200 operational flowsheets may exist for a single unit, and collectively are referred to as the plant operational 'pinboard'. When operational changes to manual devices are needed, the operational flowsheets are used to plan and develop OOs and the control centre work processes are used to manage their execution. The planning process must include the assessment of current device status, work protection, temporary jumpers, maintenance records, and other operations ongoing at the time. After developing, reviewing, and approving the OO, the work activity is authorized. During execution of the OO, the operator must sign-off each step as it is completed. Upon completion of the OO, the pinboard (operational flowsheets) is updated as required to reflect the new plant configuration and the paperwork (OO and related information) is filed in the work permit area and the records department. Overall, this process can be very time consuming, and due to the manual processes, can lead to the potential for time lags and errors in the recording of the current plant configuration.

Improvements to plant configuration management can have beneficial effects throughout the entire plant infrastructure. This has been the driving force behind programs to augment the manually intensive processes with computerized systems. The first such program in the Canadian CANDU industry was the development of the Equipment Status Monitor (ESM) [1] by Ontario Hydro for use at its Darlington NGS. The ESM replaced the traditional processes with a computerized system that facilitated the generation of OOs, maintained the status of all manually operated devices using electronic flow sheets, and included provisions for facilitating the field operation using electronic equipment verification. The intent of the system was to track the state of all manually operated devices, reduce the chance of operator error, and provide up-to-date device status to station staff. However, technological limitations imposed by the hardware and software available at the time limited the overall effectiveness of the Darlington ESM.

Subsequently, there have been many technological advances in the use of hand-held tablet computers, Computer Aided Design and Development (CADD) systems, electronic equipment identification and verification, and hypertext technologies. These technologies can facilitate the design and development of a low-cost ESM system offering improvements to the original concept. As a result, through a cooperative research and development program, Canadian CANDU utilities and Atomic Energy of Canada Limited (AECL), the design

² OTOs and OOs are the same. OTO is Ontario Hydro terminology whereas OO is used in NB Power.

organization, have applied modern information technologies to develop a new next generation ESM prototype to address the processes and information flow for efficient operational configuration management. The ESM integrates electronic operational flowsheets, equipment databases, engineering and work management systems, and computerized procedures to assess, plan, execute, track, and record changes to the plant's operational configuration. This paper presents an overview of the prototype ESM system including its operational context, high level system functional requirements, prototype design description, and benefits of the ESM towards improving plant availability, capacity factors, and safety while lowering the overall operations, maintenance, and administration costs.

OPERATIONAL CONTEXT OF THE GENERIC ESM SYSTEM

Station staff must have an accurate understanding of the current operational state of all plant systems and devices, as well as an accurate picture of the reliability and availability of all devices should changes to the operating state of the plant be required. The operational state of the plant is influenced by maintenance activities and changes to the plant design. Similarly, feedback on the operability and reliability of plant equipment provides critical input to the design and maintenance processes. It is thereby recognized that the process of managing the plant's operational configuration impacts virtually all functional groups within the station. Having correct, up-to-date plant status information ensures that optimal decisions are made and acted upon. Fewer mistakes occur, plant safety and reliability are enhanced, and higher plant availability and capacity factors follow. The operational context of the generic ESM system is shown diagrammatically in Fig.1.

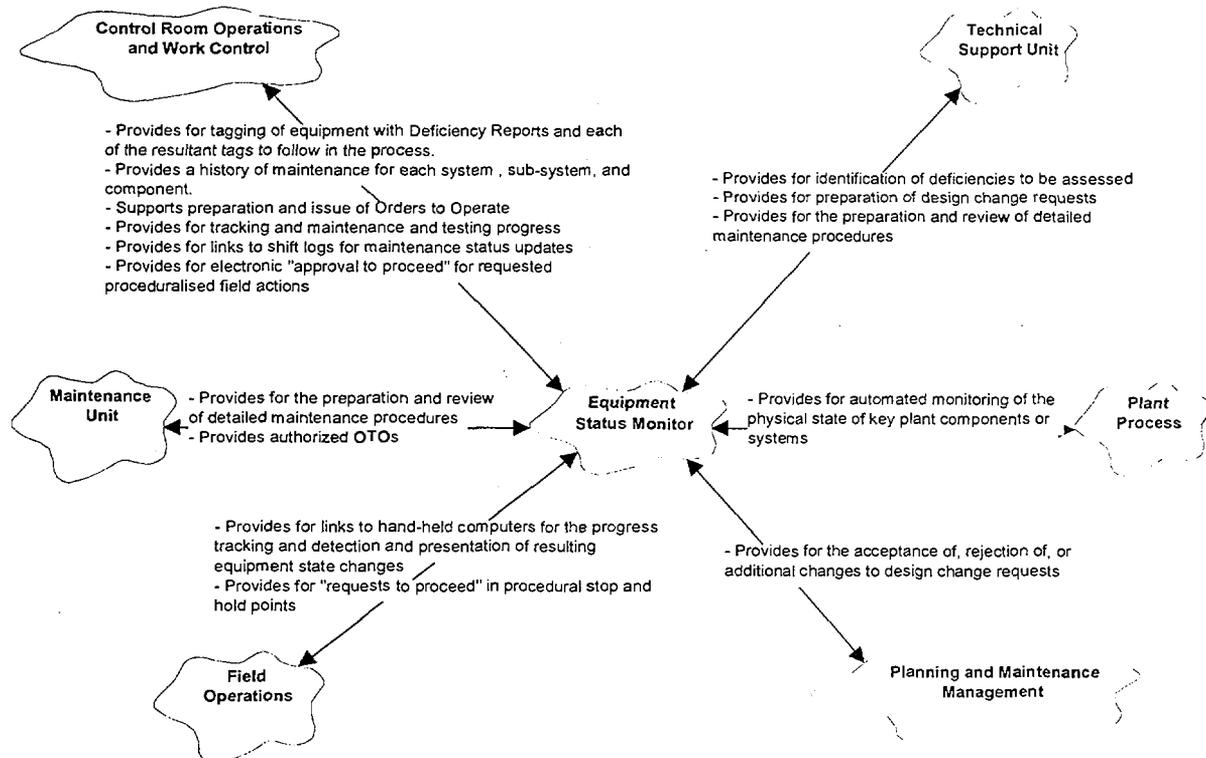


Figure 1: Operational Context of ESM.

HIGH-LEVEL ESM FUNCTIONAL REQUIREMENTS

Managing the plant's operational configuration requires the integration of design, maintenance, and operational information into an end-product that in itself is maintainable and manageable. The resulting system must provide process improvements, higher efficiency and effectiveness over the currently used manual processes. In addition, the system must successfully integrate with other plant data systems [2,3] supporting operations, technical support, maintenance, and administration.

At the core of the ESM is equipment status. Each operable device in the plant has an associated status, which may be unique to the class of component. For instance, a pump may be 'On' or 'Off', and a valve may be 'Open' or 'Closed'. The ESM system must be able to manage and maintain the creation, revision, and updating of all device types and status information associated with each operable device in the plant. This includes adding/deleting devices, changing the status of any device, and presenting this information to the user through simple operator interfaces.

A key component of the ESM is the presentation and ongoing management of plant operational flowsheets. Each flowsheet is a representation of a Process and Instrumentation Diagram (P&ID) where detailed design information not pertinent to operations has been removed and other information added to facilitate the operational processes. The ESM must be capable of maintaining electronic operational flowsheets including the implementation of revision control procedures. The ESM must be capable of retrieving and displaying any flowsheet with the current device status, work protection tag information, and up-to-date jumper records. Standard viewing functions such as panning and zooming must be available, and the system must provide hard copy prints.

Temporary changes to the plant are documented in the form of jumper records. Traditionally, jumper records are hand-drawn on the operational flowsheets held within the control centre's work control area. The ESM must be capable of accessing or incorporating a jumper record database and include mechanisms to display jumper record information. In addition, the ESM must be able to display jumper information on the operational flow sheets and include tools to update the jumper records and flowsheets under administrative control.

Work protection tags are labels that are placed on field devices to ensure work safety and protection, and to ensure that the condition of the device is guaranteed and maintained. Tags of different names and colours are typically used within the plant in accordance with the station policies and work procedures. The ESM must include mechanisms to manage the definition and application of work protection tags. This requires a work protection tag database and processes compliant with station work protection procedures. This activity is especially important during the generation and execution of OOs where work safety is potentially at risk. The ESM must be capable of accessing, viewing, and updating work protection tag information.

The maintenance histories of the plant components and associated deficiency reports are important to ongoing plant operations, the preparation of OOs, and other work processes. The ESM must include interfaces to the Work Management System to access maintenance histories and deficiency reports pertaining to all operable devices.

The ability to prepare, execute, and track OOs is a fundamental ESM requirement. The ESM must be capable of managing the initiation, creation, field execution, and completion of all OOs. Mechanisms to create and modify OOs include the revision of previously generated OOs, the use of 'point-and-click' methods using the operational flowsheets in conjunction with 'pick lists' or 'pull-down menus' of appropriate actions, or through combinations of these two mechanisms. During the creation of an OO, the ESM must be capable of displaying all relevant information from the operational flowsheets, jumper records, work protection, maintenance histories, and deficiency reports as may be required to research and complete the OO procedure. The ESM must also include facilities to manage the OO work flow in compliance with station policies and procedures. For OO execution, the ESM must include the use of a hand-held computerized procedure system. The system must include all of the necessary communication interfaces, embed and enforce the approved procedural work flow, facilitate equipment identification, handle shift turnovers, and generate time-stamped logs of the operator activities and events. Successful completion of the OO must result in the updating of the plant configuration maintained by the ESM databases and operational flowsheets.

Authorization, security, and database management must be built-in features of the ESM in order to ensure compliance with station policies and procedures, and to ensure that information within the ESM is not in any way altered without the appropriate permits. The ESM must include security measures to limit system use and OO authorizations to approved personnel in accordance with station policies and procedures. Since the ESM will contain a significant amount of information within its own database, as well as have access to other plant information systems, it is necessary to implement appropriate database management practices in order to ensure system integrity and longevity. The ESM must include mechanisms to maintain the equipment lists and operational flowsheets in compliance with the engineering and CADD systems, and to maintain the other ESM database components as necessary.

The ESM is envisaged to be the focal point of a large amount of plant data. However, it is not expected that the ESM becomes the repository of all of the information, but rather is able to query other database systems and display the appropriate information to the user. Therefore, the ESM must include the appropriate interfaces to the engineering and CADD design databases, drawings, and models. Interfaces to the plant work management system are also required for the retrieval of work histories and deficiency reports, maintenance plans, work-in-progress reports, and other such information that may be pertinent to the preparation of OOs and the monitoring of the plant equipment status. Furthermore, interfaces to plant historical databases and other process systems are needed for the automated retrieval of information associated with automated devices within the plant.

ESM DESIGN OVERVIEW

The advent of new computer hardware and software technologies has created opportunities for improving the work processes within nuclear power stations. This has been most prominent in the areas of information technologies where small, powerful, hand-held computers that resemble writing tablets, and object-orientated software tools allow the development of operational support systems well beyond the expectations of only a few years ago. These tools have been incorporated into a prototype ESM system to support the preparation, execution, and tracking of operating orders and the management of the plant's operational configuration.

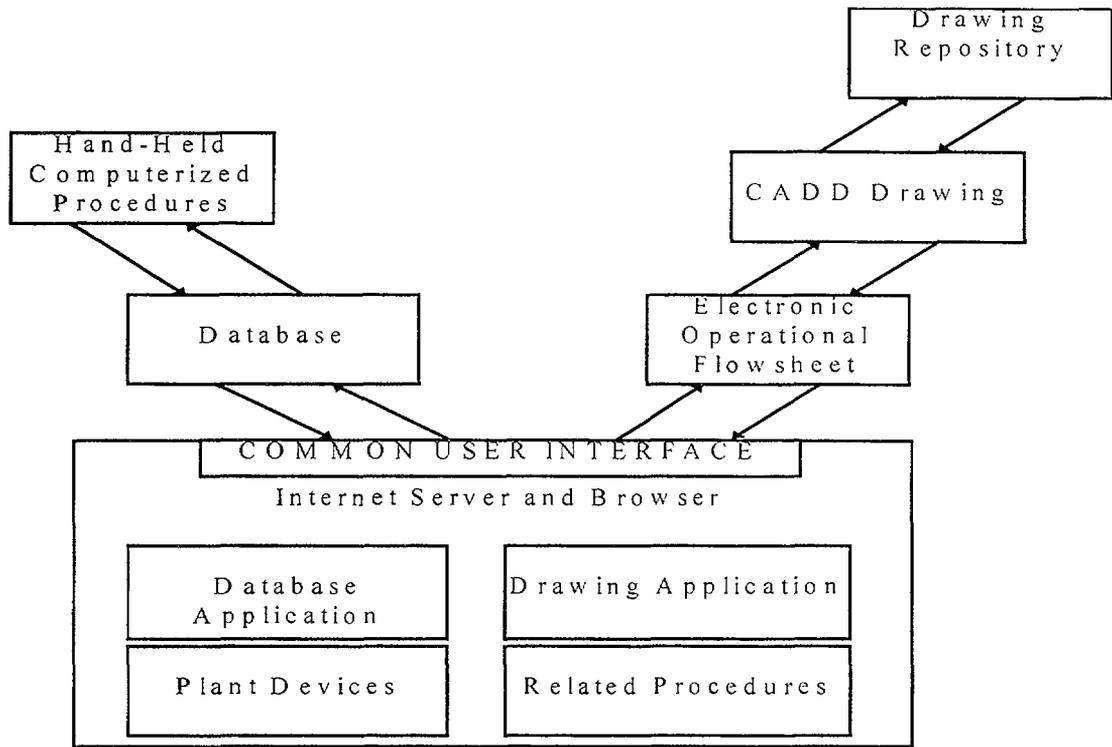


Figure 2: ESM Concept Block Diagram.

The ESM concept design incorporates a number of basic components and information flows as shown in Figure 2. The equipment database provides up-to-date equipment and system status information with cross-references to related procedures and drawings. An electronic drawing system is used to support the creation and display of electronic operational flowsheets, equipment status, jumpers, and work protection tag information. The object-orientated electronic drawing system supports programmable drawing objects that can be rendered using different colours or other attributes to indicate equipment status as extracted from the database, thereby mimicking the manual pinboard. Hand-held computer technology is used to support procedure execution. The hand-held computer technology also supports data collection and incorporates features to ensure procedural compliance and field safety. Lastly, a common user interface is utilized which is capable of supporting drawings, database queries, object linking and embedding, and external interfaces.

An important aspect of the ESM design concept is that the presentation of data and the integration of the database and drawing system components lends itself quite readily to current Internet technology. This technology provides standard interfaces supported by all major drawing system corporations, such as AutoCAD and Intergraph, and database solutions using current standards such as ODBC (Open Data Base Connectivity) and SQL (Standard Query Language). In addition, this methodology can support links to many other relational database systems including historical data systems such as PI-3 (OSI Inc.), condition based maintenance systems such as MAINSTAY (GasTops Inc.), and work management systems such as Indus Passport (Indus Group Inc.) and SAP (SAP GA). This ensures that the ESM can be fully integrated with other plant data systems supporting technical surveillance and analysis, maintenance management, and work management.

ESM DESIGN AND OPERATION

To facilitate system maintenance and a cost-effective implementation process, the ESM prototype design incorporates a number of third-party off-the-shelf products including:

- an ESM database centered around the use of Microsoft Access,
- the use of InterCap Graphic Systems ActiveCGM as the ESM interactive drawing tool supporting electronic flowsheets,
- standard Microsoft Internet browser technology (NT Internet Server, Microsoft Internet Explorer, and Front Page HyperText Markup Language (HTML) Editor) to serve as the medium to integrate and exchange data between the other ESM components, and
- a hand-held computerized procedure system developed by AECL to facilitate the field execution of operating orders and other procedures.

The ESM uses an ODBC compliant database designed around the need to gather, present, report, and query information specific to the plant operational devices. Each device can be uniquely identified by a device name and associated with engineering documentation, CADD drawings, work procedures, work orders and work permits, work schedules, historical and real-time data, and other data. The database design is best illustrated in Figure 3 where the

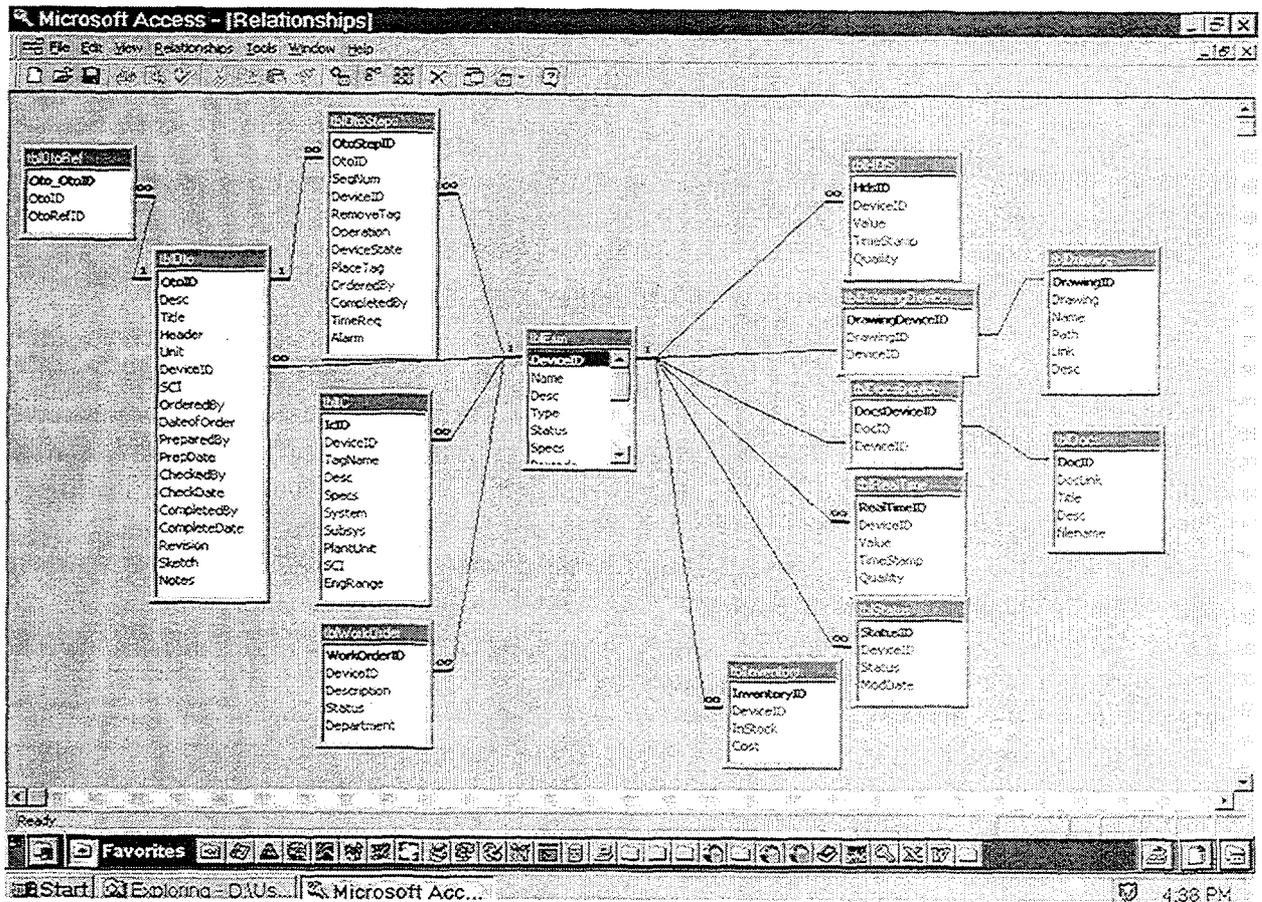


Figure 3: ESM Prototype Database Design and Relationships.

relationships between the unique device identifiers (DeviceID) and the other database components are shown. Each one to 'infinity' symbol represents a one-to-many relationship that allows a single DeviceID to be used in an 'infinite' number of OOs. Although each of the database tables are shown as part of the ESM database design, they could just as easily reside in other databases linked to the ESM through ODBC interfaces.

The drawing component of the ESM prototype provides the ability to dynamically interconnect the database and user interface through the association of drawing objects and equipment names. To achieve this both an authoring process and a display process were used. The authoring process allows drawings and their internal objects (equipment symbols) to be configured to provide interactive and animated behaviors while the display process executes the rendering, interaction, and animation of the drawing objects. The ActiveCGM product provides this functionality with its authoring tool for configuring drawing objects, and its embedded ActiveX component for displaying active drawings, interacting with users and external data. The configuration is, in fact, completed through 'point-and-click' operations using the ActiveCGM authoring interfaces.

Each of the tools previously described (Microsoft Access and ActiveCGM) have their own user interfaces and displays. However, the ESM relies on the integration and connectivity of a number of components, and therefore, these tools were integrated into a single operator interface through the use of an Internet browser based on standard Microsoft products such as NT Workstation Peer Web Server, Internet Explorer 3.01 and Front Page HTML Editor. These tools provided the data transfer mechanism between the user, ActiveCGM, and the ODBC-enabled database. The Internet server/browser tools were used to create 5 interactive HTML pages, each providing an interface to a component of the ESM. The first page serves as a container for the other four, and therefore, is transparent to the operator. The remaining four pages comprise the visible operator interface, as shown in Figure 4.

The user can individually size each of the four HTML frames. For example, if the drawing is the primary object of interest, the user can click and drag the frame separators to re-size the window.

The upper left frame is constructed from three ODBC database queries that are executed when equipment is selected on the drawing in the upper right frame, or by selecting a device name in the lower left frame. The first query captures the ESM related data, including the tag name, description, current state, latest work order and tagging information. The colour of the 'Current State' entry is dynamic depending on the current equipment status, with 'Closed' displayed in green and 'Open' in red. In a production ESM system, much more information would be included such as additional condition-based colour and text. The second query in this frame displays an active list of all drawings associated with the selected device including electrical and instrument air systems that may be used to drive the device. If a database does not already exist with these relationships, one could easily be generated using the CADD tools available at the plants. Clicking on the drawing title causes the drawing to appear in the upper right frame, and the lower left frame is refreshed to show all devices in the current drawing. The third query in the frame displays all associated procedures that reference the selected device. This may include references to other OOs (current or historic) or may extend to any category of plant procedure. For all electronic documentation, a simple search routine can be used to build this set of relationships. Selecting the document title displays the document in the lower right frame.

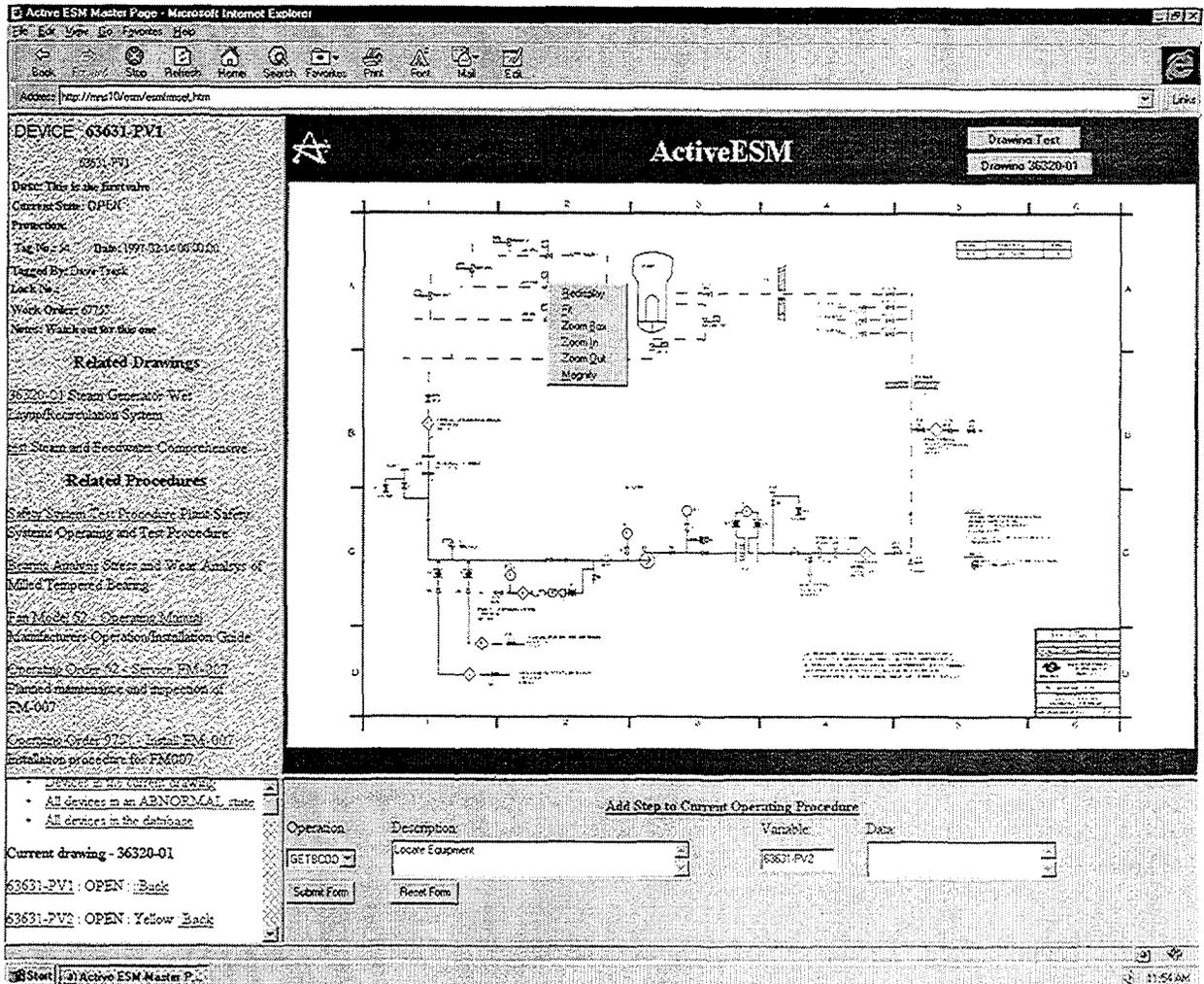


Figure 4: ESM User Interface using Internet Browser Technology.

The lower left frame also performs three ODBC queries, but displays only the device names, current state, and current protection level. The first query displays all of the devices on the current drawing, the second query displays all of the devices in the plant that are not in their pre-defined or normal state, and the third query shows all devices in the plant. Clicking on any device name will update the data in the upper left frame for the selected device. Selecting 'Back' returns the user to the top of the frame page. Searches can also be performed using the Edit/Search tool within the Edit pull-down menu and by then typing in the device name.

The lower right frame is intended to serve two purposes, the first is to display the related plant procedures when requested from the data frame in the upper right, and the second purpose of the frame is to provide a data entry form for creating and editing OOs.

The ActiveESM frame in the upper right displays animated CADD drawings. Within this frame the user can right click anywhere on the drawing to display a pop-up menu. This menu, provided as part of the ActiveX component of ActiveCGM, requires no additional programming. It features Redisplay, Fit, Zoom Box, Zoom In, Zoom Out, and Magnify. Redisplay, Zoom In, and Zoom Out are self-explanatory. Fit re-sizes the drawing such that the entire drawing is displayed within the frame. Magnify invokes a pop-up window and a

magnification frame to provide a birds-eye view of the drawing. Zoom Box allows the user to select any area of the display, which will magnify the selected area to fill the entire frame. Active elements on each drawing can be identified using one of two methods. As the cursor is moved over any active equipment symbol, the symbol colour changes to blue and the cursor changes from an arrow symbol to a hand. Secondly, if the status of any active element is not in the 'as-drawn' state, the element will appear in a colour other than black. Clicking the left mouse button on any of these active elements causes the data for the selected equipment to be queried in the upper left frame, and a pop-up menu to appear. This menu has been programmed to provide selections including 'Open', 'Close', and 'More'. These selections can be used to manually change the current operational status of any device on the drawing, or could be used as part of the process to change the operational configuration of the plant through the creation of OOs to be executed on the hand-held computerized procedure system.

OOs are created, stored, and edited within the Microsoft Access database. Each operating order is stored using a standard template (Figure 5) which includes the procedure title, revision number, author, work order information, and one or more steps, each of which includes the device name, operation, lock or tag information, and any other relevant information. The database facilitates the ability to track, edit, compare and search operating orders, by enforcing data integrity through structured data entry forms, which differ little from the standard operating order forms used today. As devices and operations are added to the procedure, the device names are validated and are then automatically added to a cross-reference table with the procedure identifier. Any queries on the device for related procedures automatically shows this relationship. In addition, other equipment data such as limits or barcodes are automatically included into the procedure to eliminate errors in transcribing and to simplify the entry process. The forms are presented, as they would appear on printed copies. Creating OOs can also be performed through the common user interface. By adding control commands to the descriptive titles in the data frame, the user can point-and-click to add the selected device and associated control to an open procedure located in the lower right frame of the display. For instance, clicking on the tag name, would add the step "Locate

Microsoft Access - [Operating Order]

File Edit View Insert Format Records Tools Window Help

NB Power POINT LEPREAU GENERATING STATION Serial No. []

OPERATING ORDER

PURPOSE

Continuation for Work Permit No. [] BSI: [] 0

Testing For Work Permit No. [] Test No. [] 0

Work Permit Holder [] Date 26-Feb-97 Time 12:07

Operating Form Description Test 00

OPERATIONS REQUIRED

Order	Device	Operation	Required State	Tag No	Lock No	Initials	PinBoard	Comments
	S3631-PV5		Open					
-10	S3631-PV2		Open	0	0			
-3	S3631-PV3		Open	0	0			
			closed					

Record: 14 of 3

ISSUING ACCEPTANCE AND ACKNOWLEDGEMENT

Prepared By	Date	Time	Test Successful	Unsuccessful	Date	Time
	26-Feb-97	12:08	<input checked="" type="checkbox"/>	<input type="checkbox"/>	26-Feb-97	12:08
Checked By	26-Feb-97	12:08	Reestablish Isolations	<input checked="" type="checkbox"/>	26-Feb-97	12:08
Issued By	26-Feb-97	12:08	PinBoard Updated			
Completed By	26-Feb-97	12:08	FlowSheet No.			

Comments: Very difficult

Export Procedure to the Hand Held Computer

Import Results from the Hand Held Computer

Record: 14 of 3

Form View

Start Microsoft Access - [O...]

8:56 AM

Figure 5: Database Template for Creating an OO.

device" to the procedure, and clicking on the current state would add the step "Operate device Open/Close". Once a procedure has been created, the steps can be reordered and edited through the common interface by modifying the step numbers and descriptions. In generating the steps of the OO, the system will also facilitate the generation of the necessary Standard Graphic Mark-up Language (SGML) tags interpreted by the Computerized Procedure Engine (CPE) software on the hand-held computer system to control the execution of the OO [4,5]. These tags appear in the procedure editing form as a drop-down list displaying the action identifier with a brief description of its use.

The execution of OOs takes place through the use of the hand-held computerized procedure system developed by the Canadian CANDU utilities and AECL as part of a cooperative CANDU Owner's Group project [4,5]. The heart of the system is the CPE software which interprets SGML tags embedded within standard text documents to control the execution of many types of nuclear procedures. SGML technology was the original standard of which HTML is a subset. HTML is a key technology used to navigate and display information on Internet web pages and within the ESM prototype.

The hand-held computerized procedure system offers many features and advantages. The hand-held is a light-weight tablet computer (1 kg) with a standard Intel processor, memory, and hard disk storage. The computer includes a 12x16 cm display with a standard 640 by 480 resolution. The computer can also be purchased with infrared and spread-spectrum radio frequency interfaces for wireless communications, as well as interfaces to barcode readers. A summary of the operational features of the CPE software are presented below.

1. The CPE assists in the navigation through the OO by highlighting the current step, and providing a table of contents and navigation buttons that allow hyperlinking to specific sections and pages. In addition, the CPE embeds the procedural workflow applicable to the procedure.
2. The CPE includes equipment verification through the use of a barcode scanner, which through the use of a fuzzy-logic interface can read partially damaged or obstructed barcodes.
3. Occasionally, steps may not be applicable based on the outcome of a previous step. In this case, the CPE uses a *strike out font* to indicate steps that are not to be performed.
4. Tag names, which may have had wild card designations in a paper-based procedure, are automatically filled in based on operator response. Data normally resident in the computer, such as the time and date, are automatically filled in to minimize operator entries and data entered in one step can be used throughout. This minimizes transcription errors.
5. When applicable, warnings and cautions are displayed in pop-up windows that require operator acknowledgment before the procedure proceeds. In addition, limits can be used to alert the operator to values that are out-of-range.
6. Calculations can be embedded in the procedure and automatically executed by the computer once all of the necessary data has been acquired.

7. The CPE can access and display engineering drawings, operational flowsheets, and other technical information associated with the procedure being executed.
8. The CPE provides a checking feature to ensure that all steps of the procedure have been completed. The CPE also provides a time-stamped list of all completed actions and results, which assist in ascertaining procedural compliance, but are also used to upload information to other systems such as the ESM for updating the equipment status.

After creating the OO using the ESM user interface, the procedure is downloaded into the portable hand-held tablet computer. This tablet computer is analogous to the standard clipboard normally used in the field. The operator interfaces to the computer using a stylus, which is a special pen which functions both as a mouse and as a writing tool. The operator performs each of the steps presented in the OO in the order provided, as controlled by the CPE software. The current step to be completed is always highlighted within a box. A sample OO created using the ESM prototype and loaded into the hand-held computer is shown in Figure 6. The steps within this OO include operator and work order identification, equipment verification at each step of the procedure, and the appropriate operating action to be performed. In addition, the OO includes the ability to write notes, add sketches, and reference engineering drawings relevant to the procedure.

One of the fundamental requirements of the ESM is to maintain an accurate, up-to-date status of the plant's operational configuration. The ability to modify the existing plant configuration is a critical element of the ESM. Two methods are available to update the operational status of any device listed within the ESM database and shown on the electronic

OPERATING ORDER DEMO PROCEDURE 1 of 2

Y N NA

Operating Order Demo Procedure

Station : Some Station
System : Steam Generator
Version Id
Revision : 0
Author : D. Trask
Revised : February 1997

Test Procedure

1) Enter your badge number.

2) Enter the work order number.

3) Locate valve 63631-PV1 63631-PV1

4) Close valve 63631-PV1

5) Locate valve 63631-PV2 63631-PV2

6) Close valve 63631-PV2

7) Confirm selection on panel PL659 (SI-200)

8) Locate valve 63631-PV5 63631-PV5

9) Close valve 63631-PV5

10) Locate valve 63631-PV6 63631-PV6

11) Check valve 63631-PV6 OPEN

12) Locate PI6522 PI6522

13) Record the pressure at PI6522 kPa [0,500]

14) Open VI6722A and record the time it takes for the pressure to drop to 100 kPa. 00:00:04.3

Forms Finish Gaps Content Font Page 1 < Back Next > Last Pg

OPERATING ORDER DEMO PROCEDURE 2 of 2

SUMMARY

PI6522 was kPa: 500
The time for the pressure to drop was: 00:00:04.3

DEFICIENCIES

17) Note any deficiencies:

Eraser

Clear

Sticky
63631-PV5

18) Reviewed by:

Eraser

Clear Dave Trask

DRAWINGS

Operational Flowsheets
Steam Generator Wet Lay-Up Recirculation 87-36320-2001-001-FS-D rev 1
Steam and Feedwater Comprehensive 87-40000-2001-02-FS-E rev 1

Forms Finish Gaps Content Font Page 1 < Back Next > Last Pg

Figure 6: A Typical Example of a Computerized OO Using the CPE Software.

operational flowsheets. The first method is to manually change the status of any device through the ESM common user interface. The operator can manually change the status of any device on the electronic flowsheet by selecting the object and picking the appropriate status from within the pop-up menu. In the final ESM implementation, this action would incorporate the appropriate controls and security to ensure that the plant status was legitimately being updated by authorized users of the ESM. In the second method, the plant operational status can be updated as the final step in completing an OO using the hand-held computerized procedure system. Upon completion of the OO in the field including the completion of the appropriate review and approvals steps as required by the work control process, the information contained within the hand-held computer can be uploaded into the ESM database. This action will automatically update the ESM equipment status and the operator will instantly see the updated information in the electronic flowsheets and database as presented in the four frames of the ESM common user interface.

BENEFITS

The ESM has been designed to facilitate efficient plant operational configuration management. Some of the direct benefits of ESM include:

- reduced operational complexity,
- easier and faster access to plant device status information,
- better visualization of the plant configuration and the status of all operable devices,
- higher legibility of plant device data and records,
- semi-automated and electronic record keeping which minimizes the more boring manual tasks and reduces the risk of losing or misplacing information,
- easier and faster access to other plant data pertinent to operational configuration management,
- enhanced processes to link the design and operational configurations,
- easy access to historic OOs facilitating the creation of new OOs faster and with fewer errors,
- improved consistency in the preparation and content of OO procedures,
- enhanced tracking and execution of OOs with built-in procedural compliance and equipment verification resulting in fewer field errors and better safety to personnel, and
- faster turn-around time in updating the operational flowsheets leading to more up-to-date and consistent information supporting other operational decisions and future operational changes.

In addition, there are other benefits that can be captured as the ESM evolves within the nuclear environment. In the future, these benefits may include:

- verification that inter-linked procedures use common descriptions of equipment, instrumentation, and expected operational response,
- computer generated annunciation when equipment as-left configurations do not comply with design basis requirements, and
- the opportunity to compare actual achieved equipment performance against previous performance, targets, and expectations.

The more efficient, up-to-date, and error-free the operational configuration management process, the greater the benefit is to plant availability and reliability. Improvements to information flow and content lead directly to more accurate operational assessments of plant status, fewer operational errors, and better decision analysis. This in turn benefits plant reliability and availability.

CONCLUSIONS

Computer technology has significantly progressed over the last few years. The advent of new information technologies has made possible the integration of diverse information sources in ways not conceivable only a short time ago. The ability to hyperlink between databases and drawing objects, the integration of information via user interfaces provided by Internet browser systems, and new pen-based hand-held tablet computers makes advances in the design of operational systems realistic and achievable.

These new technologies have been integrated into the design of a generic CANDU Equipment Status Monitor system supporting plant configuration management. The improvements that can be achieved have a number of direct benefits to storing, visualizing, retrieving, changing, and overall management of the plant's operational status. These improvements can result in higher plant reliability and availability supporting higher plant capacity and capability factors.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the contribution by the Ontario Hydro Nuclear Technology Division to the design and development of the initial ESM system currently in use at the Darlington NGS. In addition, the authors would like to acknowledge the funding provided by the CANDU Owner's Group for the research and development of the next generation ESM under project WPIR 1687.

REFERENCES

- [1] ONTARIO HYDRO, "Equipment Status Monitoring System Design Requirements", Revision 3 (1990 December).

- [2] DEVERNO, M.T. , DE GROSBOIS, J., BOSNICH, M., POTHIER, H., XIAN, C.,
“Canadian CANDU Plant Data Systems For Technical Surveillance and Analysis”,
IAEA Specialists’ Meeting on Monitoring and Diagnosis Systems to Improve Nuclear
Plant Safety and Reliability, Gloucester, U.K (1996 May).
- [3] DEVERNO, M.T. , DE GROSBOIS, J. , BOSNICH, M., POTHIER, H., XIAN, C.,
GILKS, G., “Canadian CANDU Plant Historical Data Systems: A Review and Look to
the Future”, Canadian Nuclear Association/Canadian Nuclear Society (CNA/CNS)
Annual Conference, Fredericton, NB (1996 June).
- [4] KENNEDY, E., DONIZ, K., “Hand-Held Data Collection and Procedure Environment”,
CNA/CNS Annual Conference, Fredericton, NB (1996 June).
- [5] KENNEDY, E., “A Hand-Held Computer System to Support System Surveillance
Programs”, CANDU Owner’s Group System Surveillance Workshop, Toronto, Ontario
(1996 November).

**NEXT PAGE(S)
left BLANK**