

A TASK-BASED USAGE STRATEGY FOR CONTROL CENTRE WALL DISPLAYS

by

Eric Davey
Crew Systems Solutions
Deep River, Ontario, K0J 1P0

ABSTRACT

This paper summarizes the findings from an exploratory definition of a usage strategy for multiple control centre wall displays in CANDU nuclear power plants. Wall displays are defined as large sized, vertically oriented display surfaces that may be positioned in various locations about a control room to support user information needs.

The paper begins by discussing the need for a usage strategy for all control room information resources, and then reviews the history in wall display implementation and usage in nuclear power plant control rooms. The balance of the paper discusses the approach used in characterization and review of control room task information needs and definition of a wall display usage strategy. The paper concludes by outlining some of the possible impacts on future control room design and operations that the introduction of wall displays may imply.

INTRODUCTION

In performing almost all work, people employ tools. Tools provide extension to and supplement of a person's physical and mental capabilities permitting work to be accomplished that a person alone would be incapable of. Equally important, the manner in how tools are used can greatly impact work performance. Consequently, to achieve effective task accomplishment two aspects concerning tools are important:

- Task Aligned Capabilities - The characteristics of tools should be selected to support and complement human capabilities in the performance of task objectives, and
- Usage Strategy - The ways in which tools can be used to best advantage should be specified to enable user effort to be optimally leveraged during tool use.

The first tool aspect determines the potential impact that tool application can have in supporting human performance to achieve task accomplishment. The second tool aspect charts a preferred manner of tool usage to allow realization of the tool's

potential in supporting work. The subject of this paper is the examination of this second tool aspect for wall displays in current and future CANDU control rooms.

Wall displays are defined as large sized, vertically oriented display surfaces that may be positioned in various locations about a control room, and support user information needs. Over the past ten years, a number of plant vendors and individual utilities have introduced wall displays into nuclear plant control room usage as part of both new plant designs and existing plant control room upgrades.

Large format displays have been employed in process control applications since the beginning of the consolidation of supervisory and control process responsibilities into centralized control rooms. Early implementations of large format displays consisted of mimic diagrams with embedded instruments and controls to provide both process and equipment status overview. Such implementations were mounted commonly on the faces of equipment panels and racks. Through the seventies and eighties, design practice extended the implementation experience to the use of control room walls as the display mounting structure, and the use of embedded computer displays as a supplement to or replacement for former hardware based instrumentation and controls.

These first generation large format displays were found to be useful for four purposes [1,2]:

- Plant Organization - Providing a continuous visual reference for operators of key relationships and connections between plant parameters, controls, and equipment,
- Overview Awareness - Providing a continuous display of key plant information to allow operators to establish and maintain a high-level understanding of overall plant status,
- Task Context - Providing continuous display of information on plant and/or system status that serves as the basis within which the performance and conduct of individual tasks could be judged, and
- Work Co-ordination - Providing a common external representation of plant operating context and status for operators and staff who were required to co-ordinate individual task responsibilities.

While offering these general benefits, these first generation displays exhibited the following four specific operational support limitations:

- Information Imbalance - Emphasis on representation of process and systems structure with embedded process status detail, and less attention to high level representation of plant overall status.
- Context Adaptability - Inflexibility to display more than one plant organizational context,

- Dynamic Relevance - Inability to change and highlight the information of most importance for the current operating context, and
- Distant Legibility - Inability to provide information detail in work locations other than adjacent to the display due to the need to tradeoff display legibility versus accommodation of information density within display spatial constraints.

Beginning in the 1990s, large format wall displays based on computer driven media began to be applied in control room settings. These displays overcame the former limitations in enabling use of multiple information formats in the same display space, content that changed as function of plant operating context, design of displays for legibility at greater distances, and on-line flexibility in user selection of display content and format. During this time almost all nuclear vendors began offering control rooms for new plant designs that incorporated one or more wall displays as a central control room information resource. In Canada, AECL participated in this trend by introducing wall displays into the central panels as part of the CANDU 3 and CANDU 9 new plant designs, and CANDU 6 Qinshan 1 & 2 control room implementations (see Figure 1).



Figure 1 - Qinshan Control Room and Central Panel Wall Displays.

While vendors and utilities have championed the introduction of this new display technology into control rooms, little specification or guidance has been published about the preferred manner in how these displays should to be used. Typical issues that require resolution and definition of usage guidance include:

- User Responsibility - Who manages and effects display selection for a shared-use information resource?

- Information Allocation - How are the needs for information to support plant status awareness, work planning, task context, or task detail balanced or prioritized?
- Use Coherence - How is information in wall displays to be used in conjunction with information from local workstation displays?
- Automation - What aspects of display content and format selection should be driven by changes in plant and/or task status?

OBJECTIVE and APPROACH

The objective of the study was to develop an initial definition of a usage strategy for wall displays in future CANDU control room applications. The approach applied in strategy definition involved the following steps:

- Review of information resource usage in current control rooms,
- Characterization of control room supervisory control information needs as function of operational situations, users, tasks to be supported, and current information resource allocation to media,
- Identification of the types of task information needs that would be most suitable for wall displays to provide, to complement the information needs met by other information resources, and
- Formulation of a draft usage strategy for wall displays as expressed through statements of usage principles.

INFORMATION SUPPORT NEEDS

In performing control room tasks, several types of information are required:

- Context - Information about the state of the plant and task environment within which the task must be performed.
- Status - Information about the current state of relevant processes, equipment, and resources, and work progress.
- Planning - Information about how the task is to be organized as conveyed in objectives, workplans, resource availability, and constraints.
- Direction - Information about how the task is to be accomplished as provided in procedures, guidance, operating memos, performance criteria, or operating limits.

- Reference - Information about supplementary process, equipment, and task details conveyed through such items as operating records, flowsheets, and lists of resource characteristics.
- Administrative - Information about past operating history such as conveyed in logs, checklists, notes, and reports.

All control room staff employ these information elements to varying degrees in the performance of their task responsibilities. Where specific task information needs are not met, user compensation is required. Examples of information problems that result in compensatory user behaviours include:

- Absence - Information missing or partially provided,
- Separation - Information provided away from usage location,
- Form - Information requiring conversion or translation before use,
- Detail - Information provided with inappropriate level of detail, or
- Validity - Incorrect information provided.

CHARACTERIZATION OF NEEDS

Four different operating situations were selected as the basis for characterizing representative information needs and how they are currently met; two stable states - full power operation and outage, and two manoeuvring states - plant startup and upset response from full power. Observational records of control room and simulator operations from the late 1990s were used as the initial basis for identifying representative tasks, information needs, and how information needs were satisfied [3]. This initial information was supplemented with anecdotal comments collected from operations staff during the same time period.

For each selected task, the following items were identified:

- Person(s) performing the task,
- Work location(s),
- Types of information required,
- The information resources used and their location relative to the user work location, and
- Common user compensatory behaviours required.

Key observations from an examination of this characterization of task information needs include:

- Context Representation - There is no concise representation of plant context in most states. In most cases, users must develop and maintain an understanding of plant context based on continual monitoring and synthesis of information from low-level panel and computer display indications in multiple locations.

- **Visibility of Workplans and Status** - A need to improve the visibility and accessibility of shift priorities and work status information to the control room shift team.
- **Support for Task Coordination** - Frequent need to share a common view of task information between different control room workplaces for task coordination purposes.
- **Maintaining Awareness at a Distance** - Need to permit both context and task awareness to be maintained by operators when away from their central workplace console.
- **Workplace Oversight** - Occasional need for display of information from tasks performed away from the central operator console in order to satisfy supervisory oversight needs.
- **Access to Outside News Sources** - Occasional need for access to and presentation of external news and weather information.

A PROPOSED USAGE STRATEGY

The proposed wall display usage strategy is described in terms of a series of statements of usage principles. The principles attempt to specify a usage strategy that improves overall task information provision, takes best advantage of the information communication capabilities of large format displays, and complements the information capabilities of other information resources.

The proposed wall display usage strategy comprises the following principle statements:

Control

- **Responsibility** - Assign the lead operator the authority for all wall display content selections.
- **Location** - Locate the controls for wall display content selection at the lead operator's console workplace.

Display Allocation

- **Context** - Dedicate one wall display for continuous presentation of plant context.
- **Work Plans and Status** - Present shift work plans and status on a second wall display to improve information accessibility and awareness to shift staff.

- Task Information - Normally display task information at user workplaces and consoles.

Display task information on wall displays to support:

- Co-ordination of work among several shift staff,
 - Maintenance of operator context and task awareness when removed from the central console workplace, or
 - Improved supervisory oversight of remotely performed tasks.
- Display Sharing - Where separate wall displays for simultaneous presentation of work plans and status, and task information are not available, permit the temporary displacement of workplan and status information by task information.

Once the task information is not longer required, the work plan and status information should be restored to the wall display.

Display of Context Information

- Information Representation - Customize the information content and form appropriate to what is important for each operating state.
- Update - Continuously update the representation of plant context to allow users to remain current with changes in status.
- Automatic Display Selection - Automatically present context displays customized for upset conditions when the occurrence of upset conditions are first detected.

Display of Shift Work Plans and Status

- Plan Representation - Enable display of activities and work status for a shift, and as embedded activities within larger station workplans (e.g., maintenance or outage).
- Shift Activity Representation - Permit users to organize the representations of activities by both priority and sequence within shift workplans.

Display of Task Information

- Information Priority - Emphasis should be given to presentation of task context and status information elements in comparison to planning, direction, reference and administrative information elements

DISCUSSION

Operational impacts from adoption of the wall display usage strategy may include:

- Improved Overview Awareness - Reduced user effort to develop and maintain plant and task overview awareness, and increased standardization of overview understanding among operating staff. Improved ability of operators to maintain overview awareness when away from the central console workplace.
- Reduced Workplace Disruption - Reduced dependence on verbal communication for exchange of information and understandings, and the reduced need for other shift staff to enter the lead operator's work area to acquire information.
- Reduced Secondary Task Demands - Less task effort devoted to information access, temporary retention, and understanding versus use.
- Increased Operating Flexibility - Improved ability of operators to maintain context and task awareness when away from the central console workplace.
- Improved Supervisory Oversight Potential - Improved ability to monitor the work of others through projection of their workplace displays on displays that are from other than operator console locations.

Design impacts from adoption of the wall display usage strategy include:

- Layout - Review and reconsideration of workstation and workplace layouts to ensure wall displays are visible from all work locations to make use of both context and task information presentations,
- Information Design Practice - A shift in information design practice to support a deeper understanding of information use required for context display design, rather than just information accessibility, and
- Support for Additional Types of Information - Provision for the availability of planning, operational support information, or external news sources for display on wall displays or individual workstations.

CONCLUSION

This paper has described the derivation of a proposed usage strategy for wall displays in CANDU control rooms. The usage strategy has been derived from an examination of control room task information needs and consideration of how wall displays can be most suitably used in conjunction with other control room information sources to effectively satisfy user task information needs. Computer driven wall displays offer the potential to realize substantial improvement in control room information presentation, and thus task support.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the assistance of Operating and Training colleagues at Point Lepreau, Pickering, Bruce, and Darlington plants who have contributed to the author's understanding of control room tasks and information support needs.

The author wishes to also thank Garry Mitchel, Rob Leger, Scott Malcolm, and Richard Brown of AECL whose discussions with the author provided the motivation for the paper. Lastly, the author wishes to acknowledge the contributions of Garry Mitchel, Rick Basso, and Dave Trask of AECL, and Bryan Patterson of Human Factors Practical whose comments and suggestions in the past year have helped the author to formulate the strategy principles.

REFERENCES

1. W. Stubler and J. O'Hara. Group-View Displays: Functional Characteristics and Review Criteria. Brookhaven National Laboratory technical report E2090-T4-4-12/94, 1995 January.
2. M. Chignell and D. Rivera. The Impact of Overview Displays on Operator's Situational Awareness - A Literature Review. Atomic Energy of Canada Limited research report HMSD-9-TCN-19, 1995 August.
3. E. Davey: Process Monitoring During Normal Operations at Canadian Nuclear Power Plants. Paper presented at the Human Factors and Ergonomics Society 44th Annual Meeting, San Diego, California, 2000 August.