CRITERIA FOR OPERATOR REVIEW OF WORKPLACE CHANGES

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ABSTRACT

A set of criteria for reviewing workplace changes has been developed for use by plant Operations staff. The criteria were developed to provide Operations staff with a practical framework for structuring assessments and subsequent review comments with regard to control room modifications and innovations that impact their work environment.

The criteria were assembled from design, operations and human factors engineering principles, and system review experiences with plant Operations staff over the past ten years. Operations staff at several CANDU stations helped shape the emphasis for initial criteria definition and have assisted with criteria refinement through trial applications. Use of the criteria is expected to lead to more effective and task relevant equipment evaluations by Operations staff, and ultimately lead to system modifications and innovations that better serve plant operation needs.

The paper begins with a discussion of the rationale for criteria development and the attributes of 'good' design. The balance of the paper outlines the project objectives, describes the approach applied in assembling, structuring, and refining the review criteria, and illustrates the application of the criteria in the review of a proposed control room innovation.

BACKGROUND

The Need for Operational Support Tools

CANDU plants are designed and operated with the understanding that licensed operators are ultimately responsible for the safety and productive operation of the plant. In this role, operators plan, organize, direct plant operations, and configure automated systems to achieve operational objectives. This requires that operators be supported in their roles as supervisors, controllers, and workplace administrators by computer-based workplace tools that facilitate effective task performance congruent with operational goals. Good workplace tools simplify the task, amplify an individual's task relevant abilities, and promote successful task completion without getting in the way or being a nuisance.

Change in the Operations Workplace

The basic design for current CANDU control centres was established in the early 1970s. Plants constructed since then have, for the most part, retained the same basic design and original control room functionality. However, operational support needs have not remained static, and this has led to a continual evolution in upgraded or additional control room support functions and changes to control room work practices. Several factors have been instrumental in promoting this ongoing workplace change, for example:

- Opportunities for improved plant production performance,
- Changes to the roles and responsibilities of Operations staff,
- Need to maintain existing control room functions through replacement of obsolescent equipment,
- Introduction of new control room functions via new and more capable technologies, and
- Evolving regulatory requirements.

Workplace changes can impact the ways in which tasks are performed and the relevancy of the tools in the support environment in two ways:

- Changes to Operational Practices can demand that tasks to be performed in new ways challenging the continuing relevancy and capabilities of existing control room tools, and
- Changes to Tools or the Work Environment can require control room functions to be performed in new ways demanding that old task strategies be discarded and new task strategies adopted.

Operations Participation in Change

In principle, the definition and development of changes to control room work practices and tools should involve the active participation of Operations representatives. In practice, in spite of the best of intentions, the participation of Operations staff in the definition and ongoing development of workplace changes is too often limited. For example, too frequently, Operations staff characterize their involvement as:

- Unstructured, Narrow and/or Incomplete - Comments are sought in an informal fashion or are sought within the narrow perspective of the performance of a specific task without considering the possible impacts of design decisions on other tasks that must be simultaneously performed in a practical shift situation,

- Infrequent - Comments are sought too infrequently so that mismatches, created by evolving operational needs and static development specifications, grow rather than being resolved, and
- Too Late - Comments are sought late in the development cycle so that opportunities to employ task relevant suggestions and introduce positive design changes are limited.

To address the first of these concerns, Operations staff expressed a need for a practical and effective framework and a simple set of task relevant criteria to aid in structuring review comments. Their objective was to ensure that their design input focussed on the important situational and task relevant factors, that would lead to effective task performance and thus design success, and was comprehensive and complete.

Characteristics of Good Designs

Design can be characterized by both 'process' and 'product' attributes. 'Process' attributes relate to the manner in which a design change is carried out. 'Product' attributes relate to how well the outcome of design supports users in accomplishing specific task objectives. Examples of attributes indicative of successful design drawn from representative design [1,2,3,4,5], operations-based [6,7,8], and human factors[9,10] guidance pertaining to the design and use of computer-based tools include:

- Process Attributes
  - Specifications - Evolved from operational needs.
  - User involvement - Deep and frequent design participation.
  - Decisions - Grounded in task and user understanding.
  - Evaluation - Objective confirmation in representative workplace situations.
- Product Attributes
  - Effectiveness - Supports users in task accomplishment.
  - Compatibility - Congruent with the overall workplace environment.
  - Roles - Appropriate assignment of human and automation roles.
  - Errors - Aids error recognition, recovery and minimizes error consequences.
  - Flexibility - Easily adjustable to meet changing task characteristics.
  - Learnable - Functions and features are self-evident and recognizable.
  - Aesthetics - Pleasing form that aligns with tool function.

PROJECT OBJECTIVES

The objectives for the project were to:

- Develop a framework for improving the effectiveness of operator comments on control room equipment workplace changes,
- Identify review criteria that focus comments on operational needs, in particular those attributes of a design that can lead to significant workplace impacts, and
- Refine the framework and criteria through trial application in the review of representative projects involving room equipment changes.

CRITERIA SELECTION AND EMPHASIS

In discussing industry experience, review practices, and their success in fostering effective refinement of proposed workplace changes, Operations staff repeatedly identified several factors as important for structuring a simple and complete set of review criteria. The over-riding emphasis in these discussions focussed on 'product' related attributes and in particular context and task related aspects. Consequently, the initial set of review criteria and their ongoing refinement has been organized with these two aspects in mind:

- Context Factors:
    - Operational State - The operational states for the unit in which the task is to be performed.
    - Resources - The support expected to be available to facilitate task performance (e.g., staffing, procedures, databases, and tools).
    - Concurrent Demands - Other tasks that are likely to be performed simultaneously and whose demands may interrupt or impact task performance.
- Task Factors
    - Prerequisites - Those factors and conditions that must be in place to enable task initiation and completion.
    - Strategies - The preferred and alternative strategies for performing the task, and their consistency with or differences from the way in which the task is currently performed.
    - Performance - The effectiveness with which the task can be accomplished, and the measures and criteria to be used to judge acceptable task performance.

- Attentional demands - The demands placed on an operator's attentional resources by the task (i.e., Continuous attentional demands or support for task interruption and re-continuation).

- Memory demands - The demands placed on an operator to recall or remember information critical to task performance.

- Interpretation demands - The expectations on an operator to assemble, convert and interpret data versus information.

- Error Support - The support provided for recognizing errors in task performance, recovering from errors when they occur, and minimizing error impact.

- Automation Roles - The roles assigned to automation and human operators in task performance, and the control and range of flexibility in role assignments afforded to operators.

- Compatibility - The consistency of the task in comparison with current work practices, information coding, terminology, and expression practices.

In addition, Operations staff established a target duration of 20 minutes for completing an assessment and summarizing relevant feedback comments.

THE REVIEW FRAMEWORK

The review framework selected focuses review and comments from a 'task support' rather than a 'technology feature' perspective. This choice was made to ensure that review comments and suggestions remained focussed from an operational perspective. In particular, how well the equipment being reviewed supported operators in the operational context and for task accomplishment that the equipment was intended to serve.

The review framework consists of three documents:

- Criteria Guidance - A reference list of suggested questions to be examined for each context and task factor as part of the review.
- Review Comments - A table for organizing and summarizing review comments.
- Instructions - A single page procedure of instructions outlining the steps for conducting a review.

The Criteria Guidance document provides a handy reference list of questions that can be drawn from for each review. It also provides background as to the important issues and design principles related to each context and task factor that a design should be examined

against. An example of the type of questions provided for the Error Support task factor is shown in Figure 1.

The Review Comments document organizes reviewer comments in a table format across three pages (see Figure 2). The organization chosen places each context and task factor in a separate row so that all information with respect to each factor is aligned together to facilitate use, review, and analysis.

The information for each factor is organized in four columns. The first column identifies the context or task factor under consideration. The second column identifies important aspects of the task, specific to the factor, that should be considered when conducting the review. This information serves as a mental reminder of the important things to keep in mind when conducting the review and affords review customization specific to the task under review. The third column contains space for reviewer comments about how well the equipment under review supports the task. The fourth column contains space for reviewer suggestions on how the equipment under review could provide better task support.

The table format was designed to accommodate user comments in point form to minimize the time required for comment entry. Comments on both positive and negative aspects of the design under review are encouraged. A simple ranking system is used to identify the overall importance of each comment. To capture review findings that fall outside the review framework, two additional open comment areas are provided at the end of the context and task related table sections.

The review framework used in the following way:

- Step 1 - Identification — Identify task(s) the equipment is to support.
- Step 2 - Task Criteria — Identify the factors critical for task performance and improvement.
- Step 3 - Review — Review the use of the equipment from the context of task support.
- Step 4 - Comment — Summarize comments and refinement suggestions.

An example use of the review framework is illustrated in Figure 2. The representative comments shown were drawn from a former review of a proposed change to the Critical Safety Parameter monitoring task at Pickering.

APPLICATION EXPERIENCE

The review framework and criteria have been refined through informal application by plant operators across four projects over the past few years. Feedback from users has indicated that the review framework is:

- Successful in focusing review from an operational perspective,
- Effective in identifying the key benefits and deficiencies of equipment under review from a task support perspective,
- Sufficiently comprehensive in scope, and
- Simple to apply.

Based on this initial assessment experience, the review criteria will be made available to CANDU Operations staff on a more extensive basis in the near future for further voluntary use and ongoing refinement.

CONCLUSIONS

A set of criteria for evaluating control room equipment modifications and innovations has been developed for use by plant Operations staff. The criteria emphasize operationally related context and task factors and are continuing to be refined through volunteer application by Operations staff in several settings. Use of the criteria is expected to lead to more effective and task relevant equipment evaluations by Operations staff, and ultimately lead to control room workplace changes that better serve plant operation needs.

REFERENCES

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Figure 1: Example Criteria Guidance for the Error Support Task Factor.

ERROR SUPPORT

- Does the design support Undo and Redo operations in user interactions?
- Does the design allow the user to exit the task at any time?
- Does the design assist with error recognition?
- Does the design permit and assist with user recovery from recognized errors?
- Does the design provide warning to users of:
  - Non-reversible actions,
  - Actions with major impact, and
  - Actions that will result in loss of work?
- Does the design help minimize the adverse impact of user actions?

Figure 2: Review Comments Form - Page 1

Reviewer: A.N. Operator **Phone**: 3425 **Date**: 1997 October 6

Task: Critical Safety Parameter monitoring by SOS and SCPO

Equipment: Critical Safety Parameter monitor display - Data Extraction System **Version**: Revision 2.6

Context Factors	Important Aspects	Tool Support Comments	Refinement Suggestions
Operational State	*Units 6-8 - Upset response.* *Unit 5 - Unit upset response plus Unit 5 co-ordination of containment usage in response to single unit or multiple unit upsets.*	*I - Heat sink states provided support upsets from full power but may not support all outage configurations.*	
Resources	*SCPO - To undertake CSP monitoring and data confirmation.* *SOS - CSP interpretation.* *CSP Monitoring procedure.* *Single Data Extraction system display.*	*I - SCPOs specific training in CSP monitor usage is required.* *N - CSP Monitoring procedure should be updated to reflect CSP monitor usage.*	*Include SCPOs in next round of ANO & SOS upset response training.*
Concurrent Demands	*SCPO - CSP data gathering and confirmation.* *ANO and SOS unit assessment.* *Crew stabilization of unit.*	*E - Display use conflicts could occur between CSP & Containment DES applications on Unit 5 for upsets involving vacuum building usage.* *I - Display should be oriented within SOS normal field of view when facing panels.*	

Comment Priority: **E** - Essential **I** - Important **N** - Nice to Have

Additional Comments:

Figure 2: Review Comments Form - Page 2

Task Factors	Important Aspects	Tool Support Comments	Refinement Suggestions
Prerequisites	*Functioning DES system and CSP monitor application.* *SCPO familiarity with CSP monitoring procedure.*	*I - SCPOs are generally not familiar with how to restart DES system if required.*	
Strategies	*Consistency of CSP monitoring task using CSP Display in comparison with former manual method.* *Time to transition to backup monitoring strategy if required.*	*I - A backup monitoring strategy using past practice is assumed but no guidance is offered for how to transition between the primary and assumed backup monitoring strategy.*	*When monitoring, periodically confirm CSP display values with equivalent panel indications - this will also provide practice in backup monitoring method.*
Performance	*Timeliness of detection of SP and CSP challenges.* *Effectiveness of SCPO and SOS communication.*	*I - Current display usage and CSP procedure do not promote timely detection & action on SP challenges.*	
Attentional Demands	*Monitoring changes to support parameters as well as CSPs.* *Monitoring challenges to multiple CSPs.* *Monitoring changes in heat sink state.*	*I - Action limits consistent with CSP Monitoring procedure values should be shown on trend displays as a visual cue for SCPO - SOS communication of SP and CSP challenges.*	
Memory Demands	*Information needed to be recalled from training to support task execution.* *Availability of display and parameter histories in CSP display format.*	*N - 15 minute timebase of current display limits monitoring window to too narrow a period.* *I - A display print function would be very useful for tracking progress.*	

Comment Priority: **E** - Essential **I** - Important **N** - Nice to Have

Figure 2: Review Comments Form - Page 3

Task Factors	Important Aspects	Tool Support Comments	Refinement Suggestions
Interpretation Demands	*Impact of changes in suppport parameter values on CSPs.* *Prediction of future CSP trending and rates.*	*I - Since CSP Monitor does not provide compensation for thermal time constants it may falsely indicate subcooling challenges early in an upset.*	
Error Support	*Detection of failures in recognizing significant change in SP or CSP values.* *Detection of CSP monitor failures.*	*E - Some CSP monitor failures are not easily identifiable - in particular loss of data feed and single parameter failures.*	*N - Display of the decision logic used by the monitor in calculating current subcooling margin could be useful to assist error recognition and diagnosis.*
Automation Roles	*Increase SCPO time on monitoring and reduce time in data gathering and calculations.* *Simplification of monitoring task.* *Visibility of monitor automatic processes.*	*I - Automatic data gathering, calculation and display of subcooling margin in graphic format is a big improvement over former manual methods.*	
Compatibility	*Compliance with control room standards and conventions.* *Consistency of usage with other display applications.*	*N - Symbol, labelling, and colour usage conventions should be made as consistent as possible with current control room conventions.*	

Comment Priority: **E** - Essential **I** - Important **N** - Nice to Have

Additional Comments:

Include CSP Monitor failure mode detection in SCPO training.