Human centered design for nuclear power plant control room modernization

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Many of today's control rooms have replaced or augmented older, more cumbersome control panels with visual display units (VDUs) with graphic interfaces. VDUs can simplify the human machine interface; however they also introduce new design challenges. Digitalization of previous analog man-machine interfaces imposes new demands on the operational teams, and many researches has been developed taking into account human performance, new technological possibilities, and types/levels of automation in a system, design of human–machine interfaces [1].

This research describes a human centered approach to evaluate and design human-system interfaces for nuclear power plant control rooms including graphic interfaces, the layout and informativeness of the alarm system, and the integration of electronic procedures into the control/display environment

We use LABIHS simulator to investigate the nature of operator–system interaction in a digital interface during abnormal events. The evaluation procedure has three phases. The first phase is the conceptual evaluation of the interface. It can be carried out by experts using tools like task analysis; operational experience review in similar systems; safety analysis reports; functional specification; drawing showing displays, panels, workstation, graphical interfaces and diagrams showing flows of information. In the second phase a heuristic evaluation is made based on some well-known interface evaluation criteria. It is a static simulation. It concentrates on the way in which the information is presented to the operator and involves some form of basic system operator interaction. In the third phase, the entire process is simulated, and the operators' performance is evaluated. In this phase operators have a degree of psychological involvement and we can see how they react to the simulated process in a realistic manner. It requires a simulated work setting, a detailed experimental planning, including training, data acquisition, analysis systems such as computer logs (process state, process events), operator log (human machine interface events, keyboard, mouse) and audio, video recorder (verbal protocols, communication).

We evaluated operator performance in the new designed interface during accident simulations (Loss of Coolant Accidents – LOCA and Steam Generator Tube Rupture - STGR).

Figure 1 - Operator working with the redesigned interfaces.

The old LABIHS interface design provided the performance benchmark. Initially we measure the time that operators need to identify the accident using both interfaces. The time spent by the operators to identify the LOCA and SGTR accidents, through the existing interfaces, was 362 seconds and 490 seconds, respectively. The time spent by the operators to identify the LOCA and SGTR accidents, through the new interfaces, was 338 seconds and 428 seconds, respectively. The number of screens used during the identification also change. In the existing LABIHS interface the SCO used 13 screens to identify the LOCA and 25 to identify the STGR. In the new interface this numbers fall to 8 and 10, respectively, showing a considerable reduction in navigation actions.

The performance evaluation has shown that the design solutions used in LABIHS interface (alarm systems, procedures, graphic displays) actually have effects on the usage. Therefore we reinforce the claim of the human factors and ergonomics community that the design solutions should be made considering the appropriate use of the system, emphasizing that work practices in real settings. of user interfaces, in a user-centered or activity-based design process.

References

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