

REVIEW OF HUMAN FACTORS IN OPERATOR AIDS DEVELOPMENT AT ORNL

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ABSTRACT

Three related Oak Ridge National Laboratory (ORNL) projects in the area of human factors in diagnostic aids are described. The goal of the first, sponsored by the Electric Power Research Institute (EPRI RP2184), is to provide guidance to nuclear-utility engineers in the selection and retrofit of computer-generated display systems in nuclear-plant control rooms. The goal of the second, sponsored by the Office of Research of the Nuclear Regulatory Commission (NRC), is to provide the NRC with a preview of some of the operator aids currently under development by industry for the purpose of assessing the applicability of current requirements. The goal of the third, also sponsored by the NRC, is to develop a methodology to determine the proper allocation of function between an operator and an automated system. The status of each project is given, together with the current and expected findings.

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Oak Ridge National Laboratory (ORNL) currently is involved in projects related to several areas of human factors research, including human performance evaluation, testing and training, human engineering, and management and organizational structure interface. In this paper three human engineering projects related to human factors in diagnostic aids will be described. One is sponsored by the Electric Power Research Institute (EPRI) and two by the Office of Research of the Nuclear Regulatory Commission (NRC).

I. COMPUTER-GENERATED DISPLAY SYSTEM GUIDE*

The goal of the project under EPRI sponsorship is to provide guidance to nuclear utility engineers for the selection and retrofit of computer-generated display systems in the control rooms of nuclear power plants. The premise is that guidance is needed to achieve proper integration of (1) human factors principles, (2) the constraints of applicable regulations and standards, (3) hardware and software systems that are commercially available, and (4) implementation constraints in an existing control room. ORNL and Search Technology, Inc., have developed a design process, tailored to the retrofit task, which addresses this integration from the outset of a retrofit project. Input to the design process is supplied by both design engineers and operations personnel. The process begins with the requirement for a clear and accurate definition of the intended objectives of the computer-generated display system. Then the information to be transferred to the operator via the new system to meet the objectives is defined. From the information requirements, pictures are designed which later will lead to hardware displays. These pictures are composed of elements such as mimics, bar charts, and trend graphs. The pictures are designed first, unconstrained by hardware and software limitations. The purpose of this approach is to prevent the design of hardware displays from being prematurely constrained by hardware and software limitations; the emphasis of the design of the pictures is on ensuring the effective transfer of information to the user. The constraints of hardware, software, and control room implementation are determined in parallel with the design of pictures. Some will be "hard constraints," not subject to alteration (e.g., options for the location of display devices in the control room), and some will be "soft constraints" which may be subject to trade-offs with the picture design (e.g., use of presently available hardware vs purchase of new equipment). Once the pictures are designed and the constraints are determined, the constraints are applied to the picture design to implement the pictures as displays and to specify a compatible hardware and software system.

* Research sponsored by the Electric Power Research Institute, Nuclear Power Division, Research Project RP 2184.

We believe that this approach will enhance the quality of the final display system by explicitly specifying objectives, applying human engineering principles, and explicitly identifying constraints early in the process. Such an approach also will prevent premature emphasis on hardware implementation of the displays at the expense of their information-transfer capability. The design process will be documented in a report to be published by EPRI.¹ The project is EPRI Research Project 2184; the project manager at EPRI is J. F. O'Brien.

II. REVIEW OF OPERATIONAL AIDS UNDER DEVELOPMENT BY INDUSTRY*

The goals of a second ongoing project at ORNL sponsored by the NRC are twofold. The first is to collect data on the characteristics of the operator aids currently under development by the nuclear industry for use in nuclear plant control rooms. The second is to develop a classification method for NRC use in comparing proposed operator aids to existing and proposed regulations with regard to the operability, maintainability, required training, technical and administrative support, procedures, and documentation of the aid. The purpose of the project is to provide the NRC with a preview of the operator aids which may be submitted for licensing review at some later date, and to determine whether the current and proposed NRC regulations and standards will be adequate for their licensing task should licensing be required. The project does not involve a licensing review of the proposed aids.

This project is being accomplished by ORNL and Search Technology, Inc. To date, information on ten existing aid designs has been compiled, regulations and standards applicable to operator aids have been reviewed, and the development of a classification method has begun. The bulk of the information was obtained via a questionnaire submitted to various organizations involved in developing operator aids. The questionnaire addressed the following categories: problem definition, function, design, plant interface and environment, performance, operation, maintenance and testing, user training, documentation, and development status. The data base begun by the questionnaire is dynamic, owing to the nature of current trends in aid development. The regulations and standards reviewed include NRC Regulatory Guides, NUREG reports, industry standards, and communications from NRC regulatory personnel. A report on the project results will be issued later this year.²

* Research performed for the Nuclear Regulatory Commission under DOE Interagency Agreement 40-551-75, NRC FIN No. B0438.

III. METHODOLOGY FOR ALLOCATING FUNCTIONS IN NUCLEAR POWER PLANTS*

The goal of a third project, also sponsored by the NRC, is to develop and demonstrate a methodology to determine the proper allocation of function between an operator and an automated system. This project, which is being carried out by ORNL and BioTechnology, Inc., will be completed in 1983. The methodology can be used to allocate functions whether designing a new power plant or evaluating the existing allocation in an operating power plant. The allocation procedure consists of seven iterative steps embedded in the overall process for design of the system. The procedure begins with an hypothesized allocation which is then deductively tested against human psychophysical capabilities, system constraints, reliability requirements, and operator acceptance. Upon successful completion of these tests, the allocation is examined for compatibility with the overall system design. It has been shown in a case study that such methodology can distinguish between a function that has been improperly allocated to an operator and a function that has been properly allocated to an operator but in a manner that does not provide the operator with information sufficient to perform it. In this way the methodology can assist diagnostic aid development by identifying the actual information needs of the operator. A perspective of the allocation problem and a literature review was published in 1982.³ A final report⁴ on the methodology and its application will be issued in mid-1983.

IV. SUMMARY

These projects address three important aspects of the application of human factors in operator aid development: the integration of human factors principles during the design, the appropriateness and adequacy of NRC requirements, and the identification of the information an operator needs in order to perform the functions allocated to him. We believe that a balanced team of instrumentation and control engineers and human factors specialists is required to efficiently address today's development of operator aids. ORNL Instrumentation and Controls (I&C) Division personnel and their human factors consultants constitute such a balanced team.

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