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The Importance of Function Analysis for the Nuclear Industry

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The paper will explain and demonstrate how the application of a structured function analysis (FA) method, such as Cognitive Work Analysis, can benefit the nuclear industry. Applying a structured function analysis method to the design of a system enables improvements in terms of reduced human error leading to safer, more reliable, and more cost effective plant operation.

Function analysis creates a framework for describing the action capabilities of a complex system design. It is a systematic approach for developing a model of a complex system that can be used to design human-system interfaces. Functional analysis can be applied to new design, and changes to the design of an existing system. Function analysis has been used to design computerized information systems, hardwired panels, and operating procedures in the nuclear industry world-wide. Although the application of function analysis in the nuclear industry has been focused on the design of control room interfaces, the application of FA can benefit design in other areas of a nuclear plant.

Function analysis is needed to help identify the action possibilities, which are linked in tasks, that are allocated to human operators and maintainers. Current design practices are weak in supporting the human-system interface (for operators, maintainers, designers) with physical design features and information systems. One reason for this, is that system design information, by nature, is scattered in a variety of sources leaving the system designer and even operators to use their own method to assimilate the information. Sometimes, the knowledge of these relationships internalized by designers is not formally documented, and is lost when the designer leaves the company. A second reason is that designers of complex systems must be specialized (due to the complexity of the system), and cannot know about all functional relationships in the entire system. Using function analysis to identify relationships within and between systems is helpful when: creating new designs (it can be used to model the desired system before hardware is selected), or making changes to existing designs. It is especially helpful when these relationships must be communicated to operators, maintainers, or other personnel interacting with the system.

Here are some examples to indicate how a structured analysis technique, function analysis, would have enhanced the design. A simple example can be seen in the

development of the CANDU 6 design. An early CANDU 6 design, Pickering 'A', credits a moderator dump as a second shutdown system. Later, it was realized that the moderator is an ideal heat sink and should be retained for this function. This function of the moderator may not have been realized in the early design when the focus was on a separate method of reactor shutdown. Another example is taken from simulator trials. Operators have been able to identify flow paths required for cooling in emergency situations, which the designers had never imagined when developing the design configuration. A third example draws a parallel with the use of CADDs modelling in the design of a CANDU reactor. The use of modelling in this case identified several thousand interferences…function analysis has the same potential for identifying relationships in a design.

What has the Canadian nuclear industry done to apply function analysis in the design of nuclear reactors? A number of COG documents described initial efforts in describing and applying function analysis to a CANDU reactor design. Since the COG documents, the process has been formalized in the Design Requirement and Design Description writing processes for the CANDU 9 and IRF projects. Designers are identifying more information for each system function than they have previously done. Although this is marginally more time consuming at the design stage, the benefits come during operation and maintenance, therefore reducing the lifecycle cost of a CANDU reactor. For example, operating stations currently go through a resource and capital intensive process of identifying different system performance measures that must be instrumented and retrofit additional monitoring equipment to assist in reliability centered maintenance. If these performance measures for system functions had been identified and described during the initial design, the process of adding instrumentation for reliability centered maintenance would cost significantly less. Function analysis is currently being used at AECL to design computerized displays and alarm annunciation systems.

Though functional analysis is being applied, it is not in widespread use. It is applied to select projects, by a small group of people (who know about FA and understand its benefits). Structured FA methods such as Cognitive Work Analysis, produced by research scientists working with a experimental nuclear reactor in Denmark, could be applied to the Canadian nuclear industry. The importance of function analysis to design must be conveyed and incorporated into the design of new systems. Function analysis should be applied to the design of information systems (e.g., operating procedures, maintenance manuals, control panels, manual controls) inside and outside the control room to reduce human error and achieve more reliable operation.

It is noted that the terms Function Analysis and Task Analysis are often used synonymously. Formal structured methods of function analysis such as Cognitive Work Analysis clearly delineate Function Analysis (called Work Domain Analysis) from Task Analysis (called Control Task Analysis). One of the distinctions being that Work

Domain Analysis is event independent while Control Task Analysis is event dependent. At AECL, task analyses involve organizing functions into a sequence and includes design details such as the displays and controls to be used.

The paper will illustrate how functional analysis can benefit a design by applying it to one system of a CANDU reactor.