Operator Support Technologies for Fault Tolerance and Resilience

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ABSTRACT:

The proposed work will develop and demonstrate control system technologies for nuclear plants that will significantly enhance the operator response to time-critical component faults, resulting in fewer nuclear safety challenges and higher plant capacity factors. A large class of plant upsets exists for which the probability of successful outcome will increase significantly with advanced technology for operator support. In [1] we identify situations where alternate configurations and actions in response to an event, if performed in sufficient time, can mitigate the need for a safety actuation. Presently the timeliness and appropriateness of an operator's response suffers from a poor diagnosis of the cause of the upset and the required actions. This is traceable to limited instrumentation for accurate fault characterization and the difficulty in integrating the instrument readings into a correct diagnosis.

The product of the proposed work will be a prototypic computerized operator support system (COSS), a collection of capabilities to assist operators in monitoring overall plant performance and making timely, informed decisions on appropriate control actions for the projected plant condition. This "operator advisory system" provides a means to manage the enormous amount of information an operator must process and integrate to arrive at an understanding of how the plant is operating and how its trajectory will unfold. This is a daunting task for even the most experienced operators. This system will assist the human operator with control as opposed to serving as an extension of the control system. Existing automatic control systems lack "awareness" of the plant state and the larger world in which they operate; they simply track a setpoint. In the proposed work, we sense process variable values and apply the conservation laws that govern plant operation to determine through an automated reasoning process a mutually consistent plant state. The reasoning process is transparent and familiar to the operator as it is very nearly the same qualitative reasoning process by which he would make a fault diagnosis given sufficient time and access to instrument readings. The system can then recommend to an operator the actions that can mitigate undesirable plant events and trends and return the plant to a safe operating condition with the least amount of upset possible.

Development of such technology could prove to be enormously beneficial to the currently-operating nuclear plants, as well as the array of new types of new nuclear plants that are now being built or proposed. This would result in better management of plant upsets and ultimately make a positive impact on the industry's fundamental objectives in the areas of nuclear safety, production, and cost management.