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Abstract

Physical security requirement of nuclear power plants (NPPs) in the US is regulated in a mainly prescriptive manner. This "one size fits all" approach may consequently overlook plant-specific characteristics which are beneficial for the inherent safety and security of the plant. Although a performance-based security measure has been promulgated in 10 CFR 73.55(r), current evaluation methods generally emphasize static and conservative assumptions on physical security uncertainties. This conservatism contributes to the overall operational and maintenance costs, which account to 70% of total operating expenditures for an NPP.

This paper describes an ongoing work at the Idaho National Laboratory within the Light Water Reactor Sustainability pathway, which aims to optimize physical protection system with regards to system effectiveness and dollar costs. To achieve this goal, a risk-informed approach to physical security is proposed. This approach leverages the Event Modeling Risk Assessment using Linked Diagrams (EMRALD) tool to model facility infiltration and Force-on-Force (FoF) engagement in a dynamic manner. The dynamic FoF analysis was conducted by coupling human performance uncertainties modeled in EMRALD to existing commercial 3-dimensional FoF software, i.e. SCRIBE3D, AVERT and Simajin. Meanwhile, risk analysis was accomplished by coupling the attack outcomes to existing plant Probabilistic Risk Assessment (PRA) model with FLEX strategy. This approach reduces the conservatisms in security modeling and further acknowledges the possibility for plant operators to mitigate the attack outcomes.

A sabotage attack on a hypothetical NPP facility was devised to demonstrate the proposed methodology. Dynamic FoF rules were implemented in EMRALD coupled to SCRIBE3D. This dynamic evaluation revealed an additional 21% system effectiveness in protecting the target set relative to the static modelling approach. Furthermore, the conditional core damage probability could be reduced by up to 46% by crediting operator actions in mitigating the sabotage outcomes. We evaluated the relative importance of each component of the physical security posture included in the model and assessed tradeoffs between components to identify potential opportunities for cost reduction while maintaining a specific level of system effectiveness. Results of the cost analysis will be presented in the conference. This study is expected to help NPP operators in allocating resources optimally to satisfy the security requirements.