Improving Force-on-Force Modeling and Simulation to Support Physical Security Optimization



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Physical Security Pathway

The goal of the LWRS Program Physical Security Pathway is to develop tools, methods, and technologies, and to provide the technical basis for an optimized physical security posture at nuclear power plants [1]. Force-on-Force (FOF) simulation models are used by facilities to compare and evaluate their protection strategies. This research paves way for risk-informed physical security optimization by incorporating dynamic scenarios, operator actions, FLEX portable equipment, and thermo-hydraulics analysis with the plant FOF models.

Dynamic FOF modeling is performed using the SCRIBE3D computer simulation tool developed by Sandia National Laboratories and integrating it with the dynamic assessment tool EMRALD developed at Idaho National Laboratory (INL). These FOF models are powerful tools to perform quantitative assessment of a plant's physical security performance effectiveness under simulated scenarios. These models enable the analysis of current postures, perform sensitivity analyses of variables and elements of physical security, identify strengths and weaknesses in the current strategy, explore different strategies by simulating variables and outcomes in a given sabotage scenario, and derive potential approaches to optimize a plant's physical security posture.

The current effort utilizes the following computational tools:

1. SCRIBE-3D Tabletop Recorder [2], a software tool that allows users to visually record and play-back FOF scenarios during a tabletop exercise. It offers a set of tools to visualize, organize, and record data reflecting their decisions while users develop scenarios.
2. AVERT Physical Security [3], which is 3-dimensional (3D) simulation software that analyzes the effectiveness of a physical protection system by using Monte Carlo simulations of adversarial pathways. These simulations provide analysts with an improved understanding of vulnerabilities at a facility.
3. EMRALD [4] is a dynamic risk assessment tool that is based on three-phase discrete event simulation, where the next events in time are sampled. Traditional aspects of risk assessments such as components with basic events, fault trees, and event trees are represented in a dynamic framework of state diagrams and are displayed. The user interface allows for quick and easy-to-understand modeling of scenarios, as well as the means to represent system, component, and operator actions.

EMRALD is used to manage the different FOF simulation tools and supplement the simulation capabilities with dynamic uncertainties, as shown in Figure 6. This framework allows a security analyst to relax the conservatism in their security posture and gain further insight on optimizing the posture for protection effectiveness and associated costs. The following analyses have been performed using this framework:

1. Analyzing the change in security effectiveness using randomized shift breaks.
2. Comparing the security effectiveness and cost between different physical protection configurations.
3. Analyzing operator actions to mitigate sabotage attacks, such as:
    a. The likelihood and possible pathway for control room operators to evacuate to a backup control room under certain circumstances.

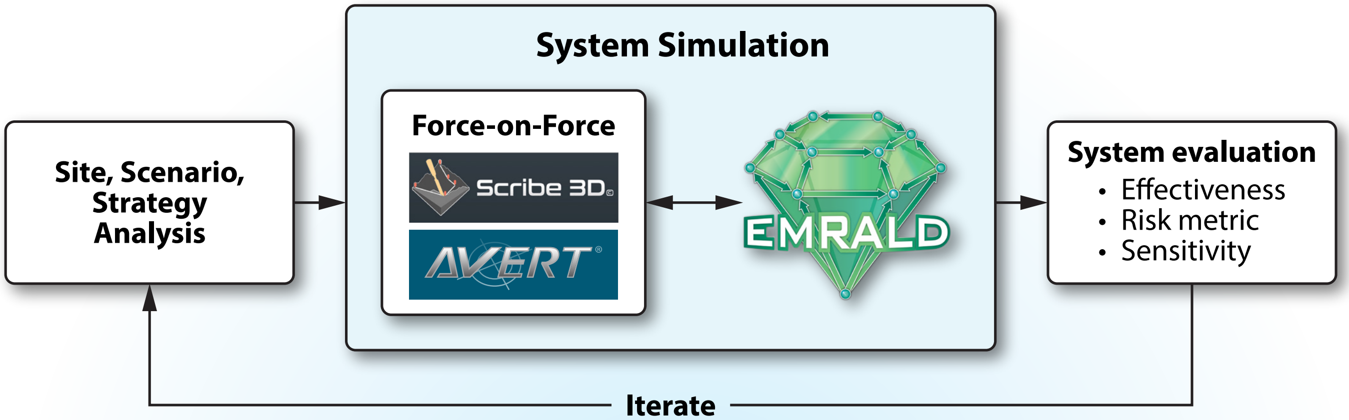

Figure 6. Dynamic FOF simulation framework

b. Timeline evaluation of diverse and flexible coping (FLEX) mitigation strategies and their success probabilities [5].

The Physical Security Pathway is also collaborating with South Texas Project Electric Generating Station and ARES Security on using dynamic modeling and simulation to: 1) obtain the most effective and economically efficient physical security posture for a future capital investment in plant security, and 2) provide technical basis for incorporating FLEX portable equipment into plant security plans and procedures.

References

1. United States Nuclear Regulatory Commission. Emergency Preparedness in Response to Terrorism. [Online] November 16, 2018. https://www.nrc.gov/about-nrc/emerg-preparedness/about-emerg-preparedness/response-terrorism.html.
2. Department of Energy. SCRIBE 3D-Tabletop Recorder v. 1.1. [Online] [Cited: January 22, 2020.] https://www.osti.gov/doecode/biblio/16918.
3. ARES Security Corporation. AVERT Physical Security. [Online] 2019. [Cited: January 22, 2020.] https://aressecuritycorp.com/avert.
4. Idaho National Laboratory. EMRALD. [Online] [Cited: January 22, 2020.] https://emrald.inl.gov/SitePages/Overview.aspx.
5. United States Nuclear Regulatory Commission. Diverse and Flexible Coping Strategies (FLEX) Implementation Guide. Washington DC, NRC, 2012.

Using Automated J-R Curve Analysis Software to Simplify Testing and Save Time

ASTM International, one of the world's largest associations of materials-centric engineers and scientists, has selected an article authored by LWRS Program researchers — Xiang (Frank) Chen, Alberto Esteban Linares, Logan Clowers, Mikhail A. Sokolov, and Randy K. Nanstad — for inclusion in the 2020 ASTM E1820 standard. The article titled, "Using Automated J-R Curve Analysis Software to Simplify Testing and Save Time," discusses newly developed automated software based on the ASTM standard E1820-18 normalization method, which is a useful tool for evaluating material fracture toughness in the ductile region. The software is user-friendly, and yields results that match the manual analysis method. Source codes were written in MATLAB and the compiled software in the form of a standalone executable and is readily compatible with modern Windows operating systems. Read more here: ASTM International selects AM&P article for inclusion in 2020 ASTM standard.