A Better, Faster, More Economical Way to Measure Fire Risk

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Measuring fire risk at a nuclear power plant is essential but is also time-consuming and expensive. A new software package integrates several existing analytical tools into an intuitive user interface has been shown in a case study to effectively automate many manual tasks, dramatically cutting time and the expense. Accurately determining the risk from numerous fire sources is currently done through a fire probabilistic risk assessment which involves many hours of evaluating cable trays, measuring distances, performing fire calculations, and then integrating all the various results into the plant's overall risk analysis model. The LWRS Program's Risk-Informed Safety Analysis pathway has completed a five-year project to create a better way to perform these tasks using a program called Fire Risk Investigation in 3D (FRI3D, pronounced "fried") [1].

This innovative software streamlines fire modeling and risk assessment, ensuring precision and efficiency by automating many tasks and providing advanced visualization features. FRI3D is being commercialized by Centroid LAB, which created the user interface and will market the product. Early indications suggest FRI3D will be attractive to the nuclear power plant and fire analysis industries. The LWRS Program researchers conducted a cost analysis using a current industry plant modification to evaluate the savings. Plants need to perform a fire analysis for all modifications, which can require new analyses up to several times a year. FRI3D reduces these manual steps, as well as the number of work hours needed to complete these tasks by personnel with specialized expertise, by using an intuitive user interface that simplifies fire modeling tasks. Engineers can import existing plant data, including floor plans, equipment locations, schematics, cable raceway locations, fire barriers, and smoke and fire detectors. Previously scanned fire models can also be imported using standard formats or by configuring custom data tools. By dragging and dropping plant components into the 3D modeling environment, users can swiftly create accurate models of the specific areas being analyzed. The 3D modeling interface resembles commercial products used to help the average person with home interior design plans.

After the model is completed, FRI3D allows users to add fire sources. With a few clicks, the software simulates a fire spreading through a modeled environment. It uses fire simulation codes that are already validated and proved, so using the program does not trigger new regulatory requirements. The simulation predicts cable and equipment failures, as shown in Figure 8. The resulting time progress fire scenario visualizes all failed items in the 3D environment, enabling analysts to assess the progression and potential damage of a fire. Upon finalizing the fire scenario, the analysts can integrate it into their own overall risk analysis software with the click of a mouse. Using FRI3D provides an average time-savings of 50% when compared to current semi-manual practices. This time-savings is especially helpful if the fire analysis is part of the critical path of a larger project, such as adding new equipment.

A nuclear power plant and fire analysis consulting company, Engineering Planning and Management, Inc. volunteered to help with a pilot case study to perform a cost-savings analysis. The plant was installing two new chillers in different locations, so calculating their fire significance was chosen as a test case. Engineering Planning and Management, Inc. performed the task using its current semi-manual methods and tools and then used FRI3D to perform a detailed analysis. Various task times were tracked, such as determining failure calculations from the zone of influence and converting to risk analysis scenarios for current methods, and then importing the plant data, compartment or zone modeling, raceway modeling, and fire source simulations for FRI3D.

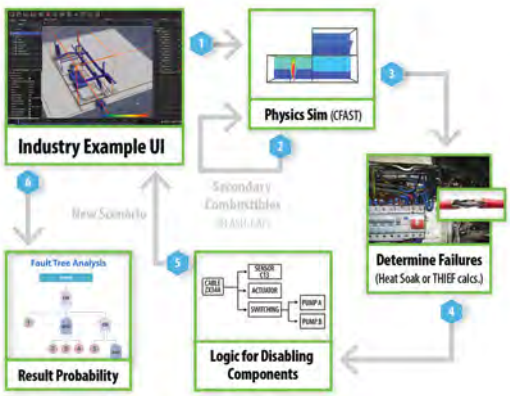

Figure 8. Automated fire scenario generation steps using the FRI3D software.

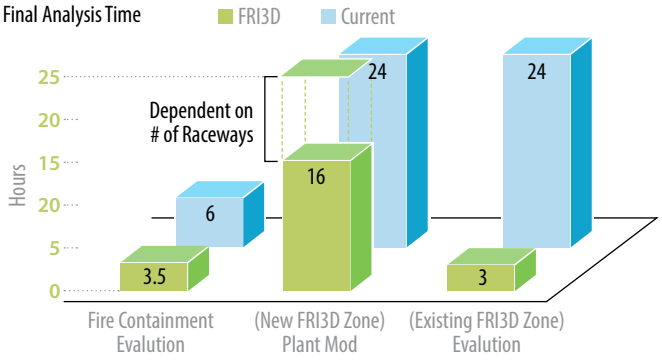

Figure 9. Timing evaluations from the industry case study comparing current methods vs. using FRI3D.

Creating the model in FRI3D and modeling the fire sources took about 32 hours. But the time-savings for auto generating the scenarios compared with current methods more than made up for the additional time. The results, including those displayed in Figure 9, showed that for fire compartments never modeled in FRI3D, there would be 0–30% time-savings (middle column), depending on how many raceways are in the room vs. the analyzed sources. If there are less than 50 raceways and several fire scenarios to analyze, a 30% time-savings is easily achieved. On the other hand, if there are more than 100 raceways and only one scenario being analyzed, there may be no time-savings for the first analysis of that compartment analyzed in FRI3D. For any subsequent changes or future fire evaluations in already modeled compartments, time would be cut by 80% (right column). More cases would need to be evaluated to determine an average time-savings per project or compartment.

Centroid LAB is working with EPM, Risk Spectrum, and PLC Fire Protection Engineering. These companies specialize in nuclear risk analysis and fire modeling and will help bring FRI3D to the nuclear industry, thereby helping to cut costs and increase realism in fire analysis. Researchers hope to add the option of flooding analysis modeling into FRI3D in the future.

Reference

1. Prescott, S., R. Christian, and R. Sampath. (2023). "FRI3D Fire Simulation Options and Verification Tasks." INL/RPT-23-70843. Idaho National Laboratory, Idaho Falls, ID, USA. Available at: https://lwrs.inl.gov/RiskInformed%20Safety%20Margin%20Characterization/FRI3D_CFAST_FDS.pdf (accessed 11 June 2024).

Welcome Brenton M. Pickrell as the Pathway Lead for the Physical Security Pathway

Brenton M. Pickrell

Brent Pickrell is the new Physical Security Pathway Lead in the Light Water Reactor Sustainability (LWRS) Program at Sandia National Laboratory. He will advance cutting-edge physical security solutions and improve risk-informed decision-making for the long-term safe and reliable operation of existing nuclear power plants. With extensive experience in leadership, and physical and nuclear security, Brent brings unique expertise to this role, supported by a B.S. from Ohio University and M.S. of Aeronautical Science from Embry-Riddle Aeronautical University.

Brent's career began in the U.S. Marine Corps and culminated 26 years later in retirement from the U.S. Air Force as a Security Forces Officer, where he led security operations on three continents, safeguarded the nation's most critical assets, and forged partnerships with local law enforcement, the Secret Service, FBI, and defense agencies of nearly 100 nations.

With demonstrated talent in leading interdisciplinary teams, integrating emerging technologies, and forging partnerships that strengthen the security landscape, Brent excels at aligning multi-billion-dollar modernization efforts with strategic directives, and championing continuous improvement to address evolving threats. Beyond his professional acumen, he is a staunch advocate for team development and building cultures grounded in trust, ethics, and mutual respect across cultural or demographic lines.