INL/EXP-24-79635-Revision-0

Dose Consequence and Probabilistic Risk Assessment Integration into Digital Documented Safety Analysis

August 2024

Changing the World's Energy Future

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http://www.inl.gov

Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

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Nuclear Safety Analysis (U750)
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Introduction

The current reactor authorization process is complex and error prone, due in part to the multitude of documents and models that must be updated manually when new design information is released. The digital Documented Safety Analysis (DSA) is intended as a tool to enhance the design and authorization process for advanced reactors by allowing the integration of multiple areas of design, analysis, and review through the use of databases and automated workflows.[1] This integration includes areas such as facility modeling, neutronics modeling, thermal hydraulics analysis, probabilistic risk assessment (PRA), dose consequence analysis, and report generation. The ultimate goal of this initiative is to provide a system where a vendor can update the reactor design and have the change propagated through the DSA, thus allowing the examination of the effect of the change upon failure rates, accident dose, component classification, etc.[1]

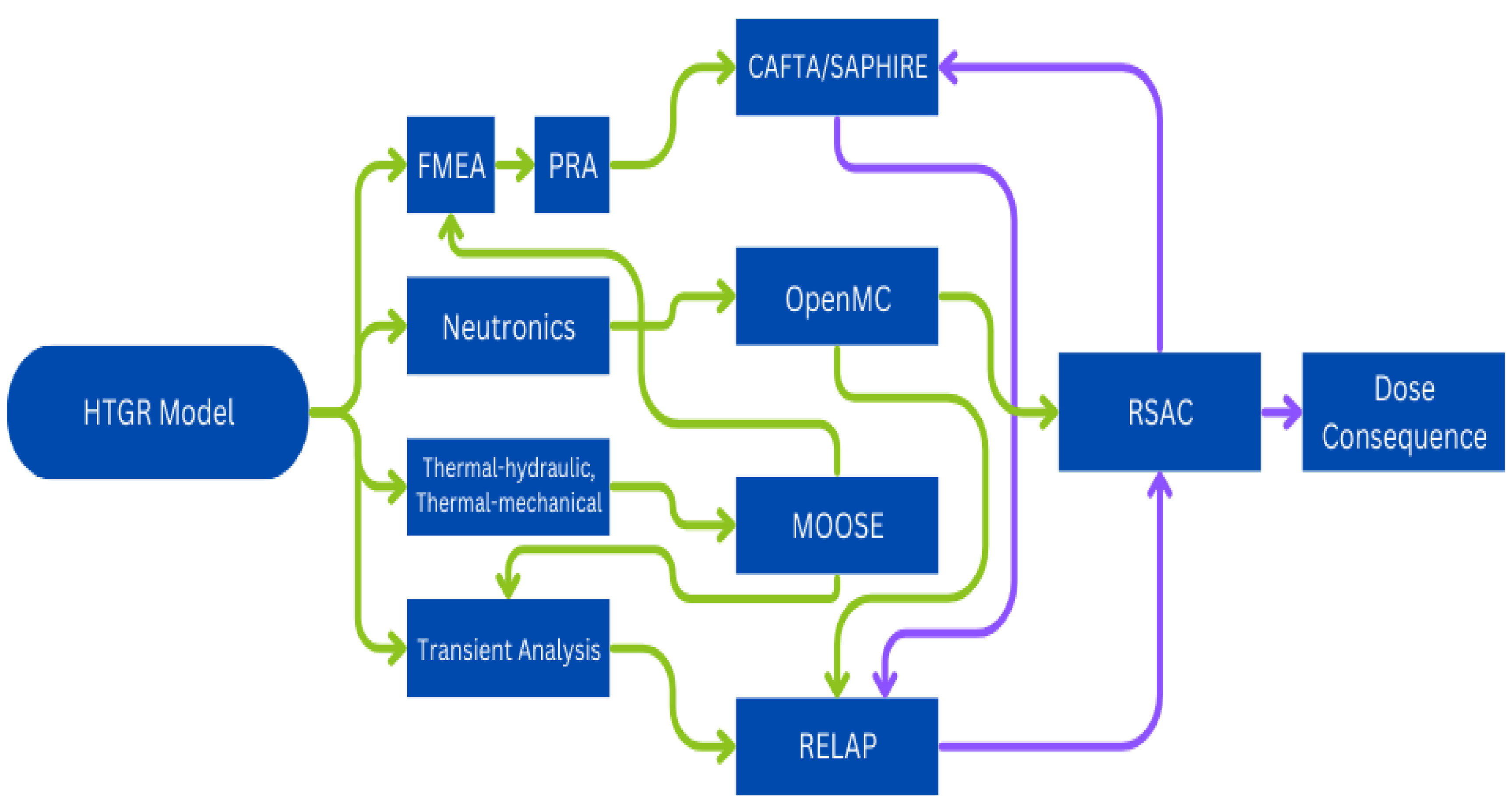

Fig 1. Workflow of HTGR models and analyses. Paths related to this work are highlighted in purple.

Objectives

This work is focused on the generation of a generic PRA model for a high temperature gas reactor (HTGR) and its integration with the Radiation Safety Analysis Computer (RSAC) software to provide estimates of radiation dose to collocated workers and members of the public. The particular goal is to provide a method for determining what system failures within the PRA lead to accident end states involving radiological release and the resulting magnitude of those releases. This information can be used to appropriately select and classify safety structures, systems, and components (SSC).

Methods

A basic PRA was generated for a generic HTGR based upon DOE-HTGR-86-011. The generic HTGR contains a cylindrical homogenous core, generic control scheme, passive heat removal, and pressure relief functions.[2]

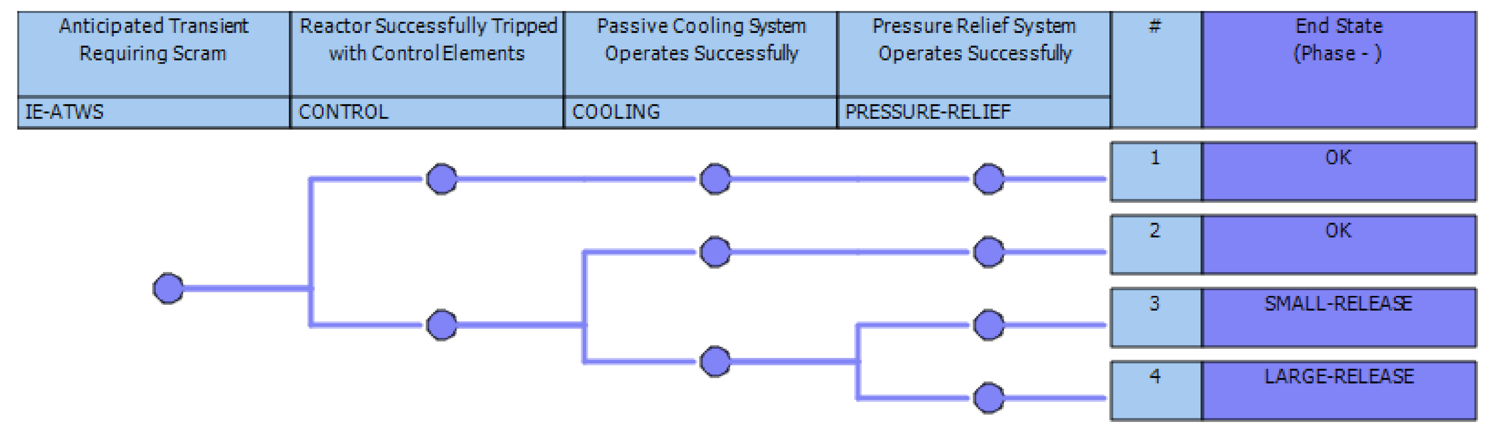

Fig 2. Event tree for Anticipated Transient Without Scram in HTGR

Dose consequence integration will consist of several steps. Executing the PRA model will inform system failures and resulting core environment. This data will drive an accident scenario in RELAP, determining the extent of damage to the core. These results will be used in RSAC to calculate radioactivity release. This data can be sent back to the PRA model to inform design parameters and accident severity.

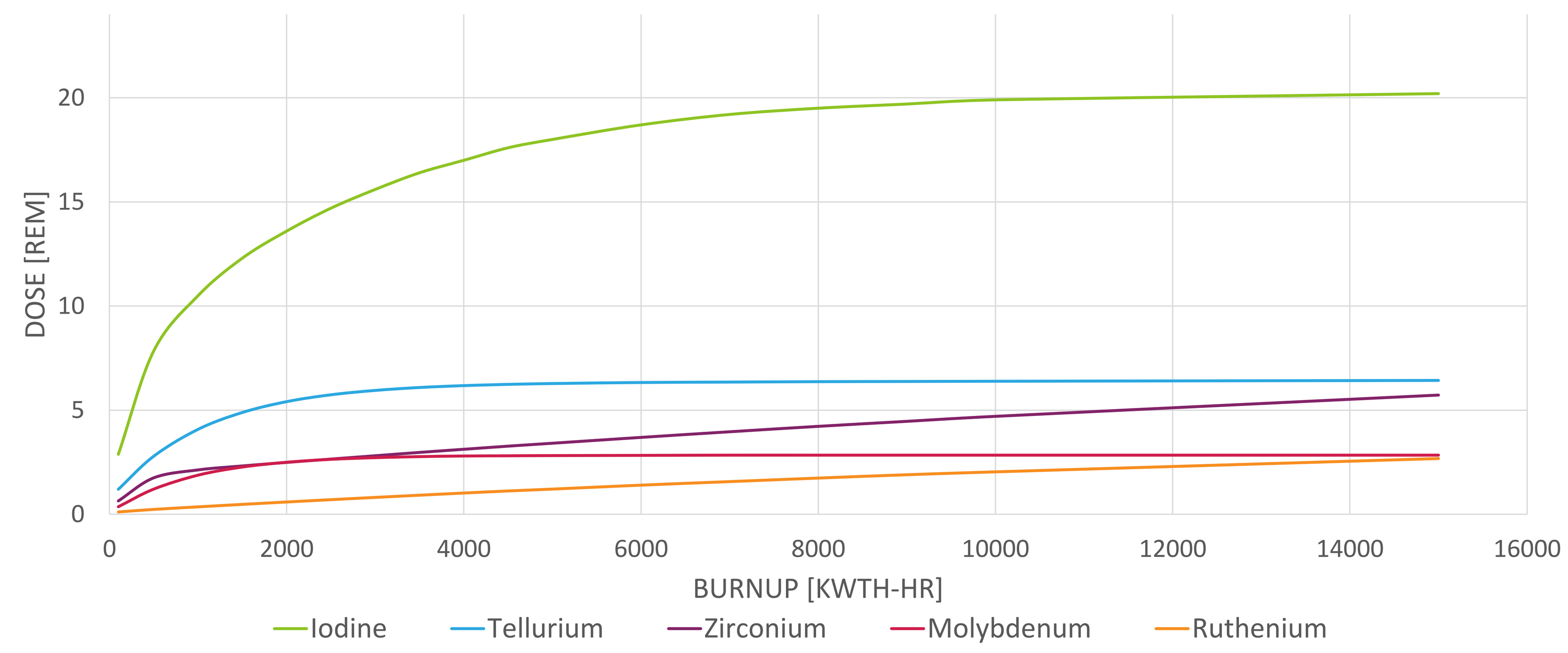

Fig 3. Example of dose consequence results as a function of core inventory burnup.

Progress/Future Work

This project is ongoing and is being conducted in collaboration with other interns and engineers. A generic PRA is nearing completion. Neutronics and thermal-hydraulic models are in progress. The Failure Mode and Effect Analysis (FMEA) database will be constructed from an existing internal data set. RSAC integration depends on the completion of all models and the configuration of the automated workflow software. Additionally, advocacy for the regulatory acceptance of a digital DSA will be required.

References

1. Lund, Matthew et al. *Framework for a Digital Documented Safety Analysis*. Idaho National Laboratory, 2024.
2. GA Technologies Inc. *Probabilistic Risk Assessment for the Standard Modular High Temperature Gas-cooled Reactor*. DOE-HTGR-86-011 Vol. I and II. Department of Energy, 1987.

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