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Merging of several codes under ADAPT for use in integrated 3S analysis of international transportation of SNF

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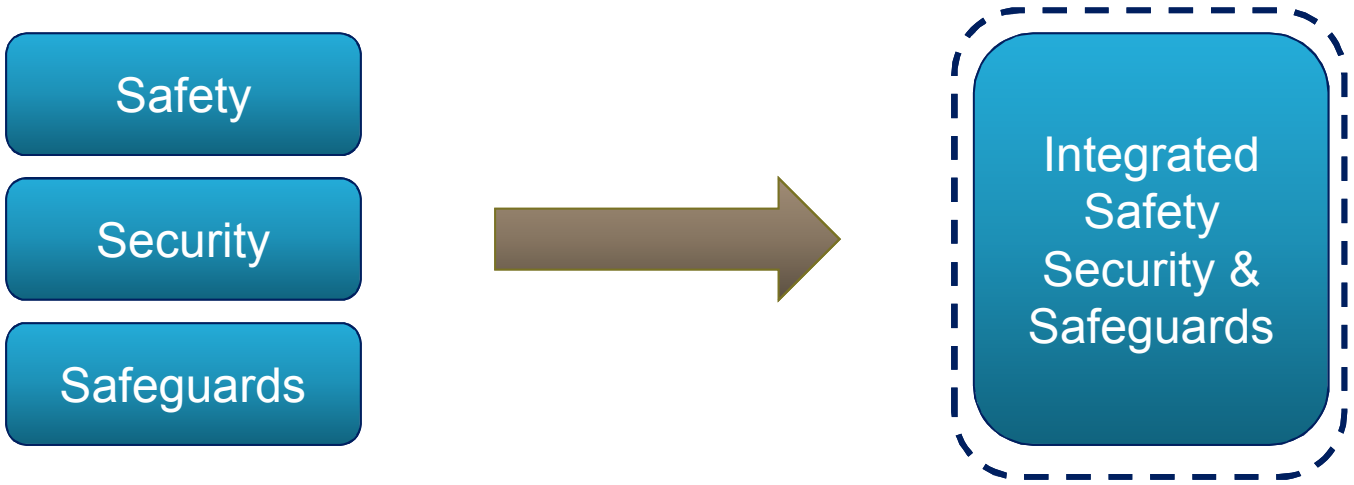
Background

- **The U.S. National Academies of Science recently stated a need for an:**

> Integrated evaluation of the threat environment, the response of packages to credible malevolent acts, and operational security requirements for protecting spent fuel and high-level waste while in transport.



- **Current research remains at the conceptual stage.**

Project Goals

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- Project is underway to develop a technically rigorous 3S approach to evaluate and mitigate SNF transportation risk.

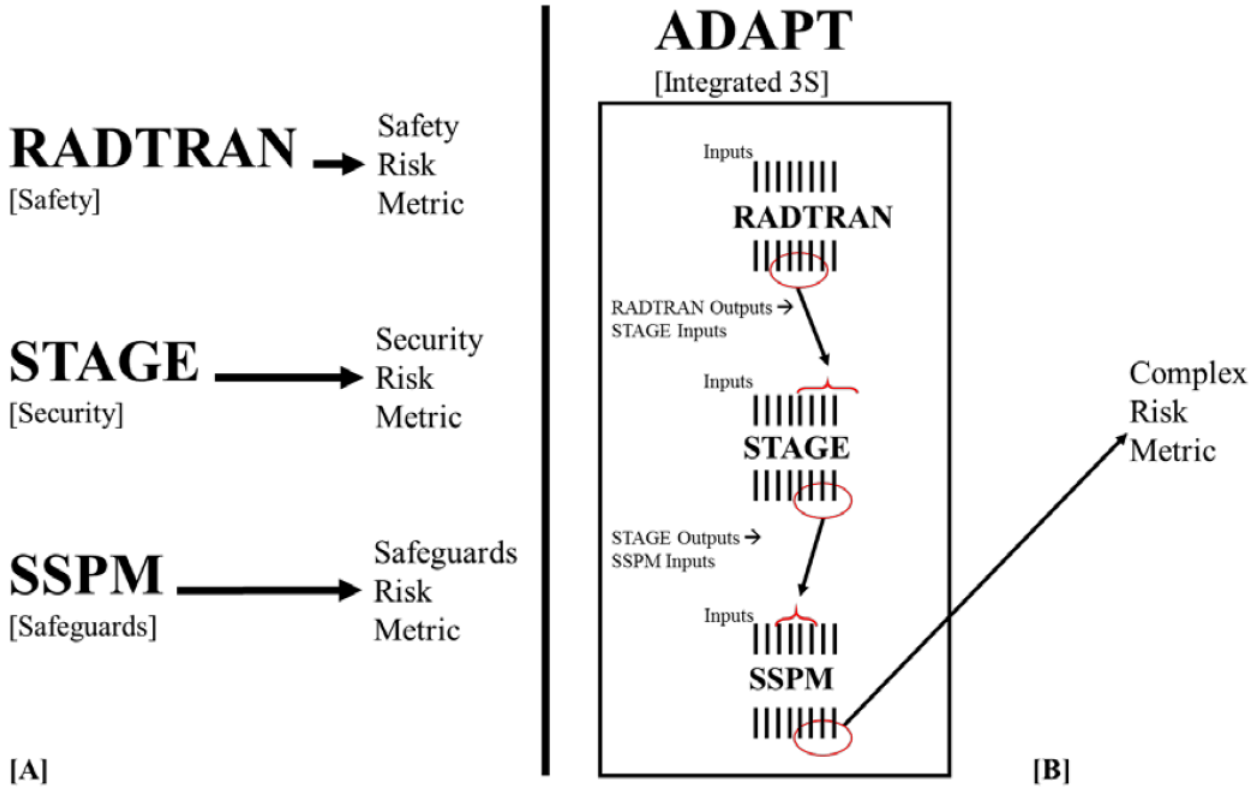
- Based on the interaction of system components to allow the SNF to successfully complete the route from origin to destination.
  - Each "S" is evaluated in isolation and compared to the integrated approach for a hypothetical case study.

- Two system approaches are being considered:
  - Dynamic Probabilistic Risk Assessment (DPRA)
  - System Theoretic Process Analysis (STPA)

- STPA uses a different form of analysis than DPRA and does not have the same technical requirements.

Previous Research Status

- The use of dynamic PRA through ADAPT was identified as a promising methodology.



- The choice of SNF cask and model route was previously determined.

Methodology

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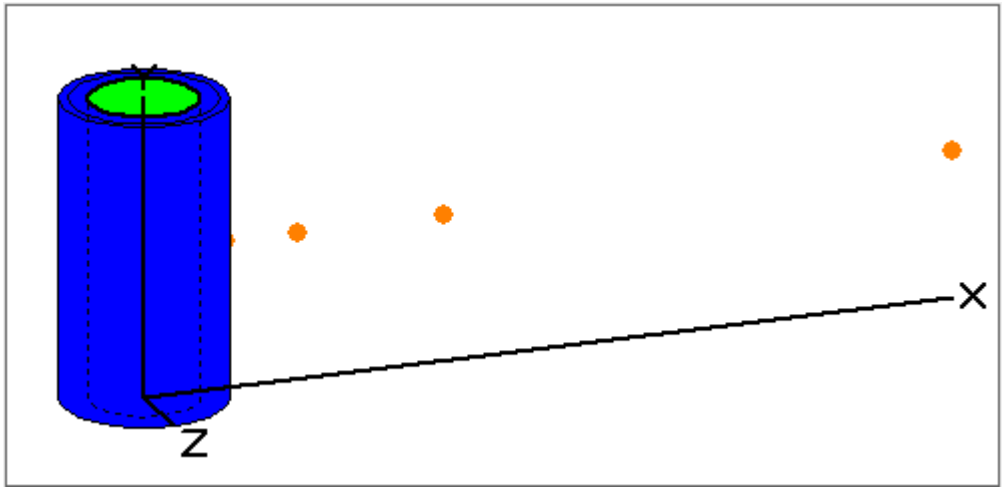
- MicroShield was used to calculate dose rates from SNF.
  - Incident-free transportation, minimal size of detectable diversion and bare assemblies
- To connect codes to ADAPT, a wrapper script is used.
  - ADAPT spawns and runs additional copies of a code at predetermined branching points based on the state of the simulation, while changing input files.
    - Edit rules are used to determine when and how to change input files
- Connections between codes were developed based on scenario
  - Situations where an event affects a combination of safety and security were prioritized.

Results

- MicroShield analysis has confirmed that the dose rate outside the cask is within regulatory guidelines.

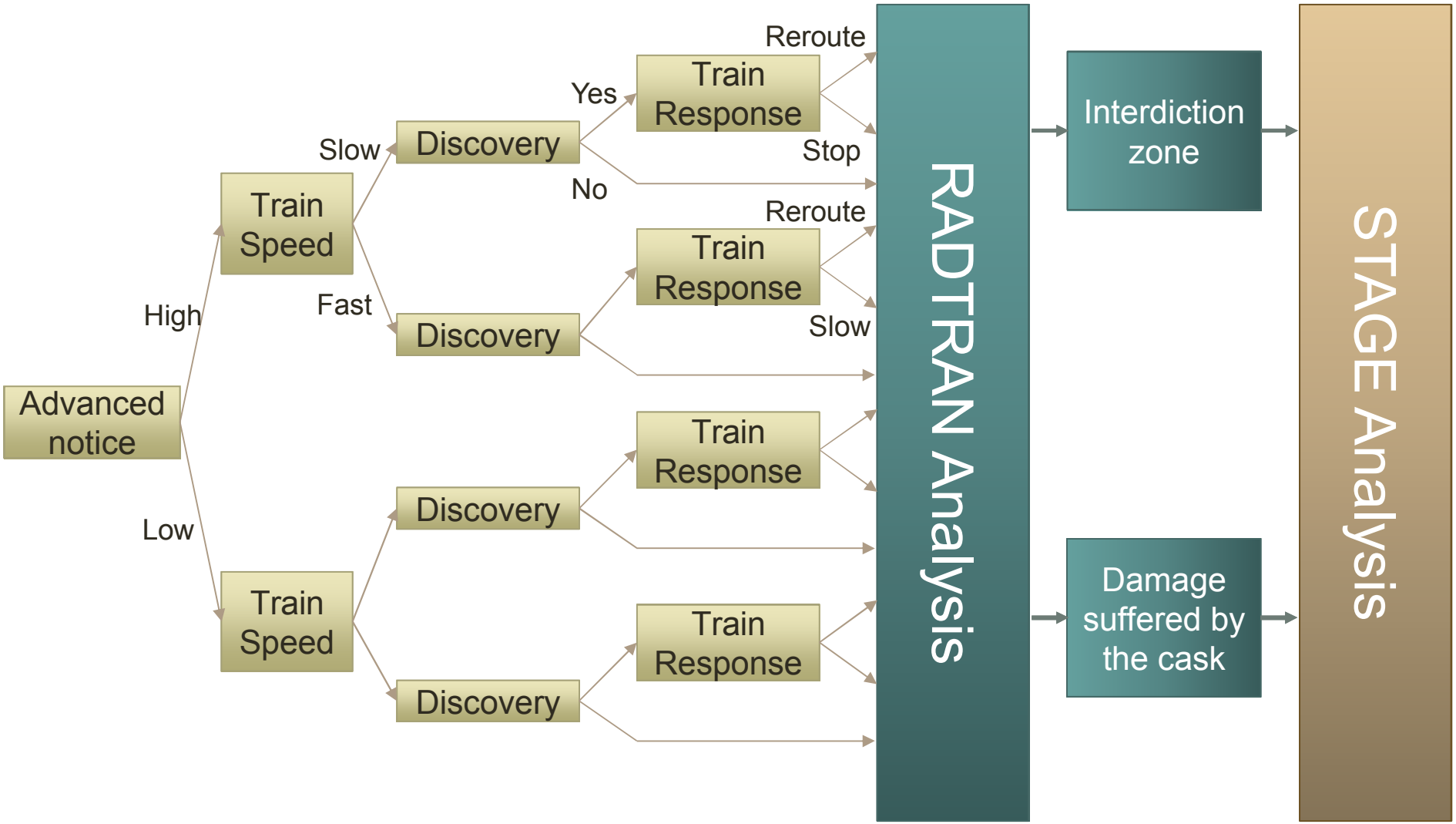
  Missing pins reduce the dose by 2 mrem/hr on the cask wall, unnoticeable from farther away.

  Bare assemblies have a dose rate of 370-550 rem/hr based on burnup and age.



- ADAPT wrapper and template for edit rules were written to link to RADTRAN

Two-Stage Attack: Derailment into Raid



Dynamic event trees used internally within STAGE analysis

Discussion

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- From these results, ADAPT can be used to manage disparate codes.
- The Two-Stage attack scenario is built on static event trees as well as dynamic event trees.
- Safeguards analysis has not yet been included.
- Work remains to integrate analysis codes into Linux for use with ADAPT

Conclusion

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- Work on this project is continuing in order to refine the RADTRAN wrapper, develop STAGE and SSPM wrappers and fully develop scenarios for DPRA analysis.

- The Two-Stage attack scenario is undergoing additional work and is expected to be included in a paper submitted to the IAEA International Conference on Nuclear Security.

Personal: Brian Cohn

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- Brian Cohn graduated from Arizona State university in 2010 with a degree in Physics.
- He is currently pursuing a Ph.D. at The Ohio State University, where he has been since 2013.
- He has worked at INL on an internship researching the use of surrogate models and adaptive sampling with the RAVEN code.