SAND2020-8121C

UWC 2020

ANS Meetings

IT'S GO TIME

Creating Momentum Toward Transformational Change

LWRS Physical Security Pathway Risk-Informed Security R&D

LWRS LIGHT WATER REACTOR SUSTAINABILITY

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LWRS Physical Security Pathway Lead

Sandia National Laboratories

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Program Goals and Objectives

- Goal
  - Enhance the safe, efficient, and economical performance of our nation's nuclear fleet and extend the operating lifetimes of this reliable source of electricity.

- Objectives
  - Enable long-term operation of the existing nuclear power plants
  - Deploy innovative approaches to improve economics and economic competitiveness of LWRs in the near-term and in future energy markets
  - Sustain safety, improve reliability, enhance economics.

- Research and development focus areas
  - Plant modernization
  - Flexible Plant Operations and Generation
  - Risk-informed systems analysis
  - Materials research
  - Physical Security

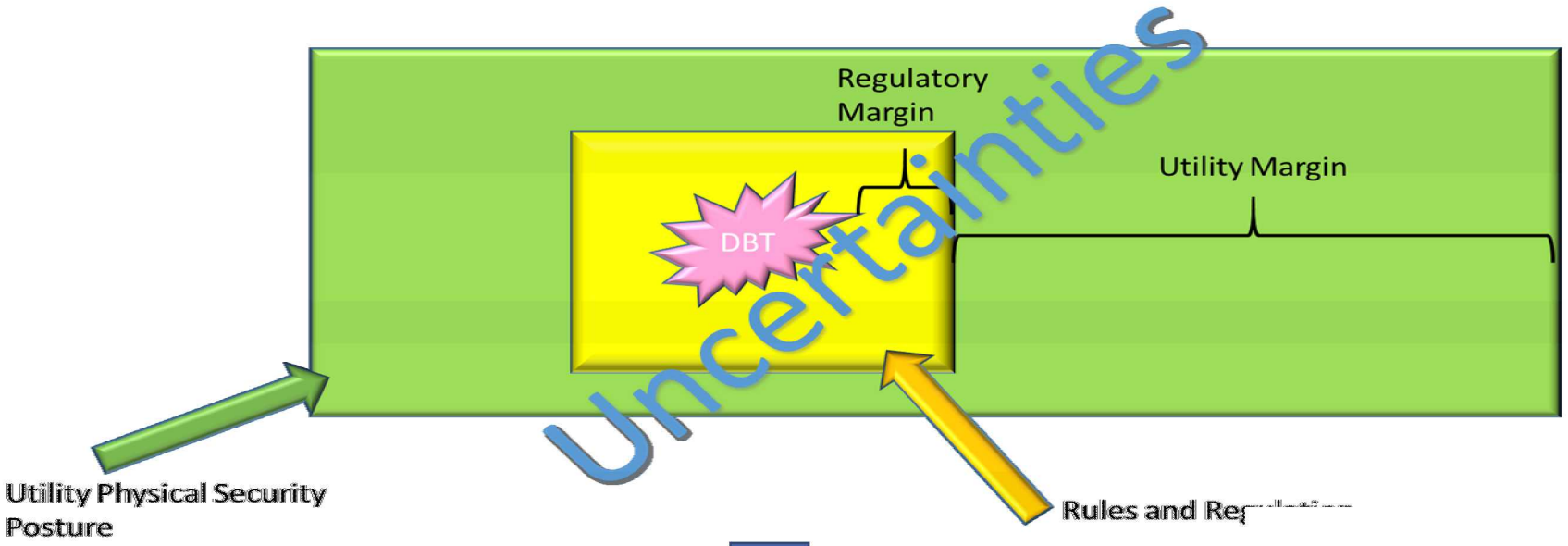
DOE's program for LWR RD&D

Nine Mile Point (Courtesy of Exelon)

Research Pathways

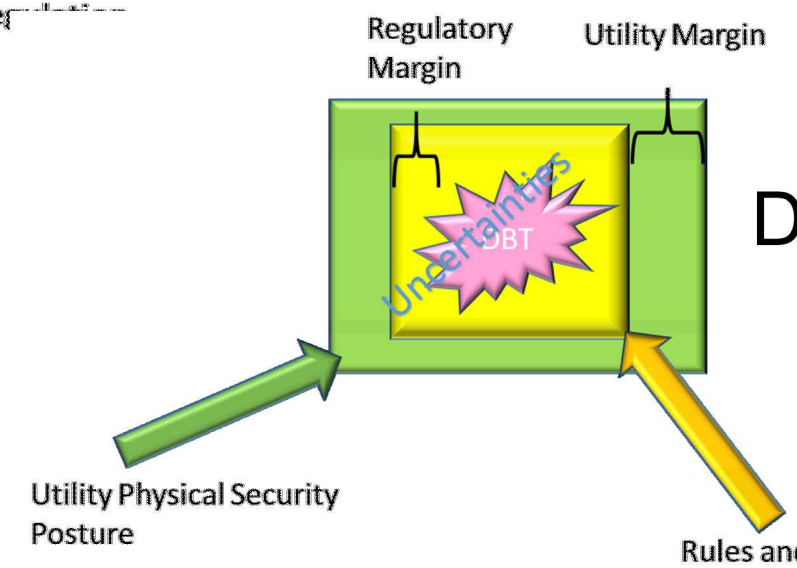
Plant Modernization	Enable plant efficiency improvements through a strategy for long-term modernization
Flexible Plant Operation & Generation	Enable diversification and increase revenue of light water reactors by deploying systems to extract electrical and thermal energy to produce non-electrical products
Risk Informed System Analysis	Develop significantly improved safety analysis methods and tools to optimize the safety, reliability, and economics of plants
Materials Research	Understand and predict long-term behavior of materials in nuclear power plants, including detecting and characterizing aging mechanisms
Physical Security	Develop and provide technologies and the technical bases to optimize physical security postures to maintain protection and improve efficiencies

Physical Security State – Current versus Desired



Current State

PSP R&D

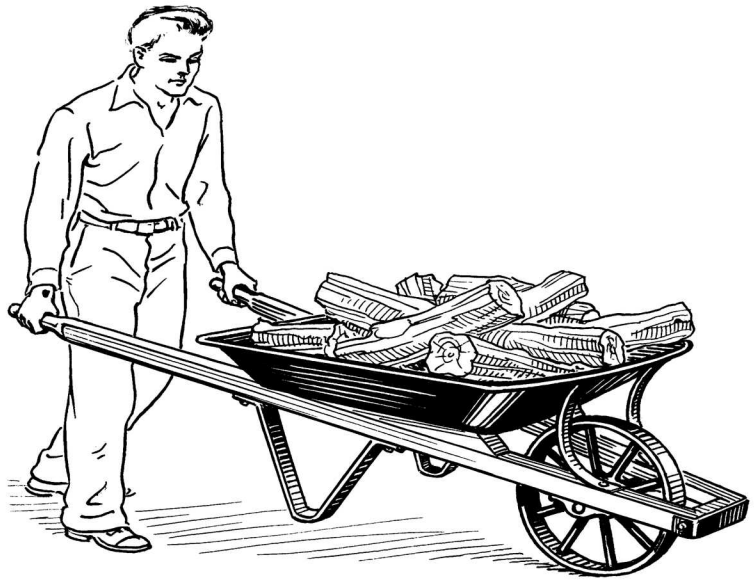


Desired State

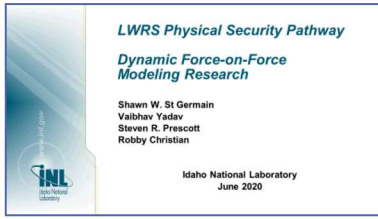
LWRS Physical Security Pathway R&D Focus

- Risk-Informing Physical Security
  - Dynamic Methods
    - Operator Action, FLEX use
    - Beyond Target Set Loss
  - Bayesian Applications to Adversary Timelines
  - Other (STPA, RIMES, HAZCADS, Other)
- Application and R&D of Advanced Technologies
  - Remote Operated Weapon Systems
  - Advanced Sensors
    - Deliberate Motion Algorithms
    - Water borne threat sensors
    - Other
- Industry Guided Needs

Physical Security Tools for Reducing Uncertainties



LWRS



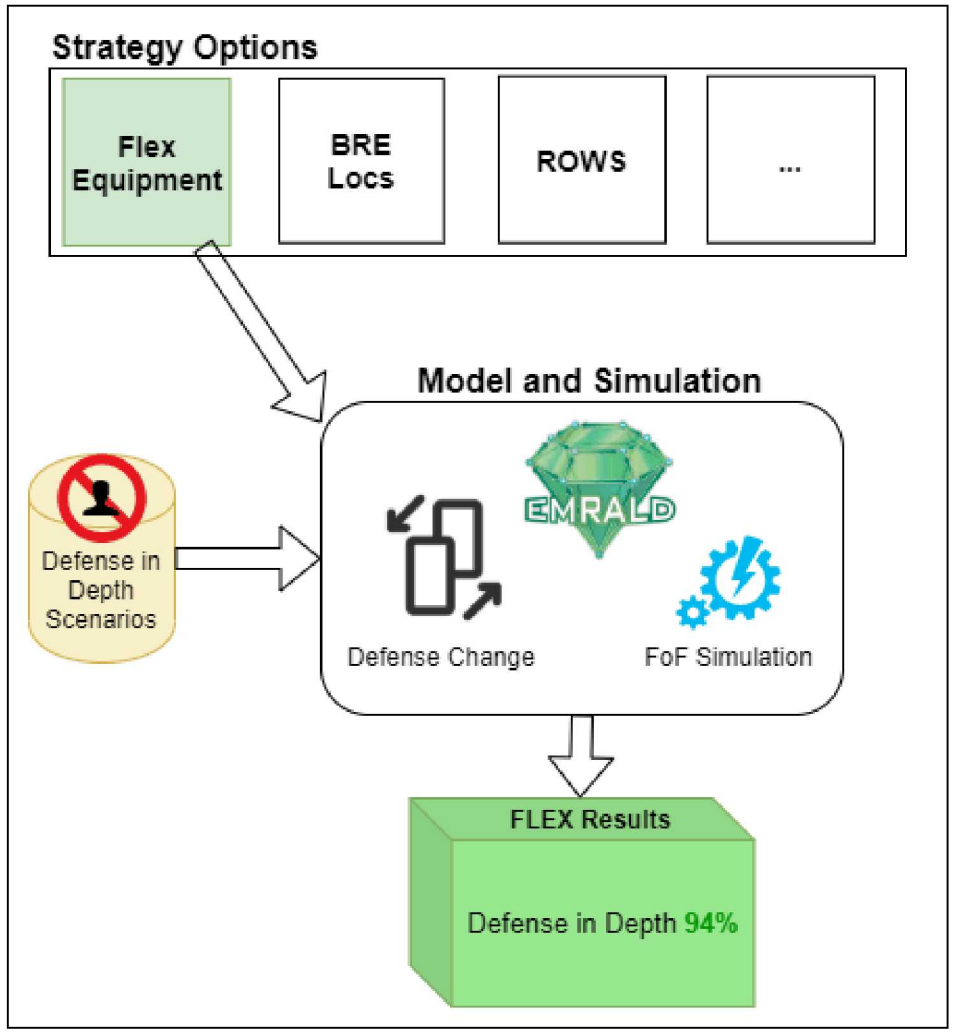
LWRS PSP Risk-Informed Activities

Research Objective

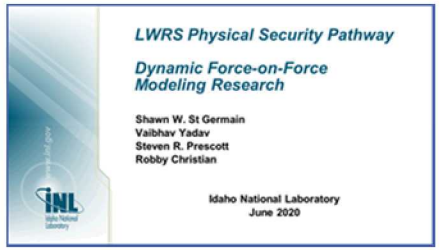
- Develop and demonstrate tools for a risk-informed physical security method capable of incorporating:
  - Dynamic risk methods,
  - FLEX portable equipment
  - Physics-based modeling and simulation
  - Operator actions
  - Tie with existing PRA models
- The enhanced dynamic modeling capabilities will enable an optimized physical security posture with
  - Reduced uncertainties and conservatism
  - Increased realism in FoF models
  - Quantitative metrics that reflect risk-informed measures of effectiveness
  - Improved technical basis for plant physical security

Potential Strategy Evaluation

1. Use research results and expert judgement to select strategy
2. Build model of Strategy using necessary tools
3. Use DiD scenarios from base results for varied data sets
4. Run simulations
5. Evaluate results for large increase in safety margin



Simulation Tools and Optimization Areas

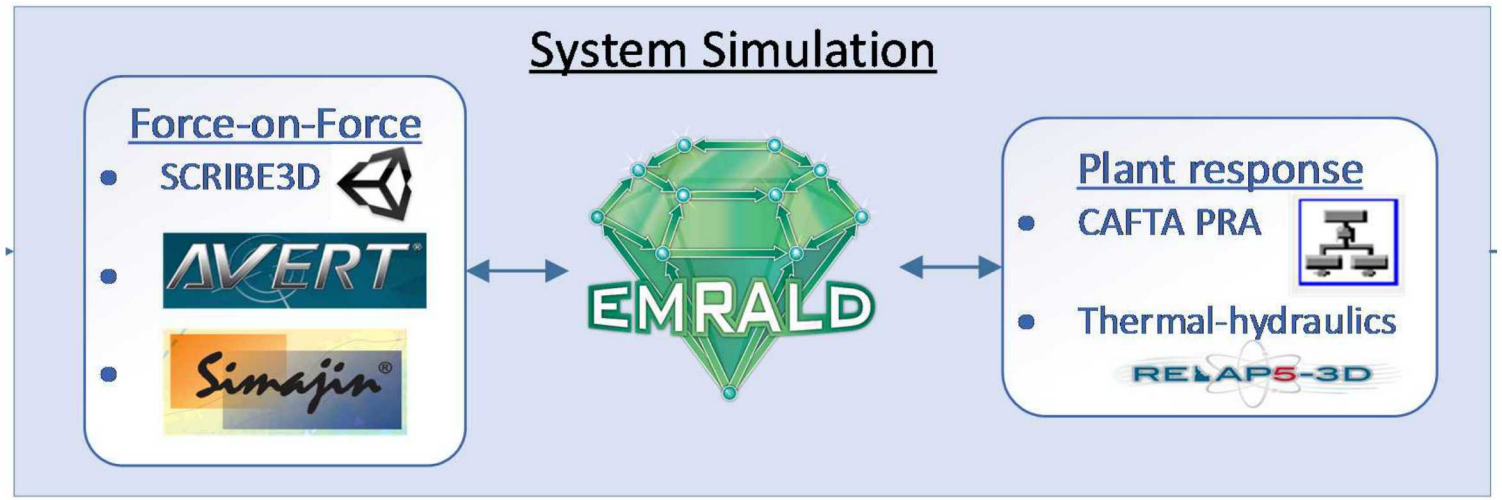


Tools

- Scribe 3D
- Avert
- Samajin
- EMRALD

Optimization Areas

- Human Performance Modeling
- Modeling Limitations
- Equipment & design Evaluation
- Flex Equipment
- BRE Optimization



Use Case Study 1 : Bathroom Breaks

Shawn W. St Germain
Vaibhav Yadav
Steven R. Prescott
Robby Christian

Idaho National Laboratory
June 2020

What risk increase is there for an attack scenario if guards are allowed to take random and unobservable bathroom breaks from BREs without a relief requirement?

Results

1E6 simulations → 560 attacks → 39 times (7%) guards not ready

Case Study: Phys. Prot. Design Comparison

- Enumerate combinations of these elements in EMRALD:
  - SPO guards
  - Mobile tactical Response Force (RF)
  - Smoke generator as an indoor delay element
  - A pair of Remote Operated Weapon Systems (ROWS)

  Total 2^4-1 = 31 combinations

LWRS LIGHT WATER REACTOR SUSTAINABILITY

LWRS Physical Security Pathway

Dynamic Force-on-Force Modeling Research

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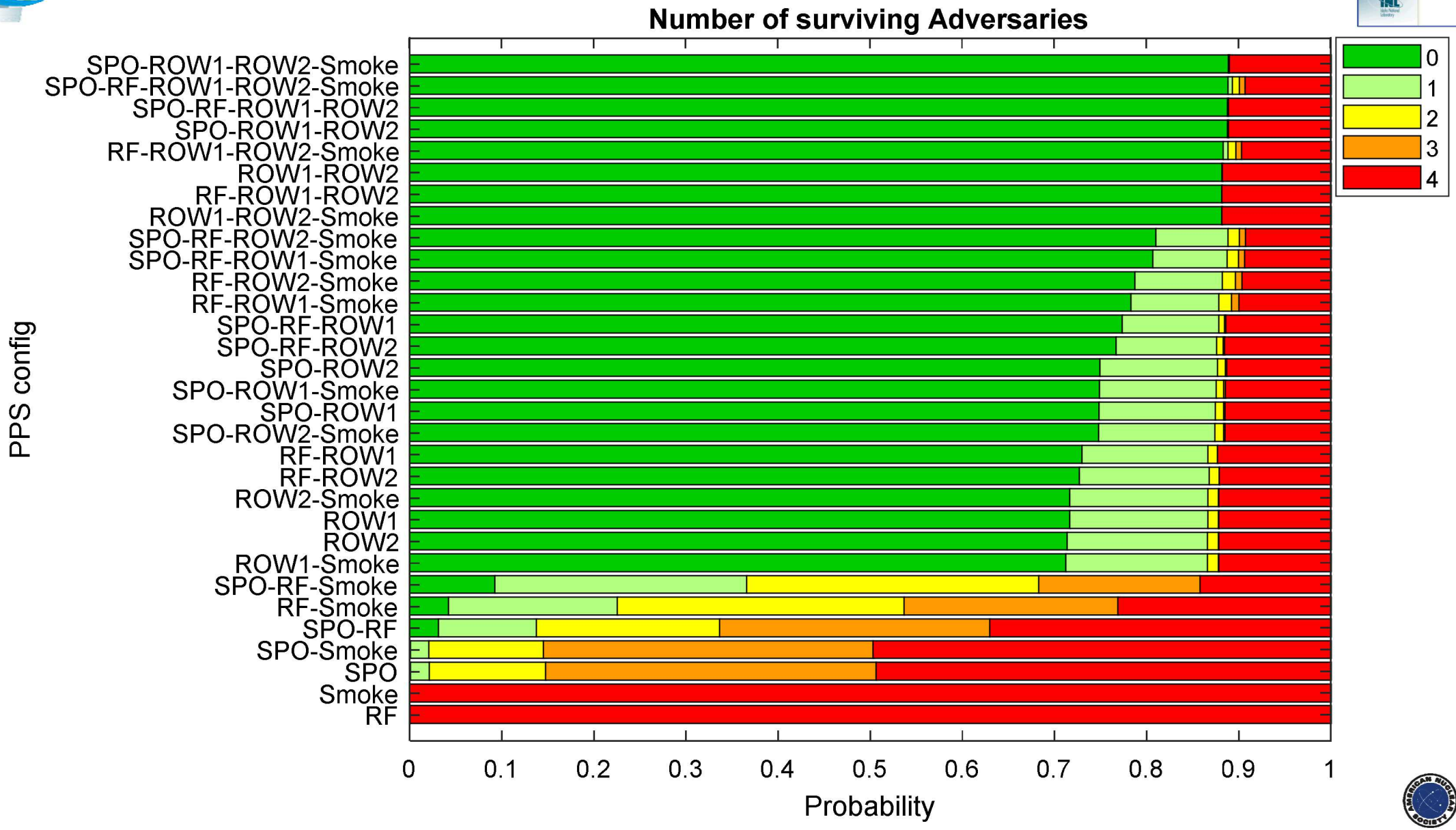

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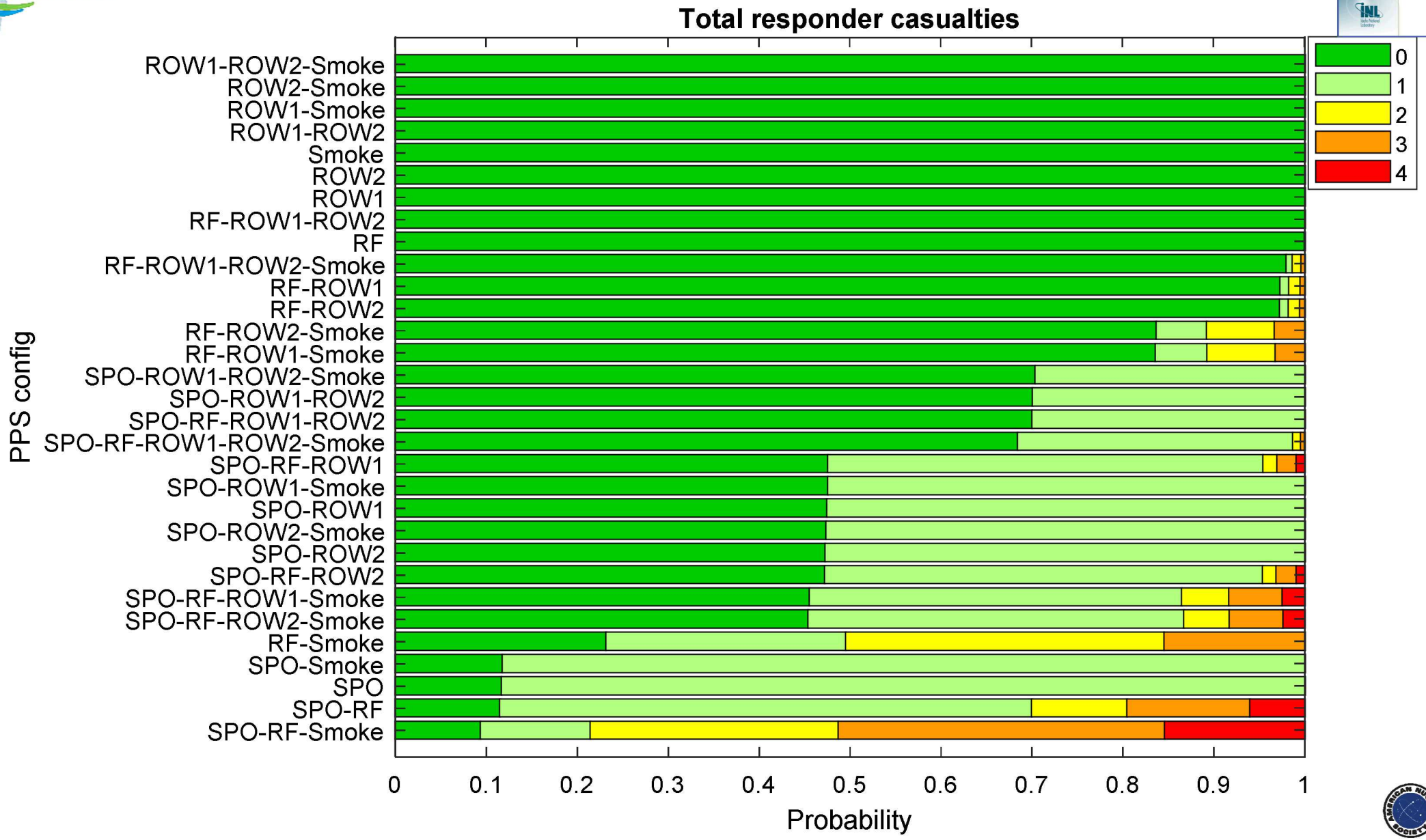

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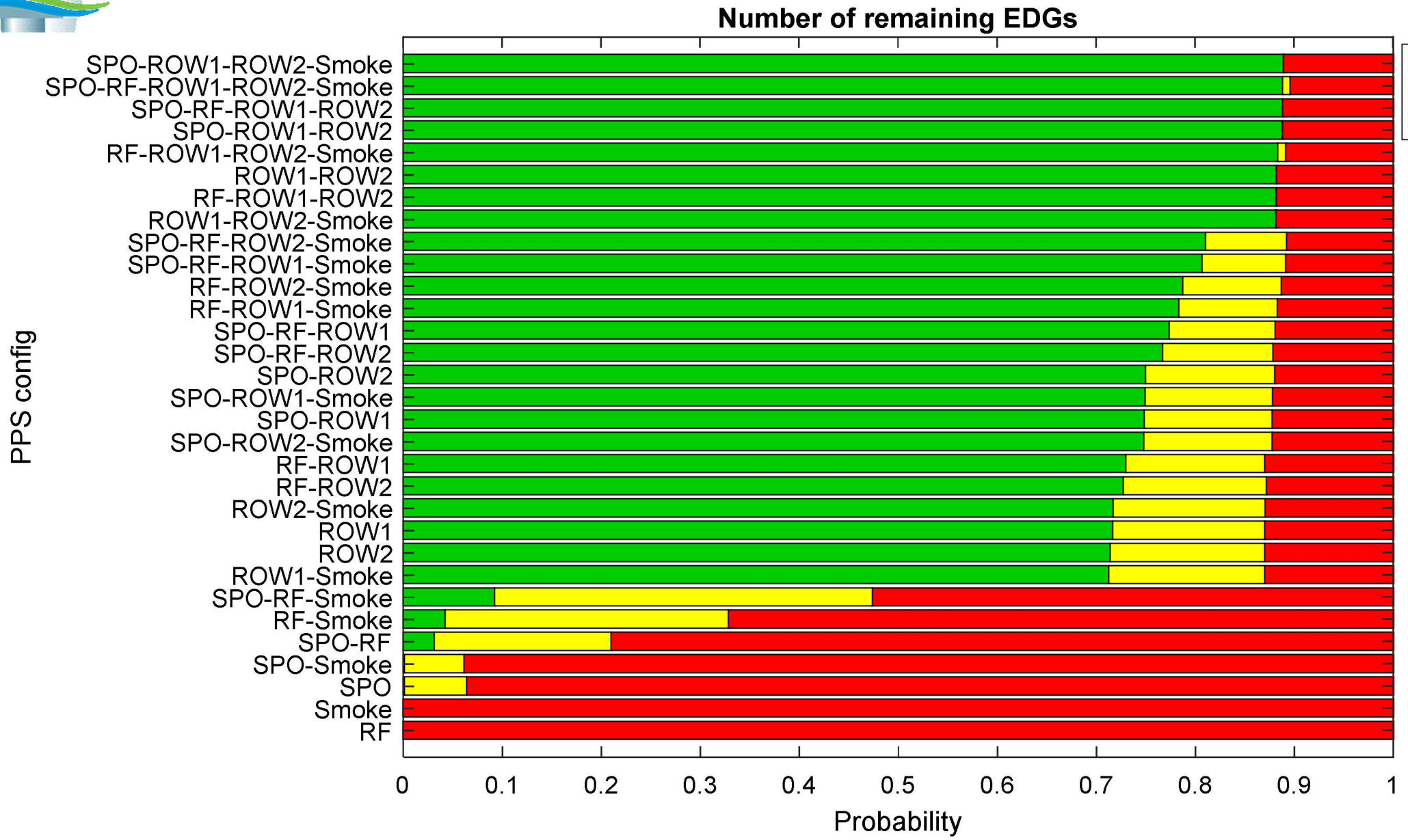

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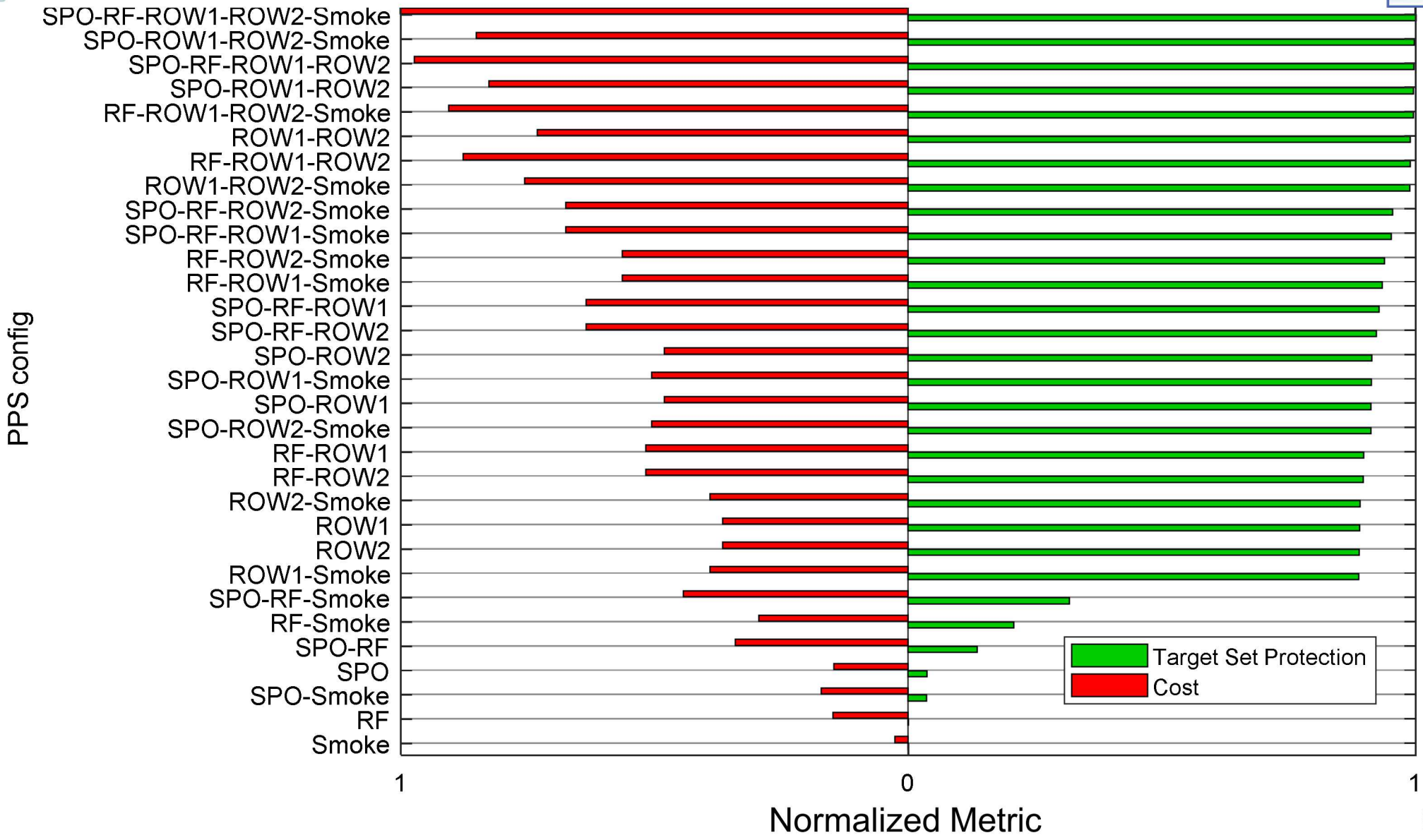
SPO-RF-ROW1-ROW2-Smoke
SPO-ROW1-ROW2-Smoke
SPO-RF-ROW1-ROW2
SPO-ROW1-ROW2
RF-ROW1-ROW2-Smoke
ROW1-ROW2
RF-ROW1-ROW2
ROW1-ROW2-Smoke
SPO-RF-ROW2-Smoke
SPO-RF-ROW1-Smoke
RF-ROW2-Smoke
RF-ROW1-Smoke
SPO-RF-ROW1
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RF-ROW1
RF-ROW2
ROW2-Smoke
ROW1
ROW2
ROW1-Smoke
SPO-RF-Smoke
RF-Smoke
SPO-RF
SPO
SPO-Smoke
RF
Smoke
PPS config
Target Set Protection
Cost
1
0
1
Normalized Metric

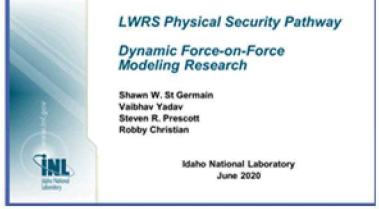
Safety Equipment

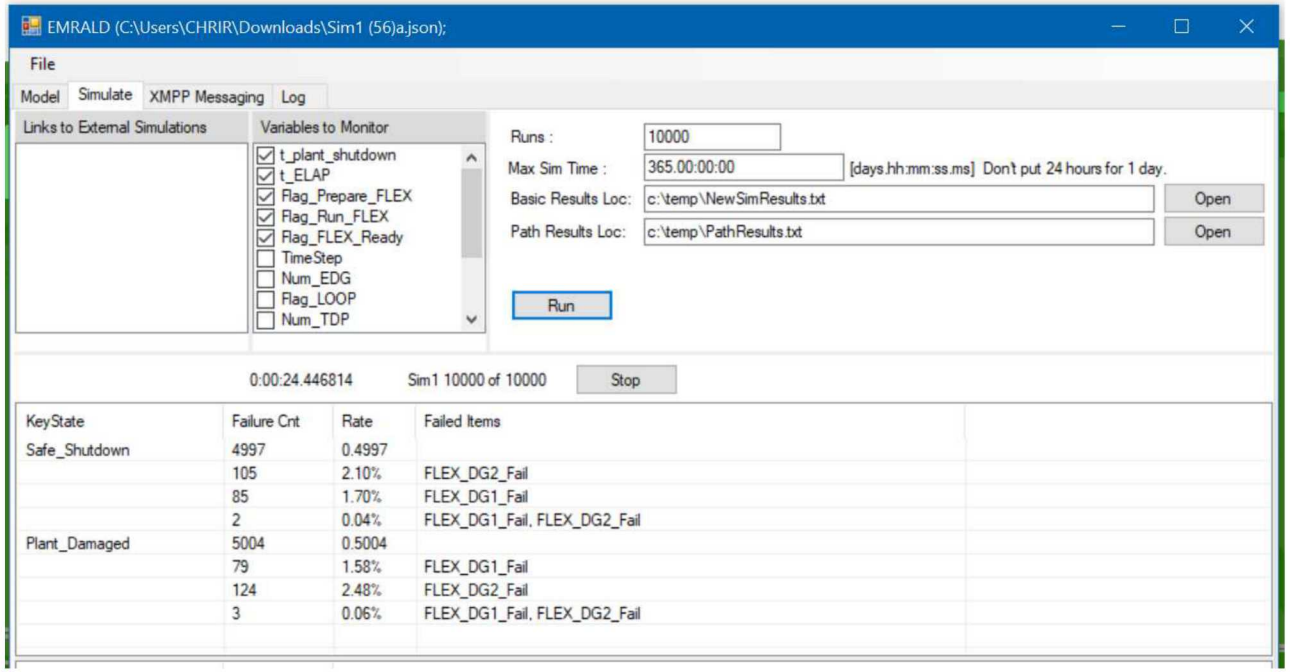
Diverse and Flexible Mitigation Strategy (FLEX)

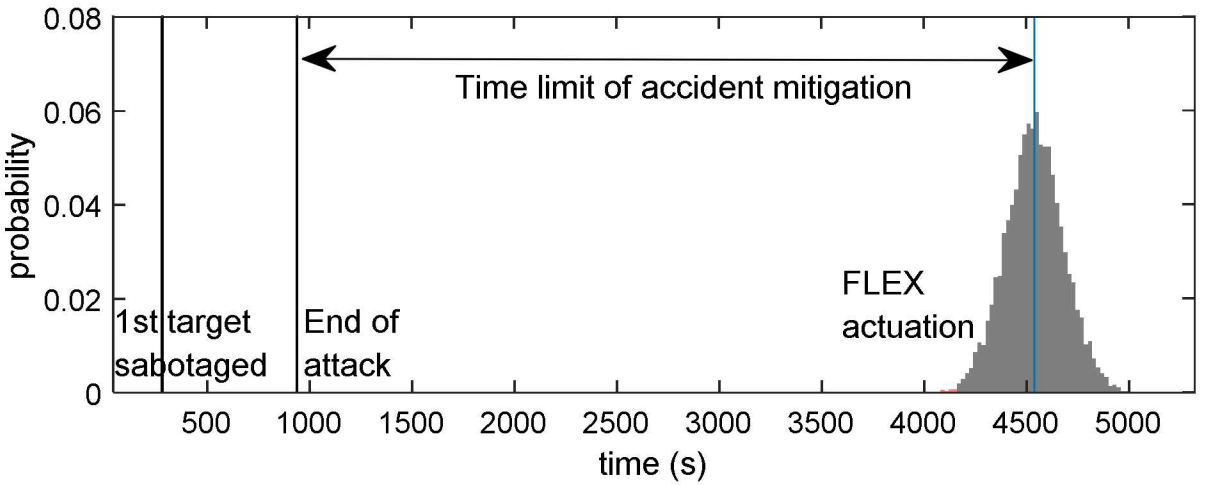
Hypothetical Plant

Scenario:
Damage NPP by sabotaging its power line, EDGs and TDPs

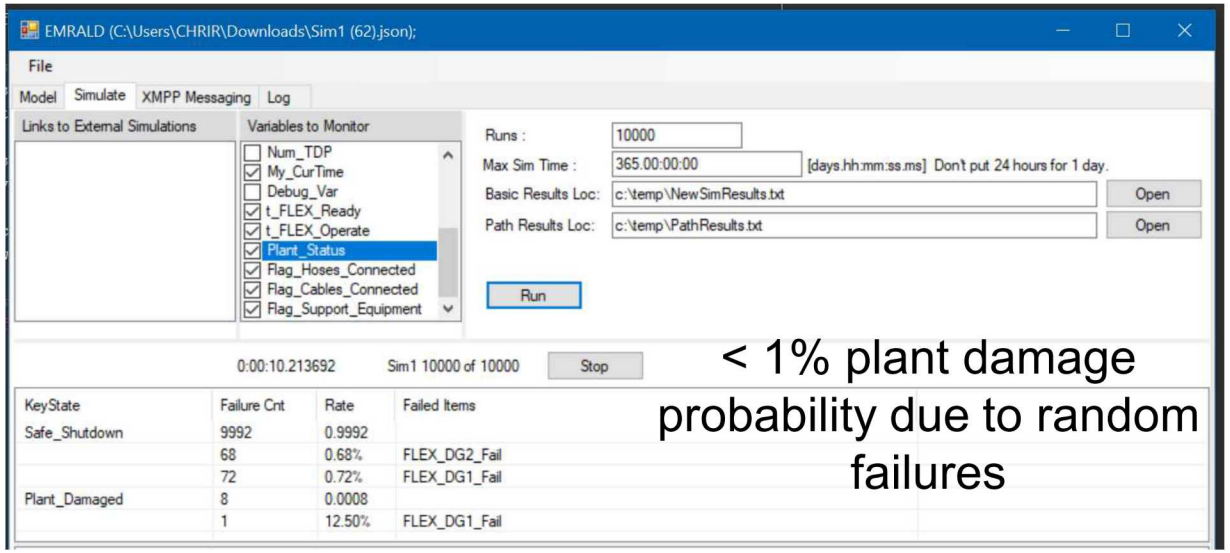
Station Blackout	AFW Using TDP	Recover Offsite Power (Early)	AFW Using MDP	Steam Removal Using MSADV	Steam Removal Using MSSV	Recover Offsite Power (Late)	NO	SP[1)]
SBO	AFT	RACE	AFM	SHR1	SHR2	RACL		
						9.61E-1	1	9.31E-1
				9.723E-1		3.9E-2 (11 HR)	2	3.78E-2
	9.963[illegible]E-1					9.0E-1	3	2.484E-2
					9.99885E-1	1.0E-1 (7 HR)	4	2.76E-3
				2.77E-2	1.15E-4		5	3.173E-6
				9.96791E-1			6	1.386E-3
			9.991486E-1		9.990484E-1		7	4.458E-6
		3.8E-1		3.209E-3	9.516E-4		8	4.246E-9
			8.514E-4				9	1.185E-6
		(1 HR)						CD in 1 hr





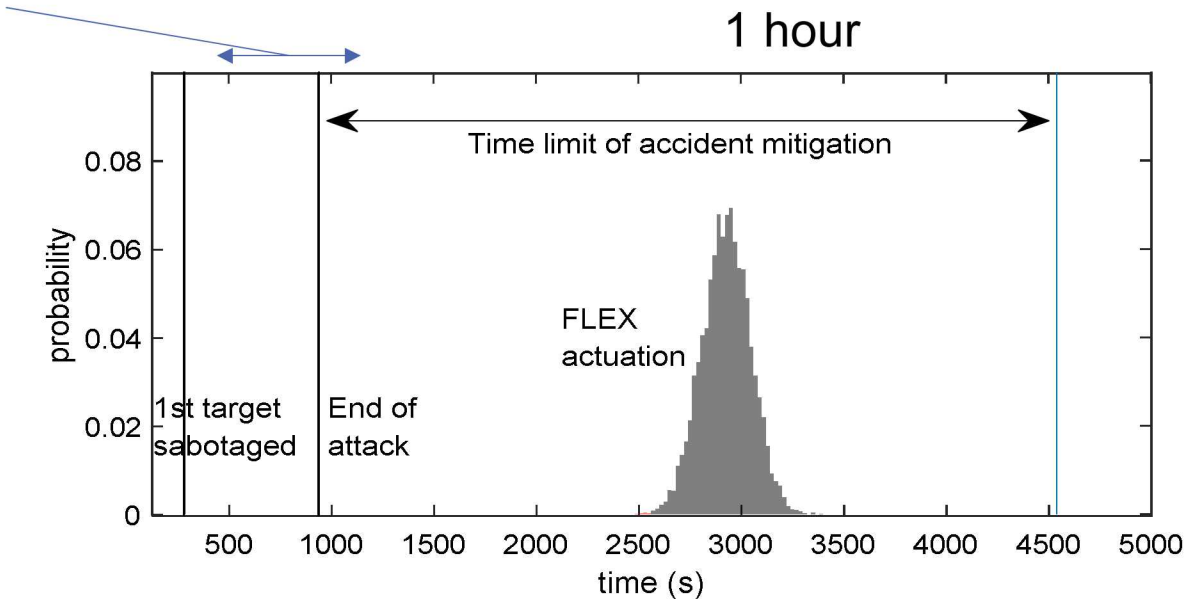


- Potential Flex Benefit
- Need rules for acceptance



< 1% plant damage probability due to random failures

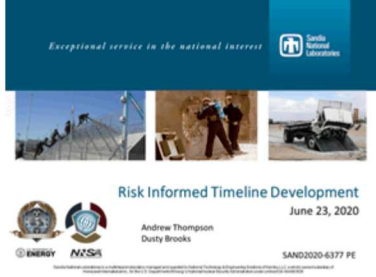
Value of non-lethal denial (e.g. sticky foam, smoke generator)



Bayesian Updating: Risk Informed Timeline Development

- Bayesian updating is a method to incorporate a prior belief and update it based on additional information that has become available
  - Prior beliefs can be subjective, such as SME judgement, or quantitative, such as previous relevant test data
- Has been widely developed in recent years to support machine learning and artificial intelligence
- While related to machine learning, does not have the same “black box” concerns that other machine learning methods can create
- Bayesian methods can be used with smaller data sets than frequentist methods, and due to the costs associate with delay tests we often work with limited data

Benefits of Risk Informed Timeline Analysis



- Moving to a risk informed method allows the focus to move from the attacks that are the fastest, to the attacks that are most likely to succeed
  - Repeat timeline analysis for multiple potential paths
  - Adversaries are going to try to maximize their chance of success, which does not always equate to the shortest timeline in and out
- Provides a broad understanding of which pathways have the most risk associated with them, allowing prioritization of funds for upgrading physical protection systems
- Provides a method for combining all available data in a statistically sound and consistent way
- Provides more detailed probability distributions for incorporating into modern system evaluation tools
- May allow reconsideration of DBT elements, as with a risk informed basis it may be feasible to address a wider range of threats, resulting in higher overall system performance

Future Goals for Risk Informed Timeline Development

- Generate a tool that can be used by SMEs to create timelines
  - Standardize methods for timeline development
  - Create GUI that is able to pull performance data from a database to simplify generation of timelines, include probability distributions when feasible
  - Allow SMEs to generate probability distributions for tasks that are not well characterized
  - Generate timeline with automatic references to data source, annotation of tasks that required SME judgement, and probability distribution curves for the time to completion and chance of success for each individual task as well as any combination of tasks
  - Include tools to utilize Bayesian updating if additional information is generated through performance testing or additional SME analysis

Key Industry Collaborations

LWRS LIGHT WATER REACTOR SUSTAINABILITY

Southern Nuclear

Xcel Energy

Entergy

STP Nuclear Operating Company

TVA

Exelon

Dominion Energy

STARS Alliance

PaloVerde GENERATING STATION

WOLF CREEK

PG&E

INL Idaho National Laboratory

NNSA National Nuclear Security Administration

OAK RIDGE National Laboratory

precision remotes Remote Weapon Stations

COUNTERFORCE DEFENSE

Sargent & Lundy

ARES SECURITY

Rhino Corps

Westinghouse

NEI NUCLEAR ENERGY INSTITUTE

EPRI ELECTRIC POWER RESEARCH INSTITUTE

U.S.NRC United States Nuclear Regulatory Commission *Protecting People and the Environment*

Sandia National Laboratories

Y-12 National Security Complex

OHIO STATE

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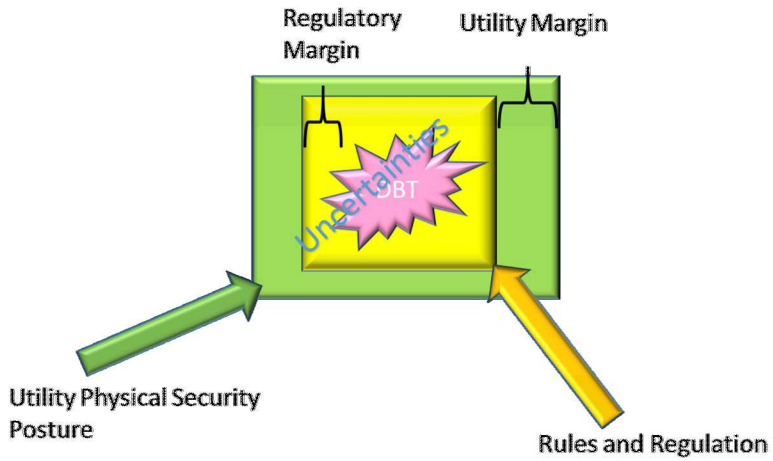
Conclusion

- **Physical Security** research aims to create tools, technologies, and risk-inform physical security decisions and activities
- Developing mitigation strategies and enhance the technical basis necessary for stakeholders to reevaluate physical security postures while meeting regulatory requirements.
- Create new technologies, methods, and tools to optimize physical security at U.S. nuclear power plants that address Design Basis and regulatory requirements.
- Near-term goal is to develop approaches to enable industry to operate nearer the staffing requirements of 10 CFR 73.55.



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