RISE

Probabilistic Safety Assessment and Management (PSAM)
PSAM 16
Honolulu Hawaii USA
2022
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Sheraton Waikiki
Honolulu, O'ahu, Hawaii
USA

DEVELOPMENT OF AN ENTERPRISE DIGITAL PLATFORM FOR RISK-INFORMED DESIGN

Cesare Frepoli, FPoliSolutions

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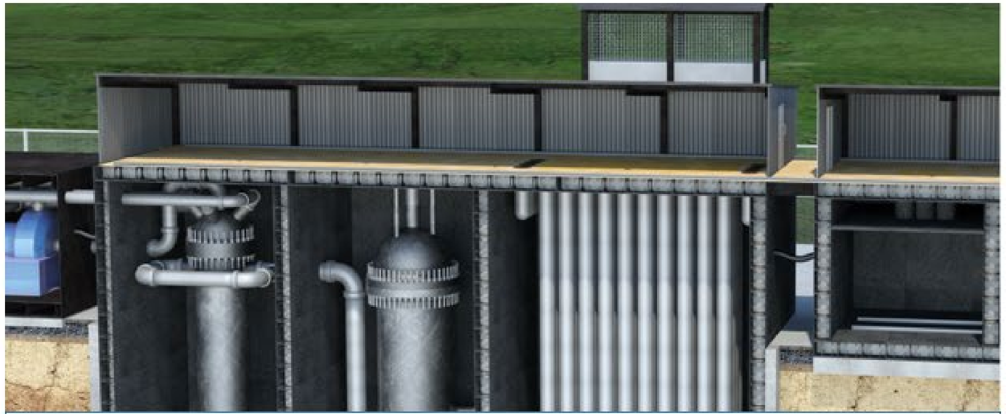
DOE Advanced Reactor Demonstration Program Is Transforming Paper Reactors into Real Reactors

ARDP



Paper Reactor

- Simple, Small, Cheap, Light
- Can be built Quickly
- Flexible Purpose
- Little Development required
- "Off the shelf" components
- Study Phase

Real Reactor

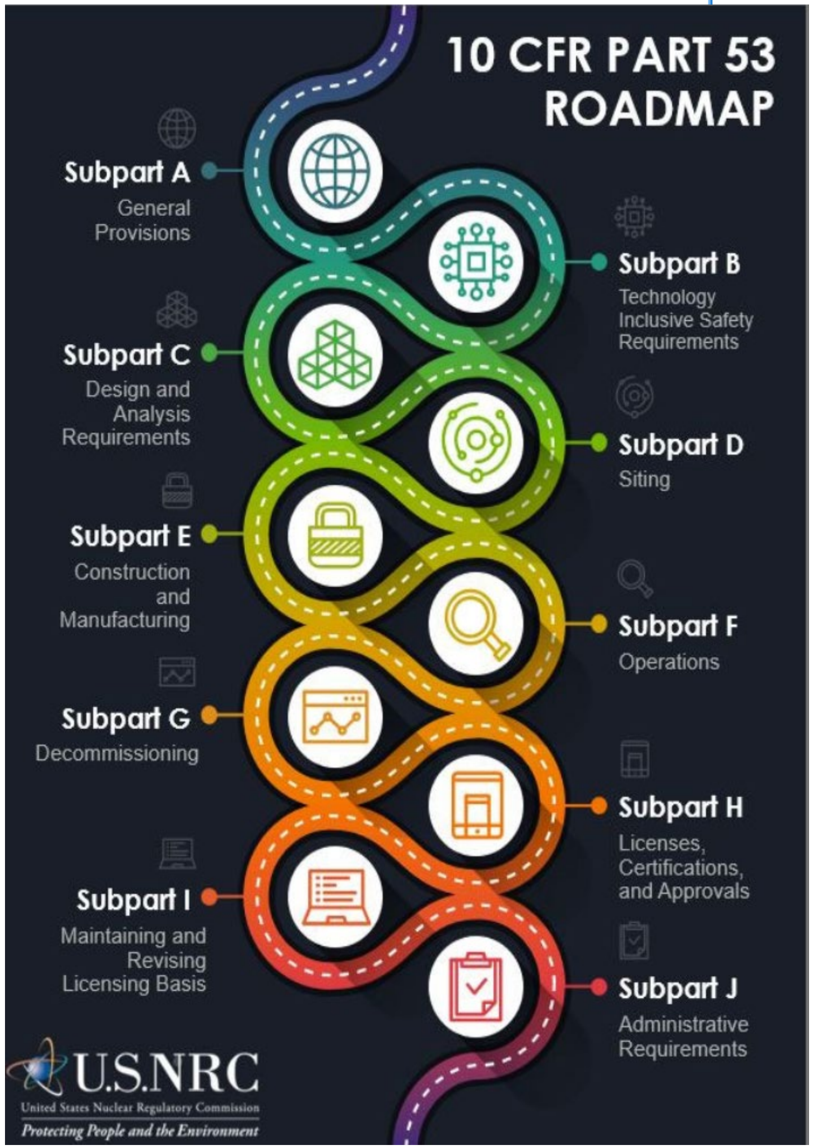
- Being Built Now
- Behind Schedule
- Development on seemingly Trivial Items
- Long Build time
- Expensive, Large, Heavy, Complicated

How can we facilitate adoption of risk-informed approach to define 'safety case' without burden with higher regulatory risks and licensing costs?

THE NPP SAFETY CASE PROBLEM

The Licensing Modernization Project

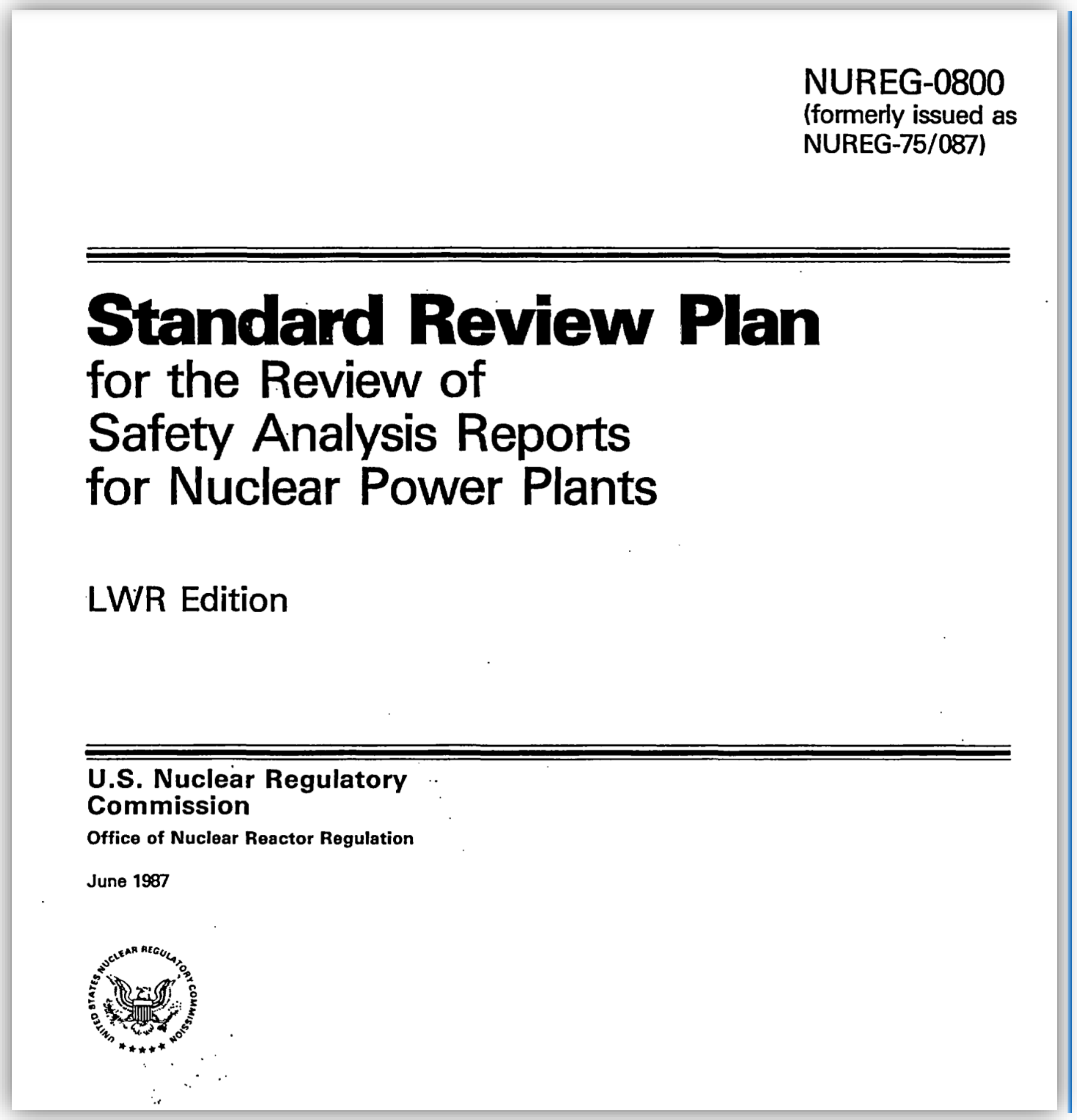
- In July 2020, the USNRC approves new approach to streamline advanced reactor licensing process → 10 CFR Part 53
- A roadmap for its implementation was published by NEI in the report NEI 18-04, Revision 1
- Several Advanced Reactor developers participated in demonstrating possible implementation of the roadmap as part of the DOE-sponsored Licensing Modernization Project (LMP)



Still, many AR developers are not fully adopting Part 53! Why??

Risk-Informed, what does it mean?

- Risk quantification boils down to answering these questions:
  - What can go wrong?
  - How likely is it?
  - What are consequences?
- Two approaches used to answer those questions:
  - Deterministic (sometime called bounding)
  - Risk-Informed
- Safety arguments can be qualitative or quantitative
  - Quantitative arguments can be deterministic or probabilistic
- Historically a deterministic approach is at the basis of the Standard Review Plan (NUREG-0800)
  - Definition of maximum credible accident/s (MCA)
  - Layers of conservative assumptions (e.g. single-failure)
  - PRA performed as 'confirmatory' step


NUREG-0800
(formerly issued as
NUREG-75/087)

Standard Review Plan
for the Review of
Safety Analysis Reports
for Nuclear Power Plants

LWR Edition

U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation

June 1987

Risk-Informed: Drivers

- USNRC trends to stronger and more risk-informed regulation
  - Performance-based
  - Technology-neutral
  - Enhanced transparency
- The Licensing Modernization Project (LMP) was the basis for NEI 18-04 roadmap
- However, industry and rulemaking is moving toward a more flexible ‘graded’ approach
  - An applicant may choose a PRA “leading approach”, as articulated in NEI 18-04.
  - Another may opt for a “confirmatory/supporting” role, more in line with the previous Part 52.
- The choice is based on the specificity of a particular technology aiming to the most efficient definition of the “safety case”
- **Industry opinion is that for very simple designs, PRA may not provide any <u>practical</u> benefit over alternative methods considered for the definition of the safety case**

Our solution to help advanced reactor developers to orchestrate the complexities associated with implementing a risk-informed design process while reducing design cycle and costs

1. Create a collaborative environment for engineering teams and stakeholders within their organization as they build the 'safety case' for their plant
2. Digest large and complex data structures needed to characterize the engineered safety features and relationships with scenarios and events
3. Optimize design to satisfy safety and economics goals
4. Guide analysts through complex workflows of simulations, data processing and qualification, analyses, and documentation
5. Maximize the value of enterprise technical data with enhanced security and process automation
6. Automate the creation of documentation and smart procedures for quality, transparency and expedited regulatory review
7. Provide a platform for maintaining the safety case throughout the life of the plant
8. Fit seamlessly within established processes of the organization

RISE Enterprise Solution

SYSTEM INGINEERING

SAFETY ANALYSIS

LICENSING

Enterprise critical data management

- System architecture
- Structures, system and components
- Test data
- System parameters
- Customer API
- Functional requirements

Modeling and simulations

- Scenarios
- Plant model and digital twin
- Physics codes / tools of choice
- Evalution model and methodologies
- Simulations workflows

Analysis

- Analytical models calibration and quantification
- Optimization
- Uncertainty quantification
- Probabilistic risk assessment
- Sensitivity analysis
- Machine learning and AI

Digital toolbox

Collaboration | Data security | Scrutability | Single point-of-truth

- Licensing basis events evaluations
- Structures, systems and components safety classifications
- Near real-time safety margins tracking, monitoring and trending
- Safety analysis reports updates

RISE Enterprise Solution

Tools + Methodology + A plant that behaves as predicted = Licensable and Operable Reactor

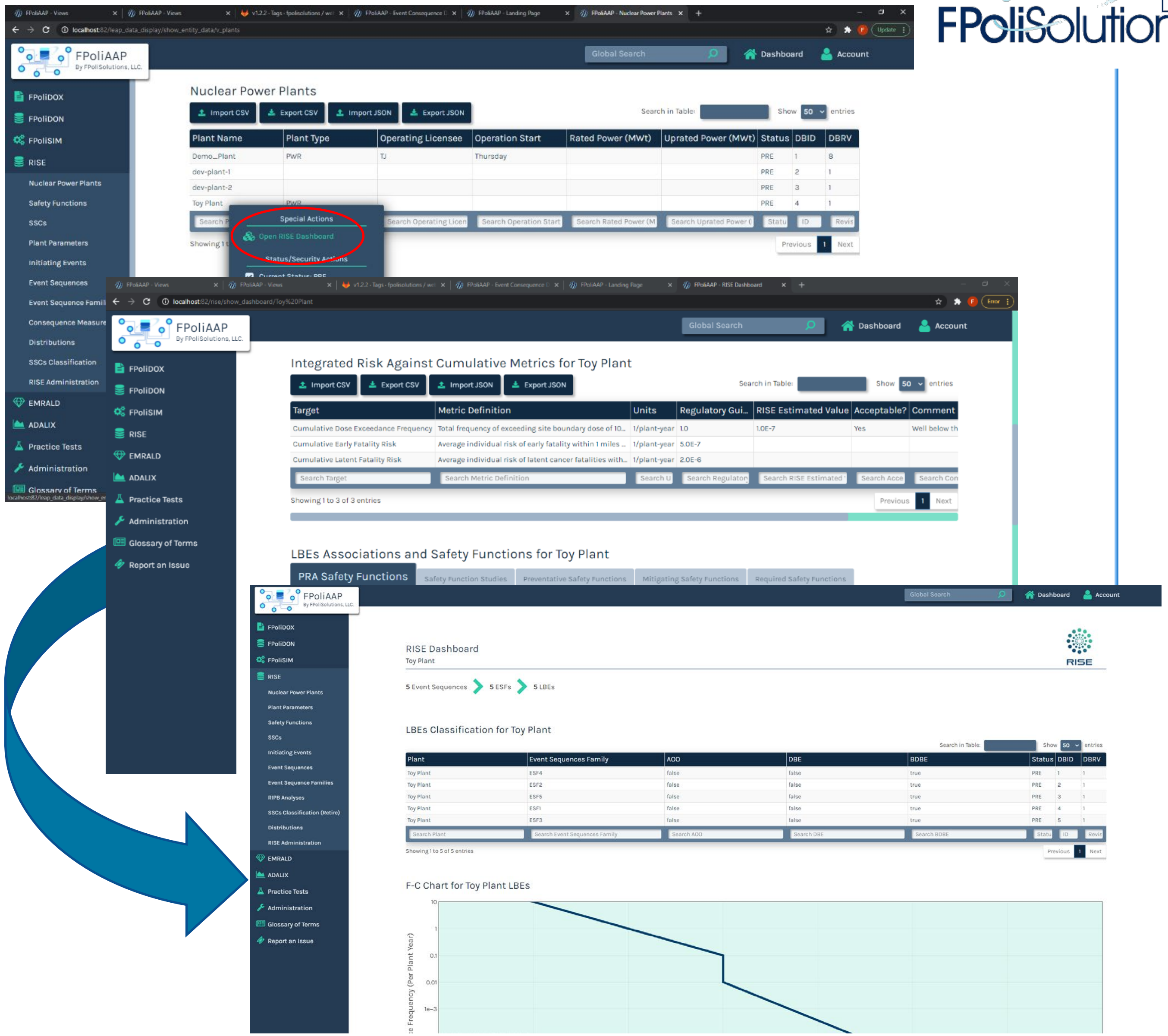
RISK-INFORMED DESIGN → Optimized design and safety margin characterization

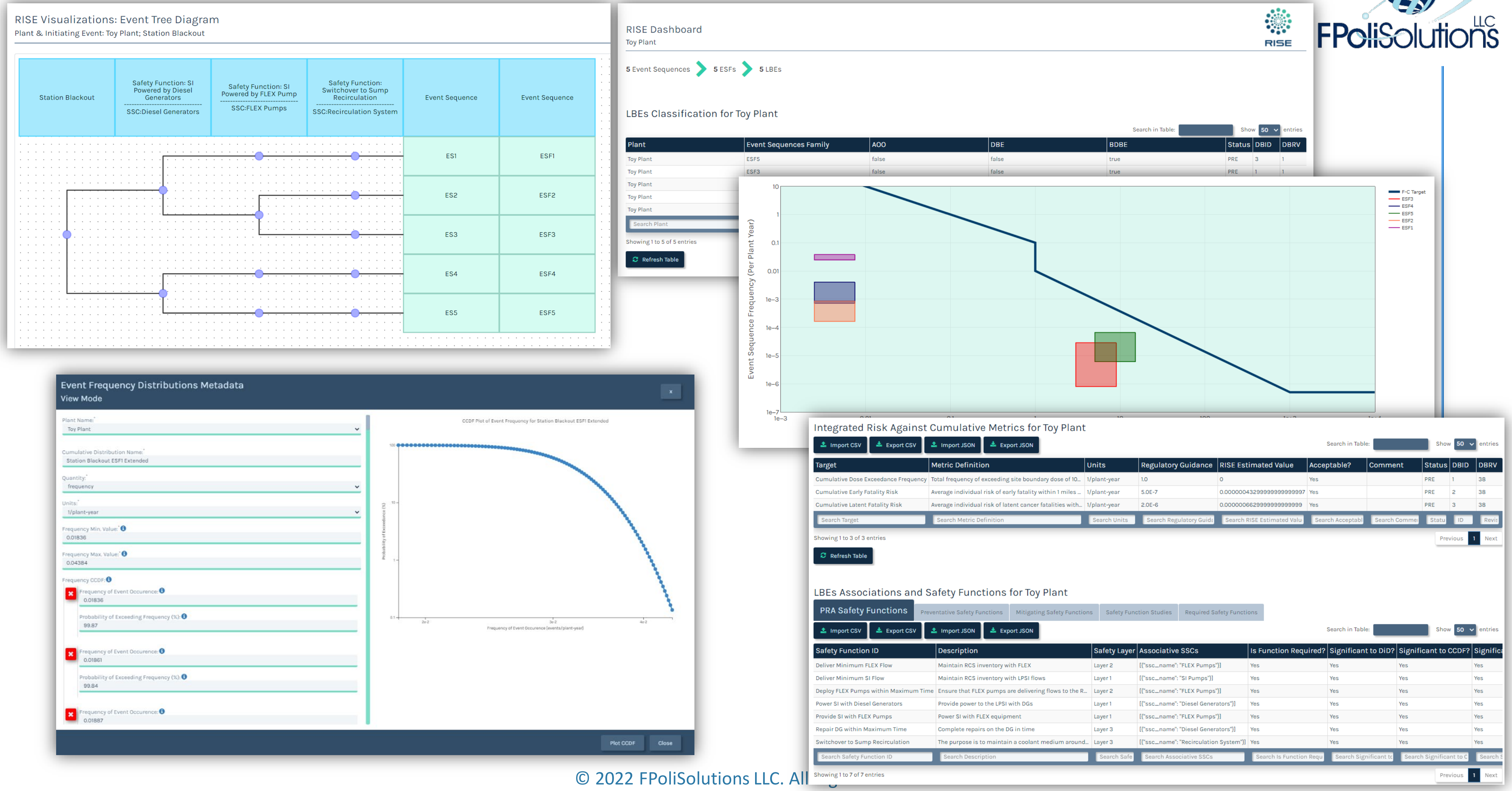
SAFETY ANALYSES → Credible and defensible defensible safety case

LICENSING → Transparent/scrutable safety case for rapid licensing and deployment → Maintainable during the operation

1. Condition monitoring and impact to risk profile
2. Automation
3. Optimize operation
4. Digital Twin

- Ability to import the engineering data (plant description) into the database
- Program the risk-informed methodology in the framework
- Orchestrate the activities around building and documenting the safety case of the target plant/design
  - Design Requirements
  - SSCs design parameters
  - Hazards identification and analysis
  - Modeling and simulation of events
  - SSCs safety classification
  - Defense-in-depth demonstration




RISE Visualizations: Event Tree Diagram
Plant & Initiating Event: Toy Plant; Station Blackout
Station Blackout
Safety Function: SI Powered by Diesel Generators
SSC:Diesel Generators
Safety Function: SI Powered by FLEX Pump
SSC:FLEX Pumps
Safety Function: Switchover to Sump Recirculation
SSC:Recirculation System
Event Sequence
Event Sequence
ES1
ESF1
ES2
ESF2
ES3
ESF3
ES4
ESF4
ES5
ESF5
RISE Dashboard
Toy Plant
RISE
5 Event Sequences
5 ESFs
5 LBEs
LBEs Classification for Toy Plant
Search in Table:
Show 50 entries
Plant | Event Sequences Family | AOO | DBE | BDBE | Status | DBID | DBRV
Toy Plant | ESF5 | false | false | true | PRE | 3 | 1
Toy Plant | ESF3 | false | false | true | PRE | 1 | 1
Toy Plant
Toy Plant
Toy Plant
Search Plant
Showing 1 to 5 of 5 entries
Refresh Table
Event Sequence Frequency (Per Plant Year)
10
1
0.1
0.01
1e−3
1e−4
1e−5
1e−6
1e−7
F-C Target
ESF3
ESF4
ESF5
ESF2
ESF1
Event Frequency Distributions Metadata
View Mode
Plant Name:
Toy Plant
Cumulative Distribution Name:
Station Blackout ESF1 Extended
Quantity:
frequency
Units:
1/plant-year
Frequency Min. Value:
0.01836
Frequency Max. Value:
0.04384
Frequency CCDF:
Frequency of Event Occurence:
0.01836
Probability of Exceeding Frequency (%):
99.87
Frequency of Event Occurence:
0.01861
Probability of Exceeding Frequency (%):
99.84
Frequency of Event Occurence:
0.01887
CCDF Plot of Event Frequency for Station Blackout ESF1 Extended
Frequency of Event Occurence (events/plant-year)
Plot CCDF
Close
Integrated Risk Against Cumulative Metrics for Toy Plant
Import CSV
Export CSV
Import JSON
Export JSON
Target | Metric Definition | Units | Regulatory Guidance | RISE Estimated Value | Acceptable? | Comment | Status | DBID | DBRV
Cumulative Dose Exceedance Frequency | Total frequency of exceeding site boundary dose of 10... | 1/plant-year | 1.0 | 0 | Yes | | PRE | 1 | 38
Cumulative Early Fatality Risk | Average individual risk of early fatality within 1 miles ... | 1/plant-year | 5.0E-7 | 0.000000432999999999997 | Yes | | PRE | 2 | 38
Cumulative Latent Fatality Risk | Average individual risk of latent cancer fatalities with... | 1/plant-year | 2.0E-6 | 0.000000662999999999999 | Yes | | PRE | 3 | 38
Showing 1 to 3 of 3 entries
Previous
Next
Refresh Table
LBEs Associations and Safety Functions for Toy Plant
PRA Safety Functions
Preventative Safety Functions
Mitigating Safety Functions
Safety Function Studies
Required Safety Functions
Safety Function ID | Description | Safety Layer | Associative SSCs | Is Function Required? | Significant to DiD? | Significant to CCDF?
Deliver Minimum FLEX Flow | Maintain RCS inventory with FLEX | Layer 2 | [{"ssc_name": "FLEX Pumps"}] | Yes | Yes | Yes
Deliver Minimum SI Flow | Maintain RCS inventory with LPSI flows | Layer 1 | [{"ssc_name": "SI Pumps"}] | Yes | Yes | Yes
Deploy FLEX Pumps within Maximum Time | Ensure that FLEX pumps are delivering flows to the R... | Layer 2 | [{"ssc_name": "FLEX Pumps"}] | Yes | Yes | Yes
Power SI with Diesel Generators | Provide power to the LPSI with DGs | Layer 1 | [{"ssc_name": "Diesel Generators"}] | Yes | Yes | Yes
Provide SI with FLEX Pumps | Power SI with FLEX equipment | Layer 1 | [{"ssc_name": "FLEX Pumps"}] | Yes | Yes | Yes
Repair DG within Maximum Time | Complete repairs on the DG in time | Layer 3 | [{"ssc_name": "Diesel Generators"}] | Yes | Yes | Yes
Switchover to Sump Recirculation | The purpose is to maintain a coolant medium around... | Layer 3 | [{"ssc_name": "Recirculation System"}] | Yes | Yes | Yes
Showing 1 to 7 of 7 entries

A Use Case: Risk-Informed a Microreactor Design

A customer needs an agile infrastructure to build the safety case for an innovative transportable micro-reactor

Compliance with drafted 10 CFR Part 53 is desired, but for more agility the customer wants to leverage inherent passive features of their design to strengthen the safety case, minimize regulatory burden and enable rapid prototyping and deployment.

Deamand: *"In a very short time deliver a quality-assured analysis conforming to NEI 18-04 (Rev 1) Risk-Informed Performance-Based Technology Guidance for a Non-Light Water Reactors"*