DEVELOPMENT OF AN ENTERPRISE DIGITAL PLATFORM FOR RISK-INFORMED DESIGN

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Abstract: Currently, many advanced reactor designs are under development in the U.S., promising sustainable solutions to the growing world energy needs. In response, the U.S. Nuclear Regulatory Commission (NRC) staff is moving forward with development of the 10 CFR Part 53 rulemaking, which will establish a new risk-informed framework for licensing and regulating such new designs. The motivation has been to develop a technology-agnostic regulatory framework; but in practice, it is important that the new rule is used and is useful, meaning that there is no unreasonable increase in regulatory burden and thus to the scope to the safety assessment. This is because the risk assessment is now folded in the design process itself, rather than being a simple confirmatory step of the design. Such a level of sophistication is only possible and practical in a highly automated and scrutable digital framework.

This paper describes a solution to this problem. An agile, generic, digital platform, called FPoliAAP, was developed to facilitate orchestration of complex workflows, taking advantage of modern software development and data management tactics while leveraging recent technologies developed at national laboratories such as Idaho National Laboratory's (INL) RAVEN and EMRALD frameworks. FPoliAAP is a suite of applications (or services) which, in the aggregate, can be seen as a "wizard" or smart procedure to help developers and regulators navigate through the process of building a transparent safety case.

One of these applications is called Risk-Informed System Engineering (RISE). The vision behind RISE has been to fully automate the workflow that connects the physical reality of the plant to its virtual representation in modeling (Digital Twin) to readily produce output which aids users in making risk-informed decisions that demonstrate the plant safety case consistent with RG 1.203, RG 1.233 and 10 CFR Part 53. For the sole purpose of illustration here, the RISE technology is presented using a simple metamodel that describes a PWR during a postulated Station Black Out (SBO) event.

1. INTRODUCTION

Currently, many advanced reactor designs are under development in the U.S., promising sustainable solutions to the growing world energy needs. In response, the U.S. Nuclear Regulatory Commission (NRC) staff is moving forward with development of the 10 CFR Part 53 rulemaking, which will establish a new risk-informed framework for licensing and regulating such new designs. The motivation has been to develop a technology-agnostic regulatory framework; but in practice, it is important that the new rule is used and is useful, meaning that there is no unreasonable increase in regulatory burden and thus to the scope to the safety assessment. This is because the risk assessment is now folded in the design process itself, rather than being a simple confirmatory step of the design. Such a level of sophistication is only possible and practical in a highly automated and scrutable digital framework.

An agile digital platform, called FPoliAAP, was developed to facilitate orchestration of complex workflows, taking advantage of modern software development and data management tactics while leveraging recent technologies developed at national laboratories such as Idaho National Laboratory's (INL) RAVEN and EMRALD frameworks. FPoliAAP is a suite of applications (or services) which, in the aggregate, can be seen as a ”wizard” to help developers and regulators navigate through the process of building a transparent safety case.

Figure 1. Licensing Modernization Project (source: [18])

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2. RISK-INFORMED DESIGN AND SAFETY CASE

The safety case for nuclear systems is a documented expression of safety, demonstrating the protective measures against uncontrolled radiological releases [12]. Safety equates to design resilience which must be coordinated with function and performance to form the foundation of a viable product. Given the real and perceived consequences of failure relating to providing power from nuclear energy, design resilience and safety take precedence over function and performance. As such, the introduction of safety characteristics early in the design process, especially for new designs, is essential to reduce uncertainties associated with safety throughout the product cycle.

The safety argument or claims can be qualitative or quantitative. Quantitative arguments can be deterministic (conservative) or probabilistic. The designer determines the most appropriate ”packaging” of such evidence with the goal of providing a logical, traceable and scrutable formal construct to regulators and, ultimately, to the public. Since the dawn of the nuclear industry, regulatory frameworks have been constructed to facilitate this complex process. Among these, the standard review plan (SRP), NUREG-0800 [13], was built on the experience of operating Light Water Reactors (LWRs), the predominant technology of the operating fleet in the U.S. The SRP is not a regulation by itself, but rather an outline of acceptable elements of review and compliance that is generally expected. The SRP suggests a specific list of initiating events to consider and classifies those in two broad categories based on anticipated frequency of occurrence, as either anticipated operational occurrence (AOO) and postulated accidents or Design Basis Accidents (DBA). Historically, the SRP and most NRC regulations and guidance are largely deterministic.

In general, the regulatory requirements and acceptance criteria were designed to ensure there are no undue risks to public safety due to the operation of nuclear facilities. The concept of “risk” to the public, as described by the NRC, can be characterized by asking, “What can go wrong?”, “How likely is it?” and “What are the consequences?”. These questions can be answered for each hypothetical scenario. The deterministic approach is well-suited to respond to most of these questions but does not address the “How likely is it?” question. This is why traditionally probabilistic risk assessment (PRA) analyses are conducted on the backend of the process to verify the safety case of a design.

In recent years, rulemaking and regulatory activities have become more “risk-informed” and “performance-based”. This trend is justified as a means to strengthen the regulations, ensure that resources are properly allocated and create a more technology-neutral regulatory environment. The Licensing Modernization Project (LMP), the roadmap formalized in NEI 18-04 and ultimately the proposed regulatory framework in the 10 CFR Part 53, is consistent with these trends. This approach asks for a maximal role of PRA early in the design process.

A risk-informed approach is currently considered by the developers of advanced reactors. However, the industry recognizes the challenges in reliance on a maximal PRA role in their design and licensing efforts. Rather, a degree of flexibility is deemed necessary, and the conversation is around a more pragmatic graded approach.

The unified industry position to Part 53 was recently included in a letter to the NRC, coordinated by NEI [14]. The letter elaborates on key elements to be considered in the rulemaking. Specifically, the view of the industry stakeholder is for the new rule to be “used and useful”, “efficient”, “technology inclusive”, “risk-informed”, “to recognize confidence in licensee control” and consider “urgency” in the finalization of the rule. With regard to the use of PRA techniques in the risk-informed approach, the industry is seeking a graded approach, with some degree of optionality through alternative requirements. 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”. The argument is that, for very simple designs, PRA may not provide any practical benefit over alternative methods considered for the definition of the safety case.

The common theme in the industry debate is the recognition that establishing an efficient and practical regulatory framework that will minimize unnecessary friction for safe and rapid deployment of new nuclear reactor technologies is a complex exercise. This also reveals the need and opportunity for the development of instruments in the digital age that can facilitate and streamline the engineering processes involved. A response to these needs is what motivated the development of the RISE application, described in the next section.

3. RISE: THE DIGITAL SOLUTION TO ORCHESTRATE RISK-INFORMED DESIGN WORKFLOWS

To address the challenges in adopting a risk-informed approach early in design, a smart instrument is needed to:

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

These quality attributes were the motivation behind the development of the RISE platform. The need was to construct a framework that can intelligently guide and organize critical engineering data and decisions toward the creation of a robust, defensible, and traceable safety case of new reactor systems and the ability to maintain the safety case throughout the entire product cycle including the conceptual and detailed design, testing, deployment and operation.

RISE is one of the applications powered by the FPoli Agile Application Platform, FPoliAAP [15]. The generic platform uses modern data management and simulation management tactics to orchestrate complex workflows with a highly and rapidly customizable UI/UX. Several use cases can be supported from test data management (FPoliDON) [16], document management (FPoliDOX) and simulation management applications (FPoliSIM). The generic framework can access a vast library of optimization and machine learning algorithms which can be invoked as needed. RISE was recently added to the suite as the service to automate and facilitate the workflow associated with NEI-18-04 as shown in Figure 2. All artifacts are stored in a central relational database which represents a single point-of-truth accessible simultaneously from multiple sites and multiple users within an organization. The data is shared among the subscribed applications.

Plant design data is loaded and warehoused from a variety of sources, reviewed and qualified. When the data is ingested and prepared for use, the powerful RISE workflow orchestrator guides the engineer through the intricacies of building a risk-informed ”safety case” of the plant design without impeding, but rather augmenting, the creative aspects and value of the engineering exercise in a collaborative framework typical of an enterprise solution.

The system engineer starts by collecting reactor design data and metadata. APIs are available to interface with user system engineering tools. Relationships to systems design requirements, engineered safety functions and parameters are established. The data set includes owner design requirements, economics targets and safety constraints. Once the available data is entered, this forms the current snapshot of the plant design with the characterization of considered systems, structures and components (SSCs). At the same time, the designer identifies and describes a list of plausible initiating events and event sequences which are then organized into a database of licensing basis events (LBEs), also known as the safety basis events.

The safety analyst enters safety evaluation criteria and metrics for the safety assessment. The user may elect to enter criteria described in NEI 18-04 (Part 53), but they are not limited to those criteria. If desired, probabilistic risk assessment artifacts and results are entered to inform the classification of LBEs. LBEs are evaluated leveraging the powerful simulation manager service, FPoliSIM. The simulation manager guides the analyst in developing the evaluation model, performing simulations – the digital twin representation of the plant – and postprocessing the results following the established metrics and criteria. FPoliSIM is essentially an API that allow a user to coordinate simulations frameworks with a variety of simulation tools. FPoliSIM is built around RAVEN technology [8] as the workflow engine. In this specific case FPoliSIM manage the workflow with RELAP5-3D through RAVEN and provide the user interface to inject data from the FPoliAAP database in the RELAP5-3D input decks.

Complex workflows that include a multi-physics representation of the plant are handled by the simulation manager FPoliSIM to ultimately lead to a realistic estimate of the event consequences. The level of sophistication of the analysis or choice of physics tools is up to the analyst and commensurate to the analysis goals. The analyst may choose to adhere closely to NEI 18-04 or follow alternate paths as deemed necessary to build the body of evidence that forms the safety case following principles of defense-in-depth. Finally, the analysis results are collected and synthetized in digital reports.

The Safety Case Manager has a comprehensive synthesis of the results through the RISE dashboard which acts as a ”wizard” to trace, document and communicate the safety case to regulators and other stakeholders. The platform is architected to streamline reviews before and during the licensing process by leveraging the scrutability and transparency of a browsable, digital media rather than traditional, flat reporting. The evolution of a design can be easily tracked and maintained in the system. The RISE dashboard (Figure 4) is where all the actions are coordinated. The dashboard is a browsable site where a team can collaborate to visually construct the safety case, including the classification of the LBEs, benchmark against risk metrics, SSCs classifications and defense-in-depth analysis (DID).

The RISE analyst relies on the simulation manager, FPoliSIM, to manage the simulations and PRA analyses necessary to evaluate frequency-consequence profiles for the events. Uncertainties are tracked and handled along the workflow and/or deterministic approaches are adopted when needed. Once safety basis events are identified, the corresponding Design Basis Accidents (DBA) are evaluated. The analysis of the DBAs should be consistent with RG 1.203, the Evaluation Model Development and Assessment Process (EMDAP). Part of the platform’s infrastructure with FPoliDOX, FPoliDON and FPoliSIM was architected to provide a digital representation of the

EMDAP roadmap. The vision was presented in [16]. Finally, the equivalent of a SRP Chapter 15 analysis report can be generated to form the licensing basis for the safety analysis. Figure 3 is a synthesis of the architecture of the RISE application.

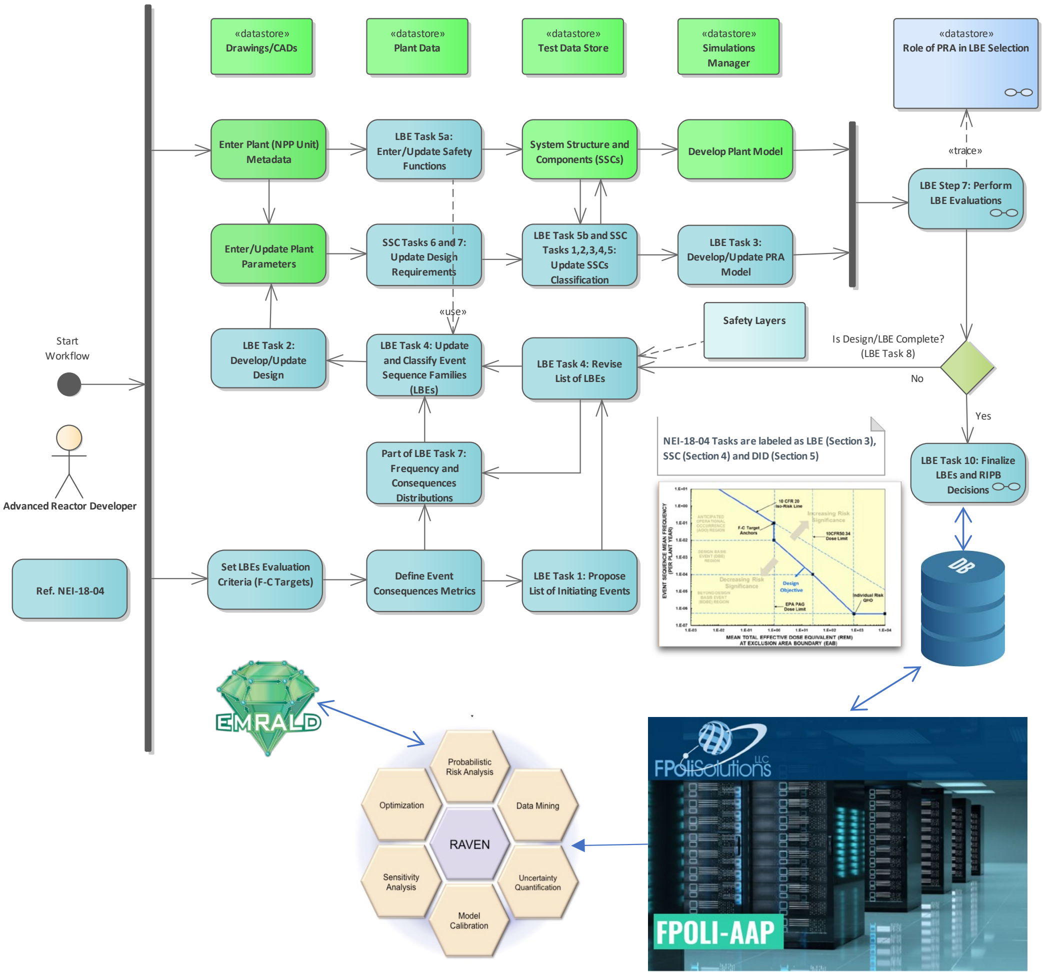


Figure 2 - Risk-Informed System Engineering (RISE) Application

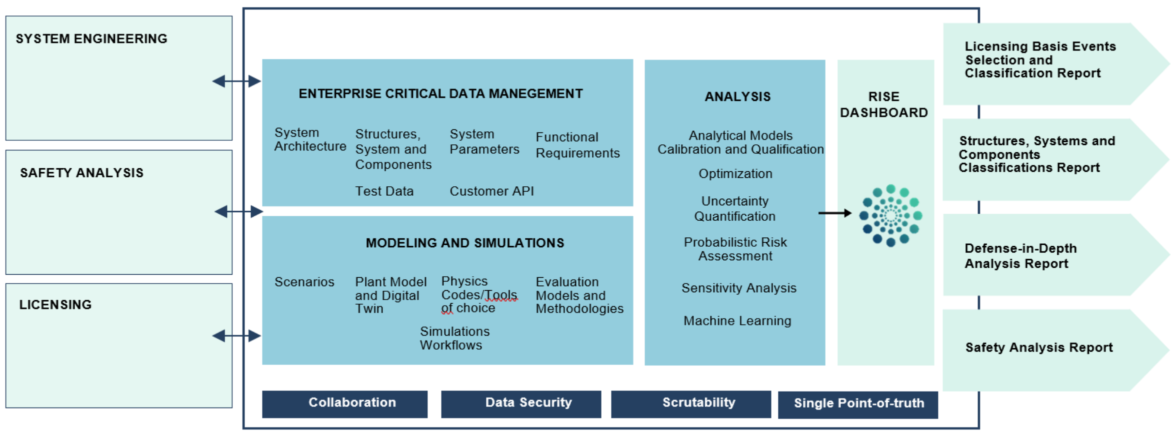


Figure 3 - RISE Application Architecture

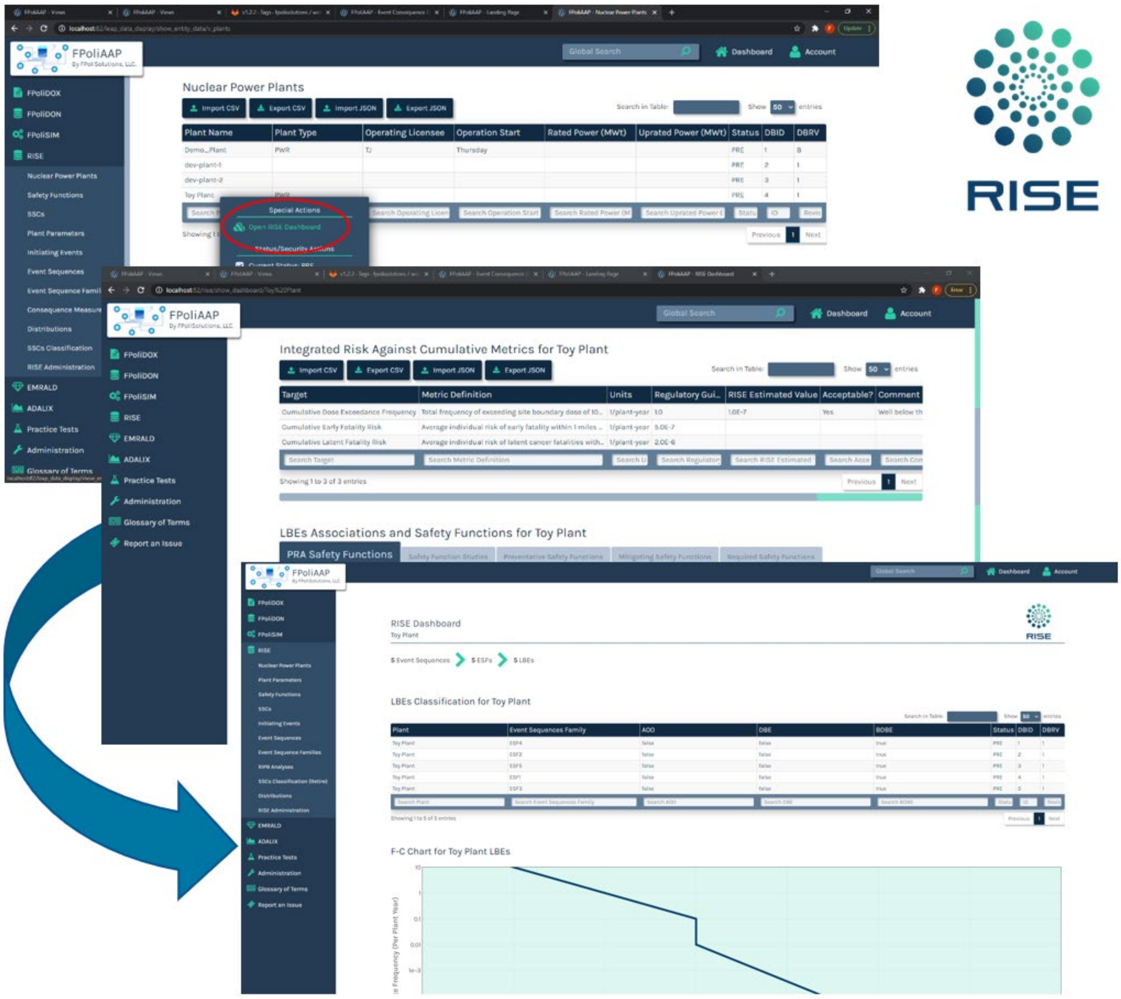


Figure 4 - RISE Application – The Dashboard

4. SAMPLE APPLICATION RESULTS

The scenario of interest in this demonstrative study is a representative PWR subject to a SBO initiating event. In this sample SBO, the PWR features SSCs engineered to perform critical safety functions that support the main safety function of maintaining a sufficient coolant inventory for removing the decay heat from the core and ultimately preventing core melt through a feed and bleed operation. The SSCs considered in this analysis are the reactor system and the rest of components that form the Nuclear Steam Supply System (NSSS) and the following engineered safety features:

1) Low Pressure Safety Injection (LPSI) pumps powered by Diesel Generators (DGs)
2) Low Pressure Safety Injection (LPSI) powered by FLEX pumps
3) Refueling Water Storage Tank (RWST)
4) Sump recirculation

The LPSI is designed to maintain sufficient inventory of liquid in the reactor vessel while steam is generated from the removal of the decay heat and assumed vented to the containment. The possible scenarios are represented by the even tree depicted in Figure 5 which leads to five event sequences, ES1 through ES5. The event sequences have one of two end states, no core damage (OK) or core damage (CD).

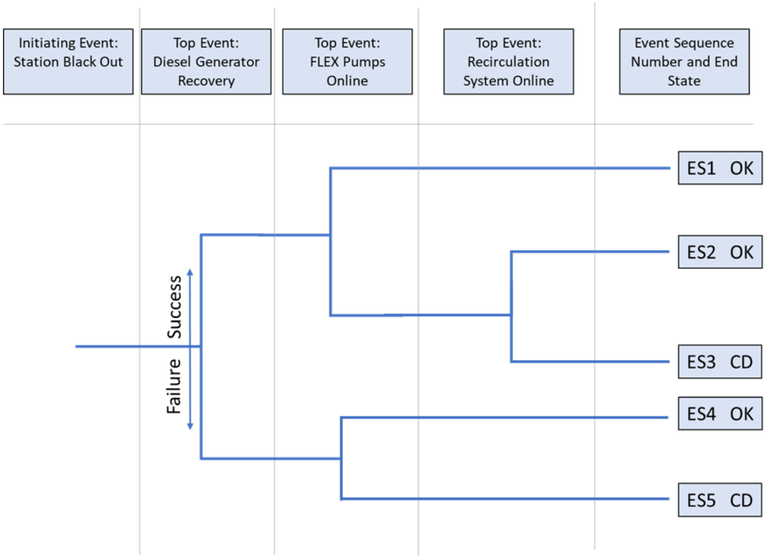


Figure 5 - Event Tree for the SBO Case

The system engineer enters the plant metadata in the relational database from the RISE UI. This includes plant parameters, safety functions and SSCs. The SSCs are associated to safety functions and functional requirements. Functional requirements are classified as Design Criteria, Owner Design Requirements, Regulatory Design Requirements or Special Treatment Requirements. Then requirements are associated to parameters. The list of parameters includes reliability targets for SSCs that may be used in PRA analysis. Storing the data and the relationships among the artifacts provides the ability to track the impact of changes automatically throughout the system by triggering events that notify the users of such changes or other events if needed.

The scenarios are defined starting from providing the list of initiating events, which then form the event sequences (ES) that form event trees. Data from the PRA tool of choice or alternative analyses are entered in the systems. Event sequences may be grouped in event sequence families (ESF) to provide some synthesis in the analysis. The frequency and its uncertainty are then calculated and associated to each ES. ES Frequencies are described as Complementary Cumulative Distribution Functions (tail distribution) as shown in Figure 6. Then, the frequencies for each ES in an ESF are aggregated to create a frequency distribution for the ESF.

ESFs can be classified based on frequency ranges. The event classification is configured in the system by the user. For example, if the analyst chooses to follow the NEI 18-04 roadmap, the values are set as shown in Figure 7. Very rare events are excluded from the analysis, while the rest form the set of Licensing Basis Events (LBEs) that are evaluated when performing a risk-informed analysis.

The consequences for each event sequence or event sequence family are evaluated using the simulation manager application, FPoliSIM. The FPoliSIM service shares the same central database and the user enters the data through the platform UI. The safety analyst provides a model of the facility which is loaded in the database. Key inputs of the computational model are associated to the plant parameters discussed above. A selected set of inputs are managed by FPoliSIM and allows the user to easily set up workflows that require the injection of changes to those inputs. For example, this level of automation is needed to perform sensitivity studies or parameter uncertainties propagation.

FPoliSIM features a generic service for postprocessing the results. The postprocessing of the simulation includes the analysis of the scenario as well as the calculation of the dose based on user-assigned metrics. For example, the user may choose to use the ”30-day total effective dose equivalent at the exclusion area boundary (rem)” as the consequences metric. Similar to the Frequency CCDF, the results are compiled as CCDF relative to the chosen metric.

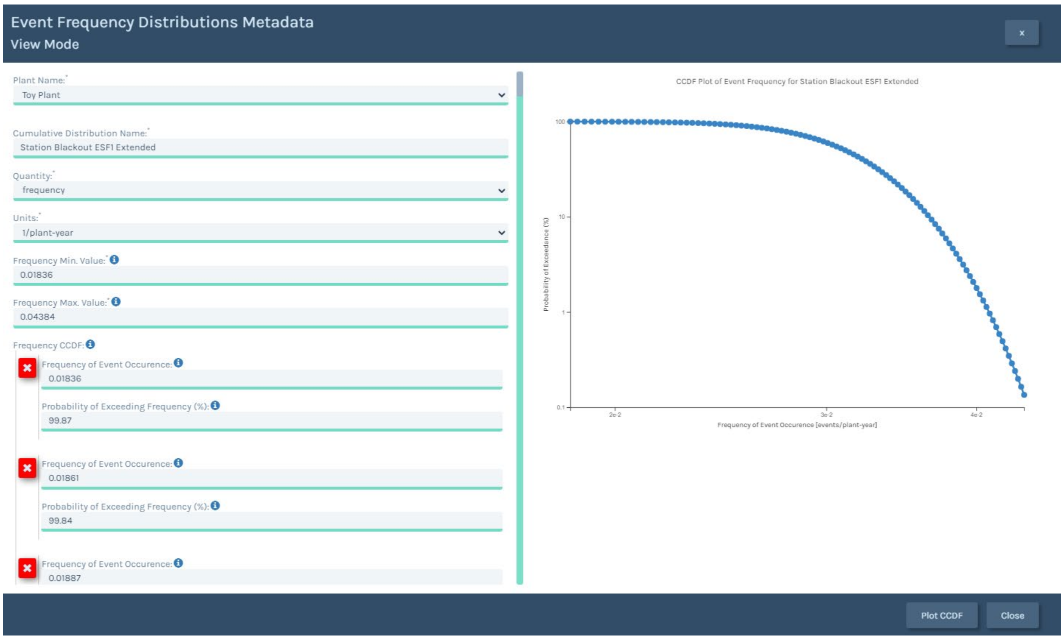
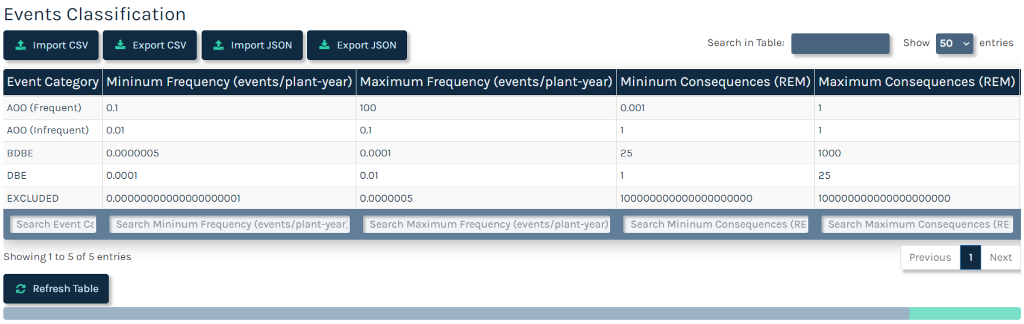


Figure 6 – Example of Frequency CCDF for an ES



Event Category	Mininum Frequency (events/plant-year)	Maximum Frequency (events/plant-year)	Mininum Consequences (REM)	Maximum Consequences (REM)
AOO (Frequent)	0.1	100	0.001	1
AOO (Infrequent)	0.01	0.1	1	1
BDBE	0.0000005	0.0001	25	1000
DBE	0.0001	0.01	1	25
EXCLUDED	0.00000000000000000001	0.0000005	100000000000000000000	100000000000000000000

Figure 7 – Events Classification

For this demonstrative problem, a simple evaluation model was developed to represent the NSSS under the assumed SBO scenario. The evaluation model was built with RELAP5-3D and similar to the simple model presented in [1]. The entire NSSS is represented by a single node. The volume contains a heat source to describe the core. The heat structure produces nuclear power using the point kinetics model, therefore providing a realistic representation of decay heat during the transient. The SI injection is represented by a flow boundary condition connected to the volume and the venting (bleed) is represented by a pressure boundary condition at the top of the volume. A combination of valves and control variables mimic the behavior of the safety systems (LPSI Pumps, DGs, FLEX, etc.). As the fuel rod model is extremely rudimentary, a simple success criterion was set as the mixture level covering the core. A first-principles level swell model was included to predict the location of the mixture level without reliance of detailed axial noding of the vessel.

A basic set of simulations is performed, where the SI flow is assumed to begin at 5 hours (18000 sec) when it succeeds, the FLEX flow is assumed to begin at 5.5 hours (19800 sec) when it succeeds and switchover to recirculation is assumed to begin at 10 hours (36000 sec) and last for 1 hour (3600 sec) when it succeeds. The liquid fraction results of the 5-event sequence are shown in Figure 8, which shows that the ES-1, ES-2 and ES-4 succeed, while ES-3 and ES-5 cause core damage. A simplified method of dose calculations is performed which assumes a low dose rate prior to core damage, and then a significantly increased dose rate after core damage. As such, the dose for each sequence will be a function of time of core damage.

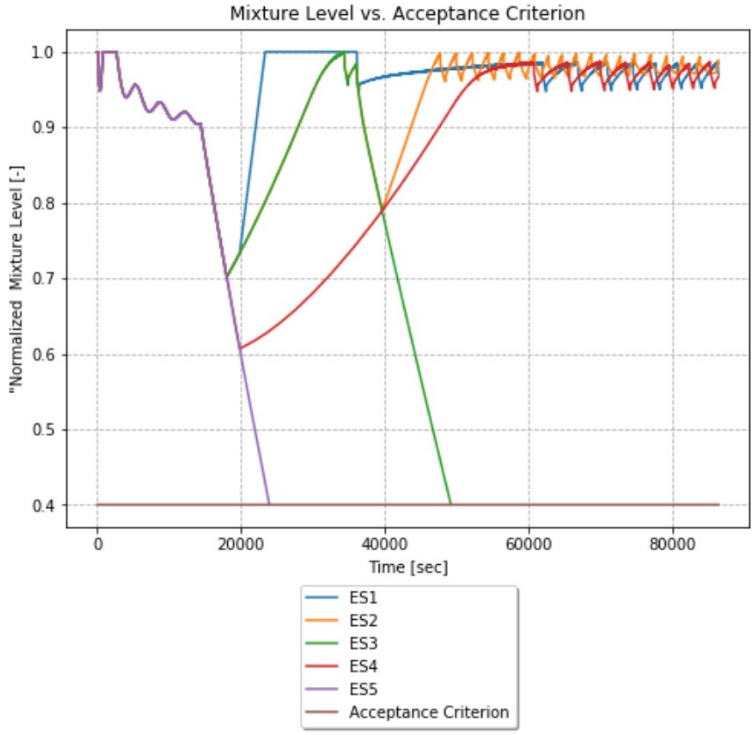


Figure 8 – Event Sequence Simulation Results

The analysis is orchestrated through the RISE dashboard (Figures 9a and 9b). The dashboard is where the Safety Case Manager administers the activity associated with the definition of the safety case. The RISE dashboard was architected to provide consistency with the draft 10 CFR Part 53, whose roadmap is described in the NEI 18-04. However, the workflow is suitable to a graded approach in which the role of the PRA analysis can range from design validation step at the end of the design cycle to a fully-coupled PRA embedded in the design process itself.

From the frequency distributions, the system automatically identifies the LBEs and classifies them in AOO, DBE and BDBE. In the demo case, all five ESs are made into individual ESFs, and all 5 make it into the final LBEs selection. However, for a typical application, there could be hundreds of ESFs which funnel down to 20-30 LBEs. From the consequences, the LBEs can be displayed in the Frequencies-Consequences (F-C) chart. In this example the acceptance criteria are based on NEI 18-04.

For those results, the integrated risk against cumulative metrics defined by the user are computed and displayed in the table below the F-C chart. Next, a multi-tab table displays the LBEs associations to the safety functions.

The system first filters and lists the applicable PRA Safety Functions (PSF). In the following two tabs, the user can view which ones were identified as ”Preventative SFs” and which ones were set to ”Mitigating SFs”. The system then queries the associations in the database and lists which LBE and/or DBE was prevented or mitigated by the SF.

In the ”Safety Function Studies” tab, the user can organize studies to identify the required SF. This is typically performed via sensitivity studies (simulations) as described in [17]. From that information the analyst can determine which SF is required. The same table also identifies which SSCs are associated to the SF. For example, in order to demonstrate the selection of required safety functions, a sensitivity study was performed which removed the Diesel Generator Recovery from consideration. The updated results were benchmarked against F-C targets. The updated ESF 5 violated the F-C target which resulted in identifying the Diesel Generator Recovery as a required safety function.

RISE Dashboard

Toy Plant

RISE

5 Event Sequences > 5 ESFs > 5 LBEs

LBEs Classification for Toy Plant

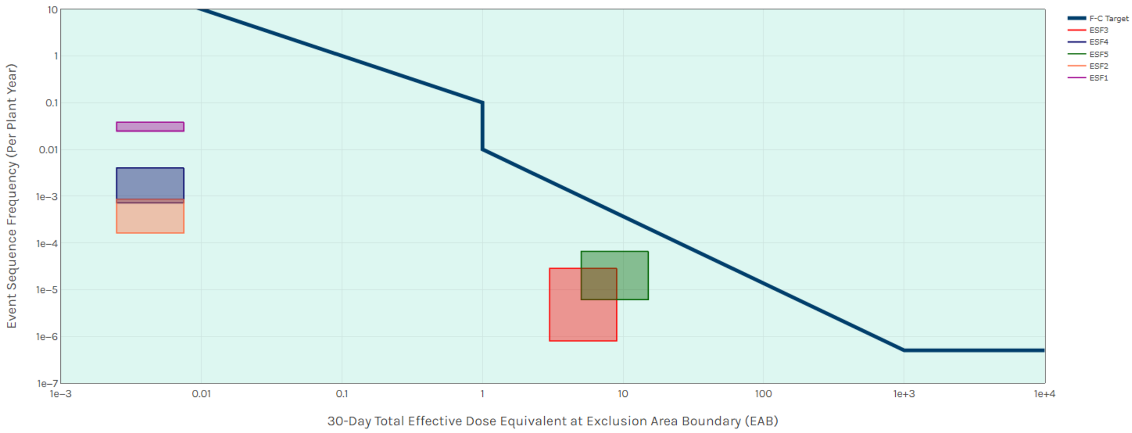
Search in Table: Show 50 entries

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	ESF4	false	true	false	PRE	2	1
Toy Plant	ESF2	false	true	false	PRE	4	1
Toy Plant	ESF1	true	false	false	PRE	5	1
Search Plant	Search Event Sequences Family	Search AOO	Search DBE	Search BDBE	Statu	ID	Revis

Showing 1 to 5 of 5 entries

Previous 1 Next

Refresh Table



Integrated Risk Against Cumulative Metrics for Toy Plant

Import CSV | Export CSV | Import JSON | Export JSON

Search in Table: Show 50 entries

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	0.0000004329999999999997	Yes		PRE	2	38
Cumulative Latent Fatality Risk	Average individual risk of latent cancer fatalities with...	1/plant-year	2.0E-6	0.0000006629999999999999	Yes		PRE	3	38
Search Target	Search Metric Definition	Search Units	Search Regulatory Guid	Search RISE Estimated Valu	Search Acceptabl	Search Comme	Statu	ID	Revis

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LBEs Associations and Safety Functions for Toy Plant

PRA Safety Functions | Preventative Safety Functions | Mitigating Safety Functions | Safety Function Studies | Required Safety Functions

Import CSV | Export CSV | Import JSON | Export JSON

Search in Table: Show 50 entries

Safety Function ID	Description	Safety Layer	Associative SSCs	Is Function Required?	Significant to DiD?	Significant to CCDF?	Significa
Deliver Minimum FLEX Flow	Maintain RCS inventory with FLEX	Layer 2	[{"ssc_name": "FLEX Pumps"}]	Yes	Yes	Yes	Yes
Deliver Minimum SI Flow	Maintain RCS inventory with LPSI flows	Layer 1	[{"ssc_name": "SI Pumps"}]	Yes	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	Yes
Power SI with Diesel Generators	Provide power to the LPSI with DGs	Layer 1	[{"ssc_name": "Diesel Generators"}]	Yes	Yes	Yes	Yes
Provide SI with FLEX Pumps	Power SI with FLEX equipment	Layer 1	[{"ssc_name": "FLEX Pumps"}]	Yes	Yes	Yes	Yes
Repair DG within Maximum Time	Complete repairs on the DG in time	Layer 3	[{"ssc_name": "Diesel Generators"}]	Yes	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	Yes
Search Safety Function ID	Search Description	Search Safe	Search Associative SSCs	Search Is Function Requ	Search Significant tc	Search Significant to C	Search S

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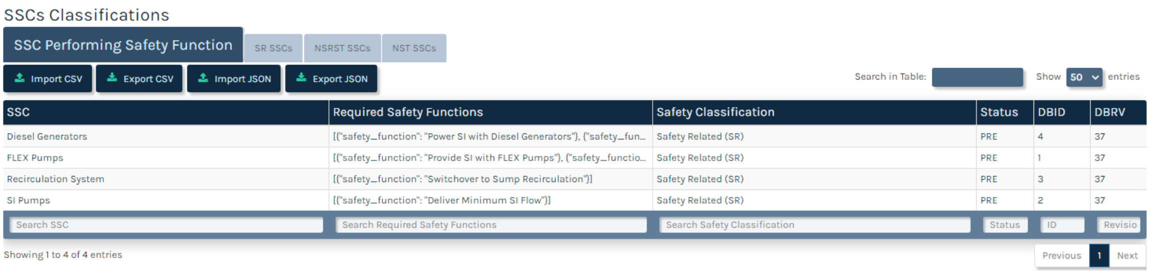
Previous 1 Next

Figure 9a – RISE Dashboard


SSCs Classifications

SSC Performing Safety Function | SR SSCs | NSRST SSCs | NST SSCs

Import CSV | Export CSV | Import JSON | Export JSON

Search in Table: Show 50 entries

SSC	Required Safety Functions	Safety Classification	Status	DBID	DBRV
Diesel Generators	[{"safety_function": "Power SI with Diesel Generators"}, {"safety_fun…	Safety Related (SR)	PRE	4	37
FLEX Pumps	[{"safety_function": "Provide SI with FLEX Pumps"}, {"safety_functio…	Safety Related (SR)	PRE	1	37
Recirculation System	[{"safety_function": "Switchover to Sump Recirculation"}]	Safety Related (SR)	PRE	3	37
SI Pumps	[{"safety_function": "Deliver Minimum SI Flow"}]	Safety Related (SR)	PRE	2	37
Search SSC	Search Required Safety Functions	Search Safety Classification	Status	ID	Revisio

Showing 1 to 4 of 4 entries

Previous 1 Next

Figure 9b – RISE Dashboard

The last table organizes the SSC classification. The SSCs that perform the SF are classified as Safety Related (SR), Non-Safety Related with Special Treatment (NSRST) or Non-Safety Related (NSR). Based on the designations of the required safety functions discussed above, the Diesel Generators are SR components.

At this point, the analyst has all the information required to determine the set of Design Basis Accidents (DBAs). According to [7], the DBAs are derived from the DBEs, but are performed crediting only the SR SSCs needed. A DBA is essentially a variation of the associated DBE where only SR SSCs are available to mitigate the postulated ESFs to within the 10 CFR 50.34 dose limits. The list of DBAs is presented in the last table of the dashboard. Finally, the Safety Case Manager can automatically generate the key reports that define the safety case.

4. CONCLUSION

As many advanced reactor developers are considering an efficient licensing path to accelerate the deployment of their solutions, the U.S. Nuclear Regulatory Commission (NRC) is moving forward with the development of the 10 CFR Part 53 rulemaking. An interesting industry debate and actions are aligned to ensure the new rule will be "used and useful" and, most importantly, achieve the original objective of establishing a new risk-informed framework where licensing and regulating of such new designs is expedited. The original motivation was to develop a technology-agnostic regulatory framework, but, in practice, the challenge is limiting the addition of burden and scope to the safety assessment which would prevent the original intent and, instead, deflect applicants from its consideration.

This paper describes a possible solution to this problem. An agile, generic, digital platform, called FPoliAAP, was developed to facilitate orchestration of complex workflows and take advantage of modern software development and data management tactics while leveraging recent technology developments at national laboratories such as Idaho National Laboratory's (INL) RAVEN and EMRALD frameworks. FPoliAAP is a suite of applications (or services) which, in the aggregate, can be seen as a "wizard" or a smart procedure to help developers and regulators navigate through the process of building a transparent safety case.

One of these applications is called Risk-Informed System Engineering (RISE). At a high level, the vision behind RISE has been to fully automate the workflow that connects the physical reality of the plant to its virtual representation in modeling (sometimes called the plant Digital Twin). RISE provides an agile vehicle to synthetize the results and to readily produce key outputs which aid users in making risk-informed decisions that demonstrate the plant safety case consistent with RG 1.203, RG 1.233 and 10 CFR Part 52 or Part 53 (a graded approach). For the sole purpose of training and illustration here, the RISE technology was presented using a simple metamodel that describes a PWR during a postulated Station Black Out (SBO) event. The final target of this methodology and digital infrastructure is the ever-growing pool of advanced and microreactor developers.

Acknowledgements

This material is based upon work supported by the U.S. Department of Energy, Office of Science, SBIR program under Award Numbers DE-SC-00015945 and DE-SC-00018755.

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