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TRTR 2022 Annual Conference
Risk-Informed Decision Making for NPUFs

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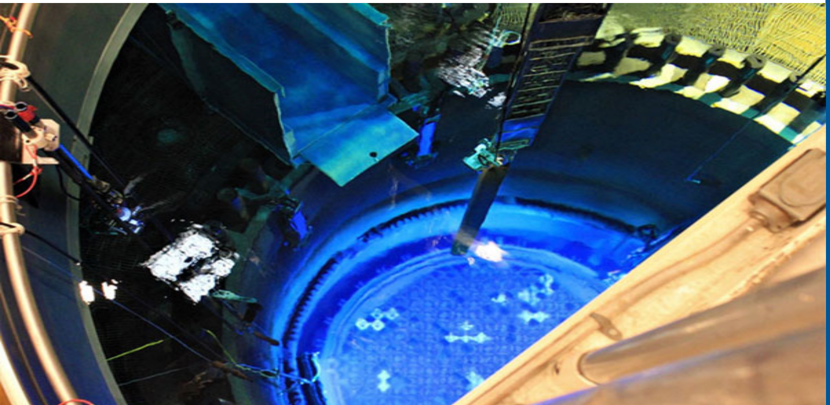

Topics

- What is risk-informed decision making
- An example of how to calculate risk
- How to use risk-informed decision making
- How risk-informed decision making applies to the TRTR community

What is Risk-Informed Decision Making?

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What is Risk-Informed Decision Making?

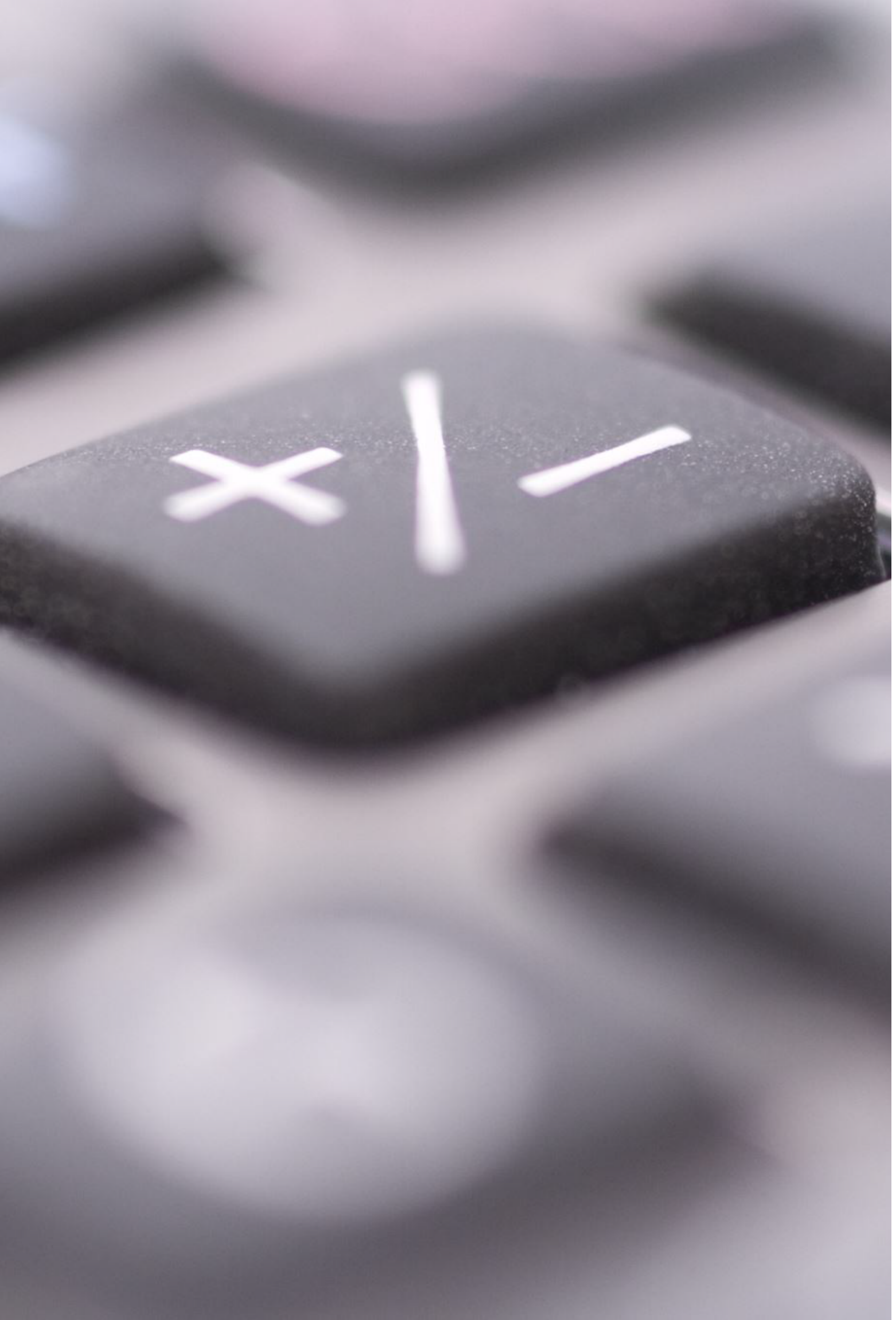
An integrated decision-making approach that incorporates risk insights.

Someone using this approach would consider:

- Utilizing risk information when thinking about issues
- Obtaining diverse input
- Conducting risk conversations
- Performing either qualitative or quantitative analysis

"Risk-based" would imply using <u>only</u> the numerical results of a risk assessment

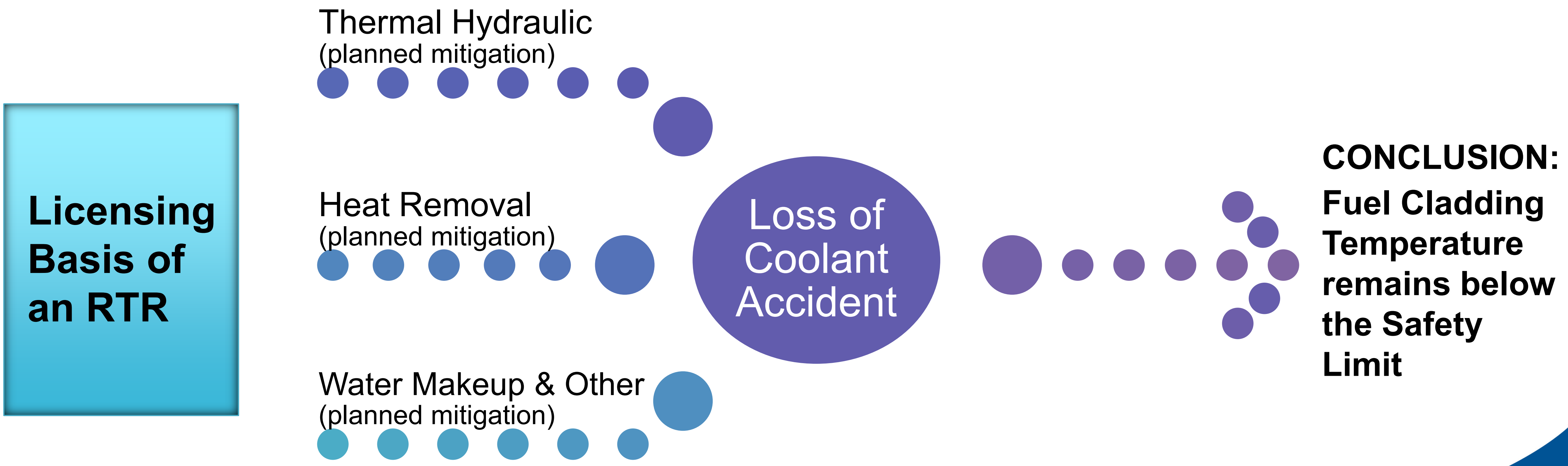
- Risk-based evaluations use models, incorporating uncertainties, assumptions, etc.



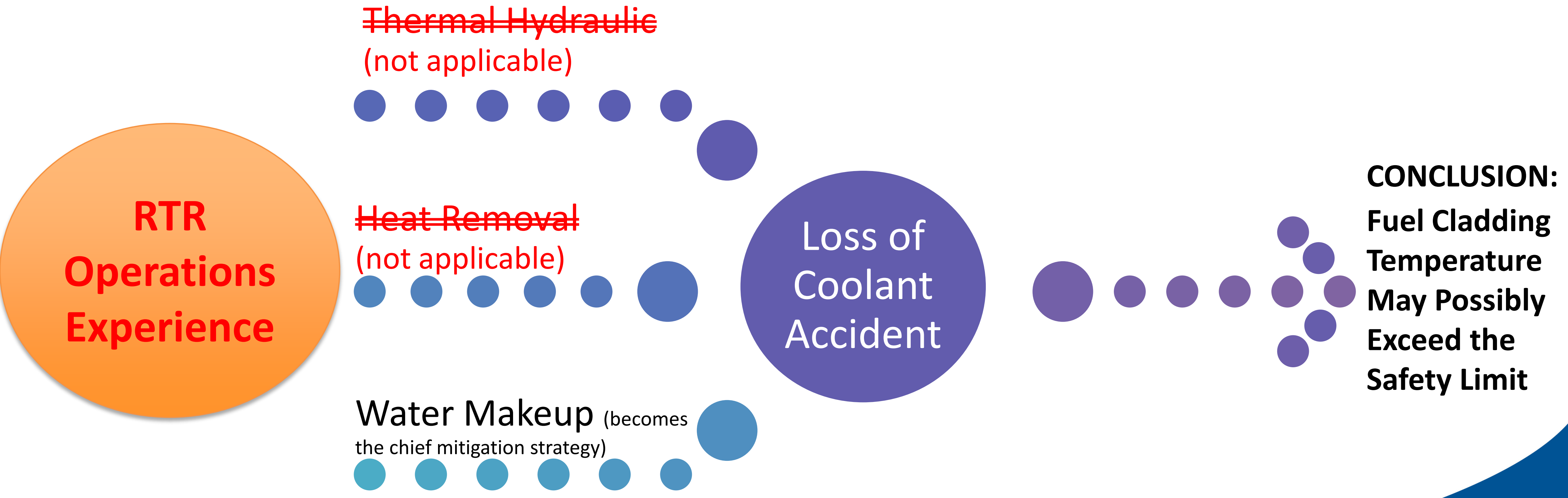
Examining the Risk of a LOCA

An RTR example of how to calculate risk for a Loss of Coolant Accident (LOCA)

Background for LOCA Example



Background for LOCA Example Continued



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What is the Risk?

Risk = Likelihood x Consequence

= **Frequency** of an event x **Probability** of failure of the mitigation strategies

- For the issue being examined, are there unanalyzed or new Initiating Events (IEs)?
- For the issue being examined, what are the frequencies of Initiating Events?

- Does the issue being examined affect any mitigation strategies?

What is the Risk of the Limiting (worst case) LOCA?

$$\text{Risk}_{\text{LOCA}} = (\text{Frequency} \times \text{Probability})$$

What is the frequency for the initiating event?

Does it affect any mitigation functions?

Factors that could affect the probability of failure of the mitigation strategies:

- Only Manual Isolation valves
- No automatic injection system
- All of the coolant drains quickly

→ Probability of Failure = 1.0

In ASME/ANS RA-Sa-2009, *Standard for Level 1 / Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications*

IE-C6 – If the frequency is less and 1E-6/yr, the IE can be screened out

Frequency of an Initiating Event – Example

What does the pipe break frequency depend on?

- Design
  - The double-end guillotine break (pipe rupture) of the 10-in coolant loop
  - Stainless steel piping with an approximately length of 300 ft.
- Operating Characteristics
  - The piping is designed to a certain ASME Code (for instance, ASME B-31.1)
  - Demineralized water, atmospheric temperature and pressure and heated up to 120 ˚F

Calculating the Pipe Break Frequency

External leakage frequency, $F_L = (2n+1)/2T$

Where n is number of external leakages and ruptures and T is operating time

External rupture frequency = $0.04 \times F_L$

Assumptions: Stainless steel, non-primary coolant system, 1990-2020

Result: External rupture frequency = $0.04 \times F_L = 4.5E\text{-}11/ft/hr$

Sources:

1. NRC Risk Assessment of Operational Events Handbook, Vol 2, Section 3, "Internal Flood Modeling and Risk Quantification," has non-primary coolant system rupture frequency
2. Idaho National Lab report EGG-SSRE-9639 (1991) that covered 1960-1990
3. NRC Office of Nuclear Regulatory Research: Component Operational Experience Degradation and Ageing Program (Database)

What is the frequency of the LOCA?

External rupture frequency = *0.04 x* F_L *= 4.5E-11/ft/hr*
(stainless steel, non-primary coolant system)

Initiating Event frequency of the LOCA	=	*4.5E-11 x length of pipe*
	=	*4.5E-11 x 300 ft x 4,360 hr/yr*
	≈	***6E-05 per year***

The resulting calculation indicated that the initiating event frequency **is not negligible.**
(If the frequency is less than $1x10^{-6}$ *, it may be considered negligible)*

Assumptions:

- The reactor typically operates 8 hours a day plus some occasional overnight operations therefore it is assumed that the reactor at-power for 50% (or 4360 hr/yr) of the time.
- No credit was given for operator actions
  - no alarm annunciating
  - the manual isolation valves cannot be operated in control room

Be riskSMART

- What can go wrong?

  (Coolant could drain quickly!)
- What are the consequences?

  (Fuel cladding probability of failure)
- What is the risk? How likely?

  (Examine pipe rupture frequency)

- Reduce operating time?
- Reduce pipe length?
- Automatic actuation of Isolation valves?
- Automatic water injection system?

- Share it here!

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Level of Risk Dictates Depth of Analysis Necessary

What if the calculated LOCA frequency is a lot lower than 1E-06/yr?

We may not need as much margin to cover uncertainty and variability.

Level of Risk	Effort
If very low risk	5 Hrs and 10 pages of analysis
If moderate risk	25 Hrs and 50 pages of analysis
If high risk	50 Hrs and 100 pages of analysis

Data to Collect for Risk-Informed Decision making

- Record equipment failures, human error, maintenance schedules
- Establish a repository for facility equipment specifications, and drawings

Risk evaluation relies upon **deterministic calculations**

- Success criteria (i.e., number of pumps) is informed by ***engineering analyses***
- Reliability and initiating event frequencies are informed by ***operating experience***
- Calculations of human reliability are informed by ***training and procedures***

What Programs can be Used to Help with Risk-Informed Decision Making

- Licensee-initiated Corrective Action Programs

  These programs gather data on all kinds of subject areas:
  - Equipment breakdowns
  - Human Error
  - Causal Factors
- Licensee-initiated Material/Part History Programs
  - Maintaining a material/part history program provides data for trending analyses and the projection of reoccurring maintenance or problems
  - Helps keep record of changes in the facility that could be lost to time

How Can the TRTR Community Use Risk-Informed Decision Making?

- Licensing actions: use risk-informed decision making when doing analyses for license amendments
  - Not all risk analysis has to be quantitative and detailed
  - Risk calculation results can inform the workload
- Sharing risk insights between facilities can be useful to the community

Questions?