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HRTD
Human Resources
Training & Development

RISK ASSESSMENT

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Objectives

- **Understand the basics of risk application**
- **Understand how NRC applies risk in regulating power reactors**

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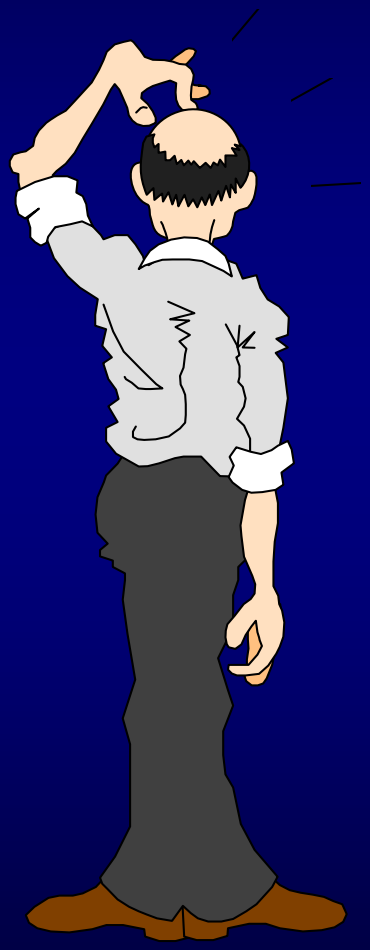

What is Risk?

- Arises from a "Danger" or "Hazard"
- Always associated with undesired occurrences
- Involves both:
  - Likelihood of undesired occurrences
  - Severity (magnitude) of the consequences

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Definition of "Risk Triplet"

- What can happen?
  - Possible scenario
- How likely is it?
  - Frequency, probability
- What will be the outcome?
  - Consequences

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Basic Terminology

- **Probability - Likelihood of an event occurring**
- **Frequency or rate - number of occurrences of some event of interest in some defined interval of time**
- **Consequence - The ultimate result of an event or sequence of events in terms of impacts on public and employee health and safety, impacts on the environment, and costs or damage**

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Ways to Assess Risk

"Objectively"

- **Numerical Approaches**

Subjectively

- **Expert Panels**

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Ways to Use Risk Information

Licensing

- **Evaluate designs for vulnerabilities**
- **Evaluate designs for adequate safety**
- **Remove requirements that offer minimal safety benefit**

Inspection

- **Select inspection areas with risk (safety) significance**
- **Properly evaluate the significance of inspection findings**
- **Monitor day-to-day risk management**

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Risk-Informed versus Risk-Based Regulation

- **Risk-Informed – Using risk to supplement deterministic methods of regulation**
- **Risk-Based – Basing regulatory decisions on risk numbers alone**

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Numerical Approaches

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Basic Terminology

Risk $\left[\frac{\text{Magnitude of Consequences}}{\text{Unit of Time}}\right] =$

Frequency $\left[\frac{\text{Scenario}}{\text{Unit of Time}}\right]$ X

Consequences $\left[\frac{\text{Magnitude}}{\text{Scenario}}\right]$

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Considering Frequency…

Consequence	Frequency	Alternate Frequency
Super Bowl	1/yr.	1.14e-4/hr.
Prednisone Purchase for Boudreaux	1/mo.	12/yr.
Paydays (NRC)	1/2wks.	.071/day
Saturday Morning	1/wk.	9.92e-5/min
Commute	2/day	10/wk.
Going to Bed	1/day	7/wk.

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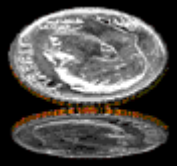
Determining & Using Frequency – *What are the Odds?*

What are the odds

that a coin toss



will come up heads?

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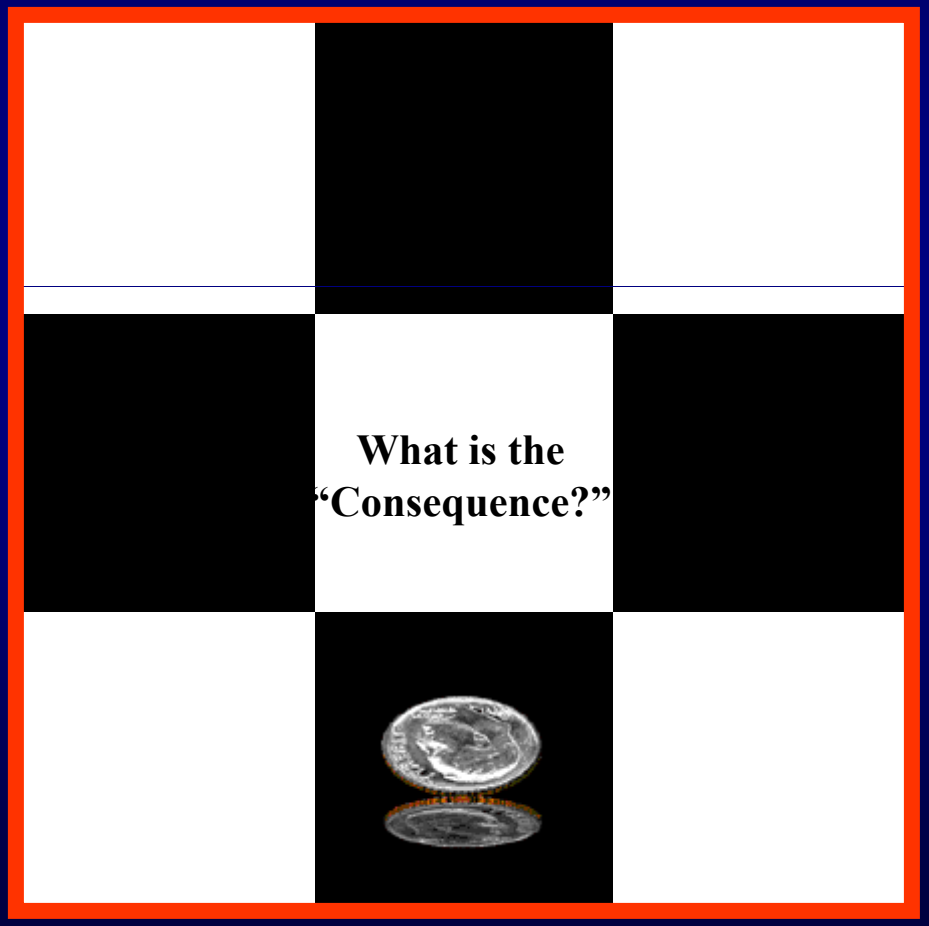
Determining & Using Frequency – *What are the Odds?*



In reactor applications, the "Consequence" can be:

- **An initiating event**
- **The failure of a component**
- **The failure of a fission product barrier**

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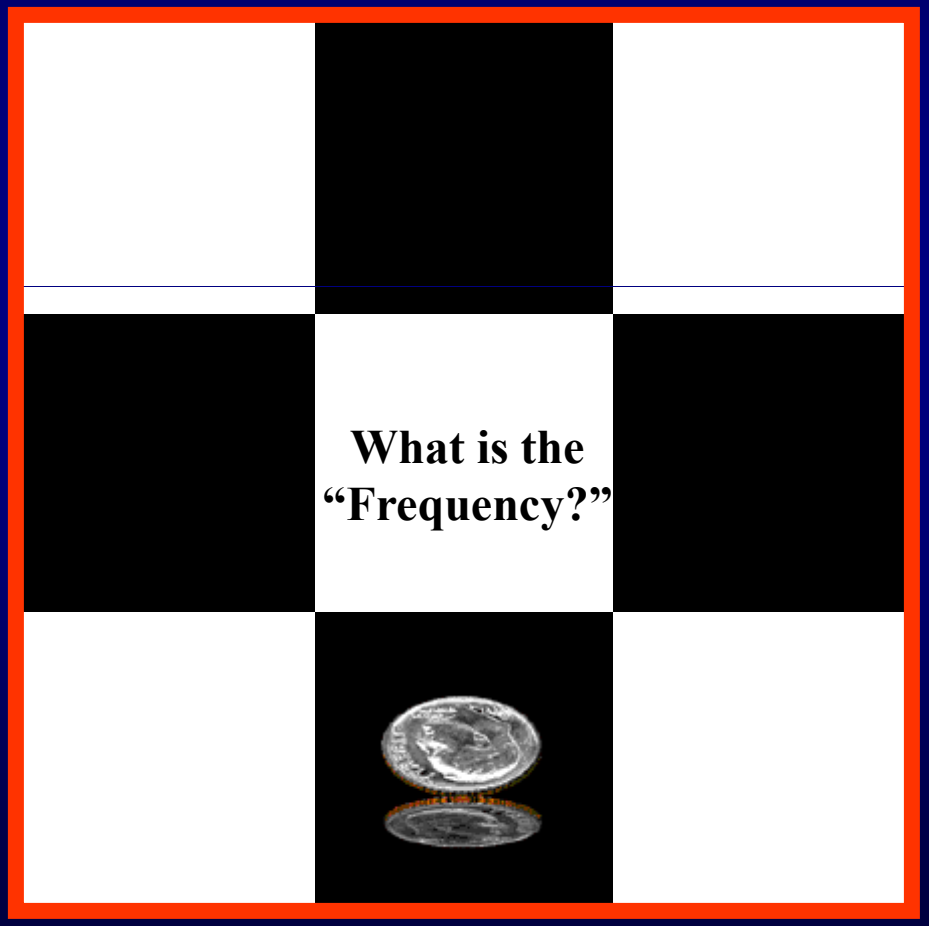
Determining & Using Frequency – *What are the Odds?*



The math works out like this:

- **Event of interest = Heads**
- **Frequency = ½ per Toss**
  - **.5 heads per toss**

Carrying this out further, if you tossed the coin 30 times per hour, the frequency could be expressed as:

15 heads per hour
360 heads per day
131,400 heads per annum

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Determining & Using Frequency – *What are the Odds?*

Frequencies of Interest

- **Scrams/Yr.**
- **Component Failure/Start**
- **Component Failure/Mission**

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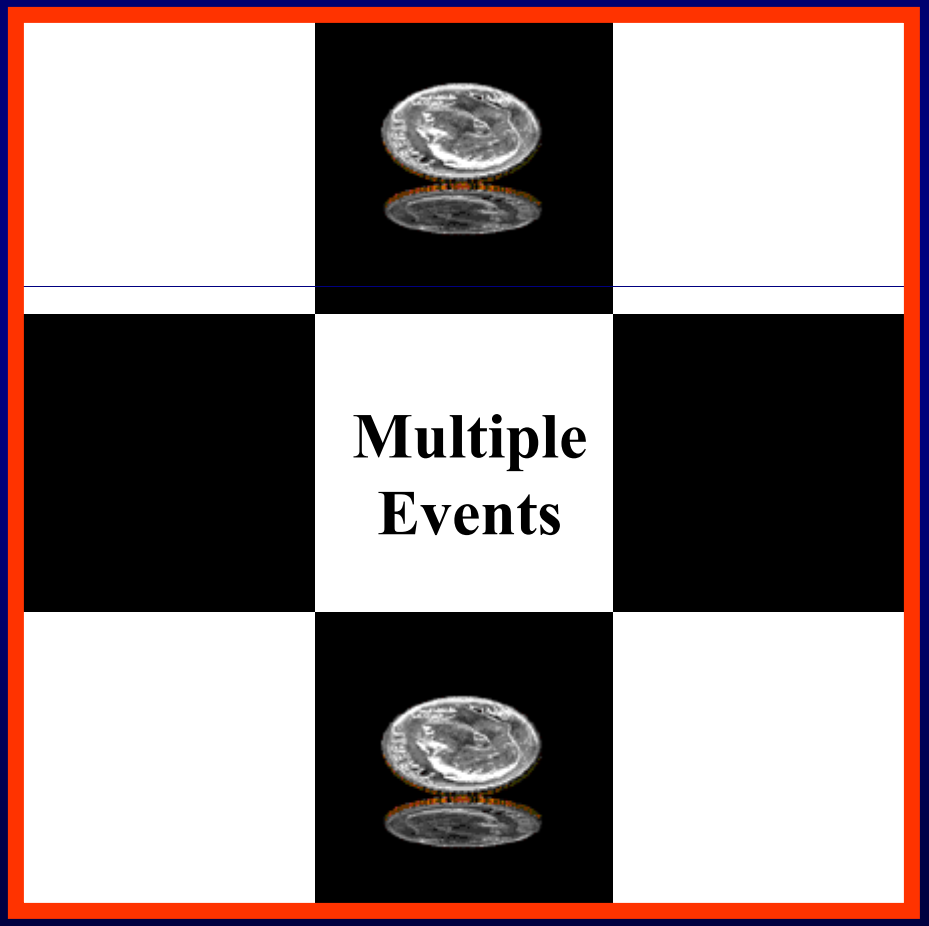
The Next Level…



What are the odds of tossing heads twice in a row?

First, the "consequence" is tossing heads twice consecutively…

Probabilities are combined by multiplying, so…

.5 heads/toss x .5 heads/toss = .25/attempt

What are the odds of tossing heads thrice in a row?

.5 x .5 x .5 = .125/attempt

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Let's Talk Hardware…

You're outside Wal☆Mart and you decide to get a 25 cent coke. What can go wrong?

- **You can drop your only quarter under the machine**
- **You can put your quarter in the machine and it gets stuck before being counted**
- **Your quarter is counted, but the machine doesn't allow you to select a drink**
- **You can select a drink but the can gets stuck before coming out of the machine**
- **The "Make Another Selection" lights are all burned out and the coin return doesn't work**

Can we calculate the odds of getting a coke?

What information do we need?

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From your extensive and frustrating previous attempts at getting drinks at Wal-Mart, you compile the following consequences and frequencies:

Consequence	Frequency of Occurrence	Frequency of Success
Dropped/Lost Quarter	1 in 20 Attempts (.05/Attempt)	19 in 20 (.95/Attempt)
Stuck Quarter	1 in 15 Attempts (.067/Attempt)	14 in 15 (.93/Attempt)
Quarter Counted/No Delivery	1 in 100 Attempts (.01/Attempt)	99 in 100 (.99/Attempt)
Stuck Coke	1 in 50 Attempts (.02/Attempt)	49 in 50 (.98/Attempt)
No Coke/No Coin Return	1 in 3 Attempts (.33/Attempts)	2 in 3 (.66/Attempt)

Now, how many different ways can things go wrong?

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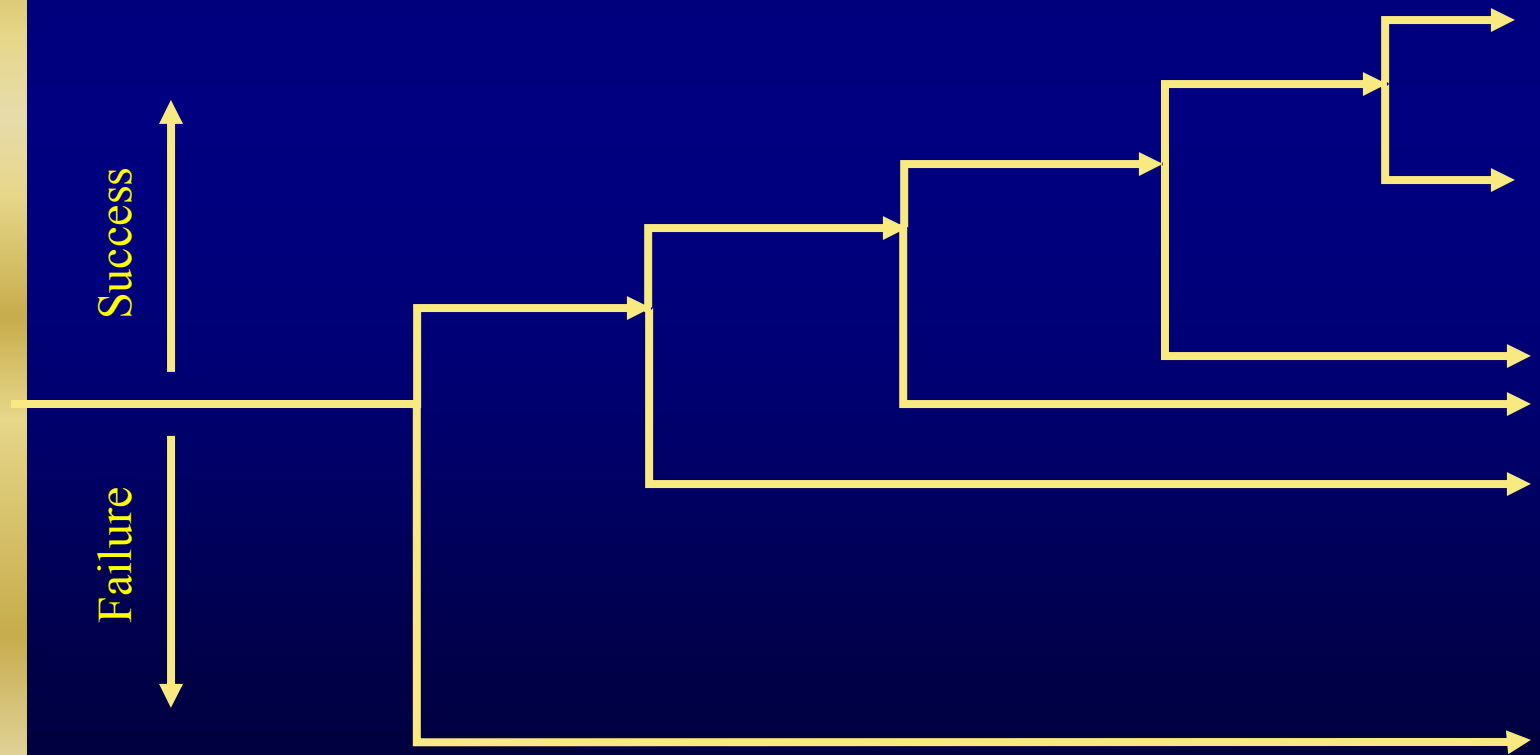
Representing the case graphically…

I Want a Coke	Dropped/Lost Quarter	Stuck Quarter	Quarter Counted/No Delivery	Stuck Coke	No Coke/No Coin Return	Outcome



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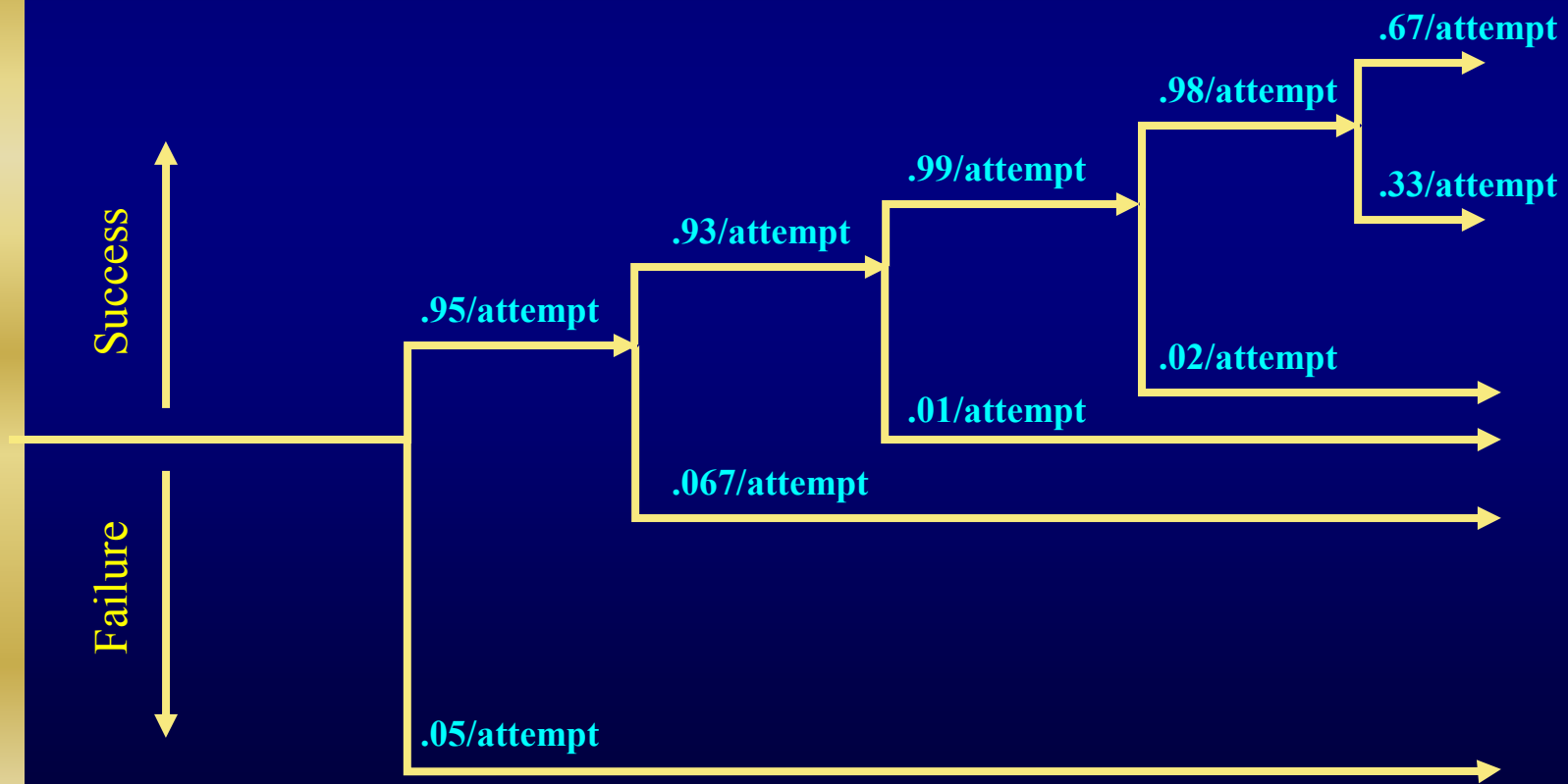
Converting Graphics to Numbers…

I Want a Coke	Dropped/Lost Quarter	Stuck Quarter	Quarter Counted/No Delivery	Stuck Coke	No Coke/No Coin Return	Frequency



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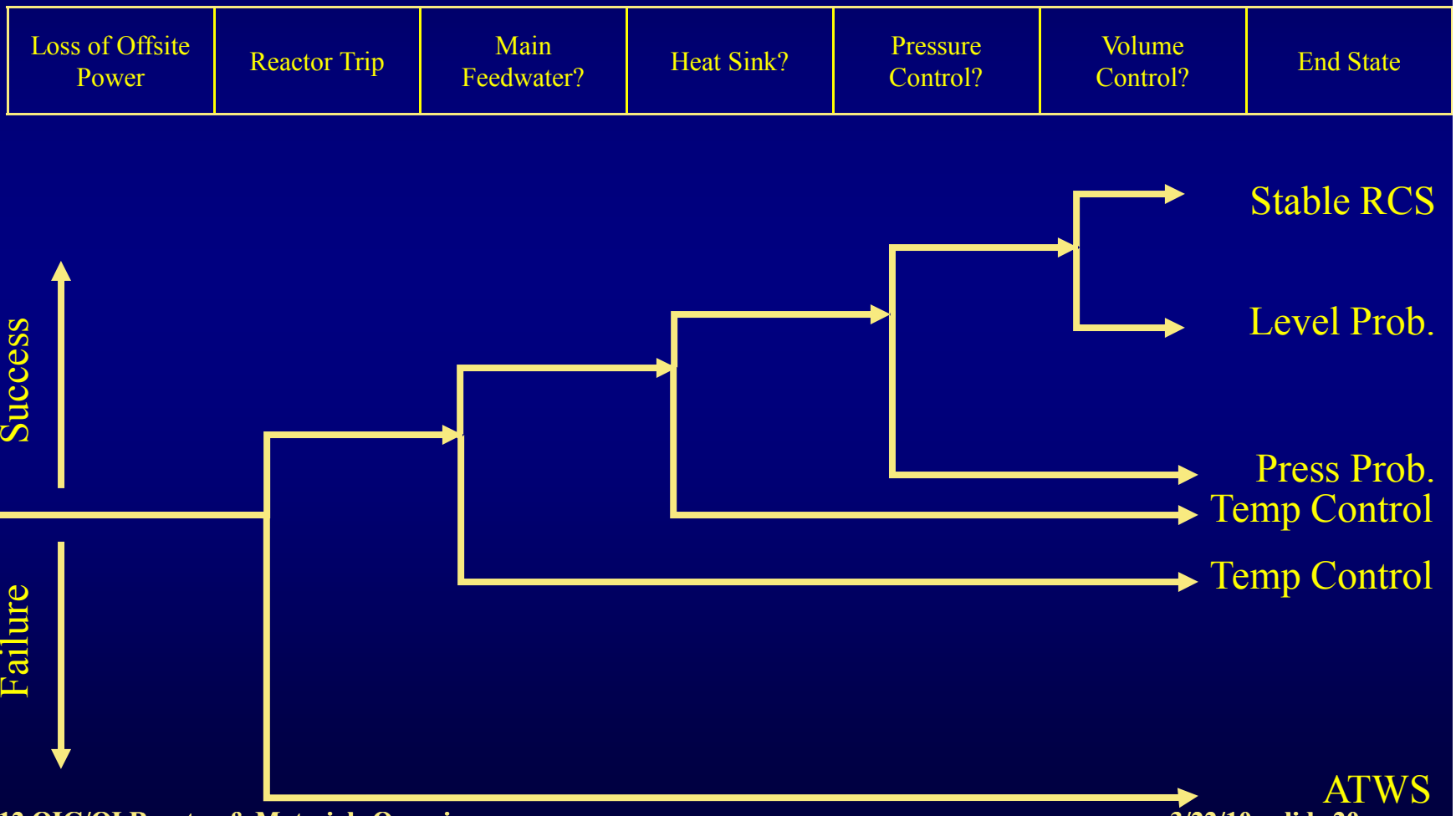
Same Approach for a Reactor Plant



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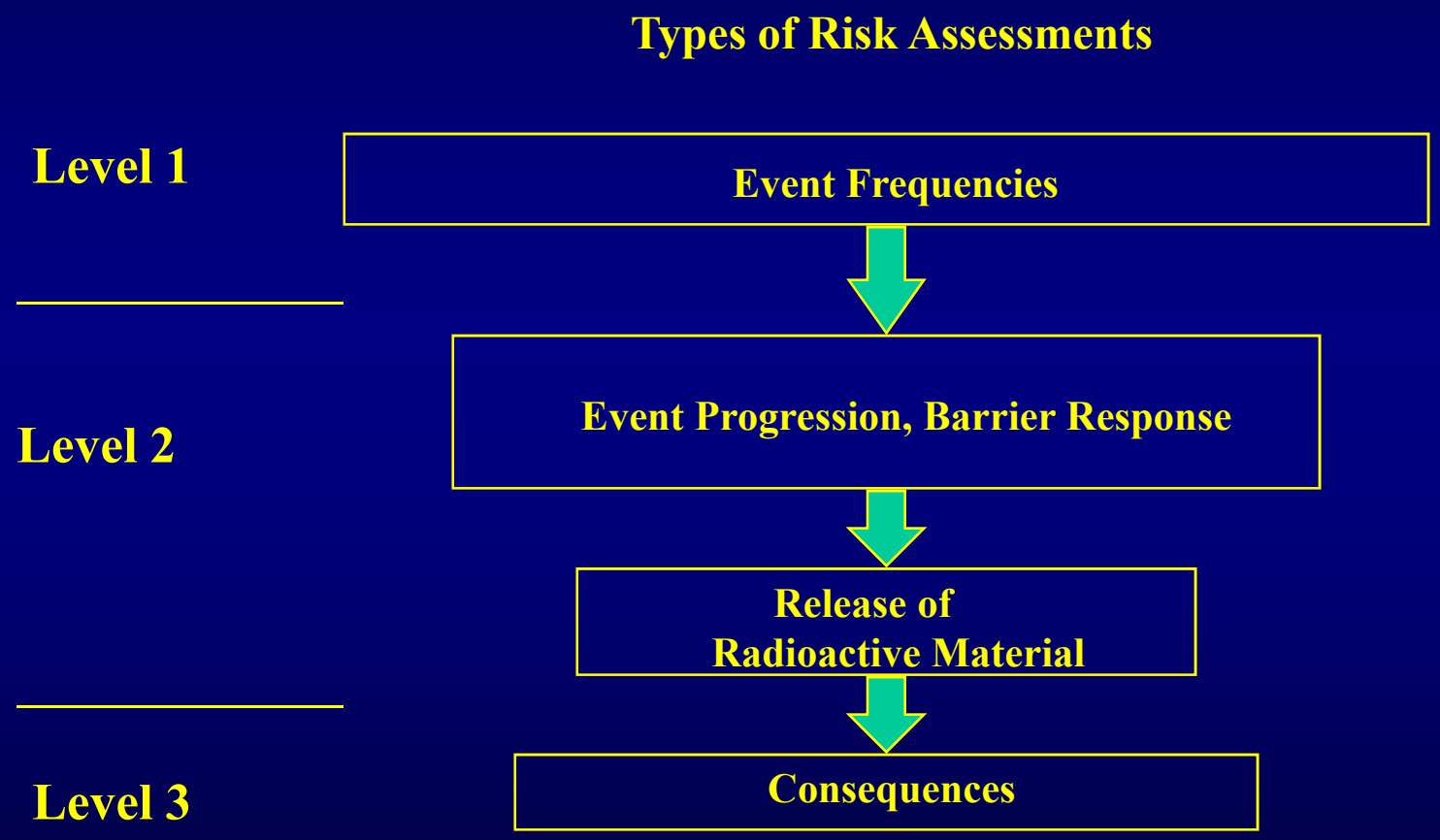

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Numerical Methods Share Commonalities

- Identify Possible Scenarios
- Estimate the Likelihood of Occurrence
- Estimate Consequences

Differences in Methods Exist

- Scope
  - CDF as Surrogate for Consequences
  - Individual Plant Examination vs. Individual Plant Examination for External Events
- Complexity
- Calculational Methodology

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Advantages of PRA

- Rigorous, Systematic Tool
- Information Integration (multidisciplinary)
- Considers Complex Interactions
- Develops Qualitative Design Insights
- Quantitative Decision-Making Possible
- Uncertainty Analysis Possible

Limitations of PRA

- Adequacy of Data
- Sensitivity to Analytic Assumptions
- Frequently not Comparable Site to Site
- Not "Living Documents"

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Seminal Moments in the History of Risk Assessment in Nuclear Power

PRA Policy Statement (ca. 1995)

- Held that probabilistic approaches enhanced traditional deterministic approaches
- Probabilistic approaches seen as improving decision-making
- Offered the possibility of reduced regulatory burden

Risk-Informed and Performance-Based White Paper (ca. 1998)

- Held risk-informed approach as preferred
- Maintained value of defense-in-depth
- Espoused performance-based approaches to regulation where possible

Risk-Informed Regulation Regulatory Guides and Standard Review Plans

- Issued to allow PRA use for specific applications

Maintenance Rule (1999)

- First regulation to require licensees to manage risk at plants

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Questions?