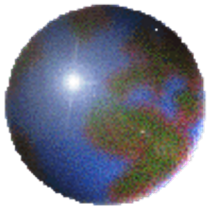


Layers of Protection Analysis

ANGELA E. SUMMERS, PH.D., P.E.
SIS-TECH Solutions, LLC

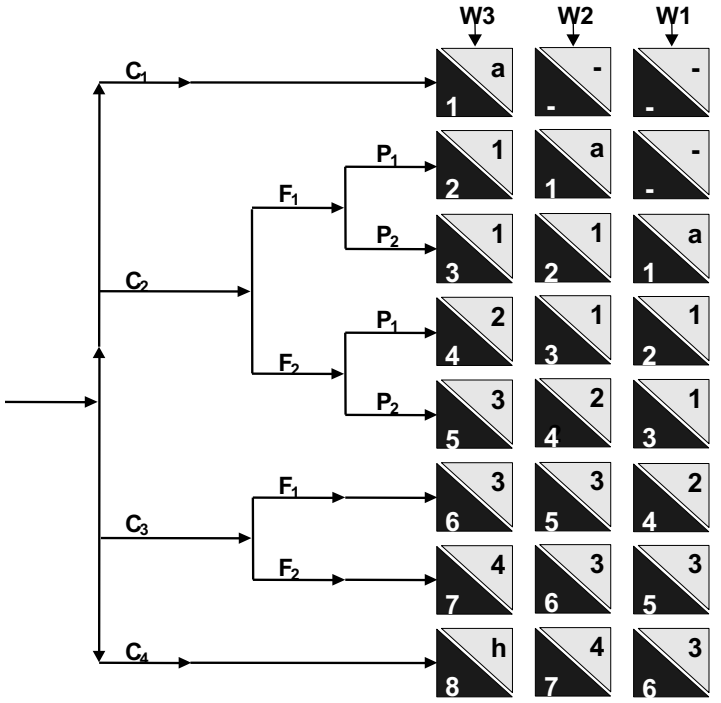
We're Proven-in-Use.

Defining risk tolerance

- Risk Matrix
- Risk Graph
- Quantitative

RISK REDUCTION FACTOR REQUIRED MATRIX						
CONSEQUENCE	4	10	10	1000	1000	TH
	3	NR	10	100	1000	1000
	2	NR	NR	10	100	100
	1	NR	NR	NR	10	10
		1	2	3	4	5
		FREQUENCY				

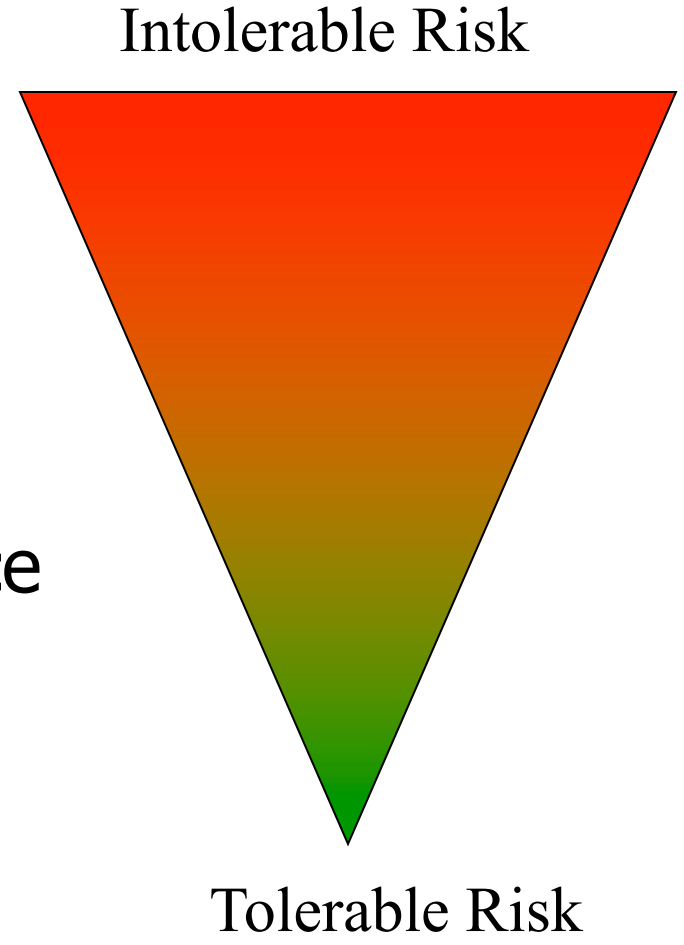
$$PFD_{avg} = F_t/F_{np} = \frac{\text{Tolerable Frequency}}{\text{Process Demand Frequency}}$$



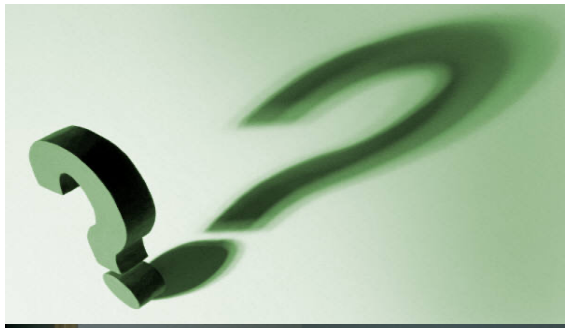
Independent Protection Layer (IPL) Analysis Objective

- Drive the consequence and/or frequency of potential incidents to an tolerable risk level

Risk = frequency * consequence



Initiating Cause



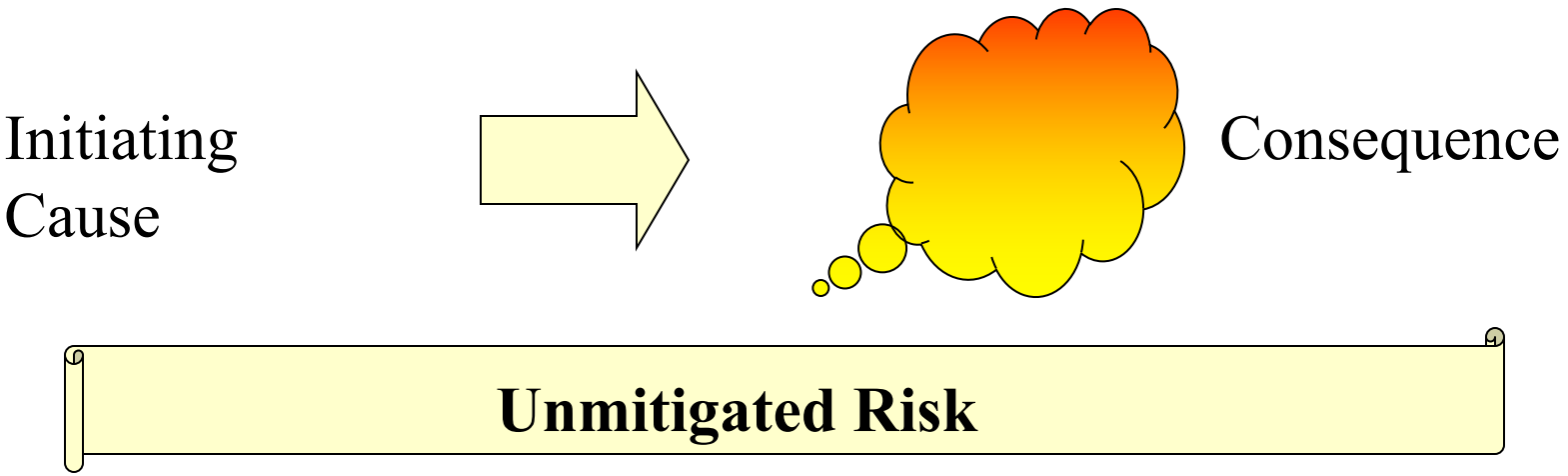
- Process Deviation
- Initiating causes
  - Equipment failures
    - instrumentation
    - pumps
    - compressors
  - human errors
  - loss of mechanical integrity
- Initiating cause frequency

Consequence

- Based on detailed description of hazard scenario.
- Examine safety, environmental, and economic risks.
- Often considers the possibility of escaping the incident and the frequency of exposure to the potential incident.
- Assessment may be qualitative or quantitative (consequence modeling)

Unmitigated Risk

- Incident Frequency = Initiating Cause Frequency
- Consequence = Scenario Consequence



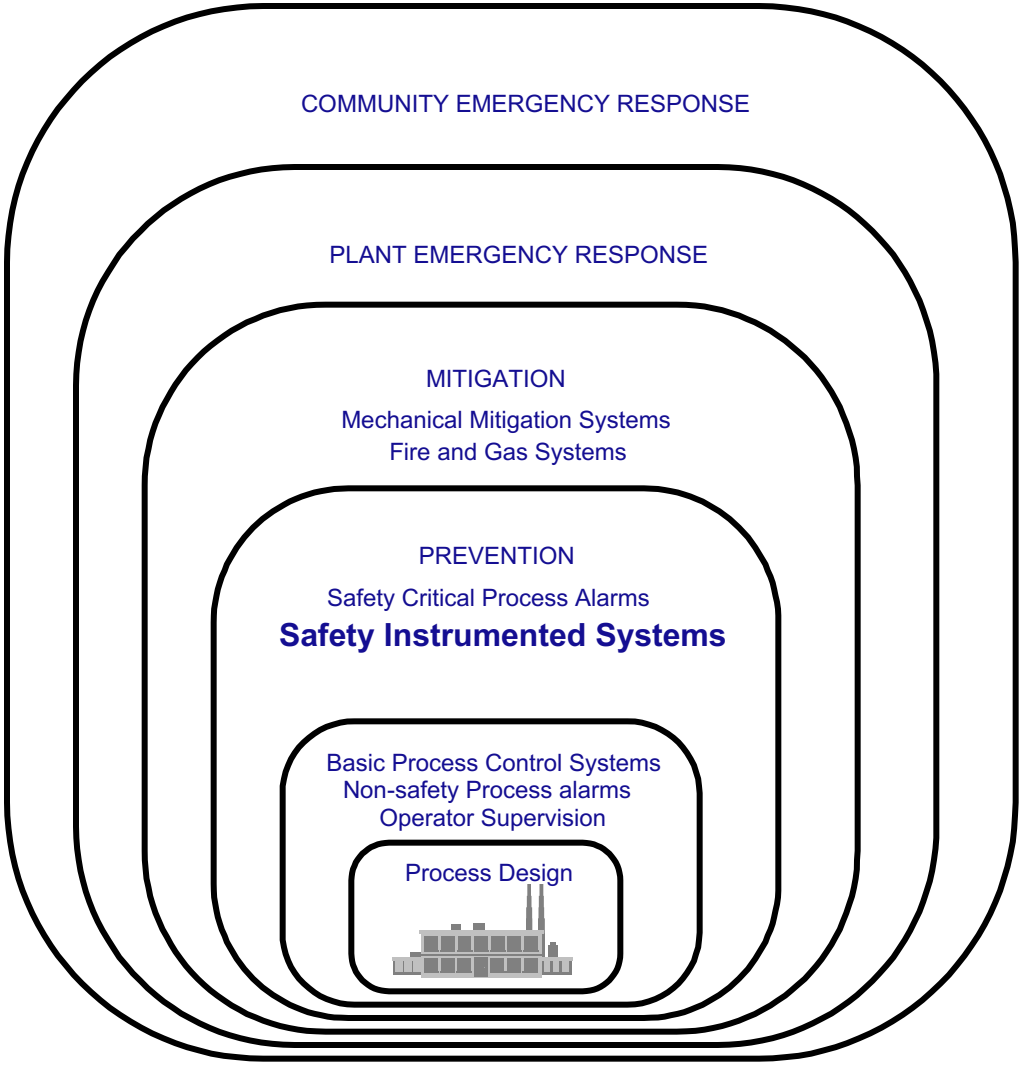
IS IT TOLERABLE?

Risk Tolerance

- Compare unmitigated risk to risk tolerance.
- If unmitigated risk is greater than risk tolerance, independent protection layers are required.

What are IPLs?

- Independent Protection Layers are often depicted as an onion skin.
- Each layer is independent in terms of operation.
- The failure of one layer does not affect the next.



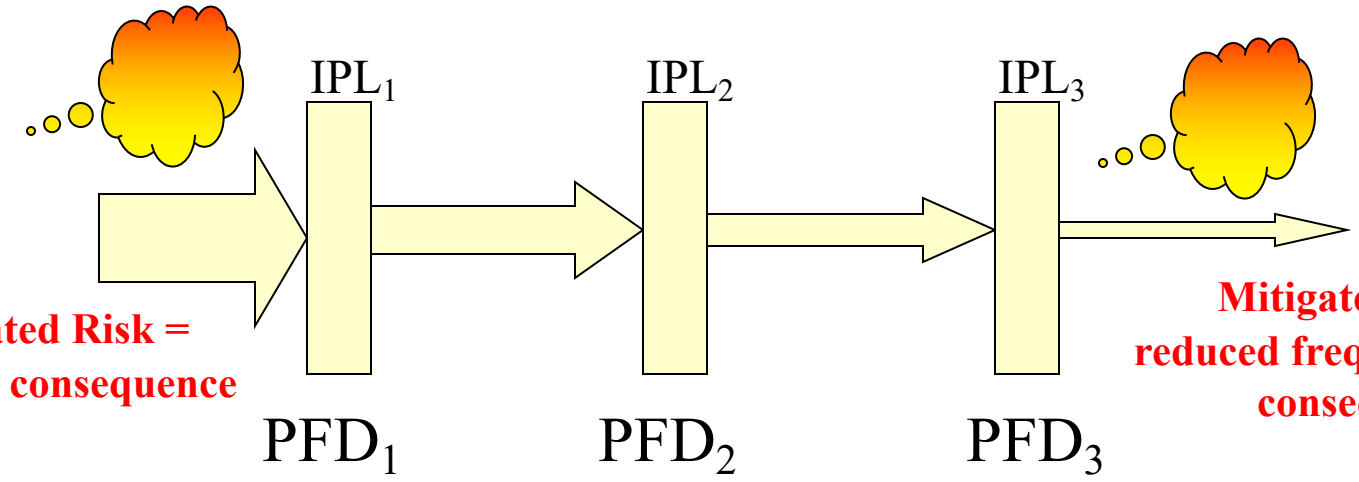
Independent Protection Layer Restrictions

- Sufficiently independent so that the failure of one IPL does not adversely affect the probability of failure of another IPL
- Designed to prevent the hazardous event, or mitigate the consequences of the event
- Designed to perform its safety function during normal, abnormal, and design basis conditions
- Auditable for performance

IPL

- IPLs can provide
  - Prevention (active – lower probability)
    - Alarm with operator response
    - Safety Instrumented System
  - Mitigation (active – lower probability/consequence)
    - Pressure relief valve
  - Protection (passive – lower consequence)
    - Dikes
    - Mechanical design
    - Barricades

Mitigated Risk – Reduce Frequency Only

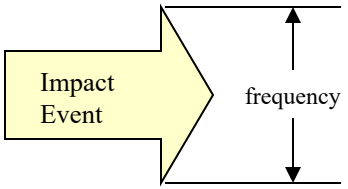


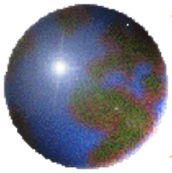
Unmitigated Risk = frequency * consequence

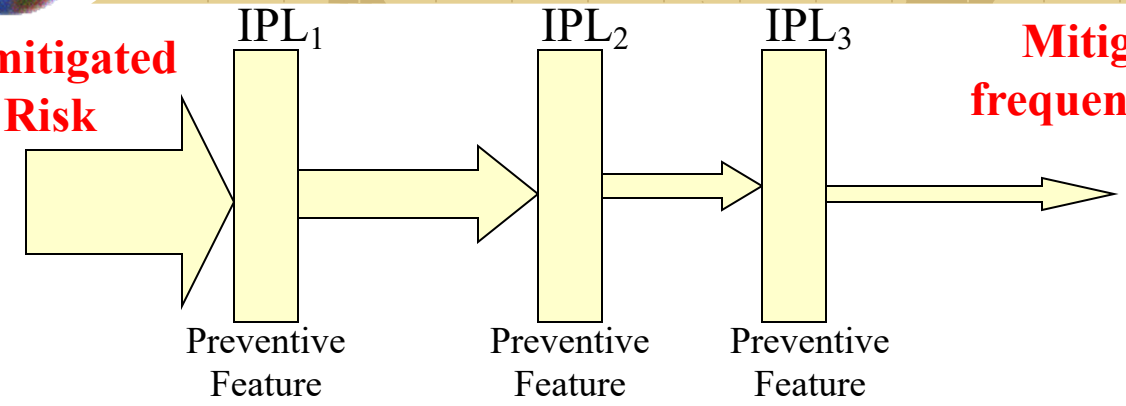
Mitigated Risk = reduced frequency * same consequence

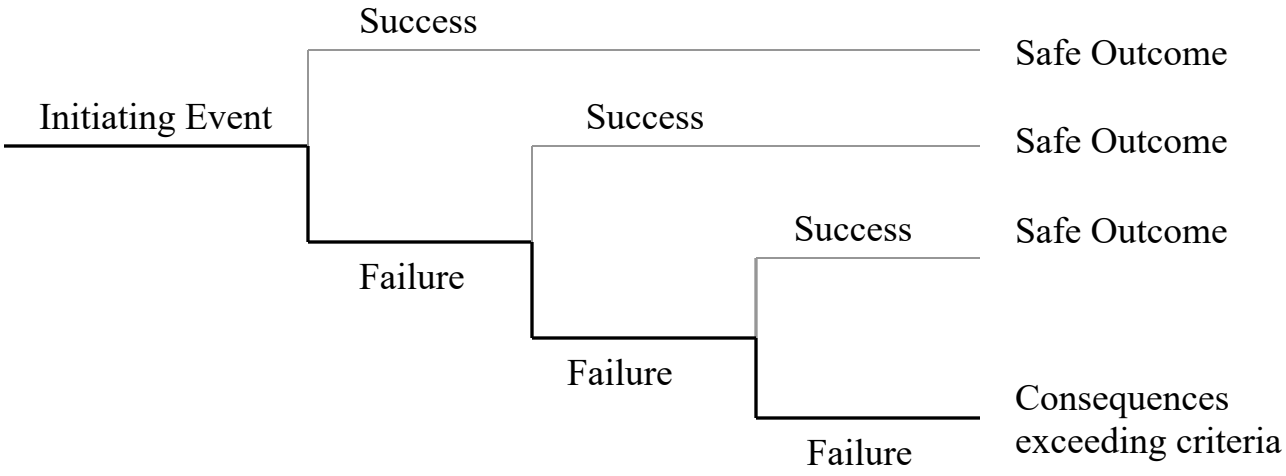
Key:

Thickness of arrow represents frequency of the consequence if later IPLs are not successful





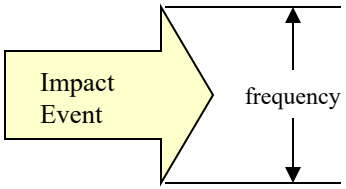


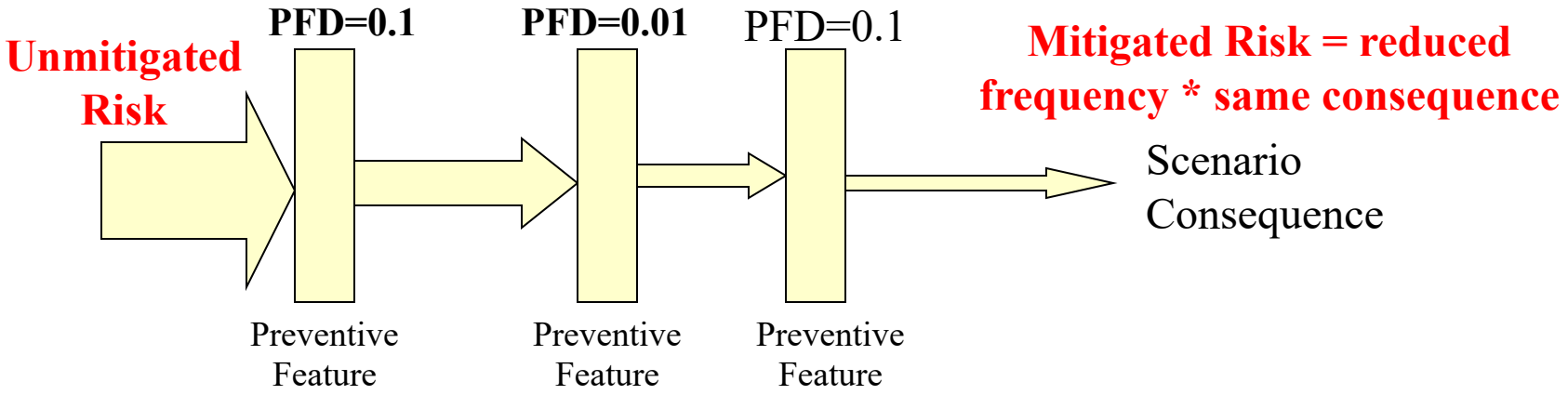


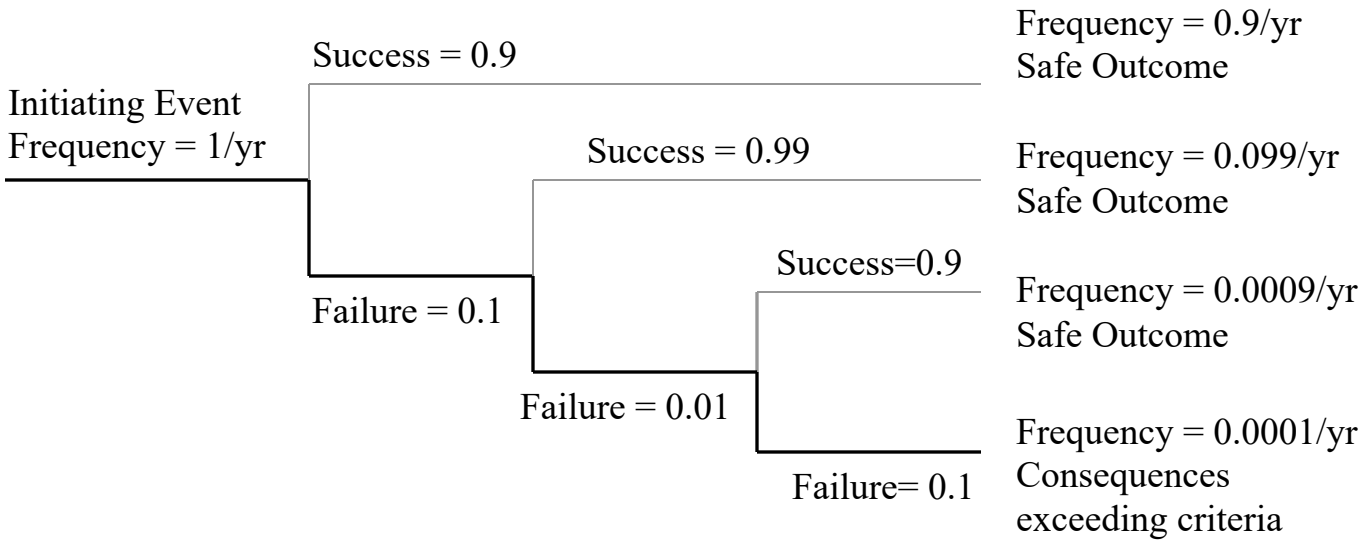
REDUCE FREQUENCY TO ACHIEVE TOLERABLE RISK

Key:

Thickness of arrow represents frequency of the consequence if later IPLs are not successful

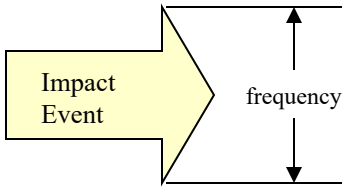




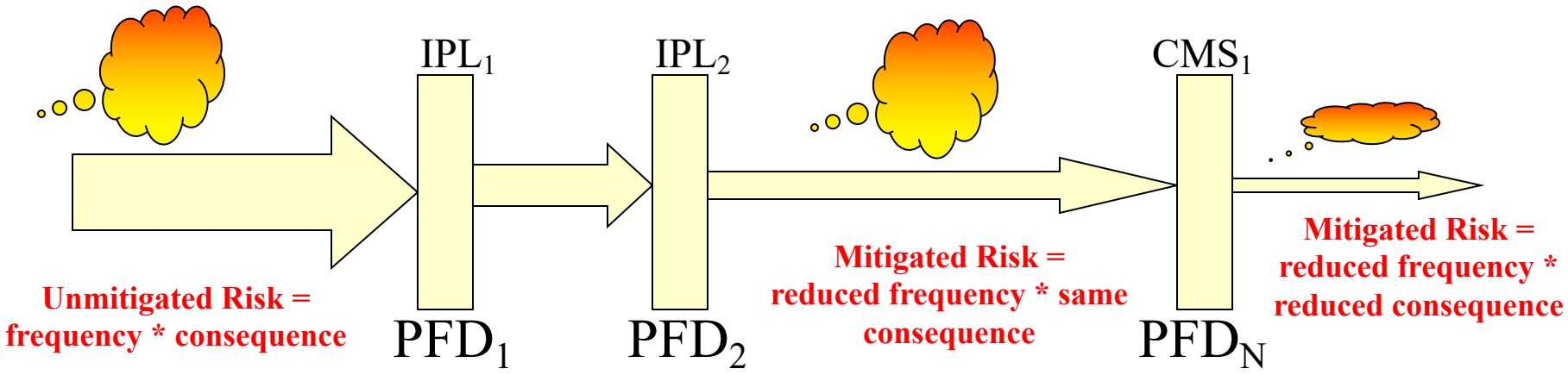


Key:

Thickness of arrow represents frequency of the consequence if later IPLs are not successful



Mitigated Risk – Reduce Frequency and Consequence



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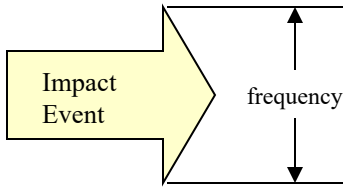

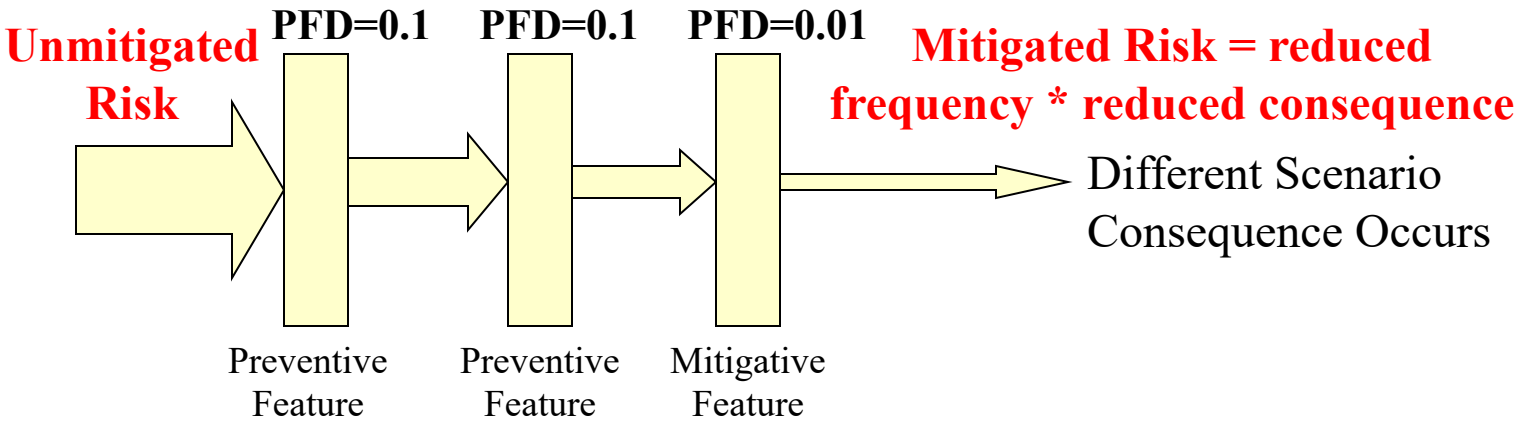

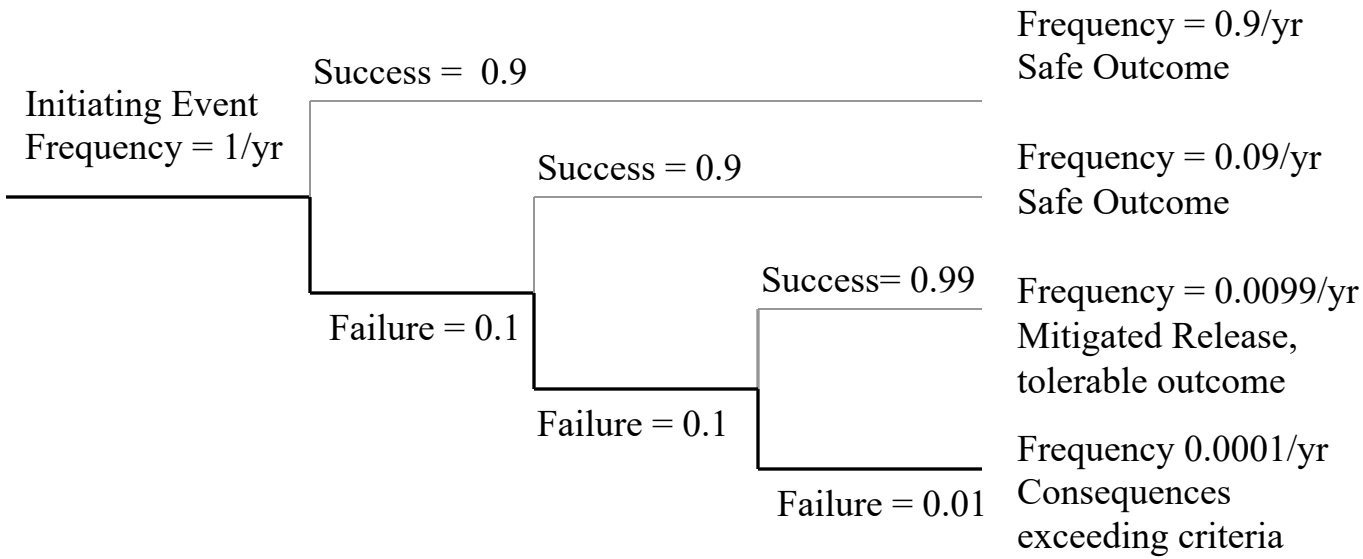

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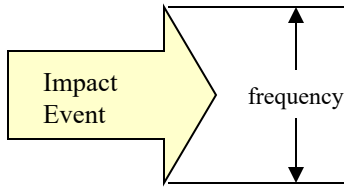
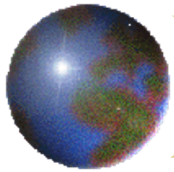


One SIL Assignment Technique



Summary

"A man is rich in proportion to the number of things he can afford to let alone."
Henry David Thoreau

Industry will be judged on how it balances the preservation of life and the environment with the need for revenue and profits.

Engineers are charged with achieving the balance.