RISK ANALYSIS
An Integrated Approach

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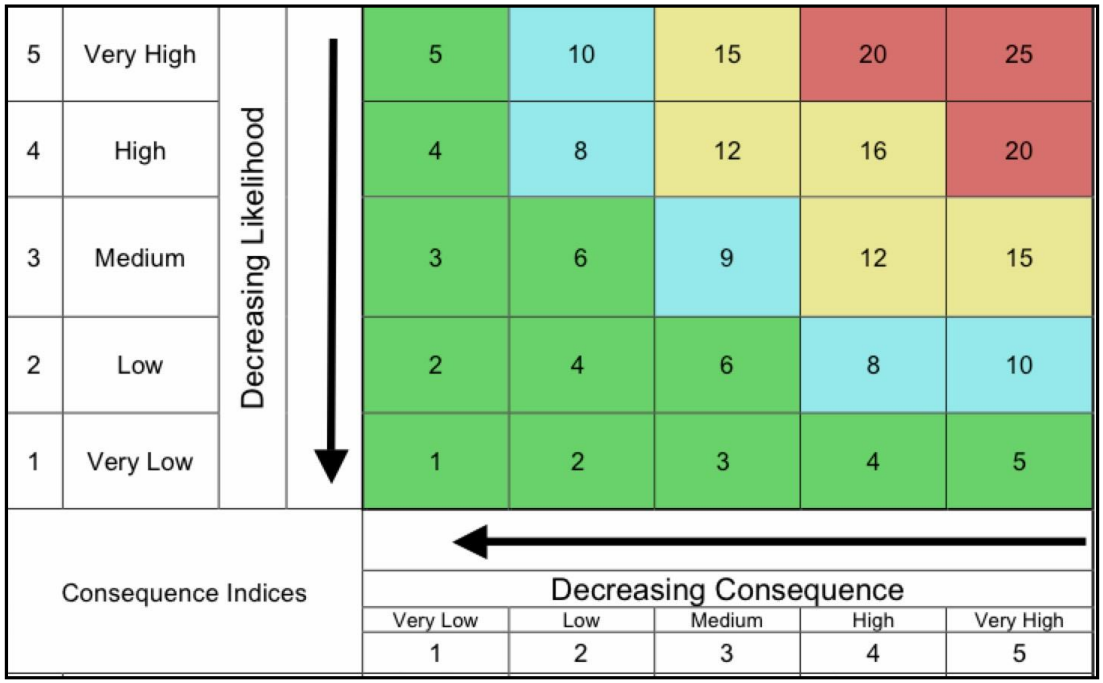
RISK ANALYSIS
An Integrated Approach

- Meeting Objective
- Problem Framing
- Risk Assessment Approaches
- Concerns
- Consideration
- Expectations

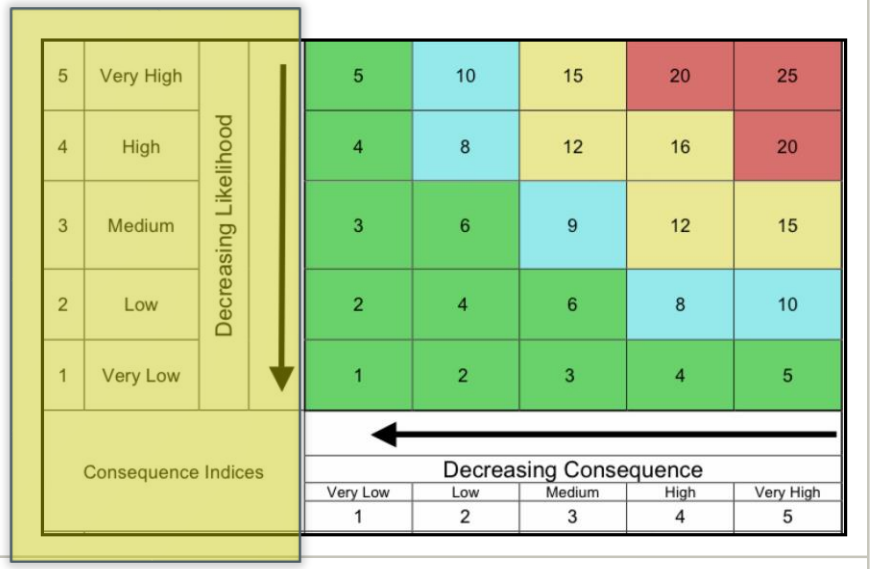
Meeting Objective -

- Develop a path-forward approach for evaluating pipeline risk.



Material Objective -

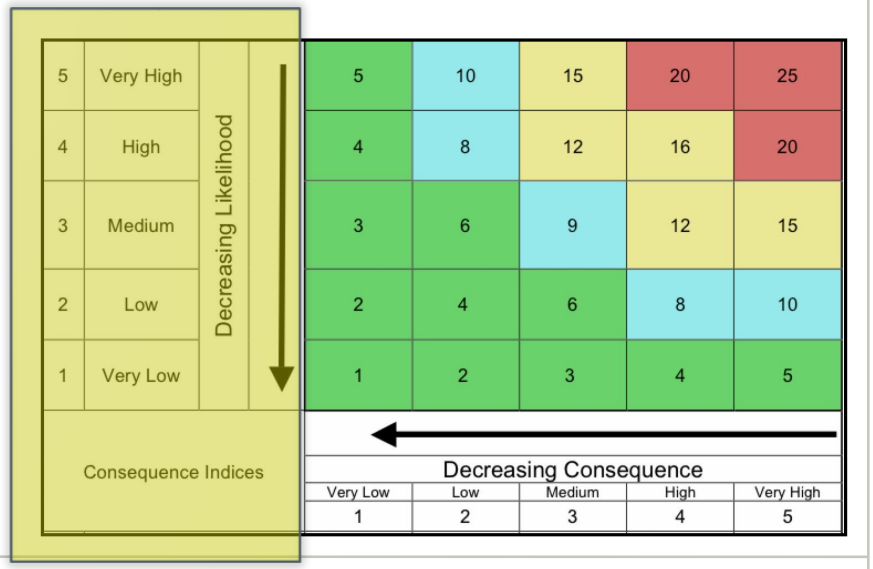
- Develop a path-forward approach for evaluating pipeline risk.
- Focus on likelihood.



Material Objective -

- Develop a path-forward approach for evaluating pipeline risk.
- Focus on likelihood.

What do we really mean when we say “likelihood”?



Tough Questions -

- What are we actually trying to calculate?
  - Random failures?
  - Systematic failures?
  - Common-mode failures?
  - Black swans?

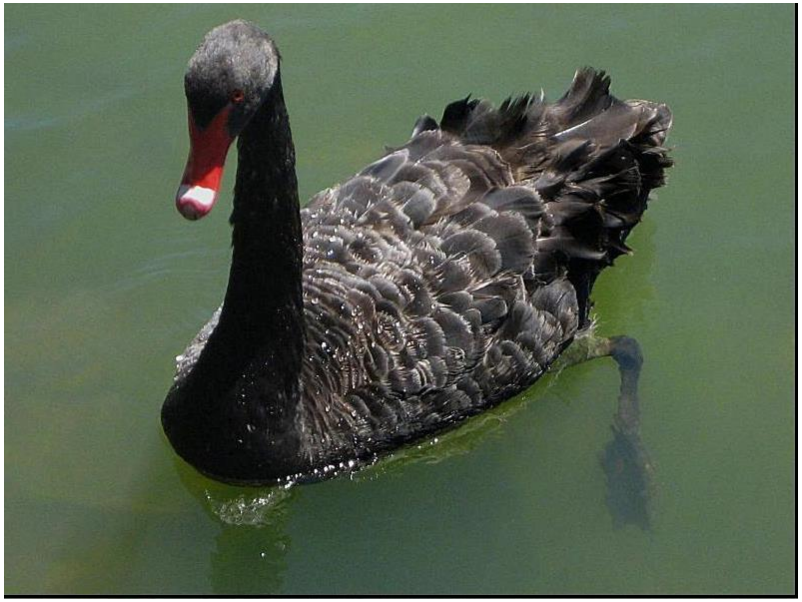
Tough Questions -

- How is this going to get us to the end goal?
  - Is the answer actionable?
  - Does the answer address location?
  - Does the answer address time?
  - What is the margin of error?
  - Is the error positive or negative?

So what do we do ???

Risk comes from not knowing what you're doing.

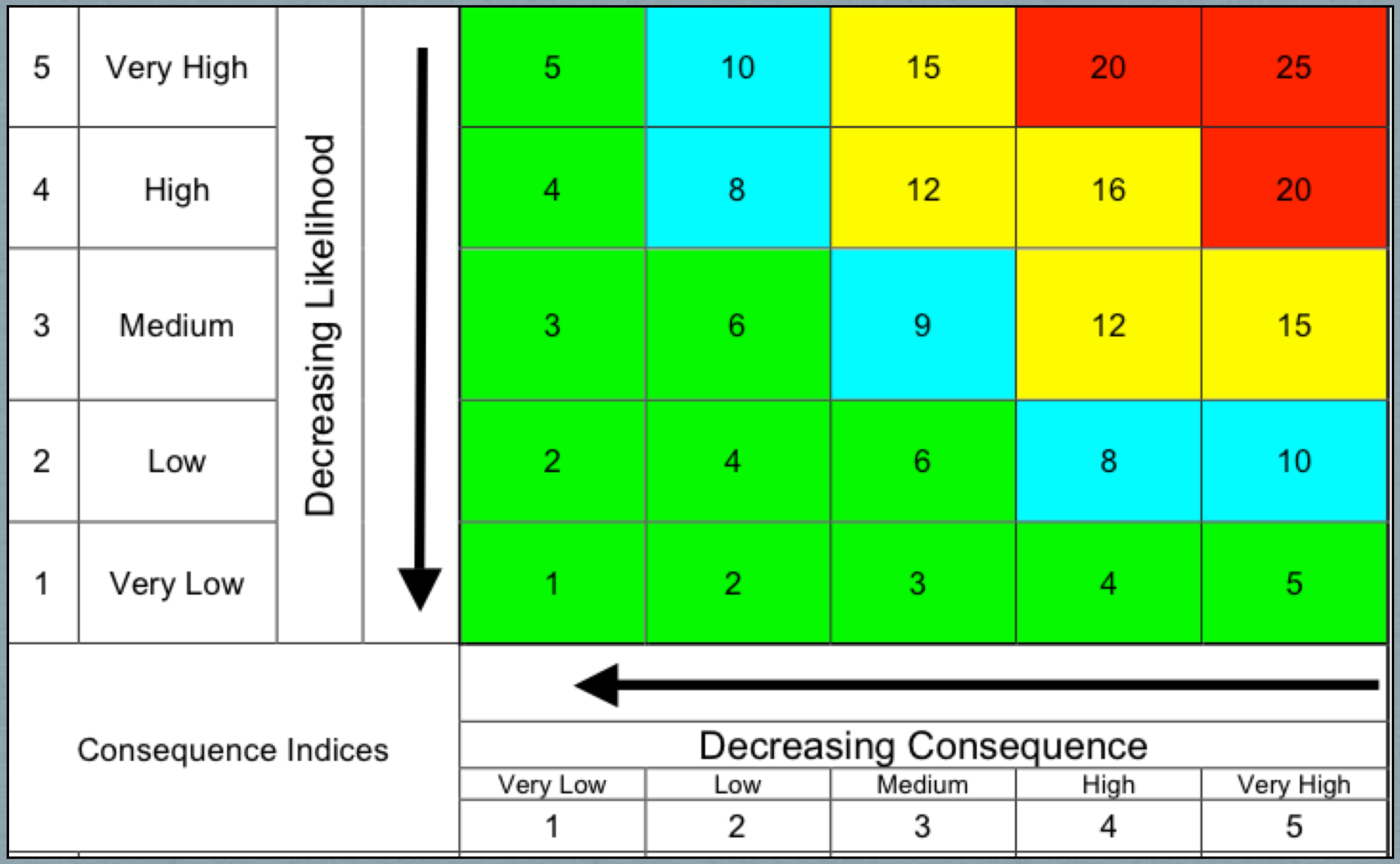
- Warren Buffett



Index-Based Assessment

	Segment A	Segment B	Segment C
Overal Rank:	**#1**	**#2**	**#3**
Average Likelihood:	**3.3**	**4.6**	**5.7**
Consequence:	**4**	**4**	**5**
Total Risk	**13.1**	**18.3**	**28.6**
Ext. Corrosion	**3**	**3**	**5**
Coating Condition	Good (somastic)	Average (heat damage, brittle FBE at the beginning)	Good-Average (replacing coating and pipe, ongoing, reduced operating temperature)
CP Efectiveness	Average (low CP spot exists)	Average (low CP spot exists)	Good
Atmospheric coating	Excellent	Excellent	good
Severity of Amonalies	<50%	<50%	<50%
Int. Corrosion	**3**	**5**	**5**
Product	Jet-A	Refined (mogas, diesel)	LSFO
Corrosion Monitoring	Yes	Yes	No
Inhibitors/Process Measures	No	Yes	No
Severity of anomalies	<50%	none	<15%
TPD	**4**	**4**	**5**
Depth of Cover	Over 3 feet	Over 3 feet	Under concrete, near RR, all developed
Signage	Adequate, line of sight	Adequate, line of sight	Adequate, line of sight
Row/Land Use	Utility coridoor, residential	Utility coridoor, residential	Agriculture, resorts
One-calls	1/week	1/week	1/quarter
Dents >2%	No new dents	No new dents	1 dent in 2005
PA Program	Effective	Effective	Effective
Incidents (damage, no one-call)	No	No	No

The Risk Matrix

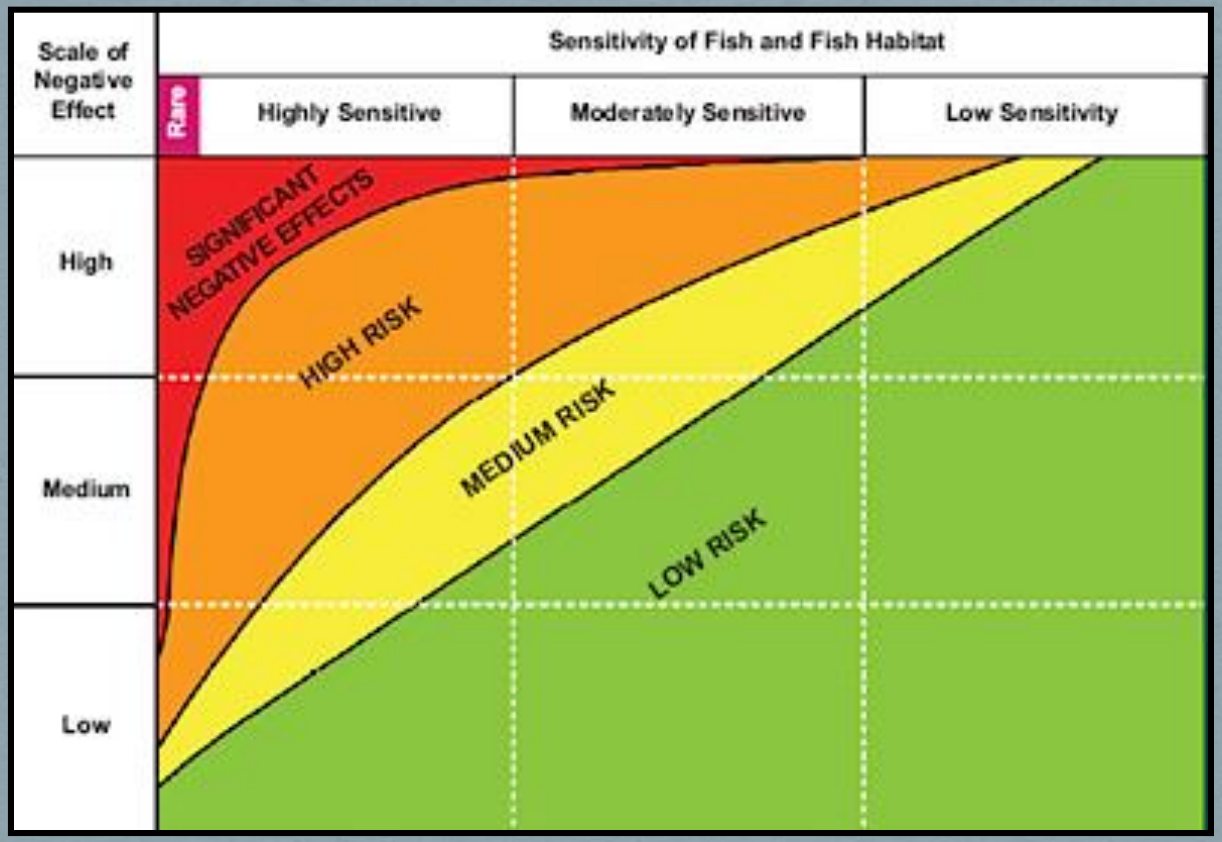


Marine Corps Risk Assessment Matrix

SEVERITY		PROBABILITY: Likely A	Probably B	May C	Unlikely D
Catastrophic	I	1	1	2	3
Critical	II	1	2	3	4
Moderate	III	2	3	3	5
Negligible	IV	3	4	5	5

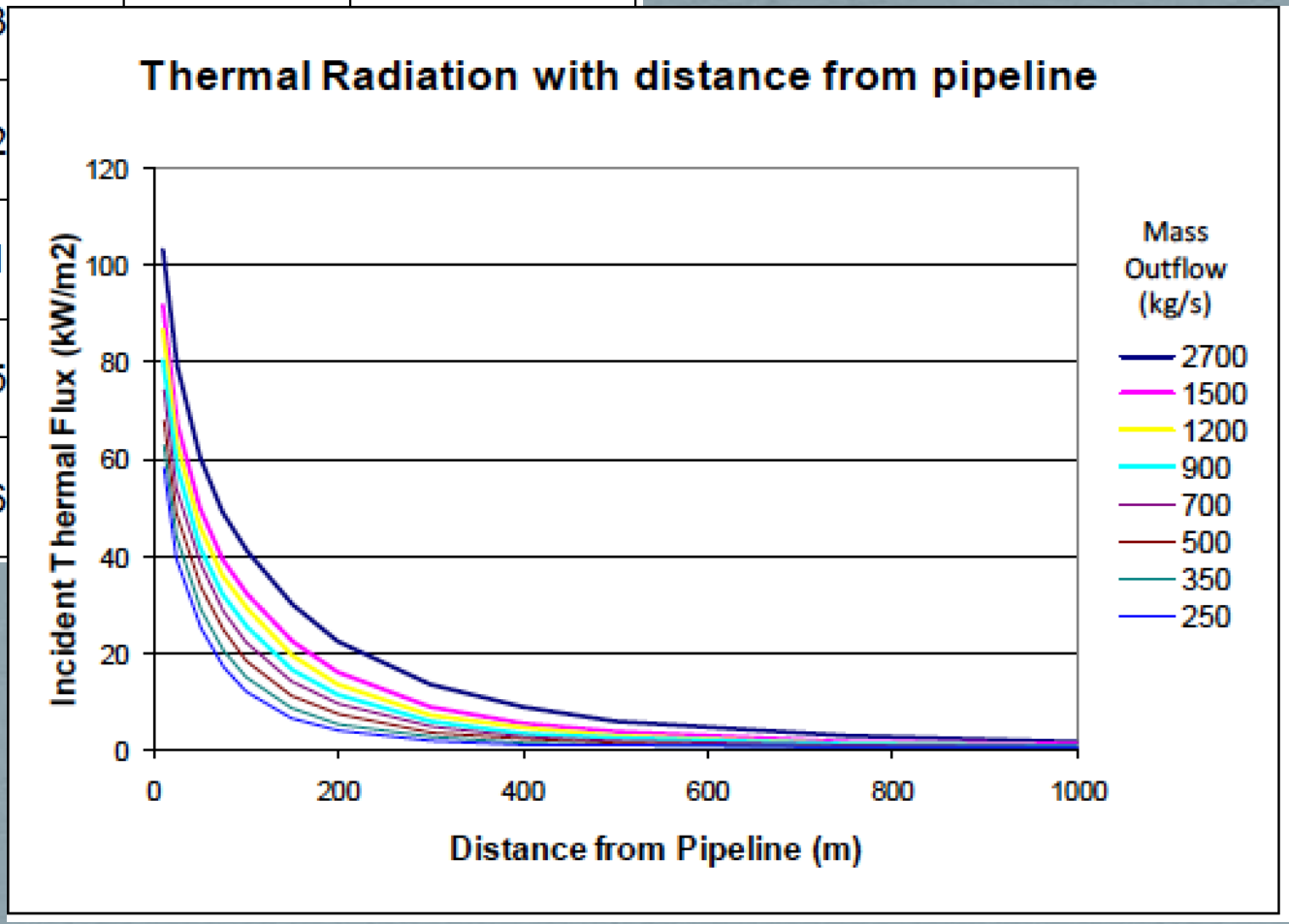
Army Risk Assessment Matrix

SEVERITY		PROBABILITY: Frequent A	Likely B	Occasional C	Seldom D	Unlikely E
Catastrophic	I	Extremely High	High	High	High	Moderate
Critical	II	Extremely High	High	High	Moderate	Low
Moderate	III	High	Moderate	Moderate	Low	Low
Negligible	IV	Moderate	Low	Low	Low	Low

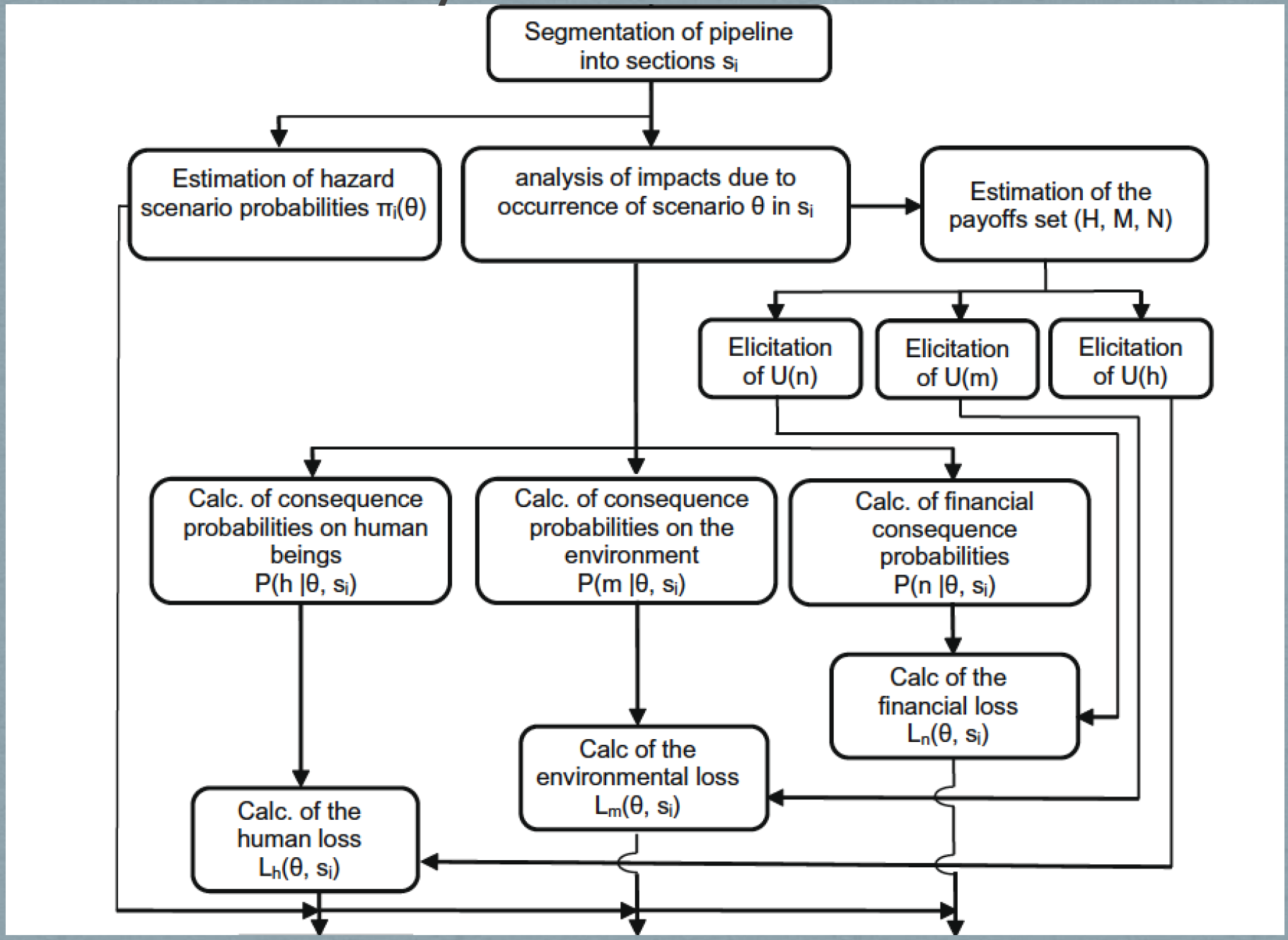


Statistics & Numerical Models

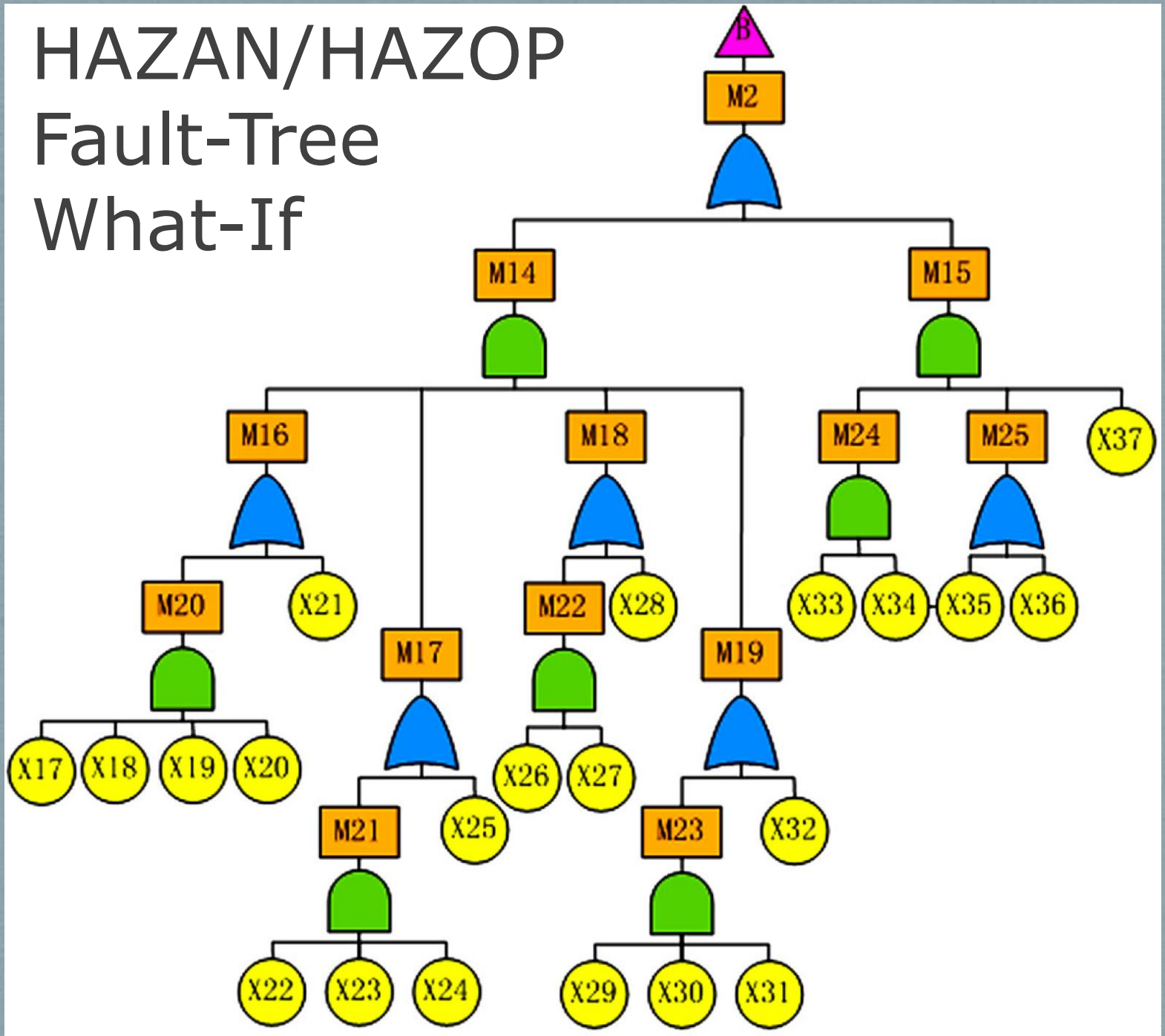
Source	Period	Exposure (10^6 kmyr)	No. of Incidents	Frequency (x 10^{-3} kmyr)
PHMSA	1992 - 2010	9.01	1383	0.153
	2006 - 2010	2.3		
NEB	2000 - 2009	0.2		
	2005 - 2009	0.1		
EGIG	1970 - 2010	3.5		
	2006 - 2010	0.6		



Bayesian Inference



HAZAN/HAZOP
Fault-Tree
What-If

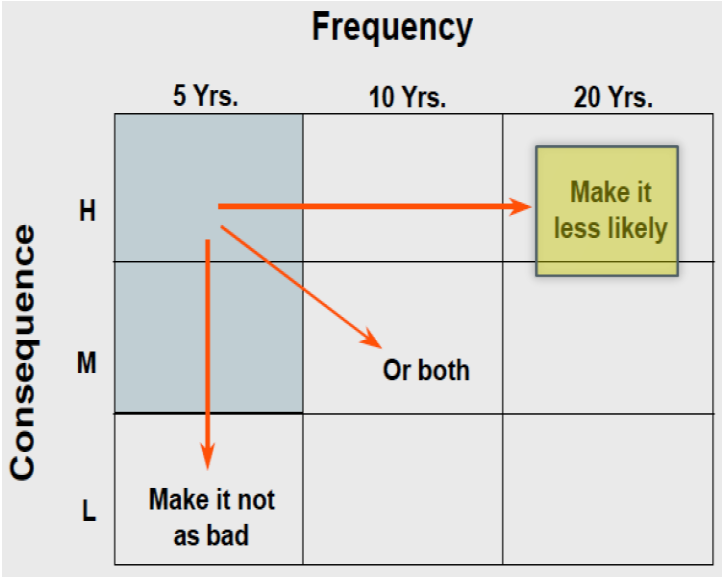


Subject-Matter Expert (SME)

THIRD PARTY DAMAGE - Risk Factors				
Evaluation of risk factors (exposure and resistance)	**Is there a potential risk increase or exposure due to this factor?**			
	Yes	**No**	**N/A**	**Comments**
Excavation activity level	☐	☒	☐	Low excavation activity. Static over past 5 years. No change in number of one-calls or locate frequency.
Damaging farming activities in the area	☐	☐	☒	No farming or tiling activities along pipeline. Pasture land only. No plowing. Only surface cutting.
Depth of cover (DOC)	☒	☐	☐	Approx. 5 ft. along entire system. One area east of Houser Rd. in road ditch is 2.5 ft.
Spans or above-ground pipe	☐	☒	☐	Only above ground pipe; located in the pump station and at the intermediate block valve (MP-22).
Above ground valves or other components	☐	☒	☐	One at MP-22. Manual block valve located 2 miles west of I-35 along Rte. 432.
Traffic damage potential (vehicle, rail, marine) or vandalism	☒	☐	☐	MP-22 has chain link fence and barbed wire. Approximately 15 ft. from Rte. 432. No bollards or pipe-rail fence. Snow could cause a car/truck accident.
Diameter/Wall thickness	☐	☒	☐	0.322" (8.625" Grade B = 52% SMYS) 8.625"/ 0.322" Ratio = 26.8
Operating stress	☐	☒	☐	Max NOP = 200 psig (avg. 120 psig) with MOP = 1350 psig NOP/MOP = 15% (8.625" Grade B = 52% SMYS)
Other (describe)	☒	☐	☐	Proposed extension of bike path south of Clifford.

So what's the Best Approach?

- Risk Matrix?
- Index-Based?
- HAZOP/Fault-Tree?
- Statistics and Models?
- Bayesian Inference?
- Subject-Matter Expert?



It depends...

- What problem are you trying to solve?
  - e.g., third-party damage vs. cyclic fatigue
- What do we know?
  - problem complexity
  - data availability
  - data quality
  - statistical validity
  - Human involvement
  - on and on...

Cautionary Note

Probabilistic models significantly underestimate the likelihood of catastrophic failure, if not deliberately exclude it.

Daichi Reactor

- Detailed PRA
- Melt-down scenario = 1×10^{-6} yrs.
- Occurred 40 years later
- Off by 10^{-5} (999,960 yrs.)

Black Swans

Probabilistic models are currently unable to predict complex and human-related failures.

Bellingham

- 19 unrelated failures
- 4 threat mechanisms
- Common-mode, Systematic, and Random

- Can't model
- Can manage

Integrated-Approach

- Statistics for predictable failure mechanisms
- Models to estimate change/evolution
- Indexes to compare low-quality data sets
- HAZOP to evaluate worst case scenarios
- Complex methods to test discrete hypotheses
- GIS to visualize the spatial component
- SMEs for knowledge and evaluation

Items for Consideration

1. Determine up front what questions you want answered.
2. Evaluate critical data and collect what's missing.
3. Understand your data quality and model uncertainty.
4. Evaluate interactive and common-mode threats.
5. Consider inherent consequence of a specific threat.
6. Require "actionable" outputs to your assessment.
7. Drive toward location/attribute-specific outputs.
10. Measure model performance moving forward.
11. Don't through out good knowledge for bad data.

Items for Consideration

Capture Error

a) Continuously consider “error”
b) Understand compounding error (e^x)
c) If's, averages, and assumptions
d) Describe the error and it’s implications
e) Impact of false positives vs. false negatives

Hopes & Desires

1. Develop a risk objectives statement
2. Justify the selected assessment approach(s)
3. Describe data quality and data limitations
4. Establish a risk decision basis
5. Validate model outputs with SMEs
6. Measure model performance & recalibrate risk

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