OIL & GAS

An Overview of Risk Models

...and Thoughts for the Future

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Background

- Three questions
  - What can go wrong?
  - How likely is it?
  - What are the consequences?
- Why do we need models?
  - Pipeline risk is complex (100s of variables) over long distance
    - Crossing the street vs. city planning
  - It is more efficient & effective than prescriptive
- What are the challenges?
  - How to marry with current IMP codes, standards, procedures, and expectations of outside stakeholders
  - Building competence and institutionalizing change

The Current State & Incremental Improvement

Relative, Index, Scoring Models

- Served us well in the past
  - Easy to setup and use
  - Simplifies maintenance priorities in large systems
  - Incorporates SME judgment
  - Mature community of practice
  - Low cost w/multiple suppliers

Scoring Model Issues

- Not designed for IMP where numbers are needed to:
  - Determine Reassessment Intervals
  - Evaluate P&M Measures
- Difficult to anchor
- Possible masking
- Technical compromises
  - Weightings, Scale direction, Interactions (dep/indep)
- Hard to validate
  - Every (near) event could have an RCA and be used to exercise the model
    - (i.e., how can model be improved to better predict?)

Index Model Downward Spiral

Risk model not built to support current IMP

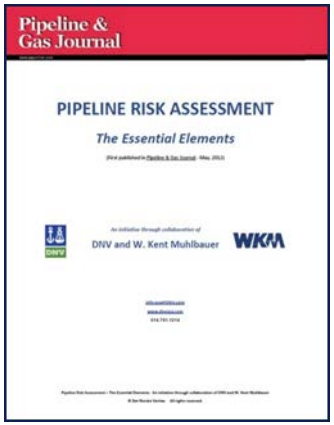
Risk Model Not Kept Up To Date

Risk Model Not Trusted

Risk Model Not Used

Essential Elements (Extracted)

- Use sound technical analyses to characterize threats, PoF, and CoF
  - Use measurable & verifiable input variables
- Include sufficient resolution
  - Along pipeline
  - Between threats to know what makes up total risk
    - e.g., to identify Low-PoF/High-CoF ‘catastrophic’ threats
- Integrate model with SME knowledge
  - Incorporate SME input to model or treat as risk-informed
  - Control bias
- Make outputs relevant to decision-makers and implementers
  - And in context of existing management system, including the IMP
- Exercise/validate the model with new events

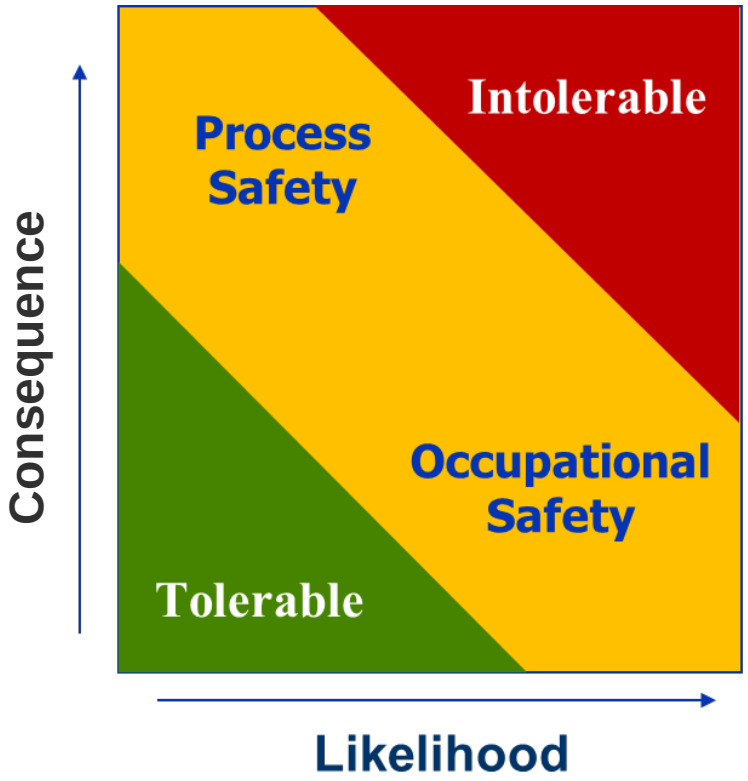


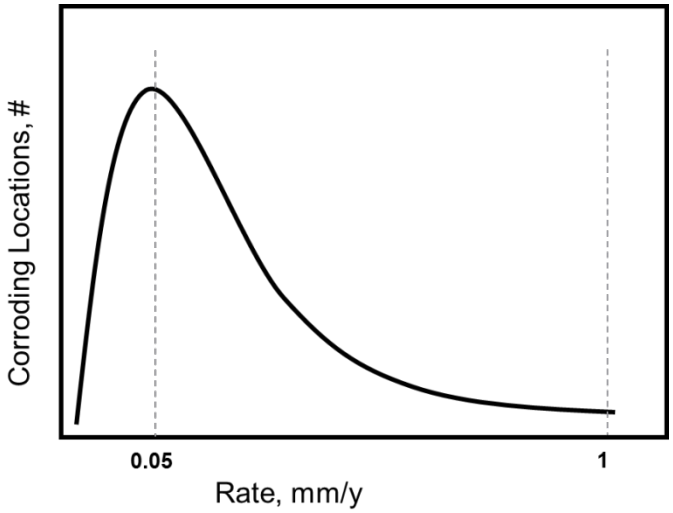
Pipeline Risk is Probabilistic, which is the Language of Uncertainty

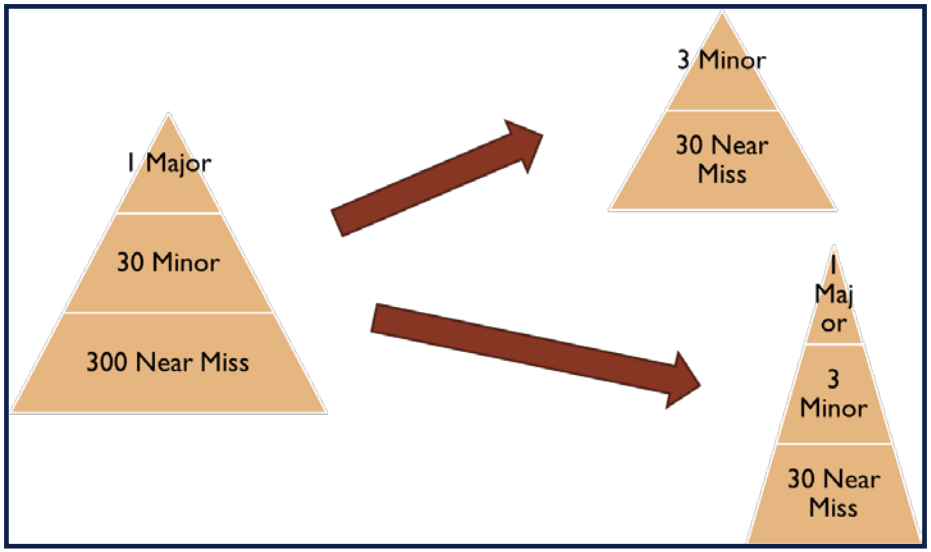
Pipeline risk is low on average, but isolated events plague the industry; we always seem surprised.

Asset Risk Management

- Unlikely events are hard to identify and manage

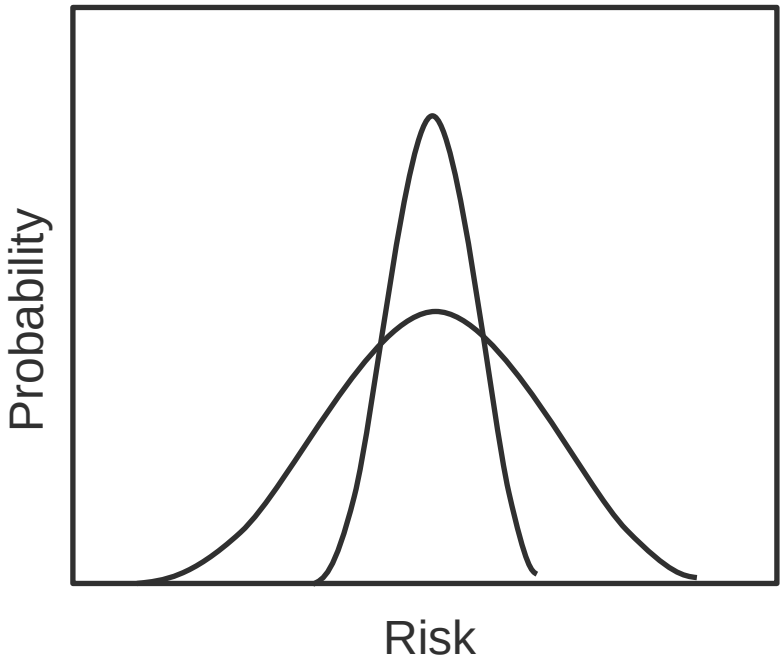


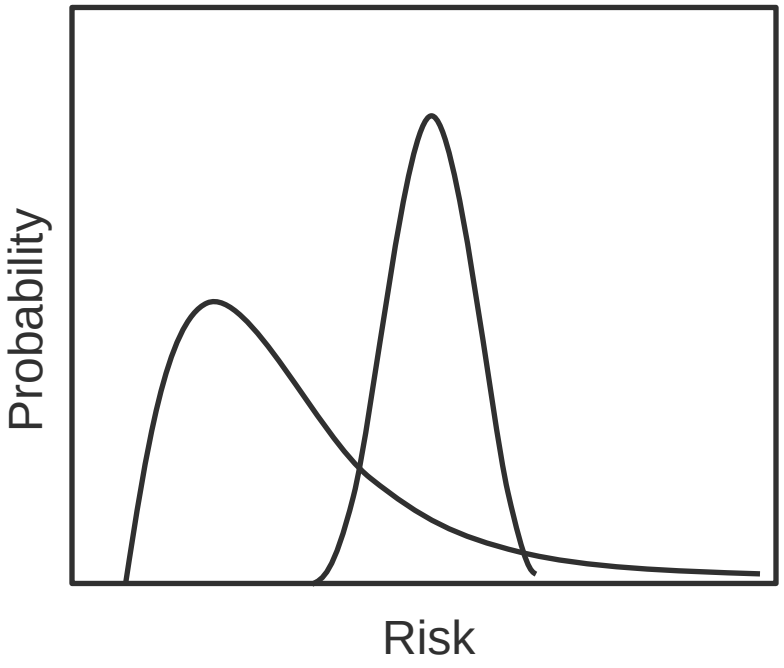




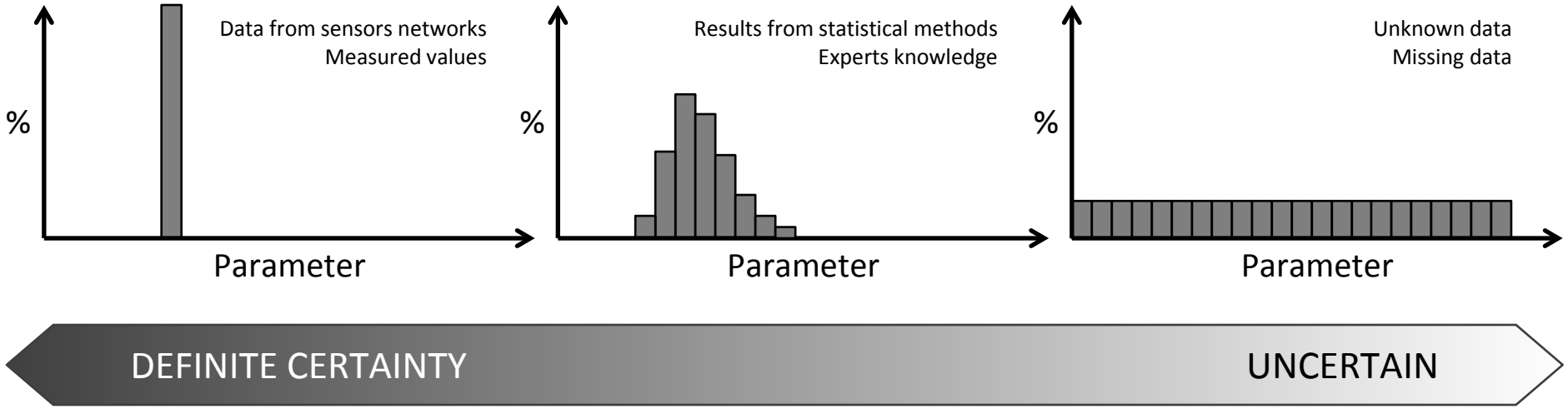
The Importance of Distributions and Extreme Values

- PoF and CoF both have distributions
  - Extreme PoF values not captured by average growth rates
  - Extreme CoF values not captured by HCA definitions



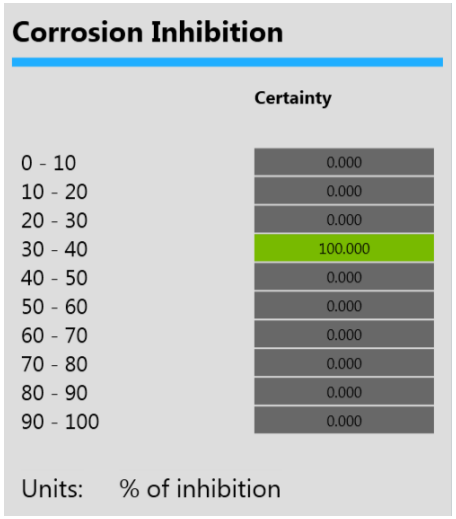


Example: Should we run a hydrotest?

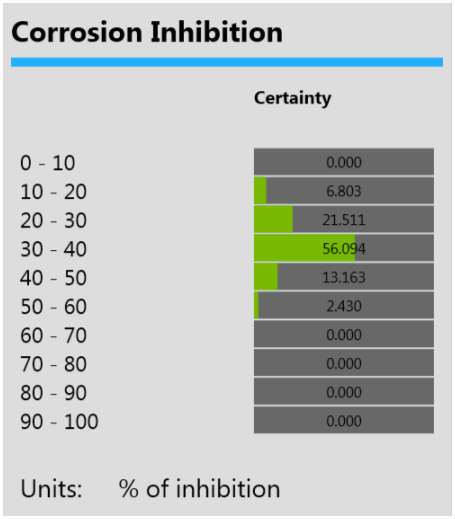

Data from sensors networks
Measured values
%
Parameter
Results from statistical methods
Experts knowledge
%
Parameter
Unknown data
Missing data
%
Parameter
DEFINITE CERTAINTY
UNCERTAIN

Improve Common QRA Models with Bottom-Up Inputs

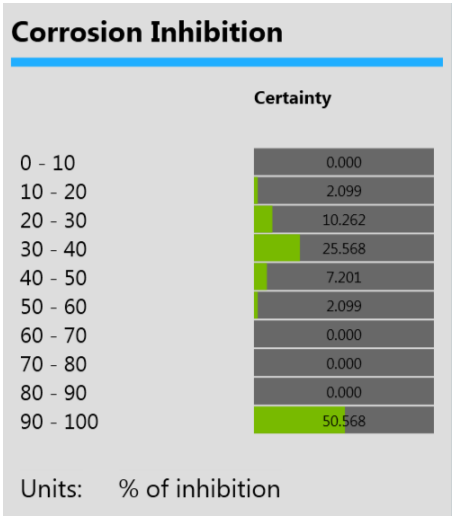
- Don’t guess; include only what you know



Single Value



Uncertain Value



Pump Problem

Unknown

Example Model Output

Limitations of Common QRA Models

- Tends to use statistical data
  - Use of historical data is lagging (i.e., backward-looking)
    - ‘driving by rear-view mirror’
    - New failure modes are not predicted
  - Site-specific effects are not considered
- Often treats variables as independent
- Forward-looking SME beliefs difficult to incorporate
  - ok if SME uses model to be risk informed

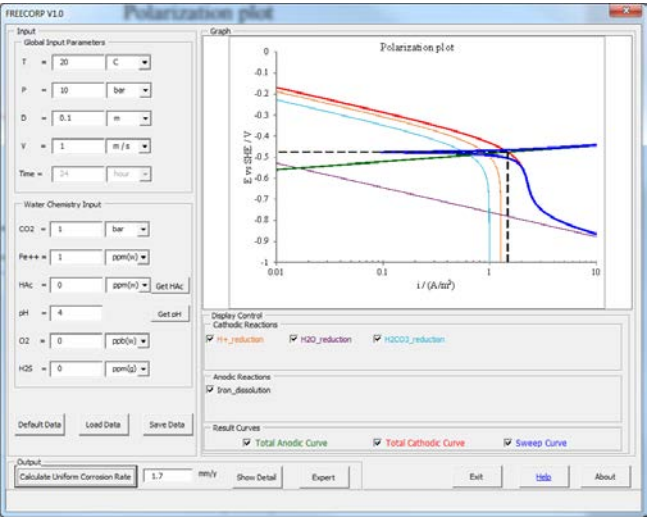
Improve Models with Bayes Theorem

- Conceptually
  - Cause has an effect on its consequence
  - Consequence has an effect on the probability of its cause
- Example
  - Lack of corrosion (e.g., learned by ILI) is used to update 1) risk profile, and 2) corrosion inhibitor effectiveness, thereby
    - Filling data gaps
    - Creating forward-looking information

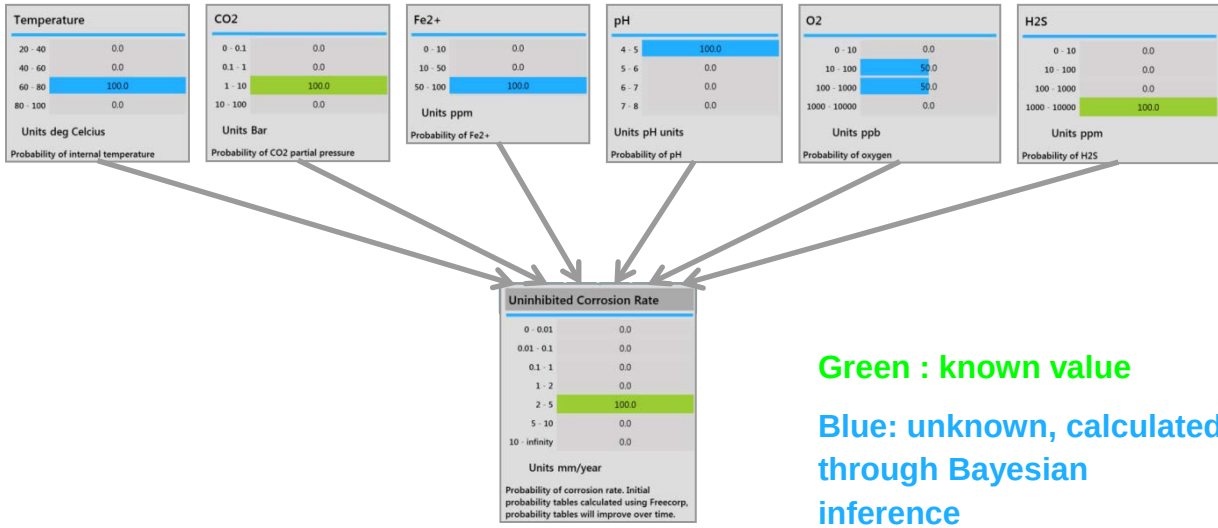
Use of Bayes Theorem

- Bayesian inference can be used to calculate probability densities of
  - Consequences from known causes (as with other models)
  - Causes knowing the consequence

CORROSION MODEL



SAME CORROSION MODEL – BAYESIAN NETWORK



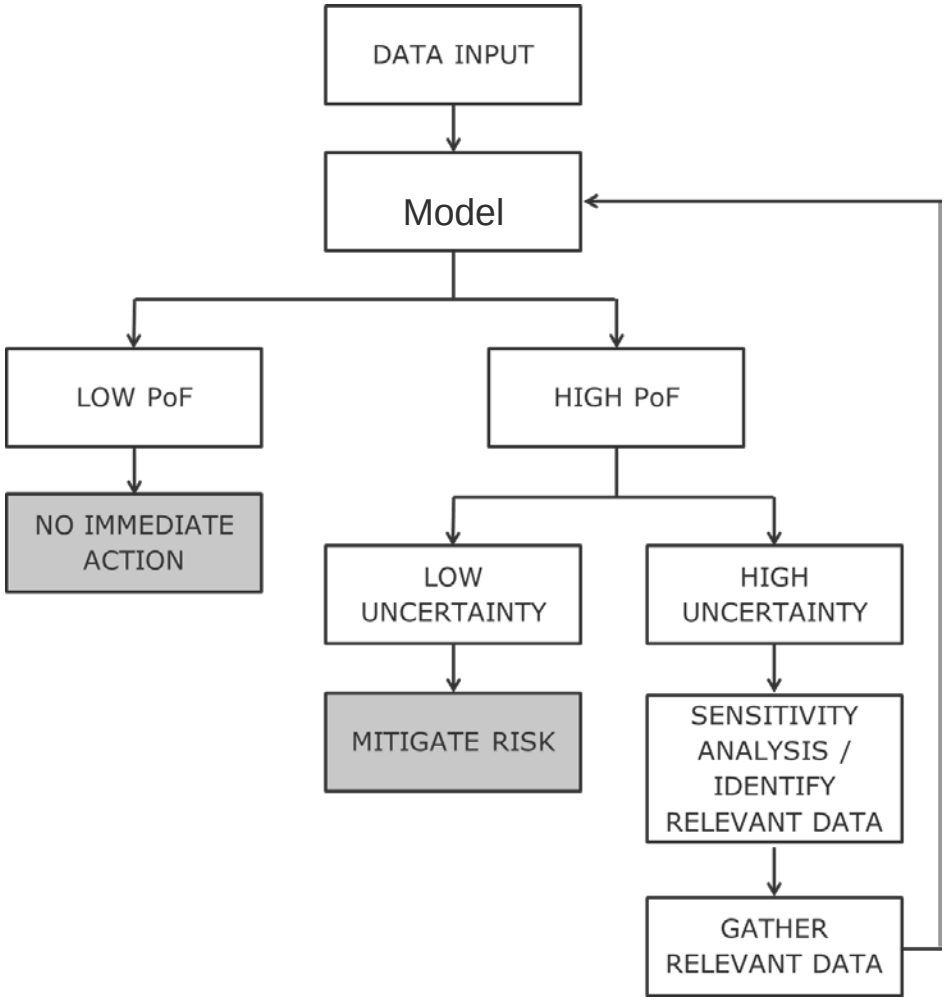
Green : known value

Blue: unknown, calculated through Bayesian inference

Optional Example – Use of ILI to Correct Corrosion Rates

- Start with low corrosion risk & input predicted corrosion rate distribution
- Predict damage distribution into the future based on growth rates
- Run ILI
- Correct probabilistic growth rates for future decision making (to include reassessment interval)

Allow Decision-Making between Maintenance Action & Data Collect



In Conclusion

- Determine objective before selecting a risk model, which can help to
  - Document IMP decisions across a pipeline network
  - Comply with regulations
  - Improve IMP effectiveness
  - Optimize maintenance
  - Systematize SME recommendations & protect against human error
  - Communicate recommendations to internal decision-makers and implementers
  - Assure outside stakeholders
  - Defend against potential future litigation
  - Integrate low-level risk management with an ERM
- Don’t forget that no model is the real thing

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