the Energy to Lead

Achieving Useful Risk Models Through Causality, Coherence and Data Development

Government/Industry Pipeline R&D Forum
Wednesday, August 6, 2014
Crowne Plaza Hotel, Rosemont, IL
Working Group #4: Improving Risk Models

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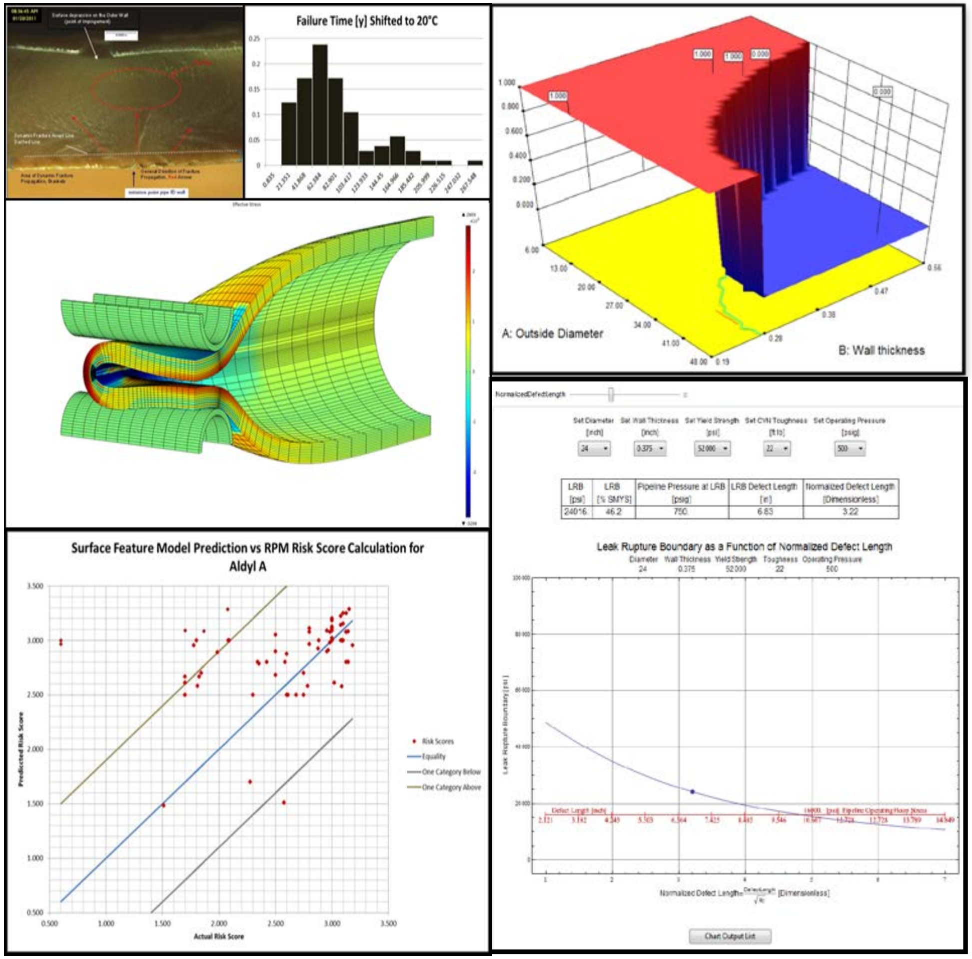
Risk Models for Decision Support

- A good risk and decision analysis framework provides reasons to stakeholders and auditors for decisions related to utility infrastructure design and operations.
- The framework must employ a multidisciplinary process that includes risk assessment, characterization, communication and management, and related optimization of decisions.
- Components of the framework include predictive models, calculators, and databases that describe the complex and interconnected behavior of utility infrastructure systems and their risks.

First Step: Causal Risk Models

- Proper identification of failure modes,
- Properly accounting for the effect of environment on these failure modes,
- Properly calculating the conditional likelihood of failure given a material, failure mode and environment,

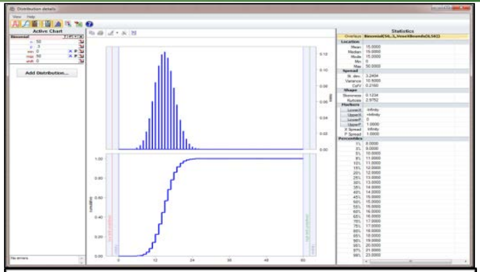


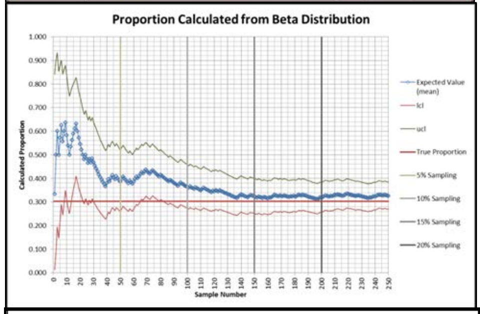
Second Step: Coherent models

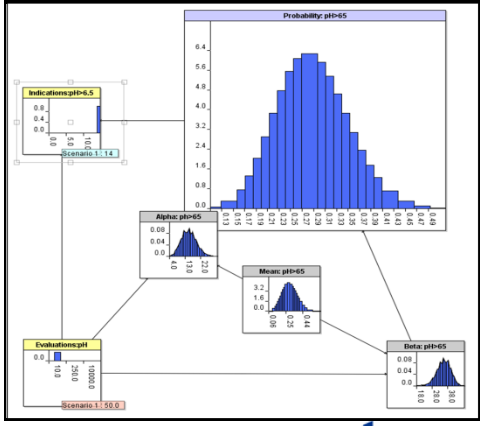
- "Index" type models do not allow apples-to-apples scenario analysis
- Subject matter expertise is subjective
- Relative risk tables reflect subjective opinion
- **Solution:** Models that enforce the laws of probability – they must be **Coherent**
  - The sum of likelihoods of all possible events is 1
  - **This allows:**
    - **Causal reasoning,**
    - **Proper investigation of root cause and**
    - **Estimation of likelihood of occurrence**

Third Step: Data Development

- There is uncertainty associated with all data collected
- Developing probability distributions from collected data is a simple task
- Probability distributions correctly depict the uncertainty and the expected value
- Properly collected and counted data will converge to the true natural frequency of occurrence

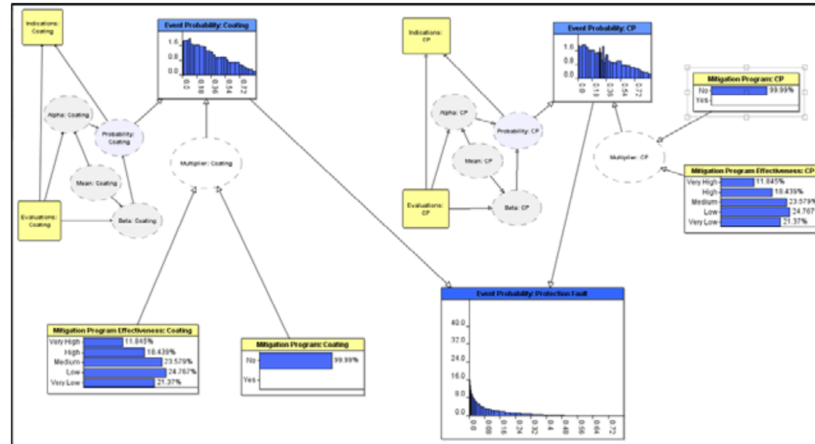


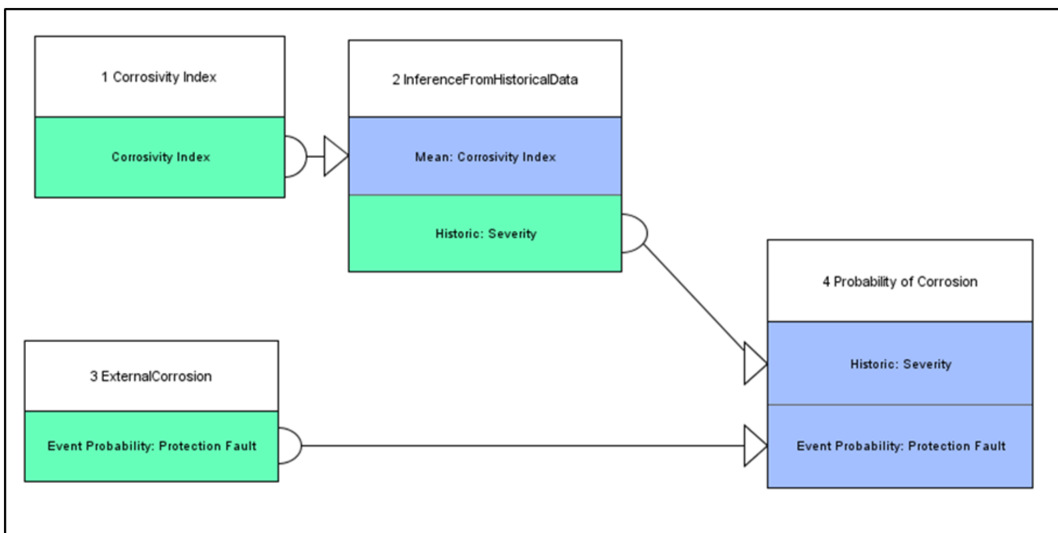


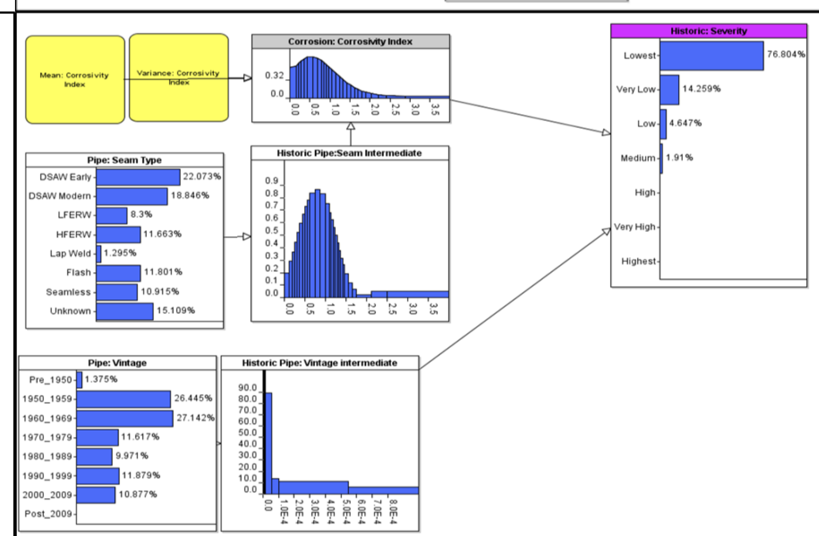


Data is Context Sensitive

- Data for each portion of the framework needs to be treated correctly
- It is important to enforce **coherence**

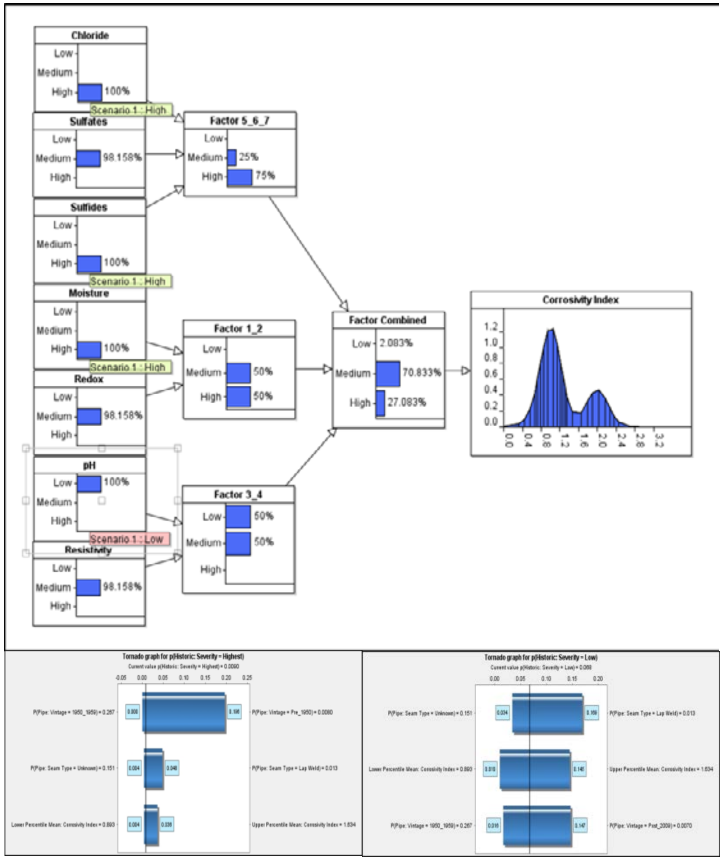






Interactions – Changing Sensitivity

- Interactions of threats can lead to unexpected probability distributions
- Sensitivity to inputs changes for different levels of the same outcome
- **Coherent frameworks are essential for proper understanding and reasoning**



Research and Development Efforts

- > Industry wide models for transmission and distribution systems are needed for:
  - Cast Iron
  - Polyethylene
  - Polyamide
  - Steel

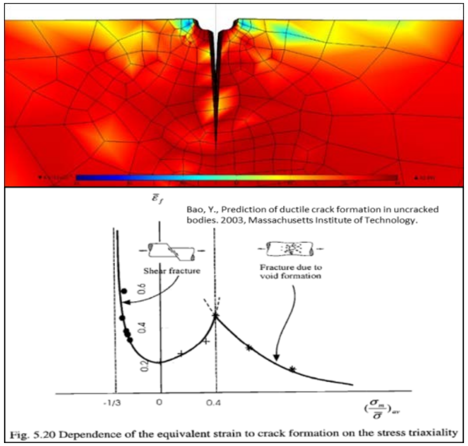
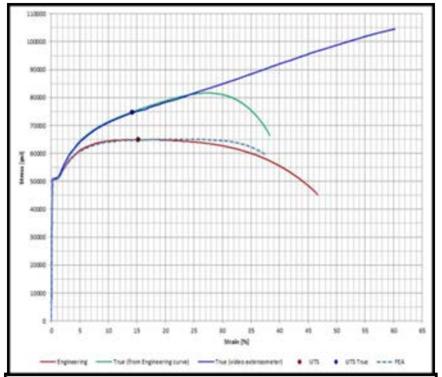
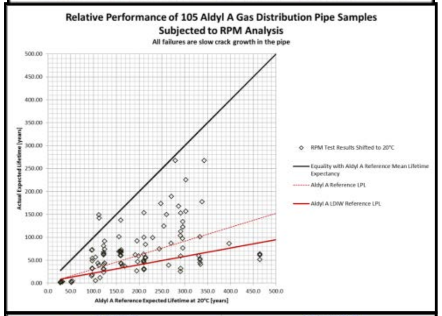
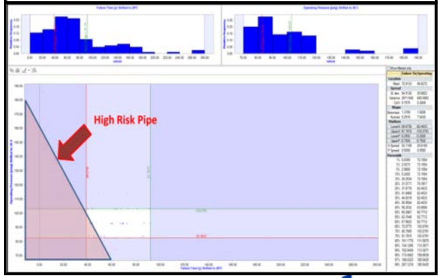


Fig. 5.20 Dependence of the equivalent strain to crack formation on the stress triaxiality



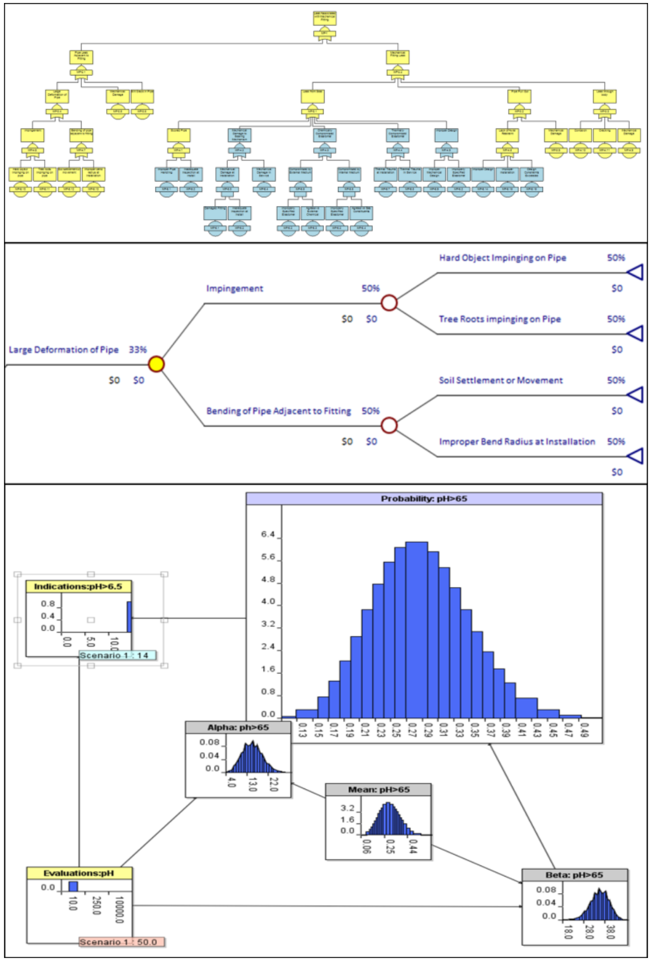




- > Material models
- > Identification of failure modes
- > Standardized Fault Tree Analyses
- > Historic data sets
- > Integration into causal risk models

Research and Development Efforts - 2

- Data collection needs to be redefined in the context of true probabilistic risk models
- Data structures and collection schema that eliminate ambiguity need to be developed
- Practical methods that embrace the use of probability distributions as the fundamental calculation element need to be developed



Research and Development Efforts - 3

- Applying this methodology to PHMSA's **LNG Failure Rate Data** can assess/refine e.g.:
  - further validation of FERC/PHMSA's baseline threshold failure rate criterion of 5E-5 to 3E-5 failures per year
  - applying to Peak-Shaving and/vs. Export LNG plants
  - applying historic (e.g. pre-1980s) vs. new or recent LNG-plant-specific data
  - applying pipe failure probability data when the applicable pipe length was not reported
  - applying generic chemical plant data vs. LNG-plant-specific data
  - impact of wall thickness on data
  - impact of expansion joints on data

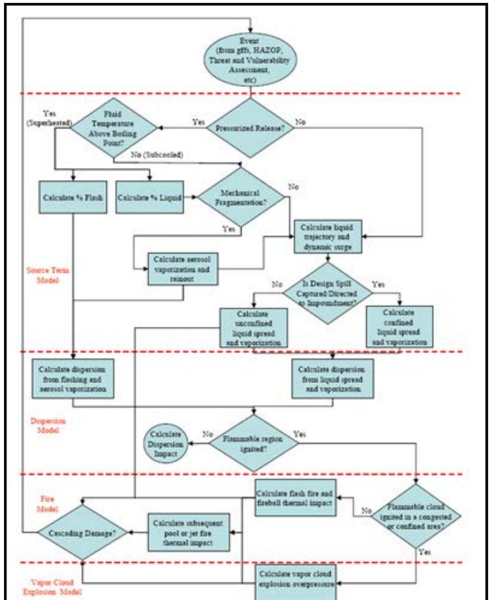


Figure 3 - Flow Diagram of Potential Consequences

Kohout, Andrew., FERC, "US Regulatory Framework and Guidance for Siting Liquefied Natural Gas Facilities–A Lifecycle Approach." Proceedings of Mary Kay O'Connor Process Safety Center, 15th International Symposium, College Station, Texas. 2012.

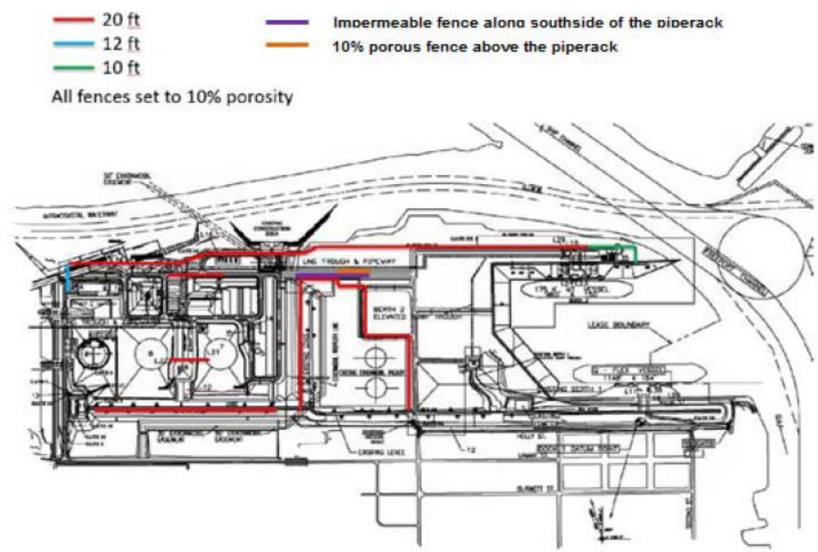
Table 1 - Nominal Failure Rates

Type of Failure	FERC Nominal Failure Rate
Piping (General)	Failures per year of operation
Rupture at Valve	9E-6 per valve
Rupture at Expansion Joint	4E-3 per expansion joint
Failure of Gasket	3E-2 per gasket
Piping: d < 50mm (2-inch)	Failures per year of operation
Catastrophic rupture	1E-6 per meter of piping
Release from hole with effective diameter of 25mm (1-inch)	5E-6 per meter of piping

http://primis.phmsa.dot.gov/lng/faqs.htm

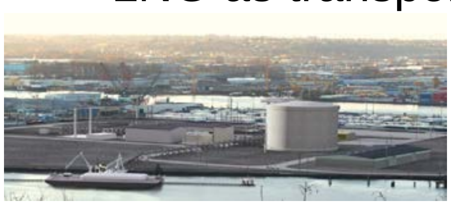
Research and Development Efforts - 4

- Potential benefits for **LNG Failure Rate** data analysis and research:
  - **Increased safety** e.g. due to potentially lower or fewer vapor fences and in-plant flammable concentrations
  - **Increased global connectivity** and harmonization of U.S. and international standards
  - **Increased environmental stewardship** e.g. if any impacts to LNG plant siting requirements permit increased use of LNG as transportation fuel



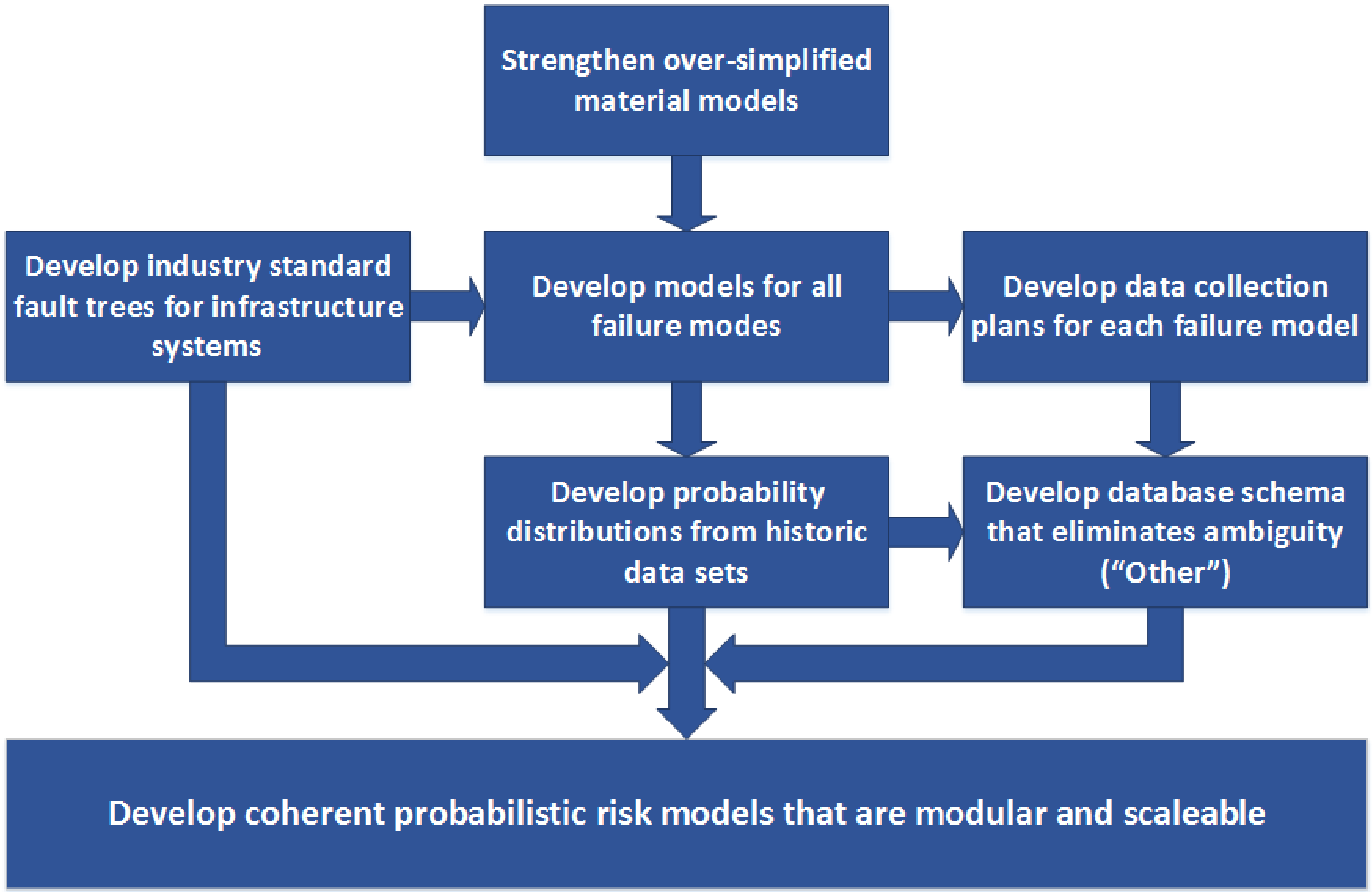
Freeport LNG, Final EIS, Sec. 4, June 2014

Figure 4.10.5-6 Vapor Barriers Proposed for the Phase II Modification Project



Puget Sound Energy's proposed LNG Peak Shaving Plant + LNG Transportation Fuels bunkering terminal in Tacoma, WA. Source: PSE's presentation at Natural Gas for Off-Road Applications Conference, June 2014, Houston

Summary of Risk Model Improvement Needs

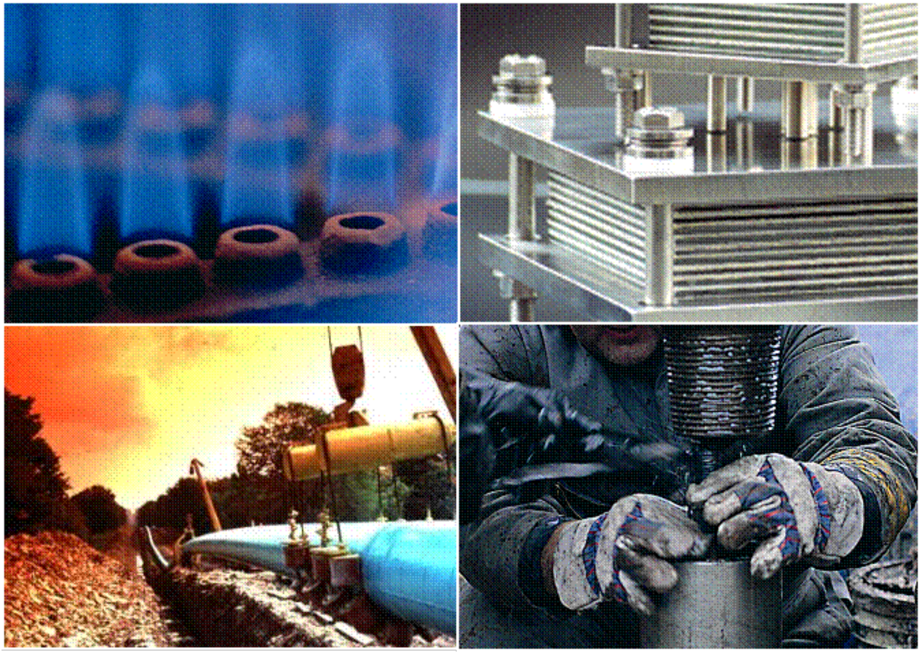


Thank You

> We thank PHMSA for the opportunity to participate in this forum to present our views on the risk models of the future

> We would also like to thank the Operations Technology Development Company (OTD) for their considerable financial support, guidance and encouragement for the research underlying the ideas we presented today.

Questions?



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Contact information:
Ernest Lever
R&D Director, Infrastructure, GTI
Ernest.Lever@gastechnology.org