Forward Thinking
ENERGY INFRASTRUCTURE CONSULTING

PROBABILISTIC RISK ASSESSMENT · GAS INFRASTRUCTURE

Quantitative Risk Assessment of a Natural Gas Transmission and Distribution Pipeline System

Segment-level likelihood and consequence modeling to target integrity spending and screen hydrogen readiness

CLIENT
Gas utility with transmission and high-pressure distribution pipelines, urban and rural territory

SERVICE LINES
Probabilistic Risk Assessment, Enterprise Risk Management

SCOPE
Threat likelihood and consequence models, integrity prioritization, hydrogen-blend screening

DURATION
11 months

~2,400 mi
of pipeline segmented and risk-scored

9
threat categories modeled (ASME B31.8S)

~12%
of mileage carrying about 60% of modeled risk

~25%
of integrity budget re-sequenced to higher-risk segments

THE CHALLENGE

The utility's integrity management program scored pipeline risk with a legacy relative index built on fixed weights and judgment. It could rank segments, but not say how likely a rupture or leak actually was, how many people were exposed, or how much risk an inspection or replacement would remove. Regulators were moving toward quantitative expectations, and the board wanted to know whether the integrity budget was reaching the right miles.

In parallel, the utility was evaluating hydrogen blending and needed to know how a blend would change threat likelihoods (embrittlement, leak rates, ignition behavior) before committing to a pilot corridor.

WHAT WE DID

1. **Segmentation and data integration.** The system was divided into dynamic segments wherever pipe attributes, class location, population density, or operating conditions changed. Pipe records, in-line inspection (ILI) results, direct assessment findings, leak history, cathodic protection surveys, excavation-damage records, and geohazard data were integrated into one segment database.
2. **Threat likelihood modeling.** For each of the nine ASME B31.8S threat categories we built likelihood models calibrated to the utility's leak and incident history and to PHMSA industry data. Corrosion threats used growth rates from repeat ILI runs; third-party damage used excavation activity and one-call density.
3. **Consequence modeling.** Consequence combined rupture and leak scenarios with potential impact radius, population and critical-facility exposure, ignition probability, supply loss to downstream customers, and environmental and repair cost, identifying high-consequence areas explicitly rather than by class location alone.
4. **Risk aggregation and integrity prioritization.** Likelihood and consequence were combined into expected-loss risk per segment and rolled up by corridor and district. Each integrity action (ILI, direct assessment, recoat, pressure reduction, replacement) was modeled for its effect on likelihood and its cost, giving risk reduction per dollar for every segment–action pair.
5. **Hydrogen-blend screening.** For candidate blend corridors, threat likelihoods were re-evaluated for blends of 5% to 20% hydrogen by volume, accounting for material susceptibility (grade, vintage, hardness, weld type), pressure-cycling fatigue, and changed leak and ignition behavior. Segments were classed as ready, ready with mitigation, or not suitable.

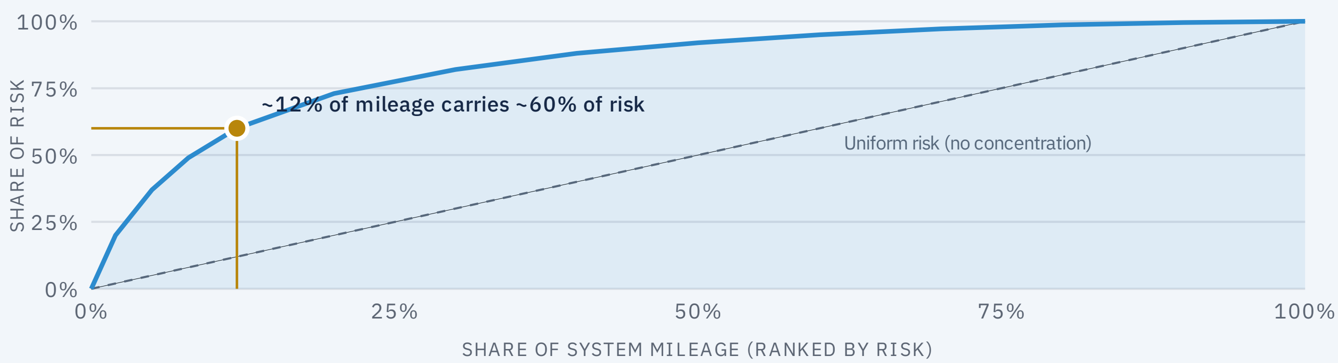
RESULTS

Risk was concentrated: about 12% of mileage carried roughly 60% of modeled risk, driven mostly by older vintage pipe in high-consequence areas with active corrosion growth and high excavation activity. Several of those segments had been mid-ranked by the legacy index because their consequence had been under-weighted.

Re-sequencing roughly a quarter of the multi-year integrity budget toward those segments delivered a materially larger modeled reduction in rupture and leak risk than the legacy plan, and identified several low-consequence segments where planned replacements could be deferred in favor of monitoring.

The hydrogen screening found that most of the proposed pilot corridor was ready for a low blend with routine mitigation, but two segments of pre-1970 pipe with hard seam welds were flagged as unsuitable and were excluded from the pilot before design money was spent.

Cumulative share of modeled pipeline risk vs. share of system mileage



Illustrative risk concentration curve. Segments ranked by expected loss; the steep initial slope is what makes targeted integrity spending efficient.

IMPACT FOR THE CLIENT

The integrity program now has a quantitative, auditable basis that can be re-run after each ILI campaign, and integrity spend is defended in terms of rupture and leak risk removed rather than an index score.

Hydrogen-blend decisions are grounded in segment-level material and threat data, giving the utility a defensible pilot corridor and a screening method for future expansion.

WHAT WE DELIVERED

- Integrated segment database and dynamic segmentation
- Threat likelihood models for nine ASME B31.8S categories
- Consequence model with high-consequence-area identification
- Integrity action cost-effectiveness library and re-sequenced multi-year plan
- Hydrogen-blend readiness screening for candidate corridors

METHODS AND STANDARDS

- Quantitative pipeline risk assessment
- ASME B31.8S and PHMSA integrity management alignment
- Corrosion growth and fatigue modeling
- Consequence and potential-impact-radius analysis
- Hydrogen compatibility screening