Before it breaks

Michael Ray and Greg Cameron, Emerson, USA, outline a data-driven, evidence-based approach to modelling pipeline risk.

There's much to be attained in navigating the inherently muddy waters of risk assessments. Examining a pipeline asset's current characteristics, as well as external factors, must come into play.

Spatial risk assessment in the context of pipeline operations necessitates the use of robust software solutions that allow for data integration from across an enterprise. The development of complex risk algorithms, using modular threat and consequence models, is allowing for high-resolution risk analysis for pipelines.

A growing number of pipeline companies are using customisable risk-modelling solutions to make more informed decisions to effectively manage and deal with risk. By combining business logic, engineering best practices, operational expertise, and asset management strategies, pipeline operators can take an integrated approach to comprehensive risk assessments.

Data chiefs

MIT Technology Insights shared the results of a recent global survey including 351 Chief Data Officers, Chief Analytics Officers, Chief Information Officers, and other senior technology executives. They revealed how much weight companies have been giving an enterprise data strategy, in alignment around business objectives such as improving operational efficiency and maintenance of physical assets.

Almost half of the oil and gas respondents had already been evaluating or implementing a new data platform to enable enterprise-wide data strategy or solutions to address current

challenges. However, only 17% of oil and gas respondents rated their organisations as high achievers on their data strategy delivery. Obtaining greater visibility through data-based analytics and actionable insights is a very real and available possibility for oil and gas companies interested in managing risk from a more holistic pipeline integrity point of view. Data integration from various sources empowers users to quantify risk more accurately, and subsequently prioritise actions to mitigate it.

Risk assessment results are only as good as the input data; any risk modelling and mitigation strategy you choose should be designed to meet the needs of your assets and utilise the data you have available. Advanced GIS software tools create sophisticated, modular models to identify threats and assess pipelines, utilising design, operations, maintenance, and assessment records or spatial risk models.

The value of risk assessments

Risk can be defined in the context of a simple equation; the consequence of failure multiplied by the likelihood of failure. From a highly objective standpoint, pipeline operators must have a clear comprehension of what types of risk they will likely face. Risk mitigation in the context of safety, pipeline integrity and economic impacts is multifaceted in the oil and gas industry, and worthy of broader discussion.

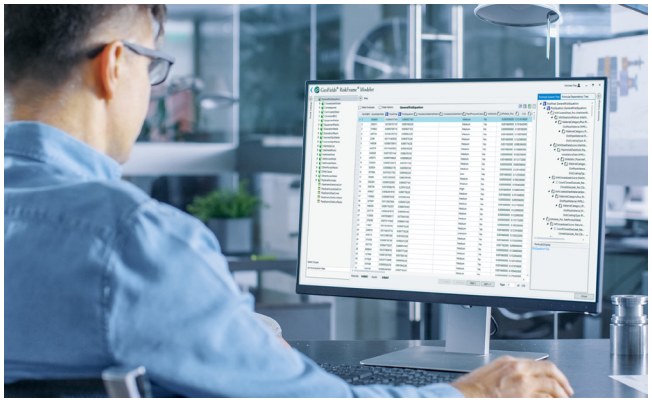

Figure 1. Users create robust risk datasets by combining defined enterprise tabular and spatial data sets with existing data in Emerson's RiskFrame software.

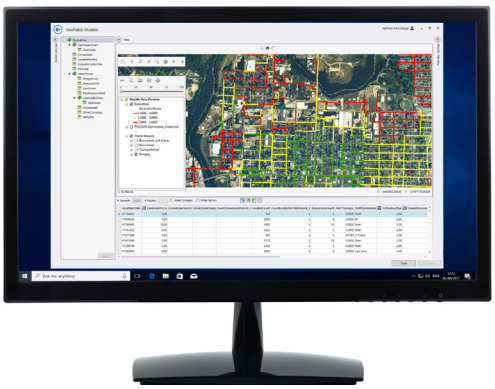

Figure 2. High risk assets are quickly identified in Emerson's RiskFrame software, enabling pipeline operators to maintain distribution system integrity.

Many risk models look at similar threats to a pipeline. Threats that should be considered in a risk model include, but are not limited to, external corrosion, internal corrosion, stress corrosion cracking, third party damage, incorrect operations, equipment failure, manufacturing defects, construction defects, and weather/outside forces.

All around the world, there is a stable group of ever-present threats operating in various states of future potential to cause harm; effectively leveraging your pipeline data paradigm can provide a clearer, more comprehensive look at an asset or portfolio of assets, amid all the knowns and unknowns. Steps can and should be taken in advance to help protect pipelines based on insights gained from empirical evidence.

When left undetected, an issue with corrosion or other types of damage can become a critical problem, ultimately impacting a pipeline's integrity and increasing the risk of failure. Of course, ageing pipelines become more susceptible to material degradation, wear and tear, and reduced operational efficiency.

Both timing and condition contribute heavily to the potential for undesirable events or outcomes. Furthermore, a lack of contemporary safety features and monitoring systems on older pipelines can equate to greater risk susceptibility, especially when considering the negative consequences associated with leaks, ruptures, or other incidents.

Solutions, such as Emerson's RiskFrame™ software, provide engineers with a tool to integrate all available data into a single reference, where complex analysis and evaluation of these threats can be performed. Risk assessment systems provide a unique view of pipeline data. Because these tools are designed to integrate data about the pipeline with external data, such as environmental and populations, engineers can create models that evaluate real-world conditions and threats to the pipeline.

The results from risk analysis allow operators to make risk-based decisions regarding inspections, repairs, and threat mitigation. This capability will improve the safety and reliability of a pipeline.

Spatial risk and GIS

GIS and spatial data play an important role in developing risk models. Operators can gather a significant amount of information about their risk based solely on where their pipeline is located. Datasets such as seismic areas, soil conditions, hydrologic features, and population/structures should always be included when building the risk model. Spatial risk assessment in the context of pipeline operations involves the use of advanced software to integrate data from across the enterprise into a customisable risk-modelling environment. This type of cutting-edge risk modelling offers unparalleled flexibility in building and running spatial risk models.

The right technology partner helps ensure as few gaps as possible in the process. The optimal solution empowers operators to accurately quantify risk, prioritise actions, and develop robust mitigation plans. It allows users to create complex risk algorithms and generate risk scores for any location on the pipeline. The solution supports industry-standard data models and incorporates spatial processing tools to translate spatial features into locations on the pipeline, streamlining data management and integration.

Flexible scenario analysis enables users to model the impact of proposed changes in source data without committing actual changes, helping identify optimal remediation activities. Versatile

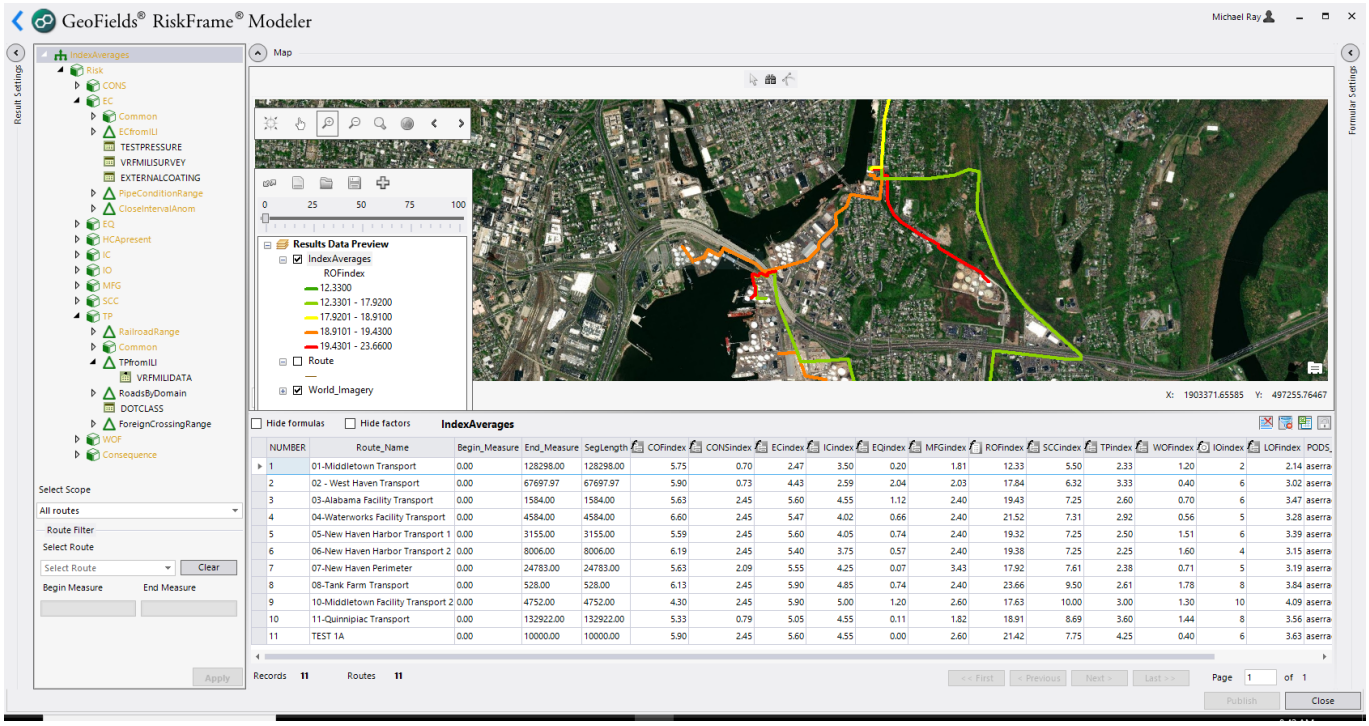

Figure 3. Emerson's RiskFrame software dynamically segments the pipeline based on real-time data links and evaluates each segment against user-defined verification logic.

reporting options facilitate data extraction, review, and sharing for mapping and online analysis.

This comprehensive approach provides valuable insights for pipeline operators to ensure the safety and integrity of their infrastructure.

Fit-for-purpose software enables users to comprehensively integrate pipeline data and GIS/spatial data. This level of integration allows for an overall highly effective risk model and assessment.

With scenario analysis and results mapping software, users can model 'What-ifs' – evaluating the impact of potential changes in source data, without editing the model or committing actual changes. Advanced software incorporates and builds on industry-leading GIS mapping software components manufactured by Esri. For example, RiskFrame software is an Esri Gold Partner, supporting industry standard pipeline data models, including PODS and UPDM.

Users create sophisticated, modular models to identify threats and assess pipelines, utilising design, operations, maintenance, and assessment records or spatial data layers stored in your enterprise database.

Quantifying risk

Risk assessments generate a lot of information for a pipeline operator. The results are often very narrow segments of data along the pipeline, with all relevant attributes consumed by the model and any output risk scores.

Each of these segments could include attributes about the pipe design, operational data, or GIS/spatial data that has been dynamically segmented onto the pipeline. The segments would also include the results of the model itself, but the result could also include scores for individual models, such as a quantified risk score for external corrosion or third-party damage.

The risk results provide operators with a quantified score for risk and threats; a pipeline operator may assess the likelihood of a specific threat, based on past experiences, industry benchmarks, and environmental factors. In response, an occurrence that could have triggered a negative consequence is reconciled.

Mitigation measures can reduce risk. Activities such as improved external coating, cathodic protection, or possibly replacing the pipe can be implemented. Even before the activities are performed, most risk modelling software can examine the measure's impact on reducing risk.

It should be noted that risk models can include historical data, trends, statistics, or other available information that could increase the likelihood of an event, and the results of any risk analysis can become actionable items. Focus is typically given to the likelihood of negative events and what can be done to reduce risk. The same principles can be applied to consequence of risk.

Operators transporting natural gas will give more weight to the human population. By studying the population density along the pipeline right-of-way, operators can identify areas of higher risk. Mitigation measures such as increased patrols, line markers, and public awareness can be implemented to reduce risk.

Operators transporting liquids, such as crude oil, will model environmental impacts. Including data about environmental sensitive areas and waterways, pipeline operators will determine areas of higher risk due to environmental concerns. Risk models can determine where additional shutoff valves or pipeline modernisation can reduce risk.

Regardless of the product being transported by pipeline, operators will need to give attention to the consequence of any pipeline failures. A quantitative approach can easily model consequence of failure and determine the most effective measures to reduce risk.

The oil and gas industry is responsible for miles of pipelines that sprawl across vast, remote areas and intersect densely populated urban areas. Stakeholders expect a great deal of integrity to be built in. At the beginning of 2023, anticipation in the industry had been centred on growing energy demands and an expected ramp up of pipeline construction or development activities in places such as Asia and North America.

Success in pipeline operations is often built on mitigating such risks. Achieving such objectives may require or be aided by gaining a better understanding of the potential negative consequences of not effectively managing it, or not planning for risk in light of the possibility for a failure.

It may be helpful to consider the ability of RiskFrame software to layer on data sources – in other words, aggregate insights based on any number of diverse data sources associated with an existing pipeline, a newly proposed pipeline, or pipeline segment, and its surroundings. The software stands on top of an operator's enterprise database of defined tabular and spatial datasets. Incorporated is a spatial processing tool to translate spatial features into tables which become part of the same data library utilised throughout the organisation.

Big consequences

No actual price tag can be put on the ability to help safeguard humans and protect their wellbeing, or the cost of unintentionally polluting the environment in which they operate. The economic cost of a pipeline break or failure, however, can be enormous. When compared to the price tag of a pipeline's fully anticipated usable lifespan being cut short prematurely, getting out in front of the potential threats and liabilities may appear more like a natural fit.

How a release will impact an area requires an accurate assessment of the risk to fully understand the consequences. While various methods can be used to assess risk, advanced risk assessment systems are recommended for more complex pipeline networks.

Consequence of failure modelling is an advanced modelling method that allows for quantification of how an asset failure will impact an area. An accurate model requires numerous data points, including gas or liquid composition, flowrate, MAOP, and the number and location of instruments such as valves along the pipeline to accurately predict the various stages of a release. This type of holistic approach leads to greater insights and improved decision-making in regards to risk mitigation.

Conclusion

To fully and accurately assess risk, companies are leveraging advanced software that offers visualisation. Real-time measurement technology combined with simulation, modelling and overall digitalisation, is allowing for creation of digital twins, an actual digital representation of a pipeline or segment. The ability to leverage evidence-based analytics and real-time decision-making into overcoming challenges associated with the would-be disparate nature of pipeline integrity and asset management scenarios have been proven.

From the way data is integrated to how threats are identified, and risks are modelled – all the way to action steps taken to get out in front of it – there are many diverse and principal factors to consider when working to identify and overcome potential points of pain, deficit or fault along a pipeline – before it breaks.