Proceedings of IPC 2004
International Pipeline Conference
October 4 - 8, 2004 Calgary, Alberta, Canada

IPC04-0246

Pipeline Integrity: Establishing Data Management Value

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ABSTRACT

For the majority of pipeline operators struggling to establish the business case for data management, records management, or geographic information systems, a step past the traditional information technology approach of return on investment (ROI) must be made.

Traditional information technology value propositions are founded on information efficiencies that, for the most part, are extremely difficult to quantify since the processes are either not presently performed or the effort associated with the existing process has not been measured. Without a baseline of the existing process, a comparative analysis using improved efficiencies cannot be quantified to substantiate a return on investment. Justification of a data management system and its associated benefits in terms of its cost relative to the cost of the data it manages (e.g. ILI, excavation, CIS etc.) is compelling since it is only on the order of 2-10%, but typically even this metric is too general an argument for most pipeline integrity managers to feel comfortable defending.

This paper will explore the process required to unearth the value of data management to support pipeline integrity. Many examples and cases will be discussed to back-up the approach to establishing value of data management for pipeline integrity.

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INTRODUCTION

Even in a regulatory regime where data management and data integration are taking center stage in audits and compliance assessment, operating companies are struggling to establish the quantitative value proposition to move forward on data management initiatives. For the majority of pipeline operators struggling to establish the business case for data management, records management, or geographic information systems, a step past the traditional information technology approach to system return on investment must be made. Justification of a data management system and its associated benefits in terms of its cost relative to the cost of the data it manages (e.g. ILI, excavation, CIS etc.) is compelling since it is only on the order of 2-10%, but typically even this metric is too general an argument for most pipeline integrity managers to feel comfortable defending.

To bridge the data management justification gap, both the cost saving and cost avoidance must be addressed in addition to intangible benefits. This is accomplished through quantifying the benefits of Business Process Improvement, Capability Creation, and Risk Management. Business Process Improvements are changes to an existing workflow that result in a bottom-line savings through reduction of resources in the form of time, staff, or operating expense. Capability Creation is the development of new skills within the existing workforce such that new analyses or queries can be answered which result in time or operating expense savings. Finally, Risk Management, in the corporate sense, adopts an insurance or point of view towards the business justification, that is, the cost of failure is X dollars while Y dollars will reduce the probability of occurrence or reduce the consequences.

We will follow four processes that are critical to a pipelines lifecycle and thereby to the value that an effective data management system can deliver. The processes to be examined consist of route selection, construction, integrity management and risk assessment.

ROUTE SELECTION

The use of geographic information systems for route selection is truly an application of data management techniques to facilitate decision-making and consensus building. The routing process has many stakeholders and many criteria – most of which are often conflicting; similar to the conflicting criteria often encountered with pipeline integrity assessments.

To perform pipeline routing much information must be collected, amassed, amalgamated, aggregated, and integrated. Prior to pipeline construction, this data will have many uses but will primarily be used to assess the environmental, engineering, and societal impacts (risks) of the pipeline. Again, similar to pipeline integrity assessments – the competencies to pull together disparate datasets for decision-making are first and foremost.

From an efficiency perspective, the routing costs (read: decision making costs) may be reduced (or optimized) substantially by controlling the amount of field time and office time spent in debates over opinions versus facts. Instead, the geographic information system focuses the decision makers to work with facts and to establish rules around how the routing will performed. Software and systems apply rules to the data without bias and can present many alternatives as the sensitivity of factors are raised or lowered. The value added here is the consistency in application of rules or criteria for selection of routes or risks.

The following is an example of unbiased and consistent application of rules to the routing process that is also able to take into consideration operational constraints.

> [1] The process had been benchmarked against TransCanada Pipeline's standard route-planning approach for selection of route alternatives and was chosen to improve the speed and consistency of route selection.
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> When these elements are integrated, a clearly defined, defensible approach to route planning and selection is created. The approach results in improved decision-making identification of critical areas, better communication with government and public interests, and increased coordination and control for internal project management.
>
> Critical issues affecting route selection (and ongoing operations and pipeline integrity) are societal risk, environmental impact, and engineering and operational efficiency. The use of GIS makes possible simultaneous consideration of these issues.
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> Third party line damage typically occurs more frequently when new lines are collocated with (or roughly parallel to and within) existing right-of-way. However, from an environmental perspective, collocation may be favourable because it minimizes landscape fragmentation.

The following is an example of direct cost savings realized through unbiased and consistent application of rules to the routing process.

> [2] Length and cost associated with existing pipeline route established through traditional approaches were compared with those of the least cost pathway through GIS best path analysis. The existing pipeline path is 34-km long and the least cost pathway is 35-km long. Although longer in length, the least cost pathway is 29% cheaper than the existing pipeline path. The cost difference is attributed to the proximity of a higher number of urban, road crossings, and river crossings that increases the overall cost of construction.

The factors included in routing analyses have far reaching benefits past the initial routing and can be used throughout the lifecycle of the pipeline. For instance, the digital elevation model can be used as part of overland flow modeling in a High Consequence Area analysis, or used to extract pipeline profile information to better align over pipeline surveys with inline inspection data, or used to classify potential erosion, mass wasting, or other geotechnical concerns.

CONSTRUCTION

Another example of where data management provides immediate and measurable benefits is in association with large diameter pipeline construction where automatic welding is utilized. This is one of the best examples for the quantification of both business process improvement and risk management for data management. By design, automatic welding is process orientated to facilitate repeatability of weld parameters. However, this cuts both ways, in that welding problems will likely continue to be repeated until the root cause is isolated and addressed. There are a multitude of parameters that impact the welding performance and the timely and robust management of these varied data streams can be critical in minimizing the timeline and financial risk associated with welding problems.

Additional capability creation and cost savings are achieved through managing the survey data such that it can be effectively leveraged in a "real time" manner for construction management. This provides immediate and measurable benefits with regard to the timely location of welds that have been identified for re-inspection due to suspected delayed cracking. Once management of these various data streams has been achieved, a complete "next day" analysis of the cost drivers for a pipeline construction project can be achieved. A good comparative value analysis would be the justification for a general ledger system to manage construction costs. No executive would question the value, while effective management of the construction data provides more timely insight into the cost drivers and facilitate cost management especially in the arena of rework.

OPERATIONS

The data collected at the outset of a pipeline project will not be thrown away after the pipeline project end construction and moves into operations. In reality (or ideally) the data that has been amassed for the pipeline project is rolled over to the operations staff for the purposes of asset management and support the pipeline lifecycle. The collected data is a natural input to any pipeline integrity management system and greatly aids in risk identification and management.

The historical methodology of simply overlaying of the data sets to visualize how they compare will only highlight the spatial errors in the various data sets. Resolution of these errors to support detailed analysis involves using elements within the data to spatially align the different data sets relative to each other and a real world location. When the data is collected with forethought and diligence, spatial integration and correlation of pipeline integrity data sets can be readily achieved through the application of structured and rigorous processes. This integration facilitates the successful validation of the integrity inspections as well as empowering the application of the integrity management program in general.

For the purposes of this paper integrity management is the operational processes involved in the mitigation of the probability of failure of a pipeline segment. The two specific processes of interest are Direct Assessment (DA) and In-line Inspection (ILI).

Direct Assessment

DA is a structured process intended for use by pipeline operators to assess and manage the impact of corrosion on the integrity of underground pipelines. DA is predicated on the ability to integrate the various data sets both in terms of the parameters and their measured location, including the alignment of indirect examinations (above ground surveys and product stream modeling) with the physical characteristics and operating history of a pipeline.

Although the NACE Recommended Practice Standard (RP 502) provides guidance to operators as to how to structure and implement External Corrosion DA (ECDA), it does not address the associated data management process required to support the successful application of ECDA.

In regards to DA the following measurable benefits can be realized:

- Accurate spatial alignment of the various datasets
- Pattern recognition though varied visualizations that aid in the decision making process
- Streamline workflow through the controlled and timely exchange of data

Accurate alignment is paramount in the initial validation of the DA methodology. Essentially this is a validation of the pre-assessment criteria being used as well as the criteria used to flag a "defect" for investigation. This alignment spans the both the pre assessment data and indirect examination surveys as well as the validation data, being either ILI or excavation results. The cost of inaccurate alignment of the data can range up to a failed application of DA leading to the application hydrostatic testing or ILI. The resulting costs range from potentially millions to retrofit an older line for launch/receipt and passage of pigs to the enormous cost and logistics of hydro testing and the resulting water disposal issues.

The more immediate cost of poor data alignment in the application of DA is the potential inconsistency of the two initial indirect examinations, which in accordance with RP 502, would necessitate a third continuous over the line survey to resolve the apparent inconsistencies. A low-end rule of thumb for a continuous over the line survey would be $500 per mile for the fieldwork.

Beyond the assessment of the indirect examination survey results, the ability to identify relationships between causal parameters other than CP and coating condition is central to refining the predictive capability of the direct assessment methodology. Effective management of the data is a requirement to support the associated visualizations of the data. The basics visualization of the data will be tabular, graphical and map based. The graphical representation addresses the relative magnitude or proportion of the measured data sets to each other or established benchmarks. Where as the map based view addresses the location of the measured parameters relative to areas of interest without the necessity to "strip" them off the imagery as discretely defined data sets.

In Line Inspection and Confirmatory DA

An in-line inspection data run can be fit onto a centreline model based on features that are common to both the model and the ILI run. This process, in essence, is the one-dimensional equivalent of rubber sheeting. For inline inspection data the control points utilized typically consist of block valves, above ground markers, and other pipeline appurtenances with known real-world positions.

Scale	Absolute Error	ILI Odometer	True Distance
		147.1 ft	87,875.5 ft
99.8%	-0.6 ft	457.7 ft	88,186.8 ft
100.0%	-0.2 ft	4,516.1 ft	92,245.4 ft
83.0%	**-1,546.5 ft**	12,046.9 ft	101,322.7 ft
98.7%	-16.2 ft	13,315.6 ft	102,607.6 ft
100.0%	0.5 ft	17,339.5 ft	106,630.9 ft
100.3%	8.6 ft	19,959.7 ft	109,242.5 ft
100.9%	0.1 ft	19,974.7 ft	109,257.4 ft
100.0%	0.5 ft	21,209.9 ft	110,492.1 ft
96.8%	**-172.1 ft**	26,398.6 ft	115,853.0 ft
99.9%	-3.9 ft	29,119.9 ft	118,578.2 ft
100.0%	1.6 ft	33,050.3 ft	122,507.0 ft
100.3%	15.3 ft	38,983.1 ft	128,424.4 ft
100.1%	5.9 ft	46,759.9 ft	136,195.4 ft

Figure 1

The utility of this spatial alignment process was exemplified with a recent ILI data set. Figure 1 shows a portion of the results from the associated alignment process. The Absolute Error field is the difference in the measured True Distance, measured along the 3D centerline model, and measured ODO distance between the two adjacent fits point (i.e. how far the ILI data had to be stretched or shrunk to align with these tow particular fit pints). The Scale field is simple the Absolute Error normalized by the distance between the fit points. This data provides immediate feedback on the alignment process in terms of identifying odometer errors or improperly located fit points. The fourth record in Figure 1with a scale of 83% clearly identifies such an odometer error due to the fact that the alignment of the immediately upstream and downstream sections are within 2% as opposed to the 17% error for the section in question. A resulting review of the ILI data determined that approximately 1500 feet of data was lost due to a speed excursion in the tool run. This case supports the use of proactive alignment of the data as the time involved to identify this error was reduced to hours, from what previously might have taken days of analysis or might possibly have gone undetected until field excavations where performed.

Another element of the effective management of ILI data is the integration of multiple ILI surveys. Rather than independently fitting these surveys against a centerline model, integration of the surveys against each other through a weld matching process will deliver an order of magnitude reduction in the relative error of the surveys. It is imperative to minimize the error in the alignment of the surveys with each other, in order to support defect matching which in turn supports the determination of growth rates.

Consistent, timely and auditable identification of dig sites is central to compliance to the new regulations, both gas and liquid. These targets can be achieved, and non-compliance costs avoided, through the facilitation of the associated workflow against the available data. A number of specific response criteria directly relate to the spatial proximity of the different types of defects to each other and the pipeline features. In many cases, each of these data points that are getting spatial compared is derived from different data sources (e.g. cracks: shear wave UT ILI, dent: calliper tool and foreign crossing: land management system). In terms of defects, an accurate analysis involves consideration of orientation around the circumference of the pipe in addition to along the pipe.

RISK ANALYSIS

Accurate and meaningful risk assessment is predicated on the correct data being used in performing the analysis. The possible costs of an inaccurate risk analysis can span a wide spectrum and are easily imagined. This paper will focus on the elements of data management that facilitate accurate analysis, rather than speculate over the costs of a product release. These elements include spatial query, accurate location attributes and representative segmentation. The spatial query tools typically available in a GIS enable the assessment of the interaction between risk receptors (structures) and the pipeline. An example of this process is the calculation of High Consequence Ares (HCA). Following up on this last example, the importance of the accurate location of attributes would be exemplified in the determination of whether an ILI defect is located within or outside an HCA.

Processes that "average" or "roll up" detailed data sets based on somewhat arbitrarily selected pipe segments undermine the validity of a company's risk assessment process, disregard most of the value captured in risk-related data sets, and provide decision makers with compromised, low confidence, risk results. The alternative is to dynamically segment the line based on the data. This process generates a new segment when any of the associated parameters changes in value. These parameters may include wall thickness, coating type, grade, class location etc. In order to support dynamic segmentation based on an attribute such as CP, the point readings need to be buffered to give them a linear extent. Another process typically applied to this point data in support of segmentation is the banding of the data into ranges. Banding is used to ensure that the resulting segments effectively identify material differences in the attribute that would result in a different risk level. In terms of CP these bands would typically transition at 850, 950 given the NACE criteria. In regards to high pH SCC, a band would be created that bounds out the range of potentials that support crack growth. Any parameter that is not used to dynamically segment the line must be given an aggregation rule. The aggregation rule determines which one value for that attribute will be assigned to the segment, given that many different values may be present for that attribute for a given segment. Examples of this would be minimum for CP, average for pH, maximum or count of metal loss depth. Going back to the high pH SCC circumstance, simply grabbing the minimum or maximum CP within a segment, could easily miss the occurrence of a portion of that segment being in the range of potentials that support SCC. This last example underlines the value and necessity of both dynamic segmentation and its proper application. Enormous efforts are expended to generate representative and useful risk algorithms, but the proper management of data to support an accurate risk calculation is often overlooked.

CONCLUSION

To establish the business case for data management, records management, or geographic information systems with a pipeline company, a step past the traditional information technology approach of return on investment (ROI) must be made.

Traditional value propositions founded on information efficiencies are extremely difficult to quantify in this case since the processes are either not presently performed or the effort associated with the existing process has not been measured. In consideration that the information to be managed represents a significant portion of the corporate intellectual property, specific cases within the context of Business Process Improvement, Capability Creation, and Risk Management need to be developed. This broad categorization will frame the discussion in a manner that can be internalized by the executive, with solid substantiation through specific examples of cost reduction in route selection, construction and operations, as well as cost avoidance through improved risk management. Keep in mind that this pipeline data management initiative can have more impact on controlling costs and regulatory compliance than the General Ledger (accounting) System your company has poured orders of magnitude more money into.

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