ASSET INTEGRITY MANAGEMENT SYSTEM – A TECHNOLOGY DEMONSTRATOR

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ABSTRACT

Asset heavy industry segments such as oil and gas, aviation, utilities, mining, civil constructions, etc., are moving towards predictive maintenance enabled by the advancement in key underlying technologies such as in-situ sensing, remote high bandwidth communications, prognostics and diagnostics. The aging asset base, which is huge in scale and size, typically operates in spatially distributed harsh environments with low remote connectivity and accessibility. Hence, key challenges to be addressed while implementing an integrity management system with predictive maintenance is in developing technically and commercially feasible mechanisms for data aggregation from remote monitoring systems and integrating with analytic systems that are capable of crunching real-time data feeds in order to predict and schedule the maintenance and repair requirements for the assets.

This paper presents a functional integration framework for an asset integrity management solution which helps an integrity manager to visualize, monitor, raise inspection work orders, track inspection results, predict and schedule the maintenance and repair operations for the infrastructure. This generic solution framework comprises of a geographical information system (GIS) dashboard to visualize, initiate and track the business processes; a work asset management system that acts as a middleware and enables the inspection and maintenance workflows across multiple modules, an occasionally connected mobile infrastructure that works on client-server configuration to capture and synchronize the remote field inspection results. The solution framework is also provisioned with dynamic risk scoring techniques, fitness for service assessment standards and other algorithms.

Keywords: Oil and Gas, Pipeline, Integrity Management, Mobility, Safety, Software, Predictive Maintenance

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INTRODUCTION

Industry segments such as oil and gas, aviation, utilities, mining, civil constructions, etc., are moving towards predictive maintenance enabled by the advancements in key underlying technologies such as in-situ sensing, remote high bandwidth communications, prognostics and diagnostics. The aging asset base, which is huge in scale and size, typically operates in spatially distributed harsh environments with low remote connectivity and accessibility. This paper takes a deeper look into the oil and gas pipelines industry in the light of recent spate of incidents and concerns about resultant threat to life and environmental damages. As of year 2010, world has nearly two million kilometers of transmission pipelines [1], out of which about 40% transmission pipelines are in USA alone. Though, the typical designed service life of a pipeline is about 25-30 years, a significant fraction of these pipelines have already exceeded 70 years in service. As shown in Figure 1, according to Pipeline and Hazardous Materials Safety Administration (PHMSA), during the last two decades alone there have been in total 10537 reportable incidents that caused 398 fatalities, 1640 injuries, property damage worth approximately $5 Billion and about 2.67 Million spilled barrels [2]. All the oil and gas pipeline operators need to comply with country specific regulations to ensure safe, reliable, and environmentally sound operation of the pipeline transportation system. Current practices in pipeline integrity management (PIM) are predominantly focused around structural integrity assurance and follow preventive maintenance methodology. This alone is insufficient to minimize the rate and business impact of these incidents. In order to contain the incidents before they occur, a paradigm shift is needed in the technology capabilities and practices that enable predictive maintenance methodology. Most of the current investments indicate conscious efforts by pipeline operators to develop these predictive technology enablers.

The theme of PIM is risk management of pipelines. It provides a tremendous opportunity for pipeline operators to innovate and develop a plan with a strong focus on business value creation while complying with the regulations.
A robust PIM strategy will enable the pipeline operator with the following benefits:

- A PIM roadmap that maximizes return on investment
- Business case and prioritization of initiatives to maximize the shareholder value
- Availability of the right data, information and knowledge about the pipeline system to objectively measure, monitor and assess risks
- A comprehensive set of metrics to predict risks which in turn drive the operational decisions
- Seamlessly integrated engineering and information technology systems which ensure data integrity, accessibility as well as optimal processing.

**CHALLENGES IN PIM IMPLEMENTATION**

According to a survey conducted by Southern Gas Association in 2007[3], the top three PIM implementation challenges faced by the pipeline operators, as shown in Figure 2, are “record keeping”, “external corrosion direct assessment (ECDA)” and “threat identification and risk analysis”. Figure 3 further highlights the problem dimensions in detail and corresponding capabilities that get impacted if these challenges are not addressed adequately. We see that the management of data and computation of risk as the common issues that cut across the top critical implementation challenges. Efficient data management is the key to define, design, implement and institutionalize a comprehensive pipeline integrity management program. This includes devising mechanisms for data aggregation from in-situ installed sensing devices and integration with analytic systems that are capable of crunching real-time data feeds, predict and schedule the maintenance and repair activities.
PIM SOLUTION FRAMEWORK

Comprehensive integration of governing business processes and underlying information systems is critical for realizing business value from PIM. However, every pipeline operator is unique in terms of their capability in managing risks related to pipeline integrity; a cookie-cutter approach to developing and implementing a PIM plan can at best be sub-optimal and a quick-fix solution. The solution lies in designing a well thought-out customized program, which addresses not only specific challenges, but also long-term business priorities.

Figure 4 describes the path that realizes an end to end integrated PIM framework. The four key enabling stages involved in an effective PIM strategy are as discussed:

![Image of PIM Solution Framework]

Fig. 4 : Path to end state: Pipeline Integrity Management Solution Framework

![Image of Challenges]

Fig. 3 : Challenges faced by Pipeline operators in Record Keeping, ECDA and Threat Identification and Risk Analysis
1) Digitization of data captured in the field e.g. ECDA and other field inspections, regular maintenance and repair activity logs, aerial surveys, leak surveys, line walks, etc., will form the first stage in enhancing and streamlining of the record keeping mechanism. Digitization will help a close tie up of the field data with the service creation to closure process.

2) Second stage deals with the data aggregation. In addition to the data from the field applications discussed above, information from various other data sources such as pipebook, design specifications, failure and repair history, supervisory control and data acquisition (SCADA) systems, training and certifications data of the field crew, delivery schedules etc., need to be integrated together into an unified data architecture (UDA) such as pipeline open data standard (PODS).

3) Third stage brings in powerful data analytics on top of the UDA to extract objective and measurable insights and key performance indicators related to the pipeline integrity. These analytical tools will enable the user to understand the impending risks at various aggregated levels of the infrastructure. Based on these risk levels
and past history correlations, analytics can help the user to assess the criticality of the infrastructure, identify and plan the mitigation activities. Figure 5 describes the Pipeline Integrity Business Risk Score (PIBRS) that is proposed in this paper. PIBRS not only takes the structural risk into consideration, but also incorporates operational and commercial risks associated with a particular pipeline. Hence, the resultant business risk score emerges as a more comprehensive and representative pipeline integrity risk indicator. Operational risks take the latent and dynamic risks related to the readiness of the organization to react and contain the incident in the event of its occurrence. Commercial risk score includes the revenue and cost risks associated with an incident in the event of its occurrence.

4) Fourth and the final stage of an effective PIM strategy is an intuitive and interactive visualization of the data related to the pipeline either on a GIS map or through visualization that creates a virtual environment of the complete infrastructure. The data that is overlaid on to this visualization layer can be a variety of information such as risks, past history of inspections, tracking of the ongoing scheduled inspections, incident history, delivery schedules, operational feeds from SCADA and much more that relates to the operations and maintenance of the pipeline infrastructure aggregated at various view levels in the visualization pane.

An illustration of integrated PIM work flow

Here we discuss a functionally integrated workflow of PIM which helps the integrity management personnel to visualize and monitor risk levels, assess the damage severities, raise inspection work orders, track the results and schedule repair activities for the pipeline.

The workflow shown in Figure 6 comprises of a GIS dashboard to visualize, initiate and track the business processes; a work and asset management system that acts as a middleware and enables the inspection and maintenance workflows across multiple systems such as the analytical layer that helps the user to assess the integrity, system that schedules and tracks the inspections, system that deals with the delivery scheduling and capacity planning, system to automate field force allocations to the work orders; an occasionally connected mobile infrastructure that works on client-server configuration to capture and synchronize the remote field inspection results. The solution framework is also provisioned with dynamic risk scoring techniques and algorithms for fitness for service assessment.

SUMMARY

Efficiency of pipeline integrity management (PIM) practices has a significant impact on the ability of a pipeline operator to create shareholder value. Aspects of PIM such as leaks and incidents not only increase the cost of operations but also impair the revenue earning potential. Efficient PIM practices can enhance the economic life of pipeline assets, thus increasing the total lifecycle business value realization from pipeline infrastructure investments. Embracing a mature business strategy as well as leveraging emerging information and communication technologies is bound to open tremendous opportunities for pipeline operators for innovating and developing a plan with stronger focus on business value creation while complying with the regulations.

REFERENCES