

**THE EVOLUTION OF DATA MANAGEMENT TO EMPOWER INTEGRITY
MANAGEMENT DECISIONS: A CASE STUDY OF AN ENTERPRISE
IMPLEMENTATION.**

Bruce Dupuis
Chief Technology Office

Baseline Technologies Inc.
540 – 5th Avenue SW
Calgary, AB, T2P 0M2
bruced@baselinetech.com

Jason Humber

BP Canada Energy Company
240 4 Avenue SW
Calgary, AB, T2P 2H8
HUMBERJL@bp.com

ABSTRACT

BP's Natural Gas Liquids business unit (NGLBU) has conducted integrity investigation and mitigation activities on its pipelines and has been following this best practice for numerous years. In recent times, NGLBU's data management initiatives focused on establishing an enterprise Geographic Information System (GIS) coupled tightly with a derivative of the Pipeline Open Data Standard (PODS) data model. During successful implementation of the GIS, an analysis identified gaps in existing data management processes for pipeline integrity information. Consequently, the business unit adopted Baseline Technology's Pipeline Information Control System (PICS) and its modules to support the pipeline integrity decision-making process on its 9000km of pipeline.

The PICS implementation leverages the existing GIS implementation while addressing a number of unresolved data management and integration issues, including:

- Integration of inline inspection with excavation results;
- Migration of above ground surveys to a common repository;
- Integration of multiple inline inspections;
- Facilitation of corrosion growth modeling;
- Structured process for prioritization of remediation;
- Structured process for integration of inline inspections with risk parameters;
- Defined data collection, storage, and integration standards.

Data management solutions based solely on a GIS require pipeline surveys without explicit positional information to be converted into a common linear reference system (typically chainage or stationing) such that disparate data sets may be overlaid and compared. This conversion, or spatial normalization, process is where much of the data management effort is spent and is often prone to error introduction. Even when small errors are introduced, the normalization process is often performed such that it is not auditable. If the underlying spatial errors are not reported, addressed, and understood, the value of the data integration and any subsequent analysis of the combined data set is questionable.

INTRODUCTION

BP's Natural Gas Liquids business unit has conducted integrity investigation and mitigation activities on its pipelines and has been following this best practice for numerous years. In recent times, NGLBU's data management initiatives focused on establishing an enterprise Geographic Information System (GIS) coupled tightly with a derivative of the Pipeline Open Data Standard data model. During successful implementation of the GIS, an analysis identified gaps in existing data management processes for pipeline integrity information. Consequently, the business unit adopted Baseline Technology's Pipeline Information Control System (PICS) and its modules to support the pipeline integrity decision-making process on its 9000km of pipeline.

IMPLEMENTATION OBJECTIVES

Although the GIS data management efforts were successfully deployed within the business unit, there remained gaps to overcome for total integration of pipeline integrity data to support business decisions. The conversion, or spatial normalization, process is where much of the data management effort is spent and is often prone to error introduction. PICS overcomes the identified gaps in the data management and decision process support through a suite of tools for adjusting survey data sets into common linear reference systems along with mechanisms through which integration errors can be quantified and identified.

Error quantification is merely one implementation objective, other objectives include:

- Migration of above ground surveys to a common repository;
- Integration of multiple inline inspections;
- Facilitation of corrosion growth modeling;
- Prioritization of remediation process improvement;
- Integration of inline inspections with risk parameters;
- Collection, storage, and integration standards;
- Visualization environment.

The PICS implementation capitalizes upon the strengths of the GIS by utilizing existing infrastructure and spatial data repositories while adding its own set of core functionality to enhance data management.

IMPLEMENTATION SCOPE

The PICS implementation is comprised of the following elements:

- Creation of 3D centerlines based on inputs from the GIS;
- Spatially fitting the ILI and above ground surveys onto the 3D model, and thereby to each other;
- Integration of multiple ILI surveys;
- Populating NDE with historical excavation data;
- Integration of inline inspection with excavation results;
- Migration of pipe property data from PODS into the PICS repository;
- Design of revised work flow processes;
- Integration of PICS and its modules with BP's computing environment and the existing NGLBU GIS.

CREATION OF 3D CENTERLINES BASED ON INPUTS FROM THE GIS

Generation of a three-dimensional pipeline model for use within PICS begins with data from the GIS. The two-dimensional pipeline centerline (note: centerline coordinates have measure values associated) draped over a digital elevation model produces a listing of longitude, latitude, measure, and elevation. This coordinate set is input into PICS to create the virtual

pipeline model (VPM) that, in turn, acts as the baseline against which integrity related data sets are fit. Important to note that the GIS governs the pipeline position but PICS governs where data exists along the centerline.

SPATIALLY FITTING THE ILI AND ABOVE GROUND SURVEYS IN SPACE, AND THEREBY TO EACH OTHER

The most recent inline inspection data run is fit onto the 3D model or virtual pipeline model (VPM) 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.

Essentially the same process is used to fit above ground surveys onto the VPM. Through "rubber sheeting" both the ILI and above ground surveys onto a common frame of reference (i.e. the VPM), both data sources are spatially normalized against each other. However, in this case, due to the high dielectric value of the coating on the majority of the pipeline system, the typical above ground surveys (e.g. cathodic protection) were not immediately relevant to their integrity management. Instead, the NGLBU is integrating its SCC environmental model to factor in the likelihood of environmental cracking in the prioritization of their proposed excavation sites considering.

INTEGRATION OF MULTIPLE ILI SURVEYS

Integration of numerous ILI surveys is accomplished through an automated weld matching process that applies a fuzzy logic algorithm to account for weld miscalls and replacements. The algorithm starts at a set of manually matched welds and progresses both upstream and downstream from the original matched set. An impediment to the application of this process on pipelines without weld tallies is the significantly discontinuous nature of the weld tallies from older ILI surveys; the welds were only reported in the immediate proximity of defects. Without the majority of the welds reported the algorithms require extensive human intervention to perform tight integration. As a result, it was decided to limit the scope of work to mapping just one legacy ILI dataset onto each VPM. Although the error bands inherent in the ILI data due to the tool technology and number of sensors on the tool is significant, the dataset was integrated to provide a spatial benchmark against which historic excavation data could be matched.

POPULATING NDE WITH HISTORICAL EXCAVATION DATA

Excavations performed since 1999 utilized CEPA's SCCdb database application for tracking excavation related data and, as such, was readily useable by PICS. However, most of the excavation data existed in a legacy database. The legacy database was typically incomplete and had a poor data structure. Specific issues with the database include:

- No weld recorded for the excavation;
- No tie to an external reference point other than inline inspection odometer;
- Only target defect recorded;
- Additional defects found during mitigation work recorded in a comments field;
- Length of excavation or pipe inspected not recorded;
- Inconsistent terminology.

As part of the conversion process, all the excavation data was standardized, structured, and imported into the new excavation data capture platform otherwise known as the Non-Destructive Evaluation (NDE) module (Figure 1). This ensured consistency amongst the data to facilitate integration with ILI data as well quality control of the data.

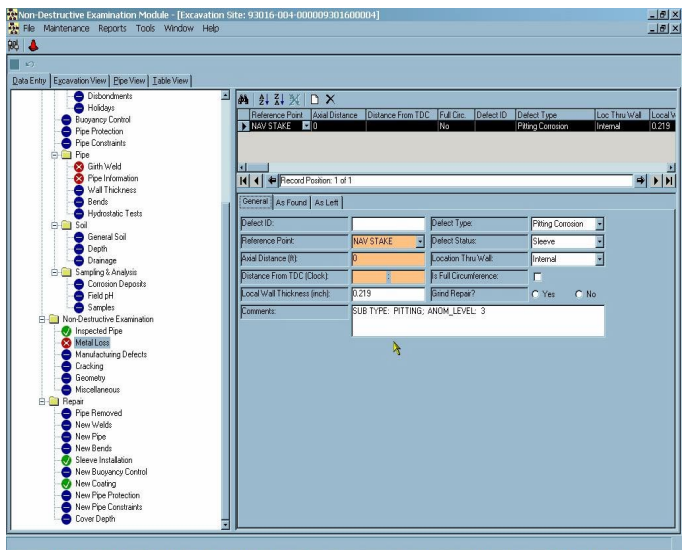


Figure 1. Excavation Data Collection Application (NDE Module)

Excavations present an opportunity to improve the overall spatial accuracy of the pipeline centerline and the corresponding data aligned along the centerline. The spatial reference mechanism found in the NGLBU historical excavation data is the inline inspection odometer reading. Unfortunately, this means the excavation does not provide any improvement to spatial accuracy for legacy inline inspections. Modification of field processes to ensure collection of required spatial references are now in place.

INTEGRATION OF INLINE INSPECTION AND EXCAVATION RESULTS

Integrating the excavation results from the NDE module with the ILI data managed within PICS is as simple as matching one weld common to both data sets. With that common point, all relevant results from an excavation (e.g. defects found, environmental conditions, and repairs affected) merge seamlessly with the ILI data to update the PICS repository (Figure 2).

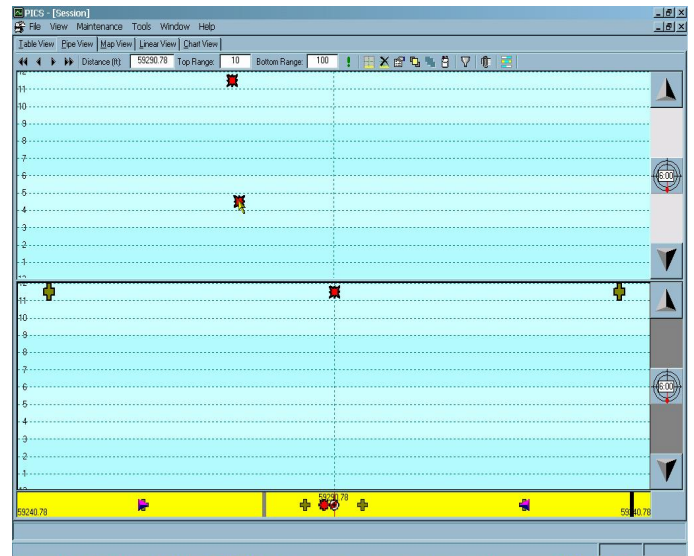


Figure 2. ILI Data Displayed Overlap of Excavation Results

MIGRATION OF PIPE PROPERTY DATA FROM PODS INTO THE PICS REPOSITORY (PICS VERSUS PODS)

The NGLBU implementation of PODS houses the following data:

- Pipe property;
- Crossings;
- Appurtenances.

The “spatial” relationships defined in PODS were not part of the NGLBU implementation. Instead, the NGLBU opted to utilize the GIS to effectively manage spatial relationships.

The challenge that arose was whether to move the PODS pipe property data into PICS or for PICS to dynamically access and update this data set within PODS. In addressing this challenge, the following considerations had to be made:

- Seamless integration between PICS, its NDE (excavation) module, and other analytic modules greatly simplifies the data management efforts otherwise required to keep data synchronous;
- The existing pipe property data set was effectively static since the outcome due to remediation work was not input into PODS.

Resolution to this challenge was found in the migration of pipe property data to the PICS repository, thus allowing NGLBU to capitalize upon the already existent pipeline lifecycle data management capabilities of PICS. With this decision, PICS required a minor modification to accommodate calculation and storage of 2D chainage. This subtle modification allows the GIS and Alignment Sheet Generator applications to utilize pipe property data directly from the PICS repository.

In conjunction with the decision mentioned above, the PICS table structure and data dictionary were modified to address crossings and pipeline appurtenances. This will allow the PODS database to be retired once these last data sets are fully migrated to PICS.

DESIGN OF REVISED WORK FLOW PROCESSES

To realize maximum return on investment in ILI and excavation programs, as well as empower reliable risk analysis, it is imperative to utilize data collection and management process that minimize the opportunity for the introduction of error or ambiguity. For this reason new workflow processes were created to leverage the capabilities of the PICS applications and control the data throughout its lifecycle. Figure 3 shows the process used in selecting the excavations resulting from an ILI survey.

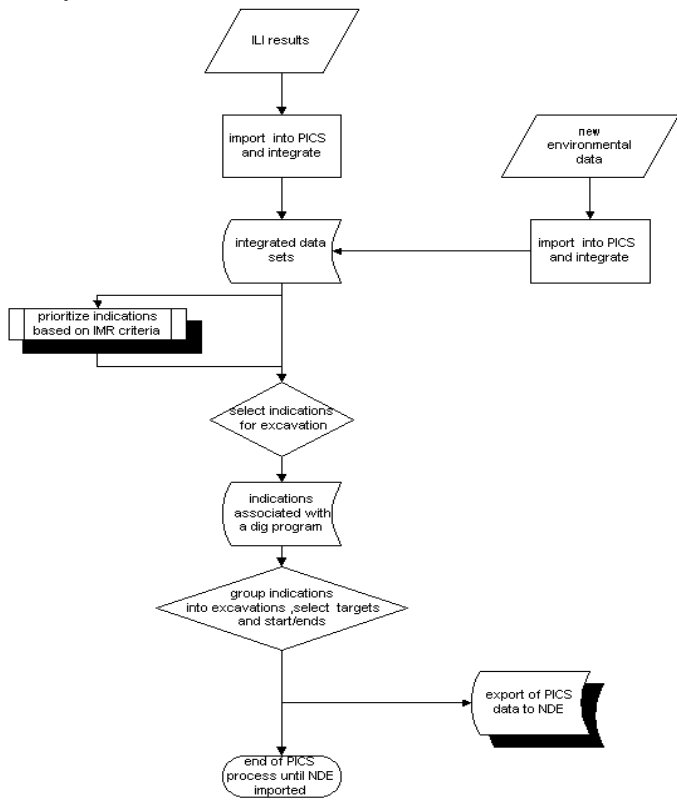


Figure 3. Dig Site Selection

Figure 4 depicts the process for integration of the excavation data with the ILI data for validation of the ILI data as well as updating of the facility management database.

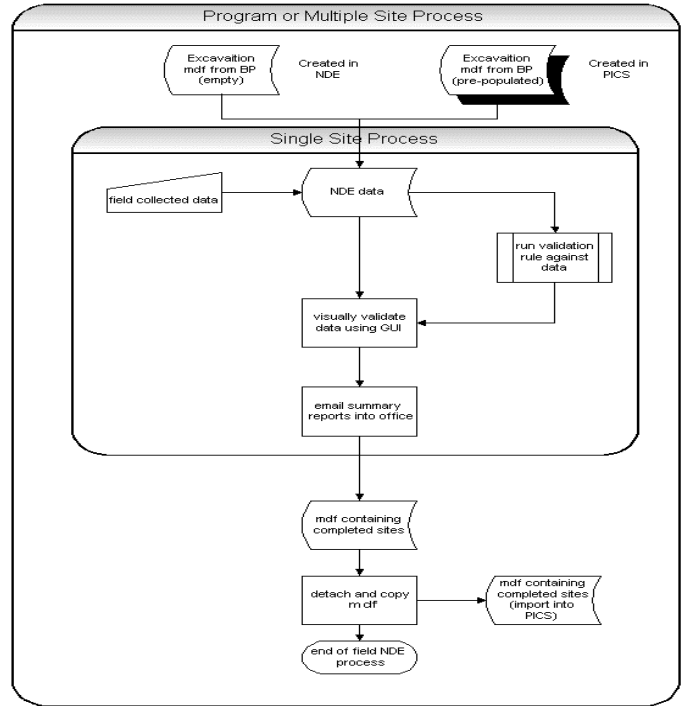


Figure 4. Integrating Excavation Results

DEPLOYMENT AND COMPUTING INFRASTRUCTURE INTEGRATION

A key requirement of the PICS implementation is to utilize the same spatial data and infrastructure developed during the enterprise GIS implementation. This task included extending the PICS map view to use ESRI Spatial Data Engine (SDE) and Axion Spatial Imaging image decompression software (Figure 5). By adopting these technologies within PICS, the same efficient data transfer mechanisms used by the GIS were evident within PICS.

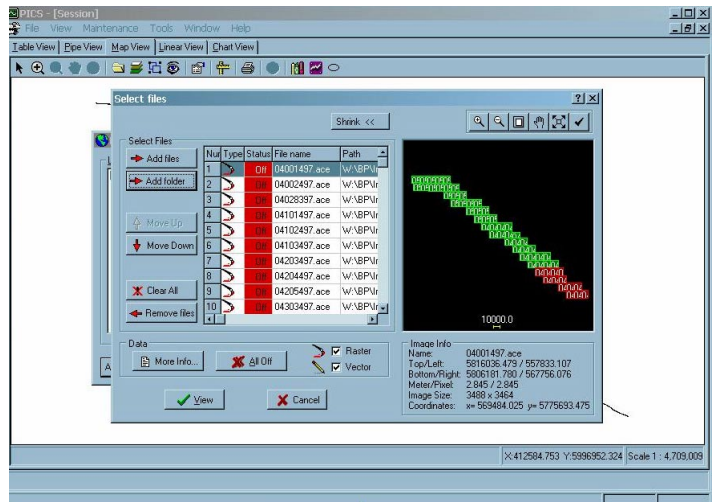


Figure 5. Graphical Interface to Load Compressed Raster Imagery

The back-end database for PICS is setup using Microsoft Data Engine (MSDE). MSDE is not capital intensive and is easily scalable to SQL Server. The approach taken by the NGLBU is to scale-up the back-end database up as the volume of users and data increases.

STATUS

At the time of writing, conversion, migration, and integration of 5000km of the total 9000km is complete. Deployment of PICS within the BP computing environment was successful as was integration with the existing spatial data management infrastructure.

PICS is a key component in the pipeline integrity decision-making process, field data collection process, and is a pivotal component of the NGLBU Pipeline Integrity Management System.

OVERVIEW AND PATH FORWARD

Having past the mid point of the implementation with all the technical hurdles addressed, the implementation is currently under budget and ahead of schedule. With a significant body of data to fuel analysis and the revised workflow processes in place, the most rewarding phase of the project is beginning; the efficiencies in data management and improved analyses are being realized in an operational environment!

Next steps involve a pilot implementation of Baseline Technology's recently released Risk Management Toolkit (RMT) as well as the application of various growth modeling and sensitivity analysis. The RMT will facilitate the application of risk assessment algorithms on the data managed in PICS as well as the associated data preparation to support the mathematical operations. Where as the growth modeling will involve the application of either general or defect specific growth rates to generate a hypothetical defect data set representative of the pipe condition at a point in the future. Spatial interaction rules and fitness for purpose analysis would then be performed on this data set.

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