Pipeline Integrity - Enhancing Integrity Management

New software solution helps Piedmont Natural Gas integrate pipeline operations data with its corporate business systems.

Piedmont Natural Gas (PNG) has implemented a major systems integration project to join pipeline integrity management with existing enterprise systems for better data management and analysis. The project was undertaken in response to the Pipeline Safety Improvement Act and resulting DOT regulations.

As part of that effort, the company formalized a pipeline integrity management and risk analysis program. The program identified roughly 445 pipe segments inside high consequence areas (HCAs). PNG operates and maintains roughly 2,000 miles of transmission pipeline throughout its service territories in North Carolina, South Carolina, and Tennessee.

As the initial work was performed to identify HCAs and to develop the company's Baseline Assessment Plan and Integrity Management Plan, it became painfully clear that a system was needed to effectively store and integrate the many streams of data involved in the process. A great deal of information was being collected in various formats by PNG personnel, consultants, and contractors performing integrity assessments. This included large volumes of digital maps, GPS points, linear stationing, close interval survey (CIS) readings, aerial photographs, external corrosion direct assessment (ECDA) data, and in-line inspection data. All this information needed to be readily available for use and analysis.

In 2005, PNG commissioned a project to integrate the needs of pipeline integrity management with its corporate business systems. The overriding objective was the creation of an integrated system to enable its pipeline integrity management risk analysis engine.

John Sullivan
Enspiria Solutions, Inc.
6560 S. Greenwood Plaza Boulevard
Suite 500
Greenwood Village, Colorado 80111-7100
jsullivan@enspiria.com

System Requirements

To design and implement the system, the utility company enlisted the services of Enspiria Solutions, Inc., a consulting and systems integration firm in Denver, Colorado. PNG and Enspiria began by assessing existing utility pipeline integrity solutions, and conducting a requirements workshop with PNG's pipeline integrity consultant.

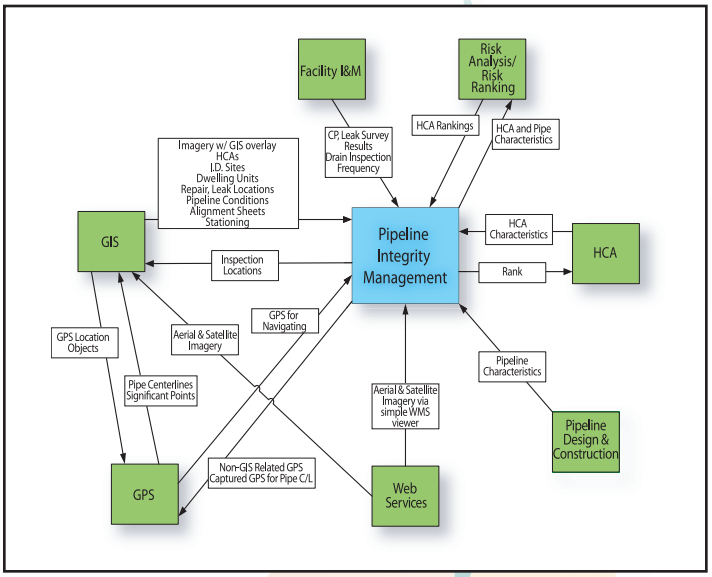
The requirements phase identified existing and needed sources of pipeline integrity data, and determined data storage and link requirements. Overall functional requirements defined for the system included the ability to:

- Analyze and identify HCAs using information such as aerial imagery and GIS
- Model stationing on pipelines
- Store and associate GPS data with pipelines, facility data, and other related data such as HCAs
- Create and maintain a large number of additional attributes related to pipelines not carried in the GIS asset information but needed for the integrity management process
- Bring together data from outside sources for the risk and HCA analysis processes (e.g., soils data, ground stability and fault data, zoning data, census data, topography data, etc.)
- Visualize various types of inspection and facility data in multiple bands relative to the GIS (alignment sheets)
- Recognize and analyze changes in the data in the system for management of change in pipeline integrity
- Provide data to the integrity management risk assessment applications via a simple interface.

The users of the new system are widely distributed throughout the company, and include corporate GIS, engineering, the pipeline integrity department, various district users throughout the service territory, and potentially outside contractors in the future. As a result, the decision was made to utilize web-based applications for all non-GIS related data entry and analysis tasks.

Initially, a very complex business context model was defined to automate all interfaces and touch points. The system requirements and work processes were then simplified both to control costs and to streamline the work required to gather and input data in the districts. A key goal was to keep the amount of analysis and interpretation time for data elements to a minimum for the district users, to avoid burdening them with additional work and loss of time performing their day to day jobs.

For example, district users would be required to place an object in the GIS when a condition was discovered relative to a pipe during their normal business operations, but they would not be required to assess impact on an HCA. The interpretation and analysis needed to determine impacts of certain data on the HCA assessment and risk analysis processes would occur downstream. This analysis would be done by GIS power users, engineering, and integrity management personnel. Another example is in the case of inspections and maintenance. Districts would still perform this work and then downstream processes would determine the impacts to HCA assessment, risk analysis, and management of change within the integrity management process.



The system context diagram illustrates how information flows between the various applications that make up PNG's integrated Pipeline Integrity Management System.

The requirements and detailed design process resulted in the following major components for the systems integration project:

- GIS integration
- Aerial imagery web service
- Global positioning system (GPS)
- Pipeline Design and Construction (PDC) and HCA web applications for data management
- Integration of GIS, PDC and HCA application data with existing pipeline integrity risk analysis applications.

GIS Integration

Because of the spatial nature of the work, the existing enterprise GIS was the logical choice for a majority of the data integration. However, several data model and functional gaps in the GIS prohibited proper support of transmission pipeline modeling and other specific needs of pipeline integrity management at PNG. To meet these needs, new GIS objects were developed to support

integrity management (HCA, Corridor, Identified Site, Dwelling Unit, ECDA Region, Condition Discovered, etc.). Modifications were also made to several existing GIS objects to support integrity management and linear referencing (e.g., values, fittings, leak, repair, etc.).

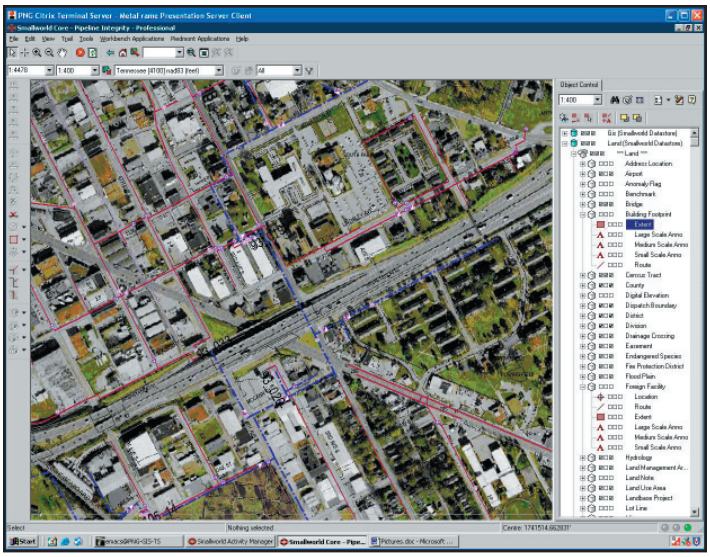
The GIS data model gaps required that a linearly referenced (stationing) pipeline model be implemented. The choices available were to either develop the functionality on the existing data model, which was configured for the utility's PNG distribution business operations (Convergent ENOM); or look for an existing third-party or industry standard pipeline model. The decision was made to purchase an existing pipeline model, the GE Smallworld Cornerstone P class C data model. The reasoning behind the decision was that the cost to develop a custom solution on the existing model would be similar to the cost of purchasing the license from the vendor, but there would be future potential to implement more of the functionality in the third-party data model solution. The implementation was limited to just what was required for this project to keep costs to a minimum. Otherwise, a full implementation of the third-party data model solution could have added significantly to the cost and duration of the project when only a small subset of the functionality was needed at the time.

Aerial Imagery Web Service

Piedmont found a cost-effective solution for the delivery of GIS and non-GIS based aerial imagery to aid in HCA identification through the implementation of a commercial web-based imagery service. This web imagery service is used across the company's entire enterprise.

A data requirement for the project was aerial imagery for the HCA analysis process and other processes within integrity management. The initial options explored included viewing external image files (MrSID) or importing and storing rasters directly in the GIS. Both of these options would require obtaining and then maintaining the data internally, which could become costly and difficult to obtain and maintain. It would also require a large amount of storage space to keep the images internal or external to the GIS, which presented a potential system administrative overhead burden.

Another option available was the use of an aerial imagery web service to provide the imagery needed. This option allows the chore of obtaining and maintaining the images to be off-loaded onto a vendor whose core business is to obtain and maintain these images. It also allows PNG to take advantage of the fact that the database is constantly updated. Input and feedback from multiple



The aerial imagery from the GlobeXplorer Web Map Service can be accessed directly from PNG's GIS. This image shows the highly accurate data provided by the downloaded image.

customers using the database will also contribute to accuracy and quality of the imagery in the database. The vendor providing the service is GlobeXplorer (in this case), but several others exist. The service is provided for an annual subscription fee or on a per transaction basis.

The ability to use the service within the GIS was accomplished by using the GIS vendor's Web Map Service (WMS) capability and the vendor's WMS server to request and display the imagery. Several free WMS viewers are also available for viewing and saving the images independent of the GIS if desired, and can be found online.

Global Positioning System

A corporate standard GPS solution resulted from the pipeline integrity management project. Some portions of the legacy transmission GIS data were digitized relative to the distribution, and are not positionally accurate. PNG needed to use GPS to capture the transmission pipeline centerlines in these areas. The data can then be imported into the GIS to create positionally correct transmission pipeline locations while maintaining the symbolic transmission pipeline location that relates to the existing distribution data.

Piedmont desired a highly accurate solution (sub-meter or, if possible, less than 30 centimeter accuracy) that could withstand the hazards of use in the field, and also wanted a central repository of data could be kept and shared by the enterprise. Another need was the ability to

integrate the solution with GIS and also capture attribute information linked to the GPS data, whether it is general information, asset information, or attribute information related to a facility or GIS object.

Based on these requirements, PNG selected a Trimble XH handheld unit with Pocket Collector software from Geospatial Innovations. The solution was reasonably straightforward: it is designed to integrate into the existing environment, while also providing for a great deal of potential functionality in the future. The latter includes the ability to automatically move GIS object locations and attribution onto the unit for location in the field, and the ability to automatically generate GIS objects from the data collected in the field. The solution also lends itself to potential integration with the inspection and maintenance solution in the future.

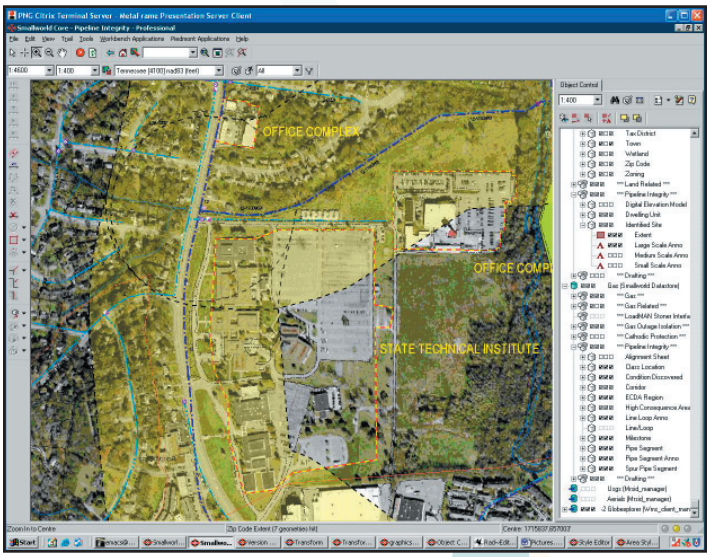
PDC and HCA Web Applications

Pipeline Design and Construction (PDC) and HCA web applications were developed to capture additional asset and engineering information now required for the pipeline integrity risk analysis process. Initially, PNG considered adding the attribution to objects in the GIS, and using the existing GIS editors to add and maintain the data. However, the company decided to create new applications external to the GIS with hooks that allow the PDC and HCA data to be viewed in the GIS. This approach provided the most flexibility, usability, and lowest development cost. Because the application was developed as a web-based application, the initial deployment was very straightforward, and updates and fixes are quickly and easily deployed.

Risk Ranking HCA Segments

A major requirement for the project was to ultimately provide a large set of variable asset, design, and construction information to the integrity management risk analysis tools used by PNG to determine relative risk ranking for HCA segments. A simple file-based solution has been developed initially due to the fact that the risk analysis tool is being migrated to a new platform by the vendor.

Data for the HCA risk analysis process is exported to the risk analysis tool, along with data relating to the ECDA process. Relative risk ranking values and information regarding the settings used in the risk analysis are transferred back to the system and stored. Risk ranking values are visible (read-only) to users in the GIS and within the external web applications. An archive of each risk analysis export is stored in the system and time stamped so that any one risk analysis run can be replicated at any point in time to review the parameters used. This provides an audit trail and archival mechanism.



HCA analysis – close up view of Identified Sites (yellow and red dashed shapes), Potential Impact Radius buffers (yellow cross hatching/yellow shading), and Transmission Lines (dark blue dashed lines).

Added Functionality

Additional functionality, developed as part of Piedmont's integrated pipeline integrity management solution, included:

- An alignment sheet application allowing the user to visualize various types of inspection and facility data in multiple bands relative to the GIS
- Integration of several third-party pipeline model applications (profile viewer, linear reference viewer, etc.)
- Applications for GPS import/export and inspection results import
- A data view interface for the viewing of external data sources
- Integration of Digital Elevation Model (DEM) data for profile modeling
- Change audit tools for pipeline integrity management of change requirements.

Success Factors

Thorough upfront requirements for engineering and detailed design proved to be a critical success factor for the project. This critical phase of the software engineering process requires a great deal of commitment and patience from users and sponsors who are involved. Piedmont committed several key people to the process, and they helped to ensure that progress was constantly being made. Also, it is easy to sell short this upfront process, because it often produces only documentation and "paperware" for the project. Because of the effort spent in

the upfront requirements and design – including understanding the company's needs and the pipeline regulations – the development and deployment of PNG's system and the accompanying integration work went very well. The system was able to be deployed immediately following a very painless site acceptance test, and a great deal of time was saved in the deployment.

A second success factor involved establishment of business processes for pipeline integrity management. As a relatively new discipline, PNG's business processes in this area were not fully defined. During the design and development of the integrated system, considerable time and effort was placed on understanding work processes and determining the optimum work flow. For example, design and construction data about the pipelines is captured in the field. While this information is needed for pipeline integrity management, in the past it was located either in individual spreadsheets, or was a matter of personal field crew knowledge. The system was designed to ensure a business process that effectively captures the field data. The upstream PDC/HCA web applications are utilized by the districts, and this data feeds into the downstream pipeline integrity management process.

Lessons Learned

Piedmont learned from its project experiences – particularly with respect to vendors and third-party software solutions. The company did experience a number of delays in getting the implementation phase of its project started. These were the result of the additional amount of time required to coordinate with each vendor to secure pricing, contracts, license agreements; and, at last, getting the vendor to deliver the software, solution, or service. While PNG ultimately allowed the Enspiria team to be the prime contractor for this task, in hindsight it is evident that this portion of the project should start as soon as possible, and sufficient time should be allocated for it. Integration of third- party software solutions requiring internet access in an operational environment was also a challenge. Many of the vendor solutions were not easily integrated into a network security environment, and required configuration of client firewalls, proxies, and network security in order to function.

Conclusion

This initial phase of work provides PNG with a solid integration framework and data foundation to continue growing its pipeline integrity management capabilities. Future applications could include trend analysis, tracking performance processes, and pre-assessment planning such as bell hole location planning, traffic control, and permitting.

About the Author

John Sullivan is a project manager with Enspiria Solutions. He has over 10 years of project engineering/management experience with gas and electric utility projects, and over 18 years of systems development and integration experience.