BIOGRAPHICAL INFORMATION

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Specific Responsibilities
Bill Meehan joined ESRI in 2002. He has extensive background in utility operations, management, including the integration of IT and GIS. Bill manages the worldwide electric and gas utility practice for ESRI. His specific responsibilities include strategic industry planning, business development, support of sales and project consulting.

Past Experience
Bill was formerly the Vice President of the Electric Operations, Vice President of Supply Chain and Manager of Engineering for NSTAR. He was the champion of Boston Edison's GIS project. Bill managed the NSTAR merger process of Boston Edison and Commonwealth Energy Systems and led the effort to comply with the Massachusetts Utility Restructuring (deregulation) Law.

Education
B.S in Electrical Engineering, Northeastern University, Boston MA
M.S in Electric Power Engineering, Rensselaer Polytechnic Institute, Troy, NY

Professional Memberships and Affiliations
Registered Professional Engineering in the Commonwealth of Massachusetts
GITA
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Awards
Multiple GITA speaker award winner

Publications and Presentations
Author of a numerous papers, articles, and the textbook, Power System Analysis by Digital Computer, he has lectured extensively and taught courses at Northeastern University and the University of Massachusetts. Bill has made a number of presentations and keynote addresses at host of industry and business functions.

MODELING HIGH PRESSURE DISTRIBUTION FOR INTEGRITY MANAGEMENT

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ABSTRACT

The Pipeline Improvement Act of 2002 and the rules that have been promulgated by the Office of Pipeline Safety have created a new demand for intensive data management, reporting and coordination of both natural gas transmission and high-pressure distribution mains. Pipeline operators have developed GIS data models and applications that are consistent with the legacy data structures of transmission. Those models use linear referencing from station to station along the pipeline.

However, the new regulations extend into the distribution system. Historically, distribution systems have been treated differently from a data modeling and an organizational view. Distribution systems are rarely stationed. Instead, pipe segments are modeled as a network data model, using point-to-point references. Workflows, data maintenance processes and reporting requirements differ between transmission and distribution departments.

GIS can be a critical tool for managing data in an organization that has both gas transmission and distribution while managing the fundamental differences.

BACKGROUND

A number of serious natural gas accidents causing death and injury, and numerous environmental accidents from liquid pipeline accidents, lead Congress to pass the Pipeline Improvement Act of 2002, which provides the level of Federal oversight to pipeline design, construction, and on-going inspection and risk mitigation. Among its requirements, the law prescribes that pipeline operators execute a pipeline integrity management program. Under Title 49 of the Code of Federal Regulations (CFR), the Department of Transportation's Research and Special Programs Administration (RSPA), Office of Pipeline Safety (OPS) was charged with enacting rules that detail the implementation requirements of the law. Part 192 (Transportation of natural and other gas by pipeline: minimum federal safety standards) has been enhanced to describe the specific implementation details.

<u>Key Concepts of the New Regulations</u>
The new regulations require natural gas pipeline operators to meet these mandates:

a. Develop and implement a comprehensive *integrity management program* for pipeline segments where a failure would have the greatest impact on the public or property

b. Identify and characterize applicable *threats* to pipeline segments that could impact a high consequence area
c. Conduct a *baseline assessment* and *periodic reassessments* of these pipeline segments
d. *Mitigate* significant defects discovered from the assessment
e. *Continuously monitor* the effectiveness of its integrity program and *modify* the program as needed to improve its effectiveness

A new key definition within the regulations is the high consequence area (HCA). This area surrounds the natural gas pipeline, which, in the event of a rupture and subsequent ignition, would cause serious injury and possibly death to anyone in that area. Pipeline operators must initially establish and document these HCAs. In effect they:

- Depend on the Department of Transportation Class Definition
- Depend the nature of the line and its potential impact (e.g. its pressure, size and wall thickness for example)
- Depend on the buildings (and other places were people congregate) and the use of the buildings that lie within close proximity to the pipeline, particularly those places where large numbers of people congregate and may have difficulty in evacuation
- Are determined by a complex spatial calculation along the pipeline.

<u>The Regulations Apply to the Distribution Business</u>

The regulations apply to all natural gas transmission pipelines.

While the focus and attention of the Federal Regulators was on Natural Gas *Transmission* and the consequences of high volume, high-pressure system events, the law can be equally applied to some *distribution* mains, particularly those operating at high pressure and in areas of significant human activity. This is because transmission is not defined by organizational structure, business application or plant accounting principles.

According to 49 CFR, Part 192, § 192.3 Definitions, a transmission line means a pipeline other than a gathering line that:

a) Transports gas from a gathering line or storage facility to a distribution center, storage facility, or large volume customer that is not downstream from a distribution center.
b) Operates at a hoop stress of 20% or more of Specified Minimum Yield Strength (SMYS)
c) Transports gas within a storage field. A large volume customer may receive similar volumes of gas as a distribution center, and includes factories, power plants, and institutional users of gas.

Hoop stress S_h is defined as the stress in a pipe of wall thickness, t, acting circumferentially in a plane perpendicular to the longitudinal axis of the pipe produced by the pressure, P, of the fluid in a pipe of diameter D and is determined by Barlow's formula (from ASME B31.8 §805.233).

$$S_h = \frac{PD}{2t}$$

49 CFR Part 192 Subpart O - Pipeline Integrity Management delineates the regulations for Integrity Management. §192.901 states that the regulations apply to all transmission lines *as defined above.* Since a number of distribution mains operated by Local Distribution Companies (LDC) fall under the definition of § 192.3, those LDC's must comply with the provisions of the new regulations. From an accounting, business and regulatory viewpoint, distribution is quite different from transmission. Regulated investor owned, public gas (municipal) or private utilities almost exclusively operate distribution gas systems. Both pipeline companies and gas utilities operate gas transmission lines.

Since distribution mains typically operate at much lower pressure than transmission, for example rarely higher than 400 to 500 psi, the business processes and drivers are quite different for distribution than for transmission.. Leaks rather then explosions are of major concern, although significant leaks which infiltrate confined structures are known to cause explosions. In many cases, high-pressure distribution mains (which could be considered transmission by the definition above) are operated by the same organizations than operate distribution.

In some cases, compliance to the new integrity management regulations may be more problematic for high-pressure distribution, especially inspection. In-line inspection may be impractical due to the lack of pigging launchers and receivers and the tight configuration and sharp bends of the system. Hydrostatic testing may be problematic due to the difficulty of water being trapped in low elevations. Direct assessment may be the only practical method for inspection. Therefore, is it critical that the data about the distribution mains be managed consistently and with an enterprise approach. That's where GIS comes in for both transmission and distribution.

GIS ROLE IN PIPELINE INTEGRITY

The DOT correctly recognized that safety consists of three essential components:

- Outstanding, accurate and coordinated information
- Consistent, methodical discovery and reporting of threats and risks to an oversight agency
- Timely mitigation and remediation of risks.

Data Management

Natural gas pipeline companies and gas distribution utilities have been collecting enormous amounts of information about their facilities for years. However, the processes, methods, documents and map products are very different. In both cases, the information has been captured in a fragmented ways. The critical data useful for basing decisions, such as inspection reports, inline inspection databases, photography and general facilities data have not always been well coordinated. This is further complicated by the different organizational structures (transmission vs. distribution) that persist in companies where different groups with different missions manage the data.

With the passage of the new law and resultant regulations, operators and utilities need a way to manage both transmission and distribution data that could form the basis for their new integrity management program. Many operators and utilities had been using GIS for engineering mapping and some limited design. The new rules heighten the need for consistent data and coordinated efforts on the part of both distribution and transmission departments within the same company. The GIS provides a common set of tools to capture, report and manage integrity related data.

Discovering and Reporting Threats

Current GIS technology allows operators to manage, coordinate, and identify discovered threats in a standard form and report them to the regulator. By capturing and coordinating both transmission and distribution data in GIS, associating scanned documents (such as historic manual inspection reports), operators will be able to comply with the new regulations in a cost effective way. Further, using common GIS tools, operators will be able to clearly delineate which parts of the distribution system needs to be included in the formal integrity management program and which parts of the distribution system that while currently are not subject to 49 CFR, Part 192, Subpart O may in the future.

For example, new Web Service technology could automatically notify operators of a potential change to a class location or of an identified site. Automated notification could be generated. A Web Service could be established that notifies the pipeline operator or utility whenever a building permit is issued near a pipeline or applicable main. The GIS could then analyze the structure to see if it impacts the class or the HCA.

GIS helps manage threat data, facilitates reporting both internally and to the regulators, and provides visualization of the set of threats on a macro level. Creating a single environment for imagery and land information for both the transmission and distribution entities that operate in the same geography facilitates the discovery of threats.

Managing Mitigation and Remediation of Risks

GIS provides a platform to help pipeline operators and utilities prioritize risk in the most cost effective way. By coordinating and effectively organizing all the relevant data relating to integrity management, operators and utilities may find that their mitigation activities can be optimized. For example, if an operator is not sure if a pipe segment is class 2 or 3, the operator may choose to take a conservative approach and assume that it is class 3. If that pipe segment cannot be inspected using in-line inspection methods, assessment may have to be direct. Direct assessment involves expensive and dangerous excavation. Conversely, if the operator assumes that the pipe is class 2, based upon inaccurate or uncoordinated data and it really is class 3 and an event occurs, the consequences for the operator will be severe.

Thus, the GIS can help to manage the mitigation activities. With solid processes and procedures in place, a GIS platform can give operators the best opportunity to make the proper decisions about mitigation and remediation, being neither too conservative (which may be expensive) nor too optimistic (which may be risky). By providing a common platform for both transmission and distribution, operators (if they have distribution) and utilities (that have both) will be better positioned to coordinate mitigation activities.

TRANSMISSION VS DISTRIBUTION DATA MODEL

As real world facilities, processes and events are automated, there needs to be a common platform to describe their data. . In early years of automation, data models were simply data tables. The tables listed data elements, such as valves or pipe segments, and lists of descriptors or attributes such as size, material and class for example. All logic, behavior and data relationships existed in the application programs that operated on the data. As relational data base management systems displaced flat data files and tables as repositories of data, the data tables evolved into a data base design with some behavior and relationships inherent in the data base schema. The object oriented databases that form the foundation for today's GIS have advanced relationships and behaviors and in fact are metaphors for the system being modeled. Today, that platform is referred to as a data model. Often that data model is described in a standard format called a Unified Data Model (UML)

In effect an early transmission data table would look no different from a distribution data table. Transmission pipes have similar attributes as distribution pipes. However, since today's data models are linked to the behavior, organization, application and even visualization of the data, the transmission and distribution data models are quite different. Further, transmission and distribution applications, maps, documents, processes, policies, reporting requirements, organization structures and historical cultures are often very different. It's no wonder that the digital representation of the data, i.e., the data model for each is quite different.

Common data models that describe natural gas transmission systems are specialized cases of pipeline data models used in the oil and gas industry. Over the past decade, GIS vendors, pipeline application providers and operators have worked collaboratively to develop pipeline data models. One clear characteristic of the various pipeline data models is linear referencing, that is, the ability to locate a point along a pipe from another reference location on the pipe. A linear referenced model is far superior to a distribution model for high-pressure transmission pipeline because of the need to mix and match difference data types, or overlays, without splitting the pipeline at each attribute change. A critical characteristic of this model is the ability to look at overlapping ranges of pipeline. Long sections of pipe with similar range features (pipe size, coating, wall thickness, SYMS) are modeled as if they were a single section of pipe, even if the event feature (gouges, welds, dents) intervened. Another term for this approach is dynamic segmentation, which recognizes that events or points along the pipeline occur dynamically, but don't create a distinct node point, thus breaking the pipe into segments at every point where an event occurs. Linear referencing solves complex transmission data management problems, such as station equations. Industry groups have collaborated to publish standard ways to describe a pipeline data model. One such group publishes a standard called Pipeline Open Data Standard (PODS). There are others. .

There have been little formal attempts to standardize on a gas distribution data model. The GIS vendor either determines the model if it is built in or it is created from scratch or shared by users who use the same GIS vendor. Some vendors publish data models for gas distribution that have been built by a consensus group of users and application providers. These are typically called network data models. They are the classic node, span models, where each section of pipe between a node is treated as a separate element. The critical characteristic of this model is the ability to trace along the pipe around the network. Connectivity is critical. While transmission lines are typically long single lines, distribution pipes have multiple paths up one street and down another. The location of distribution points (nodes) is based on real world coordinates and is created where two or more pipes come together to form a node. Stationing is rarely if ever used in distribution.

Since data models are an attempt to accurately describe real world situations, it's not surprising that the two data models are quite different. Alignment sheets, which show sections of pipeline tend to be the universal language for transmission lines are hardy ever used for distribution lines. Distribution lines are most often displayed on map grids.

Distribution GIS applications have been built around the network model. Transmission applications have been built around the linear referenced model. Yet from an engineering perspective, both transmission and distribution piping systems follow ASME B31.8. The newly enacted OPS rules follow and liberally refer to B31.8.

As noted above, the problem is that 49CFR192, Subpart O apply to some distribution mains. So from an organizational, data gathering, data modeling perspective, they are distribution. From an integrity management perspective, they are transmission. Do the data models have to be different?

To deal with this issue, there are a couple of possibilities:

1) Create a new single data model that includes classic gas transmission, high-pressure distribution that conforms to the definition of transmission and conventional low-pressure distribution mains and service lines.
2) Continue the transmission and low-pressure distribution models and create a third data model for high-pressure distribution mains that conform to the definition of transmission.
3) Continue the two data model approach and treat the high-pressure distribution as transmission only for analysis purposes.

<u>Single Data Model</u>

Creating a single data model is the easiest to conceptualize, but the most difficult to implement in a practical way. While one could argue that the transmission model is derived in part largely from outdated methodologies, like stationing and alignment sheets, conversion to a new paradigm for transmission representation in the short term is not practical since:

- Historic events that have occurred prior to automation are linked to stations and would have to converted to a new coordinate system
- Transmission pipeline information is very accurate relative to itself, but the absolute position of many transmission lines is not known precisely. Thus, this conversion would be expensive and have little benefit.
- The investment in a completely different means of displaying information from alignment sheets would probably not be worth it, given that no alternative standard exists.
- A network model for transmission system is inappropriate and unwieldy, since events are not really nodes and can occur anywhere along the pipeline.

Given the volume of distribution data segments and the frequency of transactions to the system, changing the distribution model to align with transmission would slow the entire distribution management process down without adding any additional benefit.

In effect, one size does not fit all.

Create a New High-Pressure Distribution Data Model

Creating a separate and distinct data model just for high-pressure distribution that incorporates some elements of both the distribution data model and transmission has some serious drawbacks as well:

- Stationing would have to be introduced to the high-pressure distribution main system or the transmission applications would have to be restructured to work in a networked model environment.
- It's not clear which elements from the distribution system would apply. Only until the analysis is completed would one be able to determine if that segment of line actually was to be treated as a transmission segment from an OPS rule. In effect, one would have to model the high-pressure distribution system first in order to find out if a particular segment needed to be modeled.
- Adds more complexity to the workflow, especially to those high-pressure mains that don't fall into the transmission definition.
- The distribution applications would have to be restructured for a new more complex data model.
- The connectivity between the high and low-pressure systems becomes complicated.

Adding a third data model complicates the workflow, adds more complexity to the current distribution applications and introduces additional decision making as to what is or isn't included in the high-pressure distribution system from an OPS reporting viewpoint.

Maintain Separate Transmission and Distribution Data Models

For the vast majority of applications, the network data model works well for high-pressure distribution system and should continue to be used. A practical approach for Integrity Management is:

- Maintain a single distribution gas data model including high-pressure distribution mains that are classified as transmission by 49 CFR, PART 192, § 192.3.
- Maintain a transmission data model, but migrate to a single transmission and distribution land base data model and associated imagery including the workflows to manage the land-base data. This may require adjustment of the transmission data to the distribution land base. The stations then can be fixed in a real coordinate system and be referenced both by using linear referencing and by using real world coordinates.
- Periodically migrate the distribution system temporarily to a transmission data model. This can be done automatically.
- Perform integrity management on the temporary data. All data transactions are done on the distribution data model.

While this introduces an extra step in the process, it recognizes the essential differences that exist between the transmission system and the distribution system from a workflow, organization and presentation viewpoint.

PRACTICAL IMPLEMENTATION AT CENTERPOINT ENERGY

In recent years, CenterPoint Energy has consolidated all of their GIS operations into a standard GIS platform used for both the electric and gas distribution system. Consequently, one gas distribution model and one common data repository were designed and are in use today by various CenterPoint Energy enterprise departments. While this combined distribution environment meets all the day to day electric and gas distribution GIS needs of CenterPoint Energy, it does not provide an efficient model upon which OPS required high pressure pipeline integrity management, analysis and regulatory reporting can be achieved.

CenterPoint Energy has recognized that while their current electric and gas distribution GIS environment is state of the art and leads the industry, they must implement changes to their system in order to integrate applications that will meet Pipeline Integrity Management requirements.

CenterPoint Energy wanted to improve the overall process of data management, discovery of threats and mitigation activities for both transmission and distribution without an undue burden on day-to-day operations. Some of the initiatives were:

- Consolidate both transmission and distribution GIS
- Utilize the same land-base and imagery for both transmission and distribution networks
- Continue to improve efficiency and productivity of the GIS workers
- Standardize processes as much as practical.

While the current high-pressure gas distribution data and high pressure transmission pipeline data is currently maintained in a networked data set, the current models are not compatible with a linear referenced model required for high pressure transmission and distribution pipeline applications. Therefore, CenterPoint has designed and implemented a linear referenced model and suite of applications. Also, a workflow was designed and implemented that allows the current staff of GIS editors to perform their general design and data maintenance (as-built) activities with the current suite of GIS based editing tools, while providing an automated process for regular high pressure transmission and distribution data extraction, reformatting and import into the linear referenced model. Ultimately, gas transmission (pipeline, not high pressure distribution that meets the definition of transmission) will have a permanent transmission data model.

ENTERPRISE IMPLICATIONS

GIS is considered enterprise if, by design, it is part of the overall IT architecture of the company. This implies that GIS is integrated with the standard corporate systems, such as asset management, supply chain, engineering, analysis and SCADA. The new regulations require that pipeline operators change their fundamental business processes. GIS is a key tool for compliance and has a variety of applications for, at a minimum, complying with regulations and at most providing core IT technology for the enterprise. Every physical asset a pipeline company owns has a spatial component. GIS can eliminate decentralized islands of data and applications to improve management and workflow. GIS, integrated with financial, supply chain, human resources and environmental areas provide powerful business intelligence. Enterprise GIS facilitates the compliance process aides in the design, field inspection, asset management and pipeline siting processes. By viewing GIS as a standard platform for both transmission and distribution, CenterPoint Energy continues to fine tune the notion of true Enterprise GIS.

SUMMARY

Natural gas pipeline safety is a major concern. The Pipeline Safety Improvement Act of 2002 started a long process of stringent compliance requirements. Fortunately for pipeline operators, tools and data are available to help. GIS is one of them.

Since the new regulations may apply to some high-pressure distribution systems, utilities must create workflows, analysis techniques and reporting means to deal with this new regulatory impact. Since historically transmission has been modeled quite differently from distribution, this offers a challenge to operators who have both transmission and distribution. Creating a single data model overly burdens the workflow of both systems. CenterPoint Energy examined a number of possibilities and along with some redesign of work flows, created a practical approach that utilizes the natural advantages of both transmission and distribution data models.