GIS Based Risk Analysis – Simplifying the Risk Assessment Process

David Adler
Principal Engineer – System Integrity
NiSource Gas Transmission and Storage

John Beets
Principal GIS Technologist
Willbros Engineering
NiSource Gas Transmission and Storage

- Serve 16 states
- Over 15,000 miles of natural gas pipeline from the Gulf Coast to New York
- One of the largest underground storage systems in North America
- Headquarters in Houston
- Significant presence in Charleston WV, including some engineering and most GIS personnel
• Hundreds of miles of pipe that look just like the previous mile

• Multiple pipelines in a single right-of-way

• Common characteristics and threats (e.g. age, material, coating)

• Close to 100% “piggable” – probably the best data gathering method

Some of the System is Long-Haul
Some of the System Looks More Like an Oversize Distribution Company

- Very little is standard
- Lots of single feeds to towns and small cities
- Unique characteristics and threats (e.g., age, material, coating)
- Most lines not piggable; reduced ability to directly gather information
- Greater challenge to manage risk
Assignment: Effectively Manage Risk

Likelihood of Failure

\[ \text{Risk} = \text{Likelihood} \times \text{Consequence of Failure} \]

- Likelihood is a measure of threats to the pipeline
- Consequence could be Public Safety, Environmental, or Financial

“No effective program leads to regulatory compliance”
“Effective” Risk Management: Ancient History

Resource Allocation: Who can do the best job of describing why their project is most important to the company’s future?

No definitive basis for objective, risk-based decision making.
Effective Risk Management: First Real Efforts (1990s)

Pre-determined, relevant questions, but still generic:

• Is the project required by regulation?
• Does it improve public and/or employee safety?
• Does it improve system reliability?
• Does it improve the company’s bottom line?

This change broke up the “big story” into smaller parts that could be more easily examined. Represented the first shot at finding a common basis for evaluating large projects.

- Set expectations for Integrity Management Program
- Set timelines for certain activities
- Required Pipeline Operators to Identify the threats that applied to various portions of their system

<table>
<thead>
<tr>
<th>External Corrosion</th>
<th>Internal Corrosion</th>
<th>Stress Corrosion Cracking</th>
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<tbody>
<tr>
<td>Mechanical Damage</td>
<td>Manufacturing/Materials</td>
<td>Construction</td>
</tr>
<tr>
<td>Weather / Outside Forces</td>
<td>Equipment Malfunction</td>
<td>Incorrect Operations</td>
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</table>

- Required regular assessments of pipelines (in the highest consequence areas) using a method that ensures safety in light of the identified threats
Effective Risk Management: Subject Matter Experts (SMEs) Develop Data Element Spreadsheet (2003 - 2005)

Pros
- 104 Questions on threats to our facilities in the most highly developed areas
- For 1000 HCAs = 104,000 questions asked
  - Risk team learned a lot about the system and our field employees
  - Field employees learned a lot about risk concepts
  - Data was gathered from front-line employees’ brains
  - Data quality improvements were made to our GIS

Cons
- Time consuming – 100 man days to run risk
- No dynamic segments - Risk based on “combined worst-case scenario” in each HCA
- Difficult to update
- No evaluation of facilities outside HCAs

But we finally had a uniform way to evaluate risk across the “High Consequence” parts of our company!

- Data extracted from multiple information systems in company
- Data then processed externally (outside of GIS) in consultant’s proprietary System

**Pros**

- Dynamic segmentation enabled use of high-resolution data
- Analysis extended beyond HCAs
- Good opportunity to work with knowledgeable experts
- Continually identified areas where company data was weak
- Reinforced our confidence in our original (104 questions) results

**Cons**

- Lack of uniform data alignment in existing systems caused problems
- Process for dealing with data quality issues was cumbersome
- Required extensive development of complex default data rules
- Extra data handling increased chances for errors
- Did we try to do too much based on the quality of data available at that time?
GIS History

- Initial GIS development at NiSource was in an Intergraph FRAMME environment
- Migration to ESRI ArcGIS Pipeline Data Model (APDM) based solution in late 2004, completed in 2005
- Currently utilizing an APDM 5.0 Geodatabase
- Late 2009 decision – Risk solution to be tightly integrated with enterprise GIS
Risk Model

Risk = (Likelihood of Failure) x (Consequence of Failure)

or (D x R x I x P x Interactive) x (Consequence)

- **D** = Drivers (e.g., pipe age)
- **R** = Resistors (e.g., coating type)
- **I** = Indicators (e.g., pig (ILI) indications)
- **P** = Preventors (e.g., ILI year)
Current (GIS) Risk Solution

Most successful risk process to date

- System designed from ground up around data available in the enterprise GIS
- 80 + input variables
- GIS based tools for processing key datasets (such as ILI anomaly data and habitable structures)
- Dynamic segmentation
  - GIS based tools readily available
  - Provides results at highest resolution available
- Fast turn around (if no changes to algorithm)
Current (GIS) Risk Solution

Risk Data Flow:

NCT&S Risk Data Flow/Processing
April 2011
Current (GIS) Risk Solution

Pros of a GIS based solution:

- Flexibility – NiSource controls software functions and resulting solution capabilities
- Requires no data translation – operates directly against APDM GIS database
- Readily available spatial analysis functions increase the processing capabilities of the solution
- Open solution provides flexible access to other data sources:
  - Other company sources
  - Third-party data (RexTag, ESRI data appliance)
  - Public domain data sources (FEMA flood, National Highway Performance Monitoring System)
Cons of a GIS based solution:

- Flexibility – Easy to make changes, so the temptation to change must be controlled – or the risk results will always be changing
- Suggest once a year updates to algorithm, with archiving
- ArcGIS expertise is required to work through issues that may arise
  - Our set-up works well – an engineer familiar with pipeline threats plus a GIS expert (Company / Consultant / Both)
- End user tools not yet readily available within ArcGIS (custom reporting, web access, scenario development, etc.)
  - We are using a third-party end user solution, with typical integration challenges – thankfully everyone works well together
Current (GIS) Risk Solution

System components – software processing tools
1. ArcGIS 9.3 – APDM 5.0
2. Geo-Processing Tools (GPT) – Eagle Information Mapping
3. Python scripting

System components – end user tools
1. Geonamic web-based dashboard, reporting and scenario development (under implementation)
2. Alignment sheet generation
3. ArcGIS display and map generation
4. Export to Excel, Access (MS Office based tools)
Current (GIS) Risk Solution

System processing sequence:

1. Extract and generate feature classes
2. Process ILI and other survey data to obtain affected pipeline range and date of survey
3. Perform GIS based polygon overlay analysis (external data)
   - FEMA flood data
   - Ground stability
   - Ground acceleration (seismic)
   - Lightning strikes
   - Odorization (based on counties)
Current (GIS) Risk Solution

System processing sequence (continued)

4. Potential Impact Circle (PIC) calculations
   - Population (residential, limited mobility, 4 story building, etc.)
   - Railroads
   - Foreign pipelines
   - Refineries, chemical plants, power plants, etc.
   - High traffic areas

5. Application of point feature data to linear pipeline
   - Unauthorized encroachments
   - Leaks
   - Equipment counts
   - ILI anomalies
   - CP test results
Current (GIS) Risk Solution

System processing sequence (continued)

6. Off line features encroaching on pipeline
   – Foreign pipelines
   – Electric transmission lines
   – Transportation features (roads, railroads, navigable waterways)

7. Resolve linear feature overlap (timing)
   – Coating
   – Strength tests
   – Line cleaning and treating
   – ILI
   – ROW Maintenance
Current (GIS) Risk Solution

System processing sequence (continued)

8. Dynamic Segmentation
   – 47 linear features

9. Risk Algorithm Calculations
   – Weightings lookup
   – Core calculations
   – Interactive threats

10. Results upload to APDM
Structure Processing

Structure unit counts within PIR
Structure Processing

Multi-unit structure counts
Unauthorized Encroachments

Within 1,000 feet of pipeline –

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Material & Manufacturing Defects
Count of overlapping 40 foot easements
3rd Party Crossings & Encroachments
Within 100 foot buffer of pipeline
Highway Performance Monitoring System

Highway segments within potential impact circle
Consequence Factor in Risk Results

Structure density
Likelihood of Failure Factor - Risk Results

External corrosion
Total Risk Results

Main Drivers: Public safety, materials & manufacturing, internal corrosion
Total Risk Results

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GIS Based Risk Assessment

Summary:

1. Risk integration with GIS makes sense
   – Simplified data access
   – Powerful spatial analysis tools
   – Flexible map presentation tools
   – Flexibility to recognize and adapt to a changing environment:
     • Ability to quickly adapt to changing risk factors across a dynamic system
     • Ability to refresh risk results quickly as changes occur across the system

2. Lessons learned
   – Data availability & accuracy a primary constraint
   – Need readily available location information in other systems (Maximo)