Technology Advancements in Pipeline Data Management

Jeff Allen, Pipeline Practice Lead
Common Patterns for Pipeline Organizations

**Mapping & Visualization**
Understand locations and relationships with maps and visual representations

**Data Management**
Collect, organize, and maintain accurate locations and details about assets and resources

**Field Mobility**
Manage and enable a mobile workforce to collect and access information in the field

**Monitoring**
Track, manage, and monitor assets and resources in real-time

**Analytics**
Discover, quantify, and predict trends and patterns to improve outcomes

**Design & Planning**
Evaluate alternative solutions and create optimal designs

**Decision Support**
Gain situational awareness, and enable information-driven decision making

**Customer Engagement**
Communicate and collaborate with citizens and external communities of interest

**Sharing & Collaboration**
Empower everyone to easily discover, use, make, and share geographic information
### Common Patterns for Pipeline Organizations

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Enabling the Platform Across the Pipeline Lifecycle

- **Asset Development**
  - Planning
  - Rights of Way
  - Engineering
  - Design
  - Construction

- **Asset Management**
  - GIS
  - MAOP
  - TVC

- **Pipe Integrity**
  - Risk
  - ILI
  - HCA
  - Class

- **Asset Operations**
  - Inspection
  - Maintenance
  - Network Control
  - Emergency Management

- **Health, Safety & Environment**
  - Health
  - Safety
  - Environmental Management

- **Business Management**
  - Tax Accounting
  - Business Intelligence
  - Revenue Protection
  - Human Resources
  - Legal

- **Customers & Regulators**
  - Marketing
  - Sales
  - Customer Service
  - Regulatory Compliance
Enabling the Platform Across the Pipeline Lifecycle

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Two new Esri technologies to meet that need:

- ArcGIS Pipeline Referencing (APR)
- ArcGIS Utility Network Management Extension (Utility Network)
Changes in Technology

Client-Server Architecture

Web Services System Architecture

Desktop  Desktop  Desktop

Desktop  Web  Mobile Devices

Web Services Server

RDBMS

RDBMS
ArcGIS Pipeline Referencing
What is ArcGIS Pipeline Referencing?

Enables Linear Referencing

Linear Referencing is a data management technique that allows you to maintain route and event data from multiple measurement systems on a common geographic basis.
Dynamic Segmentation
APR Information Model

Schema for route centerline management

- **Routes (Network)**: Route features
- **Centerline Sequence**: Key table for M-N relationship between Centerline and Route
- **Calibration Points**: Point feature class that stores route measures
- **Centerline**: Line feature class that stores route geometry

...with support for Engineering Stationing
Industry Data Models

- Supports:
  - Esri Utility and Pipeline Data Model (UPDM)
  - Pipeline Open Data Standard (PODS) Lite
  - Or any schema that implements the location model.

...making pipeline data more inter operable
Pipeline Referencing Overview

**Information Model**
- Network, Routes
- Events

**ArcGIS Desktop**
- LRS Network editing
- LRS management tools
- Geoprocessing tools
- Internationalized

**ArcGIS Enterprise**
- LRS web services
- Developer API samples

**Web Application**
- Event editing
- Event query
- Event QC
Demonstration
Utility Network
Utility Network

- Provide the ability to model, edit, and analyze networks using all Esri platform clients
- Better support a true representation of what is in the ground
- Support highly responsive editing and analysis capabilities
- Improve data quality with better rule base and error management

Network functionality everywhere

.portal

Sync

Mobile Apps
Geodatabase Information Model for Utility Network

- A single Utility Network contains:
  - A polygon feature class of the service territory
  - A single shared structure network
  - Multiple domain networks

```
Enterprise Geodatabase

Utility Network Feature Dataset
- ServiceArea Polygon feature class
- StructureJunction Point feature class
- StructureLine Polyline feature class
- StructureBoundary Polygon feature class
- Gas/Liquid Pipeline Domain Network
- Electric Domain Network
- Water Domain Network
```
Domain networks are associated with a collection of rules.
- Rules control what features may be connected or associated with.

Each domain network contains five core feature classes:
- Device
- Line
- Assembly
- Junction
- SubnetLine
• Method for managing physical assets of oil and gas pipe systems
• Supports linear referencing data management with ArcGIS Pipeline Referencing
• Supports Network Topology data management with Utility Network

Domain Assets
- Oil & Gas network
- Structural network
- Cathodic protection network

Integrity
- Pipeline Referencing
- Inline Inspection Data
- Integrity Compliance Data

Inspections
- Asset Inspections
- Compliance Inspections

Utility and Pipeline Data Model
Utility Network Editing
Editing Templates – Tools

Edit Ribbon Tab

Create Features Pane

Modify Features Pane

Editing Toolbar
Editing Templates: Group Templates

• Create multiple features with a single sketch

• Examples:
  - Valve Assembly
  - Launcher / Receiver Assembly

• Options depend on primary template
  - Polygon – add other polygons, lines, and points
  - Line – add other lines and points
  - Point – add other points (can use line sketch)
Network Rules: What are They

- Network rules are used to ensure data structure and data quality – e.g.,
  - What feature type can connect to what feature type
  - A line feature must have a point feature at its coincident endpoint with another line feature of a different type (i.e., a system junction cannot be created)
  - Can a feature type be contained within another feature type
Network Rules: Types of Rules

There are 5 types of rules in the Utility Network Rule Base. (Junction-Junction Connectivity, Junction-Edge Connectivity, Edge-Junction-Edge Connectivity, Containment, Structural Attachment)

-Junction to junction Connectivity: Defines which device or junction features can be connected to one another. For example, a Gas Device /Valve connected to a Gas Junction /Tee/ Metal 3-way.

-Junction-Edge Connectivity: Defines which lines can be connected to device or junction features. For example, a Gas Device/Meter/Customer Meter can be connected to a Gas Line/Service/Service Line

-Edge to Junction to Edge Connectivity: Rules define a valid configuration of a line connected to a device or junction feature which is connected to a line. For example, a 12" pipe can be connected to a 10" pipe only if there is a reducer device where they connect

-Containment: Rules define which types of features can be containers. Additionally rules define which types of features can be contained within a container. For example, a GasAssembly / Regulator Station / can contain a GasDevice / Regulator feature.

-Structural Attachment: Rules to define associations between gas device and gas junction assets with Structure Junctions. For example a StructureJunction / Pipe Hanger can connect to a GasJunction / Connection Point. The Connection Point is the location along a Gas Pipe segment where the Pipe Hanger attached to the gas system.
**Network Rules: Edge to Junction to Edge Connectivity**

- Identifies valid junctions which can connect between two edges
  - Example: To connect a 12” gas main to a 8” gas main requires a Reducer junction.

### Edge-Junction-Edge Connectivity

<table>
<thead>
<tr>
<th>ID</th>
<th>From Class</th>
<th>From Asset Group</th>
<th>From Asset Type</th>
<th>To Class</th>
<th>To Asset Group</th>
<th>To Asset Type</th>
<th>Via Class</th>
<th>Via Asset Group</th>
<th>Via Asset Type</th>
<th>Via Terminal</th>
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<tbody>
<tr>
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<td>Line Heater</td>
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<td>UPDMDevice</td>
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<td>Custody Transfer to Distribution</td>
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</tr>
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</table>
Network Rules: Error Features

• All association are checked when they are added; if the association does not correspond to a rule, an error is raised (but an error feature is not created)

• Associations are checked when they are validated as well because:
  - Once an association is added, the user can change the assetgroup or assettype values of the features in the association, validate network topology needs to detect the inconsistency caused by this.
  - The reconcile process can generate associations with missing features (deleted as result of reconcile)

• Error features are system managed and persisted in one of three error tables, depending upon geometry (i.e., point, line, polygon)
Demonstration
Containment: What are Containers

- Containers are an association between features
  - E.g., a valve inside a pump station, or regulator inside a regulator station
- Allow dense collection of features to be represented as a single feature
- Only Structures and Assemblies can be designated as containers
Containment: Associations

• For containers, rules constrain what types of Lines, Devices or Junctions may be contained in within a specific container

• Deletion of a container behavior
  Restrict – (default) if content exist, raise an error; this forces the user to first delete all content
  Set to none – all containment associations are deleted, content’s containment status is set to none
  Cascade – all content is deleted
Demonstration
Utility Network Terminals and Subnetworks
Terminals: Overview

• A terminal is a logical connection location on a Device
  - Terminals are not supported on Junctions

• Terminals support more realistic modeling of Devices
  - Important for determining the gas flow direction

• Terminals allow a Device to be mapped to a collection of junction and edge elements in the network topology

• Terminals are defined for certain Devices, not all
  - Devices that require a high pressure and low pressure for analytic purposes (e.g., regulators and Compressors)
  - Devices whose traversal is bi-directional (e.g., valve)
The utility network will support at most eight terminals on a device.

<table>
<thead>
<tr>
<th>Pressure Reducing Terminal</th>
<th>Pressure Increasing Terminals</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Regulators</td>
<td>- Compressors</td>
</tr>
<tr>
<td>- Pressure Reducing Valve</td>
<td>- Compressor Station</td>
</tr>
<tr>
<td>- Regulator Station</td>
<td></td>
</tr>
<tr>
<td>- Town Border Station</td>
<td>- High pressure</td>
</tr>
<tr>
<td></td>
<td>- Low pressure</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Generic OneFlow Terminal</td>
<td>Generic BiFlow terminal</td>
</tr>
<tr>
<td>- Wellhead Source Flange</td>
<td>Valve-Critical</td>
</tr>
<tr>
<td>- Wellhead</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Port One</td>
</tr>
<tr>
<td></td>
<td>- Port Two</td>
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<tr>
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<tr>
<td>CPCurrent</td>
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</tr>
<tr>
<td>- Anodes</td>
<td>Current In</td>
</tr>
<tr>
<td>- Rectifiers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Current Out</td>
</tr>
</tbody>
</table>

High pressure

Low pressure

Inflow

Outflow

Port One

Port Two

High Pressure
Subnetworks: Overview

Subnetworks are connected sub-portions of the network that are used for:
- Driving analytic operations
- Labeling and map production
- Visualization (pressure zone, CP Area)
- Summarization of asset attributes
- Exporting subset of network to external systems

• Tier representations of Gas system
  - System zones
  - Pressure zones
  - Isolation zones
  - CP Zones
Subnetworks: Subnetwork Controllers

• **Subnetwork Controllers define the sources or sinks of a subnetwork**
  - Example: Gas Transmission Pressure Tier sources are Compressors
  - Example: Cathodic Protection Tier sources are Rectifiers
  - Examples: Gas Distribution Isolation Tier sources are Critical Valves

• **Specifying a subnetwork controller is defined at the terminal level**
  - Allows a valve (each side) to be a source for isolation zones

• **Subnetwork controllers are defined using the Modify Subnetwork Controller tool in ArcGIS Pro**
Subnetworks: MAOP for Pressure

- Maximum Allowable Operating Pressure (MAOP) for a single pressure zone is the MAOP of the asset in the pressure zone with the lowest MAOP value.

![Diagram showing MAOP values for different components: Regulator (R), Valve (V), Weld (W), Tee (T), Customer Meter (M). MAOP Values: 250, 225, 200, 225, 215, 225, 245, 125, 225.]

*A pressure zone is only as strong as its weakest component.*
Demonstration
Utility Network Tracing
Tracing: What is Tracing

- Tracing entails assembling a subset of utility network elements that meet a specified criteria
- Tracing uses network data to provide business value to utilities
  - Answers questions and solves problems about the current state of the network
    - What valves need to be closed to shut off gas to this location?
    - What rectifiers are associated to a specific cathodic protection zone?
  - Helps organize business practices
    - How can I create a SCADA system diagram to give to my control room staff?
Tracing: Gas Analysis

Determine a path directionally from a location in a connected network to a separator or separators that bound it.

Sources
- Gas / Product sources

Isolation Zone
- Primary
- Secondary
- Emergency

Pressure Zones
- Gas / Product pressure

Cathodic Protection
- CP zone
- Find closest CP source
- Find closest CP test point
- Which part(s) is not in a CP zone
Tracing: Starting Points

- Many traces require radiating outward from a specific location or set of locations
  - Starting points define these locations
- May be added or deleted using the Trace Locations pane
- Can be placed on junctions or edges
Tracing: Barriers

- Barriers define locations at which the traversal of a trace should terminate
  - Feature on which barrier is placed not included in results
- May be added or deleted using the Trace Locations pane
- Barriers are stored in a feature class in the default project workspace
Tracing: Basic Traces

- Connected
- Subnetwork
- Subnetwork Controllers
- Upstream
- Downstream
- Loops
- Shortest Path
Tracing: Connected Trace

- Finds all features connected to a given set of starting points
  - Subnetwork controllers are not required
  - All terminal paths are returned in a terminal device
Demonstration
Utility Network Diagrams
Network Diagrams

Network Diagrams are completely integrated into the Utility Network

- Out of the box you can select data and generate diagrams
- Diagrams can be configured to be automatically generated/updated during subnetwork management
- Diagram tools are part of the Utility Network toolbox

*NOTE: Although network diagrams are the replacement for Schematic diagrams from the 10.x geometric network world, not all the capabilities from schematics exists in network diagrams. We are currently only supporting data that is in a utility network.*
Network Diagrams

- Network Diagram is the *new term* we are using for the *old concept of Schematics*.
- Network Diagrams are a core part of the utility network, not an extension.
- Network Diagrams within the utility network provide an integrated mechanism for working with diagrams. It allows users to efficiently create multilevel representations, readily check network connectivity, and easily obtain logical views of any utility network.
Demonstration