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

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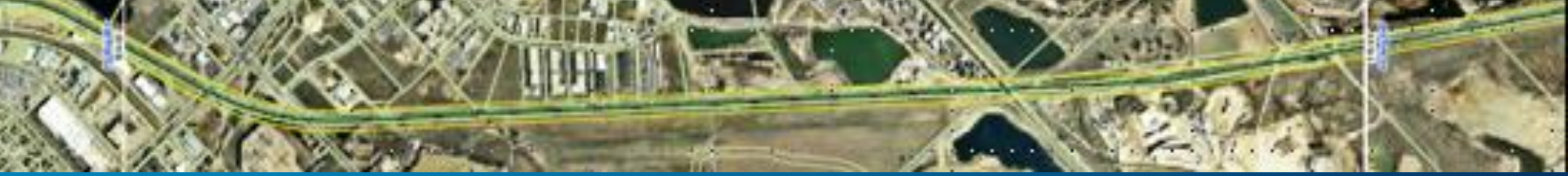


Enabling the Platform Across the Pipeline Lifecycle

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

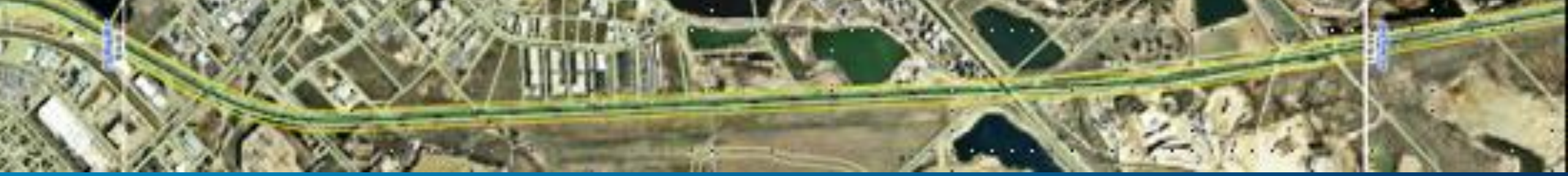
- Health
- Safety
- Environmental Management

Business Management

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

Customers & Regulators

- Marketing
- Sales
- Customer Service
- Regulatory Compliance



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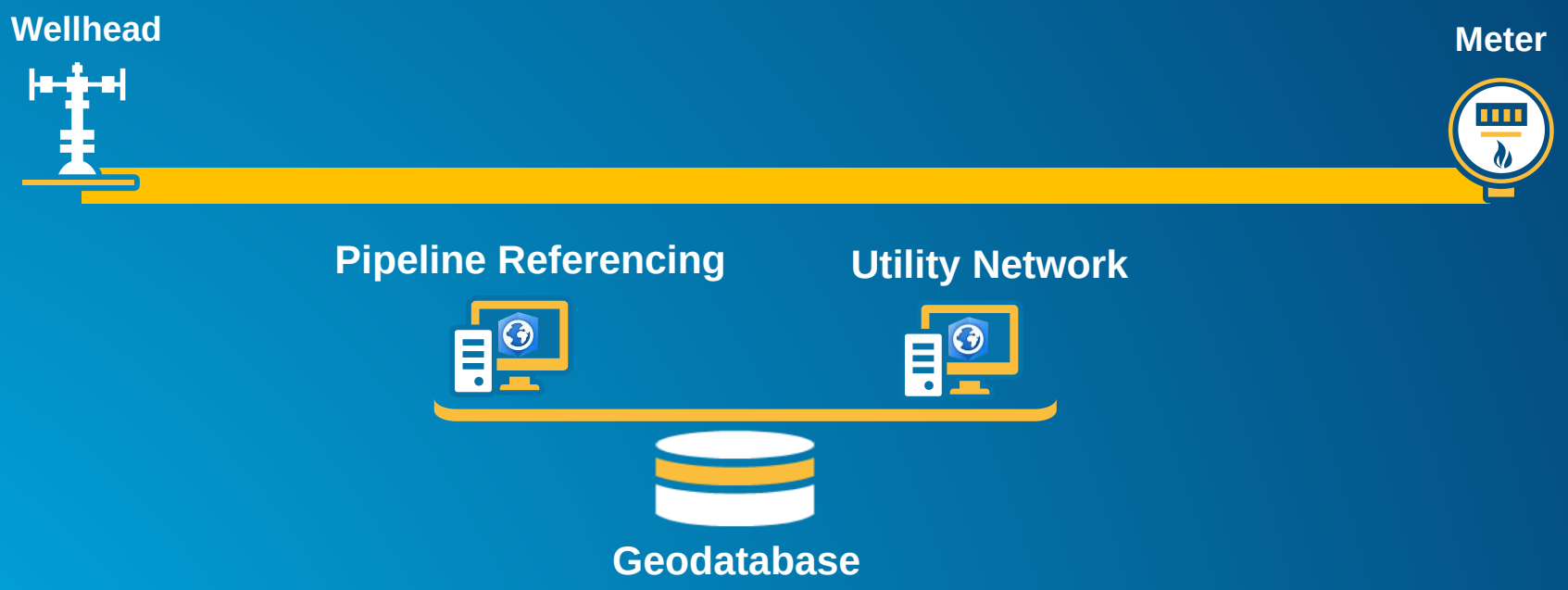
UPSTREAM
MIDSTREAM
DOWNSTREAM
Oil or Gas Offshore Wells
Oil or Gas Onshore Wells
Gathering Pipelines
Oil Processing
Oil Storage
Oil Transmission
Pump Station
Aerial Patrol
Gas Processing
Gas Transmission
Underground Gas Storage
New Construction and Inspections
Compressor Station
LNG Facilities
Oil Refining
Electric
Industrial
Utilities & Distribution
Regulator Station
Residential

ArcGIS for Pipelines – System of Record

Managing the system from wellhead to meter with a single system

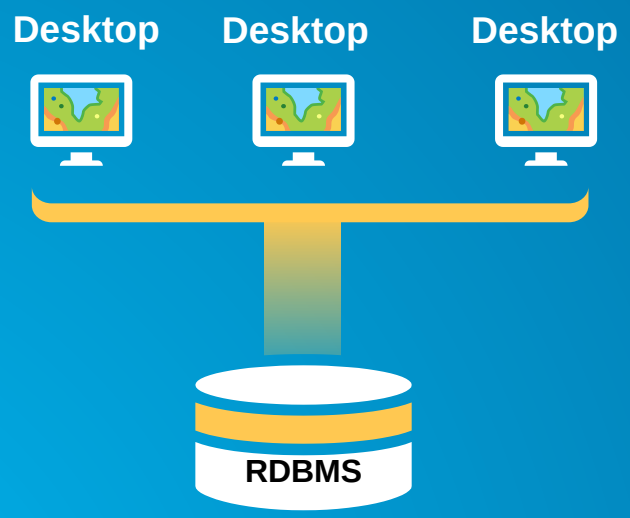


Two new Esri technologies to meet that need:

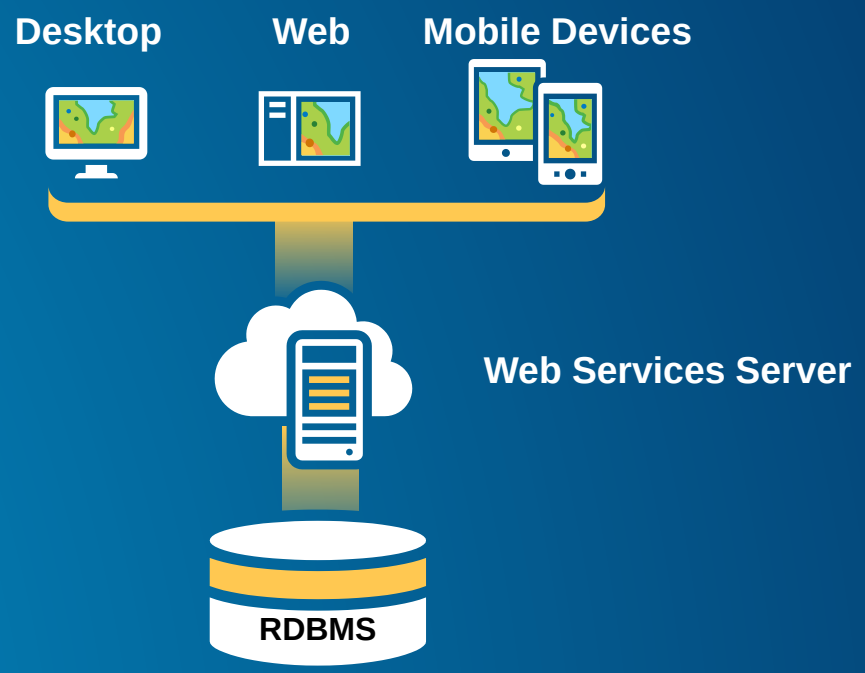
- ArcGIS Pipeline Referencing (APR)
- ArcGIS Utility Network Management Extension (Utility Network)

Changes in Technology

Client-Server Architecture



Web Services System Architecture

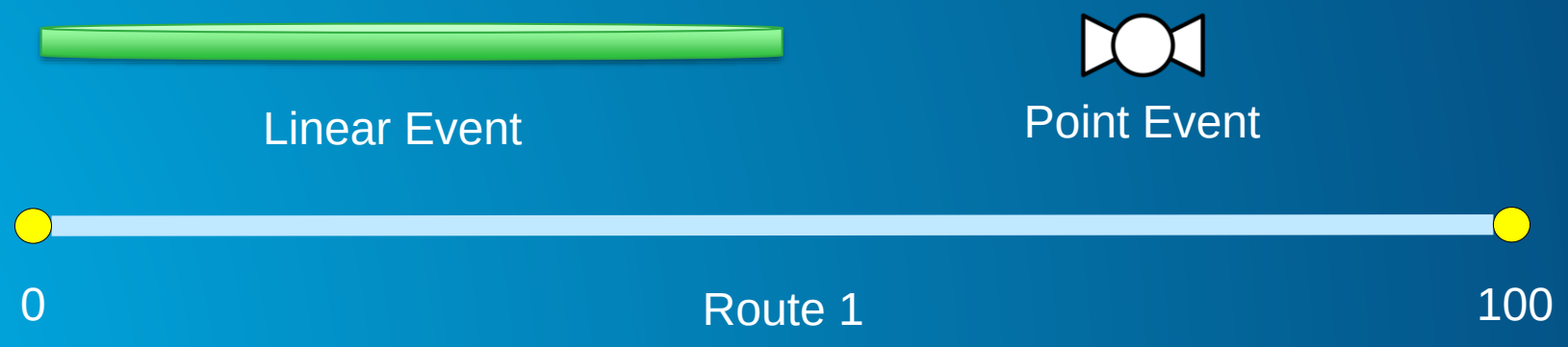


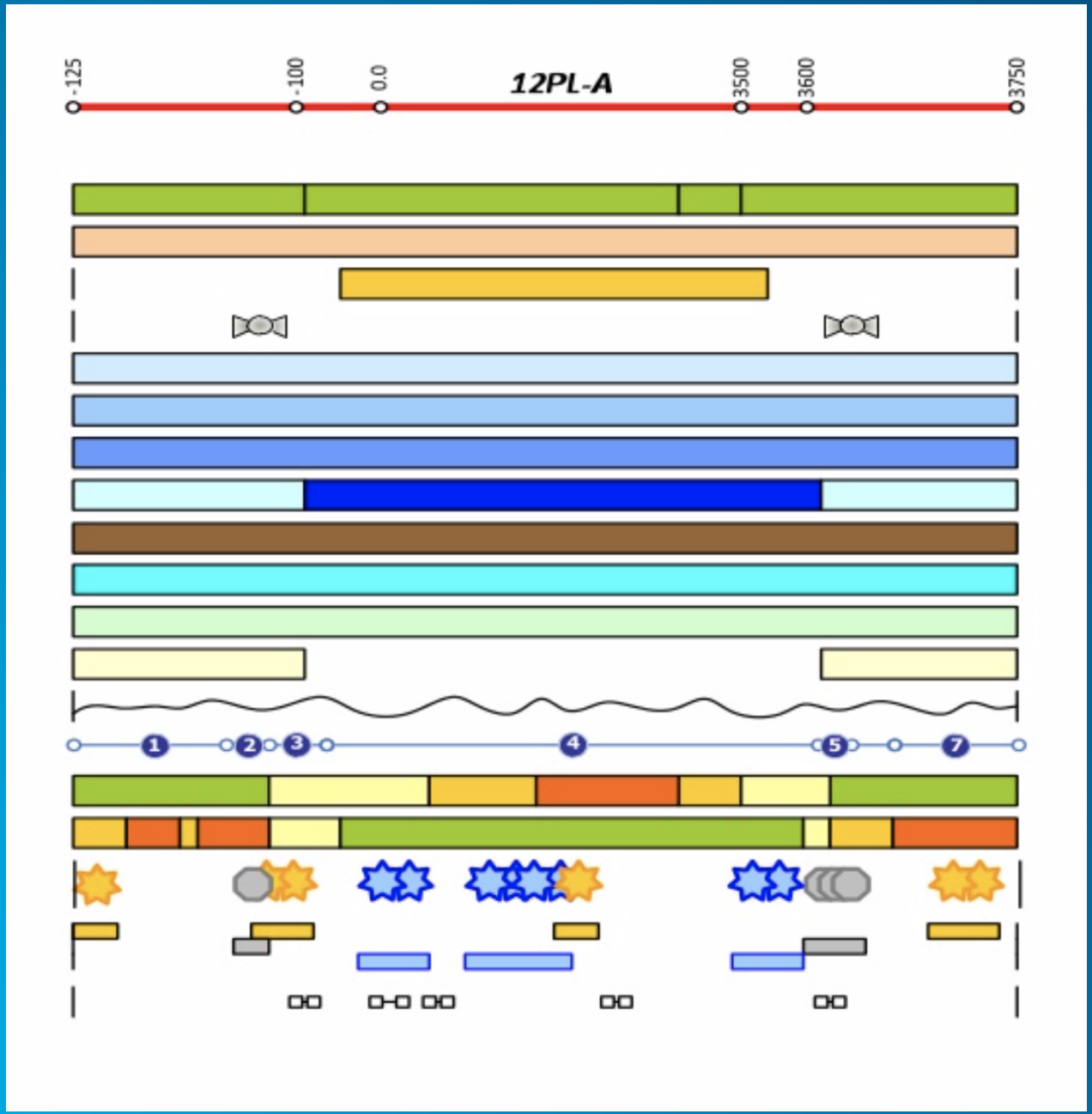
ArcGIS Pipeline Referencing

What is ArcGIS Pipeline Referencing?

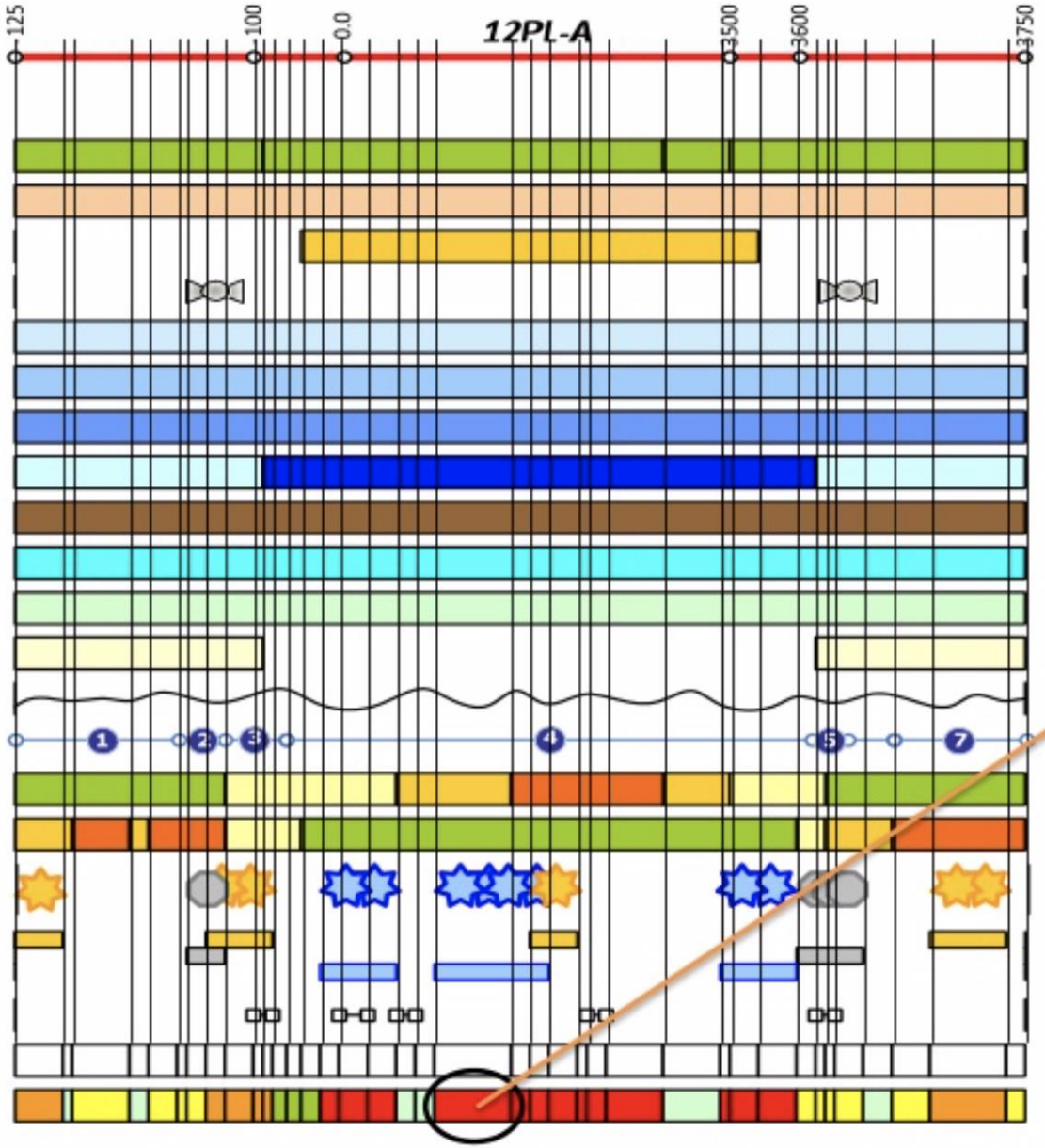
Enables Linear Referencing

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.




-125
-100
0.0
12PL-A
3500
3600
3750
1
2
3
4
5
7

Dynamic Segmentation



Attributes for a single segment

Pipline	12PL-A
BeginMeasure	900
EndMeasure	1400
WallThickness	0.357
OutsideDiameter	12"
Grade	x42000
InstallDate	6/1/1998
SeamType	DSAW
Manufacturer	ACME
PrimaryCoatingType	FBE
PC_InstallDate	1/1/1998
PC_Thickness	15 mils
SecondaryCoatingType	Concrete
SecC_InstallDate	6/1/1998
SecC_Thickness	3"
FlowRate	120
OperatingTemp	120
MAOP	1400 psi
Location	Underwater
LastILIInspectionDate	1/1/2012
ILI_ToolType	MFL
LastHydroTestDate	1/6/2011
HT_Pressure	1600 psi
HT_Duration	16 hours
LastVisualInspectDate	None
LowestCPReading	-0.08 Mv
SegmentType	Seabed
Environment	Fair
IncidentHistory	Good
InternalCorrosion	Yes - High
ExternalCorrsion	None
Dents	None
Spans	None
RelativeRisk	High

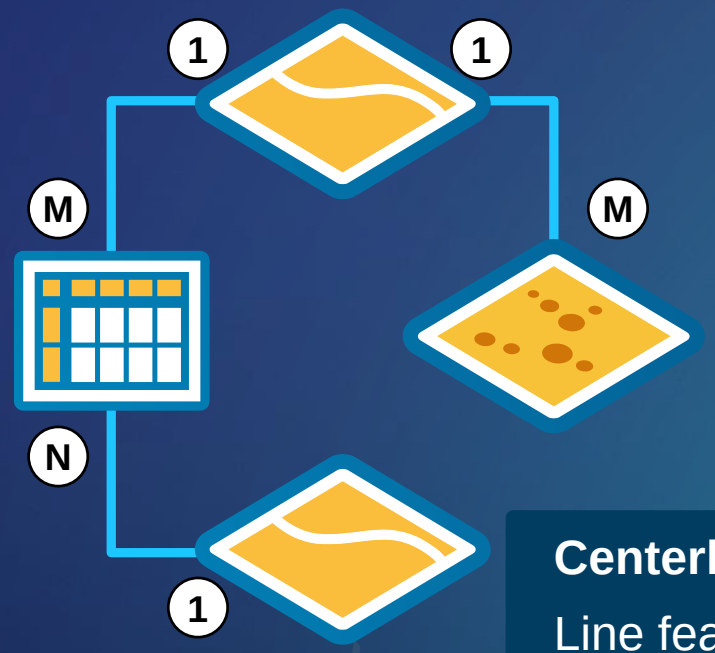
APR Information Model

Schema for route centerline management

Routes *(Network)*

Route features

Separate feature class for each LRM



Centerline Sequence

Key table for M-N relationship between Centerline and Route

Calibration Points

Point feature class that stores route measures

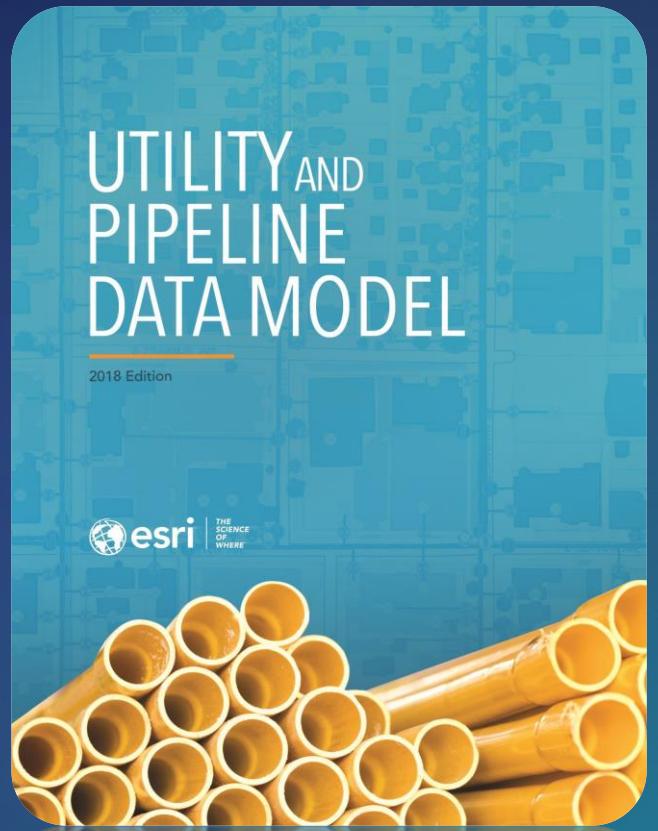
Centerline

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.

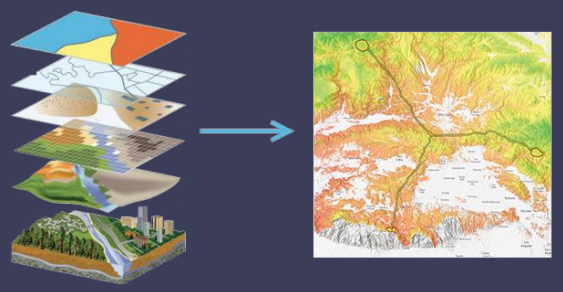


PODS Lite
Next Generation

…making pipeline data more inter operable

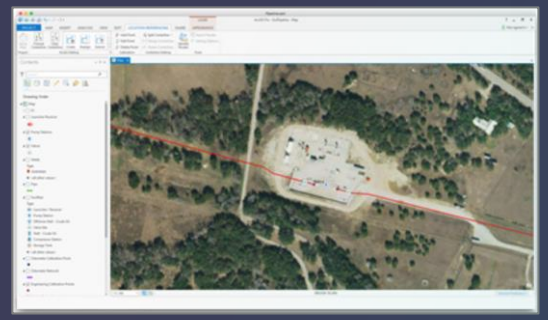
Pipeline Referencing Overview

Information Model



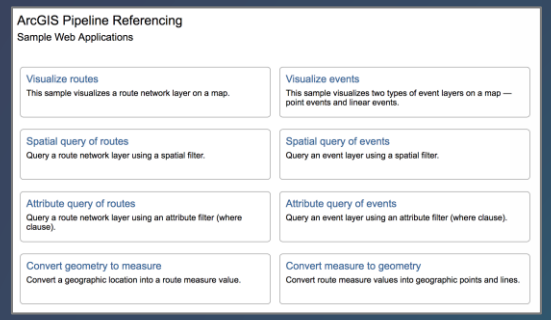
- Network, Routes
- Events

ArcGIS Desktop



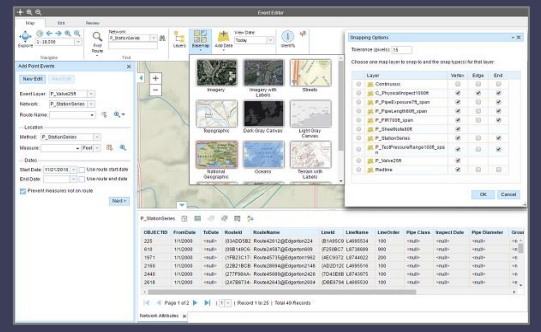
- LRS Network editing
- LRS management tools
- Geoprocessing tools
- Internationalized

ArcGIS Enterprise



- LRS web services
- Developer API samples

Web Application



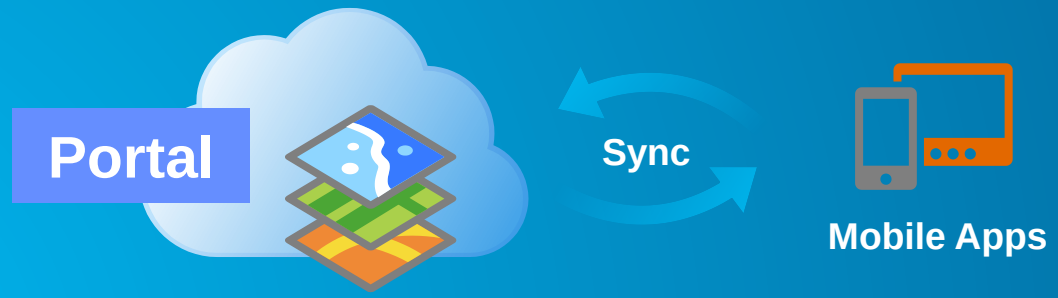
- Event editing
- Event query
- Event QC

Demonstration

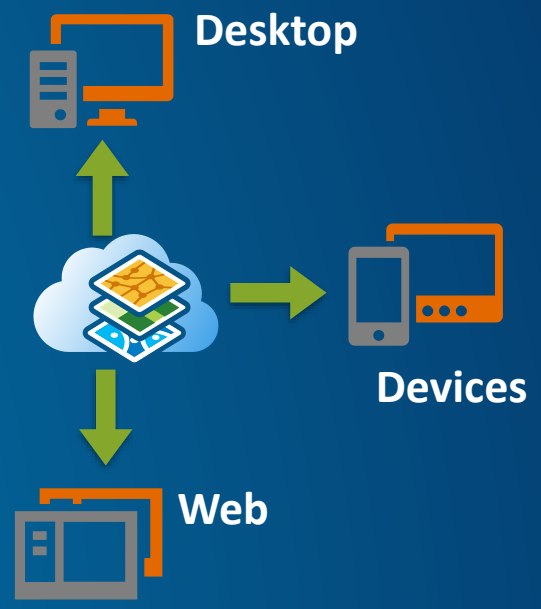
Utility Network

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



Utility Network Asset Package

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

Utility Network Feature Dataset

ServiceArea Polygon feature class

StructureJunction Point feature class

StructureLine Polyline feature class

StructureBoundary Polygon feature class

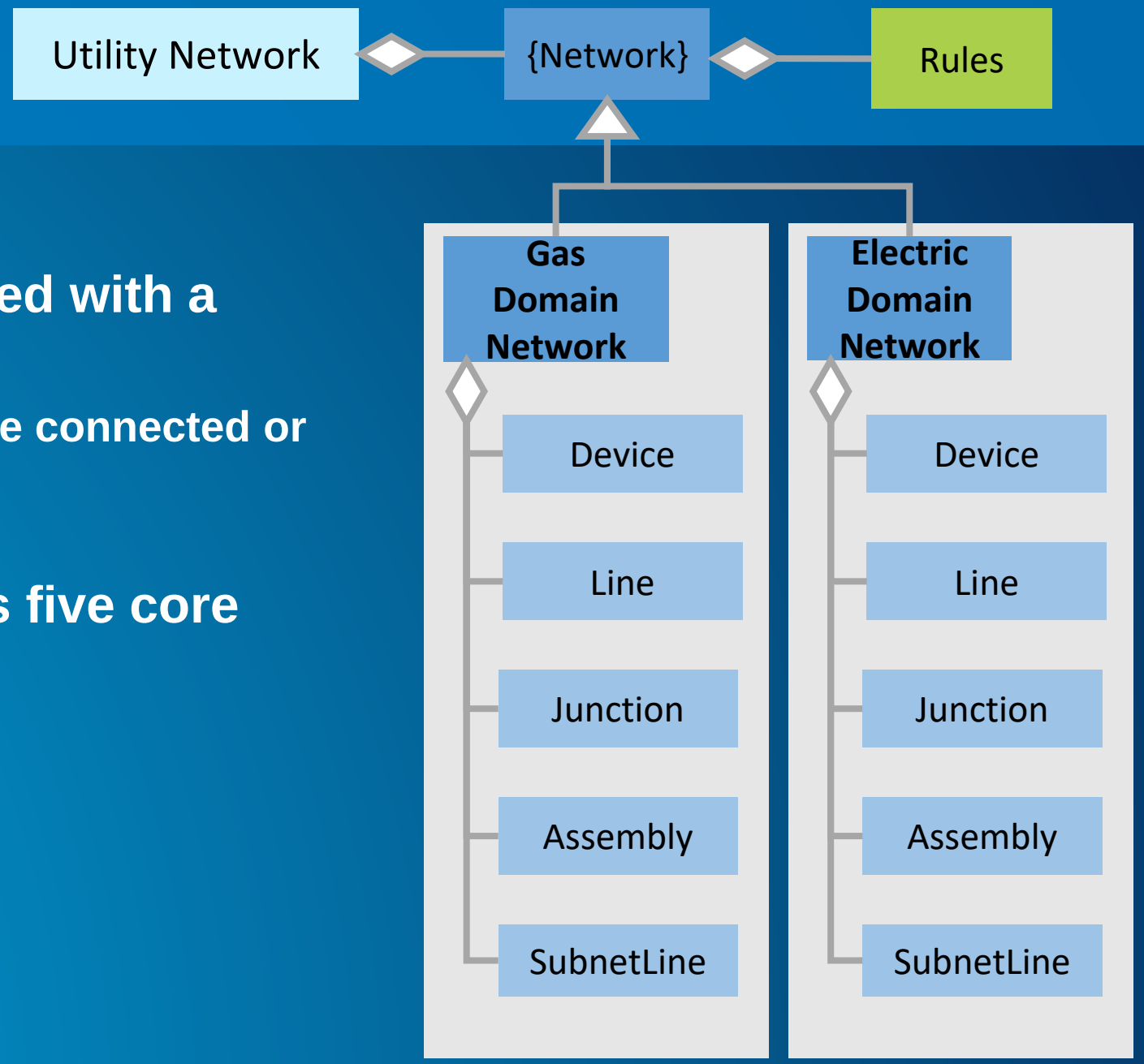
Gas/Liquid Pipeline Domain Network

Electric Domain Network

Water Domain Network

Information Model

- 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



UPDM 2018 Edition

- 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

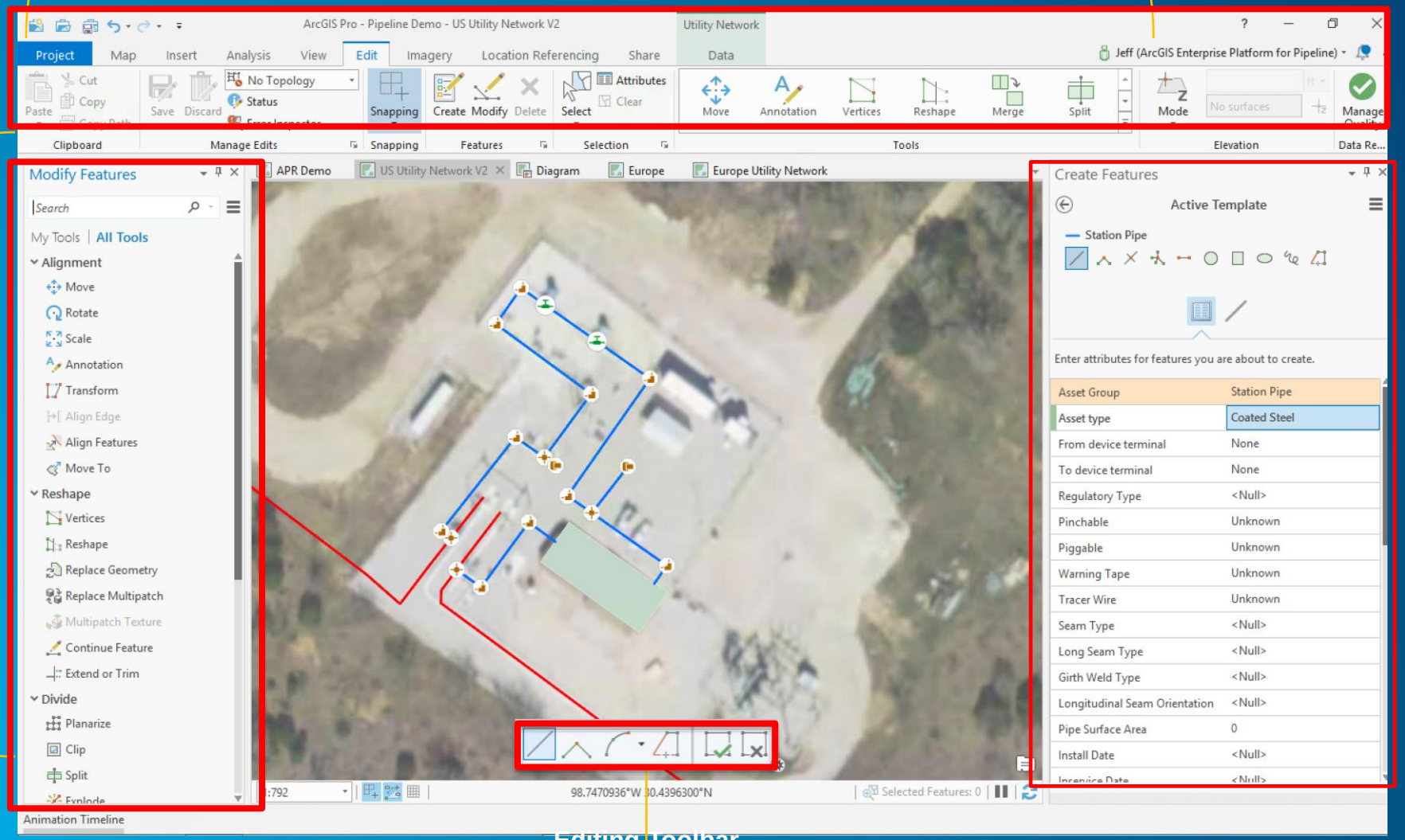
Domain Assets	Integrity	Inspections
Oil & Gas network	Pipeline Referencing	Asset Inspections
Structural network	Inline Inspection Data	Compliance Inspections
Cathodic protection network	Integrity Compliance Data	

Utility and Pipeline Data Model

Utility Network Editing

Editing Templates – Tools

Edit Ribbon Tab



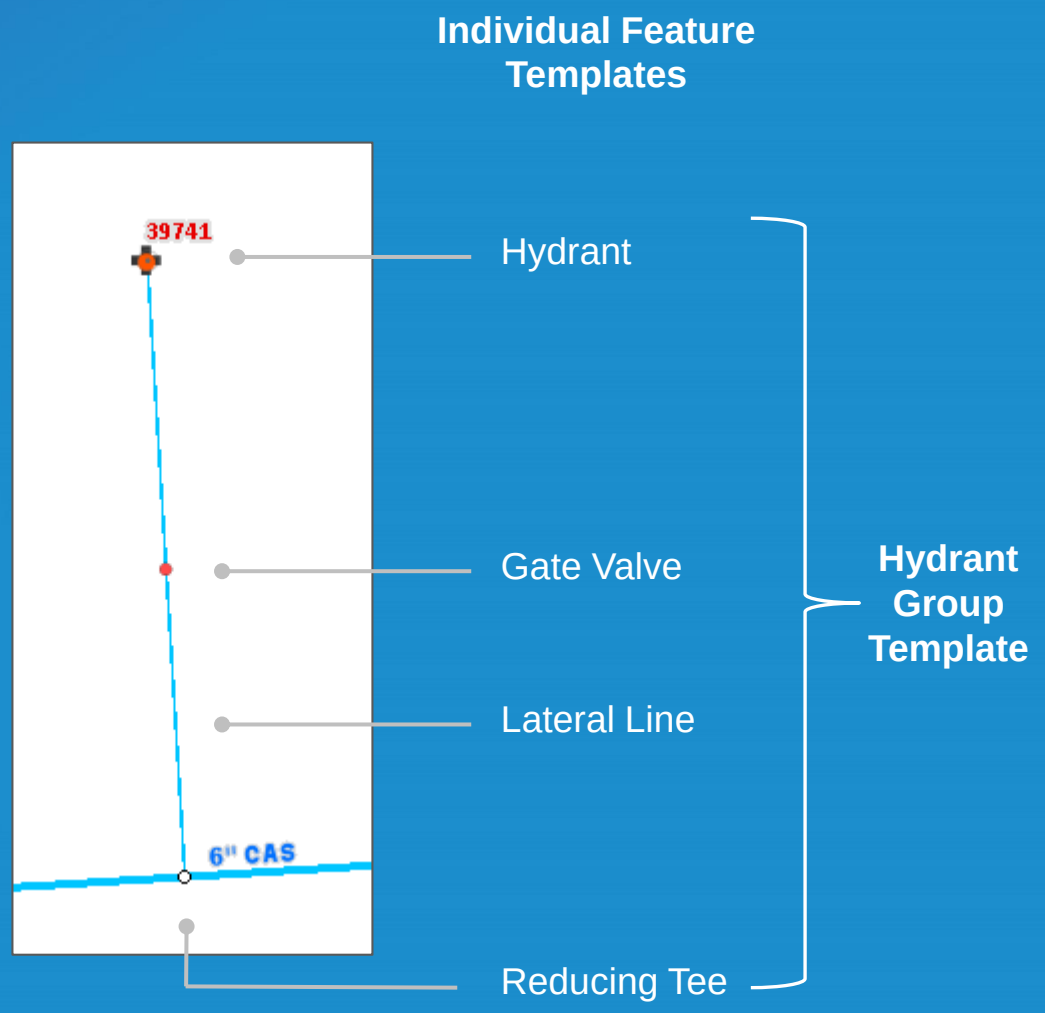
Create Features Pane

Modify Features Pane

Editing Toolbar

Editing Templates: Group Templates

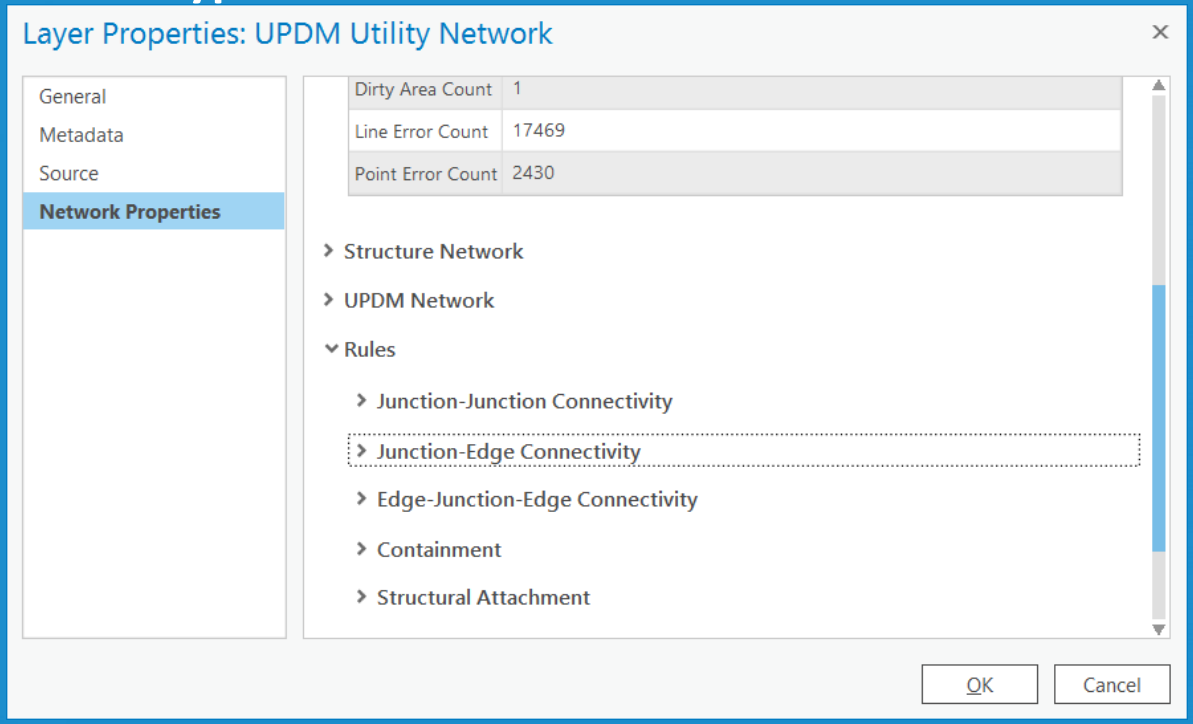
- **Create multiple features with a single sketch**
- **Examples:**
  - Valve Assembly
  - Launcher / Receiver Assembly
- **Options depend on primary template**
  - Polygon – add other polygons, lines, and points
  - Line – add other lines and points
  - Point – add other points (can use line sketch)



Utility Network Rules

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

Sort By ID (default)

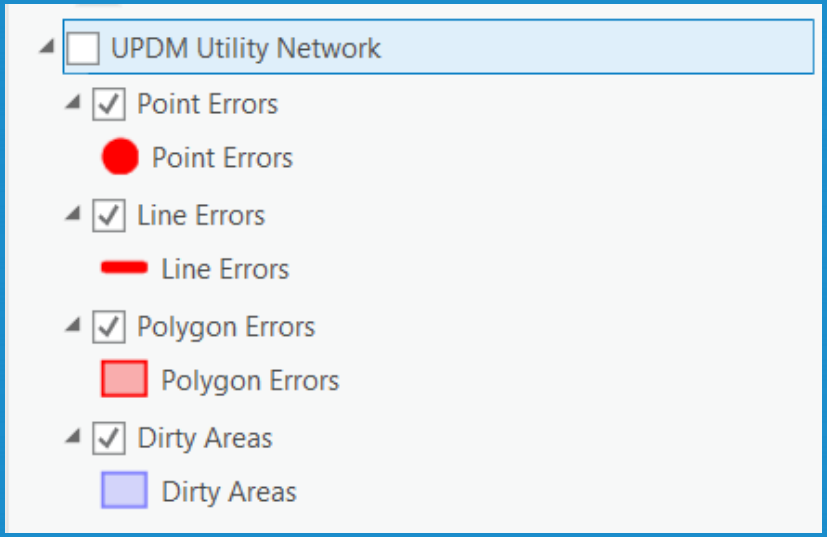
ID	From Class	From Asset Group	From Asset Type	To Class	To Asset Group	To Asset Type	Via Class	Via Asset Group	Via Asset Type	Via Terminal	Created Time
452	UPDMLine	Bare Steel	Distribution	UPDMLine	Ductile Iron	Distribution	UPDMDevice	Scrubber	*	*	2017-10-27 14:10:25
453	UPDMLine	Bare Steel	Distribution	UPDMLine	Ductile Iron	Distribution	UPDMDevice	Short Stop	*	*	2017-10-27 14:10:25
454	UPDMLine	Bare Steel	Distribution	UPDMLine	Ductile Iron	Distribution	UPDMDevice	Strainer	*	*	2017-10-27 14:10:25
455	UPDMLine	Bare Steel	Distribution	UPDMLine	Ductile Iron	Distribution	UPDMDevice	Temp Source Location	Regulator Station	*	2017-10-27 14:10:25
456	UPDMLine	Bare Steel	Distribution	UPDMLine	Ductile Iron	Distribution	UPDMDevice	Valve	*	*	2017-10-27 14:10:25
457	UPDMLine	Bare Steel	Distribution	UPDMLine	Ductile Iron	Distribution	UPDMJunction	Line Heater	*	*	2017-10-27 14:10:25
458	UPDMLine	Bare Steel	Distribution	UPDMLine	Ductile Iron	Transmission	UPDMDevice	Meter	Custody Transfer to Distribution	*	2017-10-27 14:10:25
459	UPDMLine	Bare Steel	Distribution	UPDMLine	Ductile Iron	Transmission	UPDMDevice	Temp Source Location	Town Border Station	*	2017-10-27 14:10:25
460	UPDMLine	Bare Steel	Distribution	UPDMLine	Plastic Other	Distribution	UPDMDevice	Lamp	*	*	2017-10-27 14:10:25
461	UPDMLine	Bare Steel	Distribution	UPDMLine	Plastic Other	Distribution	UPDMDevice	Meter	Utility	*	2017-10-27 14:10:25

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)

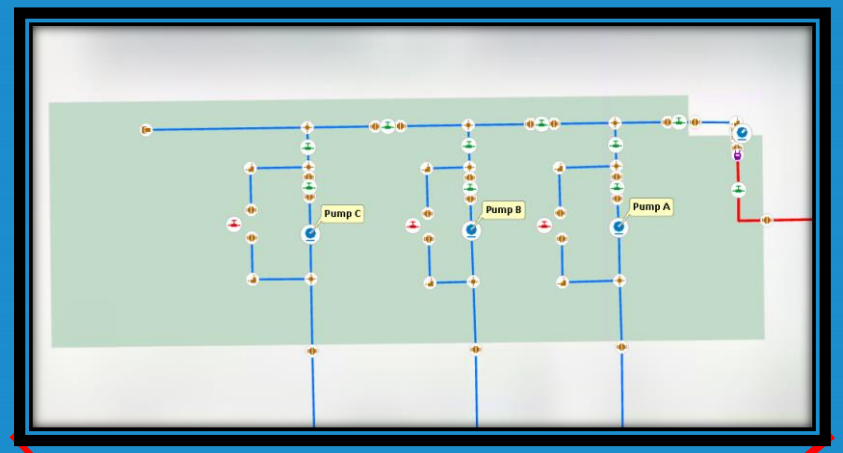


Demonstration

Utility Network Containment

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**

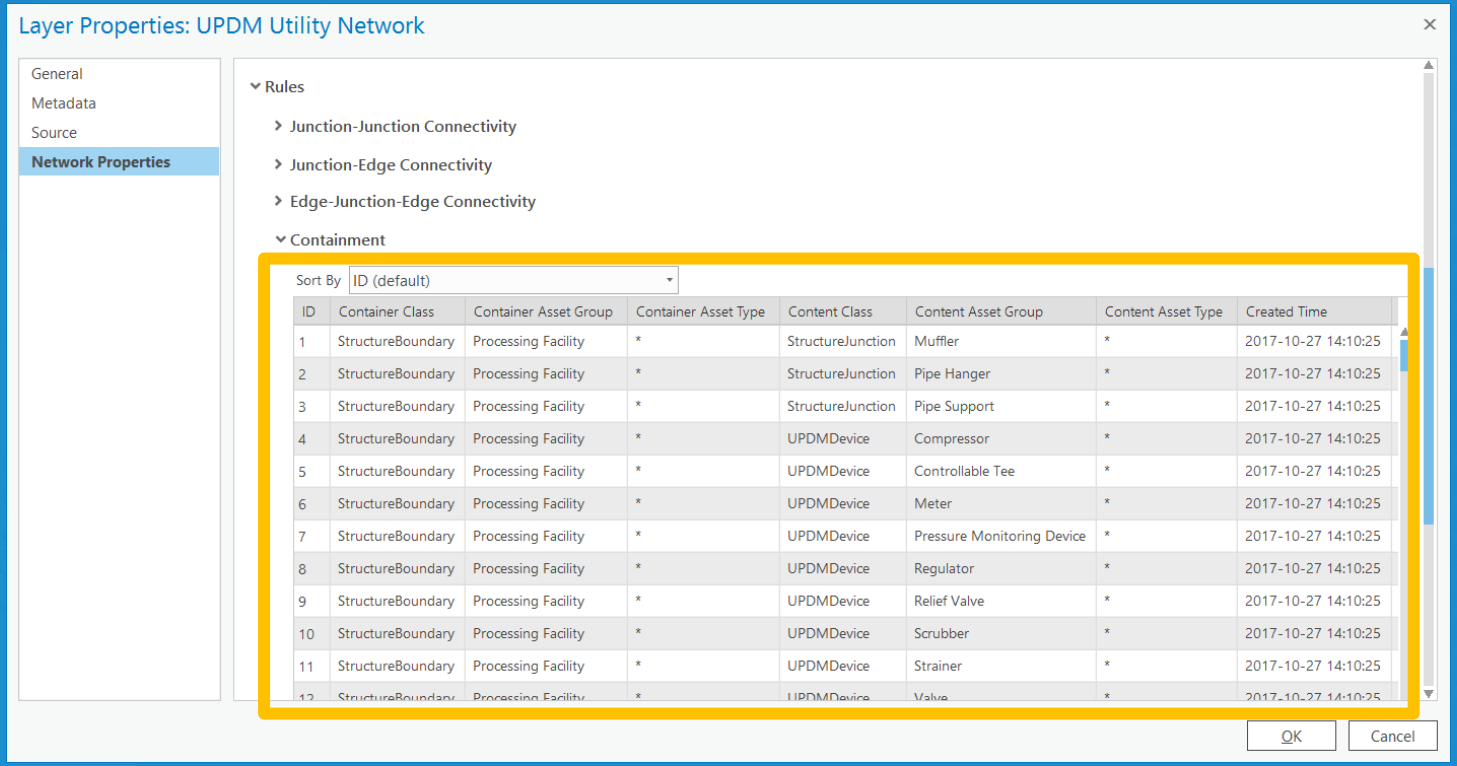


Containment: Associations

- 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



ID	Container Class	Container Asset Group	Container Asset Type	Content Class	Content Asset Group	Content Asset Type	Created Time
1	StructureBoundary	Processing Facility	*	StructureJunction	Muffler	*	2017-10-27 14:10:25
2	StructureBoundary	Processing Facility	*	StructureJunction	Pipe Hanger	*	2017-10-27 14:10:25
3	StructureBoundary	Processing Facility	*	StructureJunction	Pipe Support	*	2017-10-27 14:10:25
4	StructureBoundary	Processing Facility	*	UPDMDevice	Compressor	*	2017-10-27 14:10:25
5	StructureBoundary	Processing Facility	*	UPDMDevice	Controllable Tee	*	2017-10-27 14:10:25
6	StructureBoundary	Processing Facility	*	UPDMDevice	Meter	*	2017-10-27 14:10:25
7	StructureBoundary	Processing Facility	*	UPDMDevice	Pressure Monitoring Device	*	2017-10-27 14:10:25
8	StructureBoundary	Processing Facility	*	UPDMDevice	Regulator	*	2017-10-27 14:10:25
9	StructureBoundary	Processing Facility	*	UPDMDevice	Relief Valve	*	2017-10-27 14:10:25
10	StructureBoundary	Processing Facility	*	UPDMDevice	Scrubber	*	2017-10-27 14:10:25
11	StructureBoundary	Processing Facility	*	UPDMDevice	Strainer	*	2017-10-27 14:10:25
12	StructureBoundary	Processing Facility	*	UPDMDevice	Valve	*	2017-10-27 14:10:25

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)

Terminals: Example Configurations

- **The utility network will support at most eight terminals on a device**

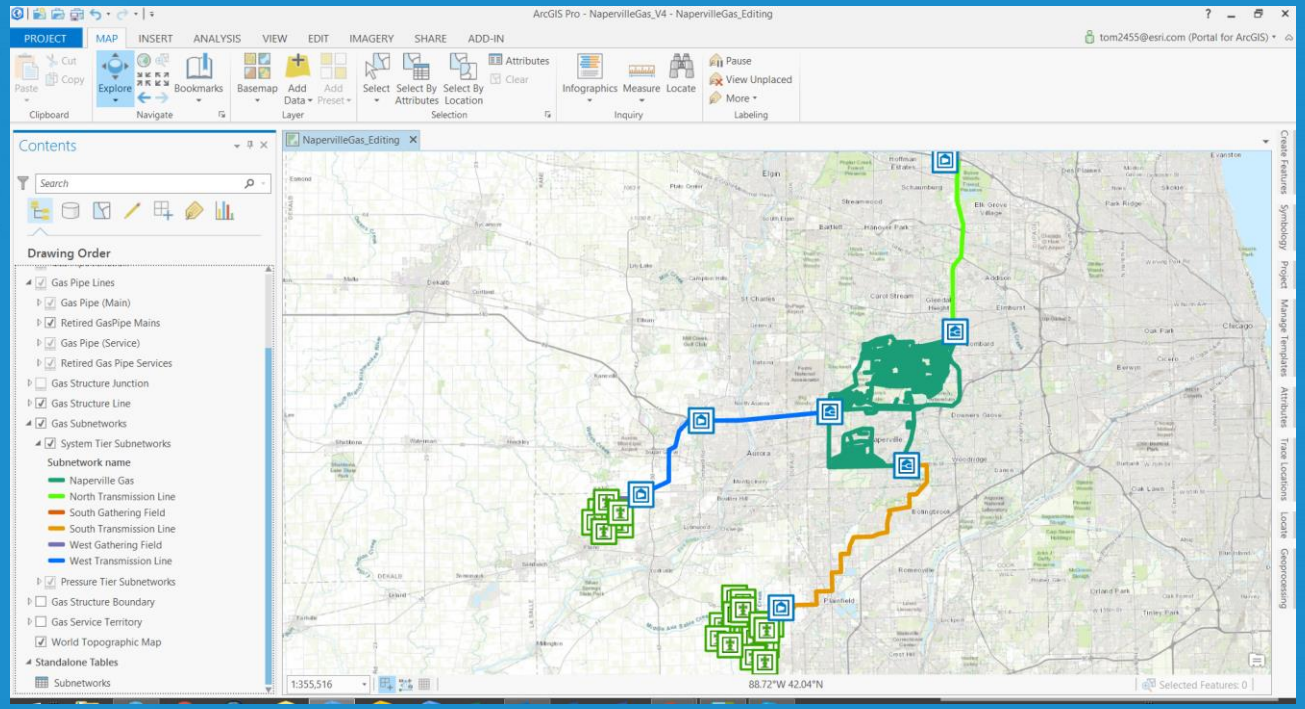
Pressure Reducing Terminal -Regulators -Pressure Reducing Valve -Regulator Station -Town Border Station High pressure Low pressure	Pressure Increasing Terminals -Compressors -Compressor Station Low pressure High Pressure
Generic OneFlow Terminal -Wellhead Source Flange -Wellhead Inflow Outflow	Generic BiFlow terminal Valve-Critical Port One Port Two
CPCurrent -Anodes -Rectifiers Current In Current Out	

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.**

A pressure zone is only as strong as its weakest component

Demonstration

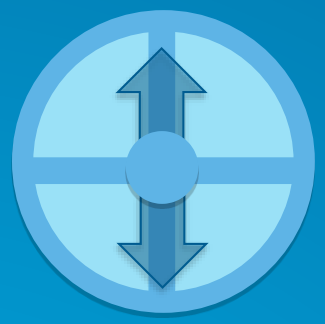
Utility Network Tracing

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

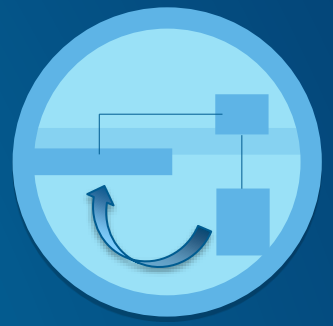
- Gas / Product sources

Isolation Zone

- Primary
- Secondary
- Emergency

Pressure Zones

- Gas / Product pressure

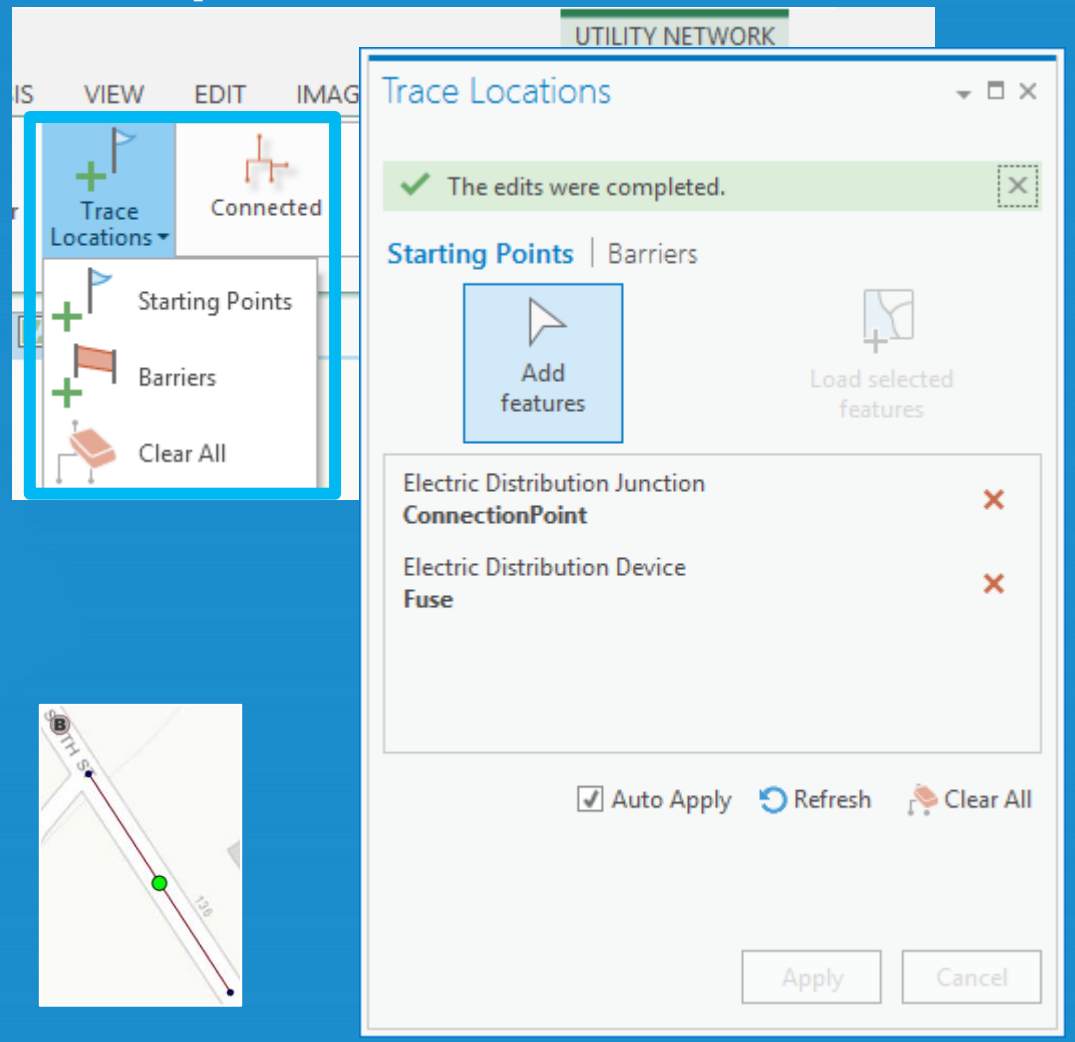


Cathodic Protection

- CP zone
- Find closest CP source
- Find closest CP test point
- Which part(s) is not in a CP zone

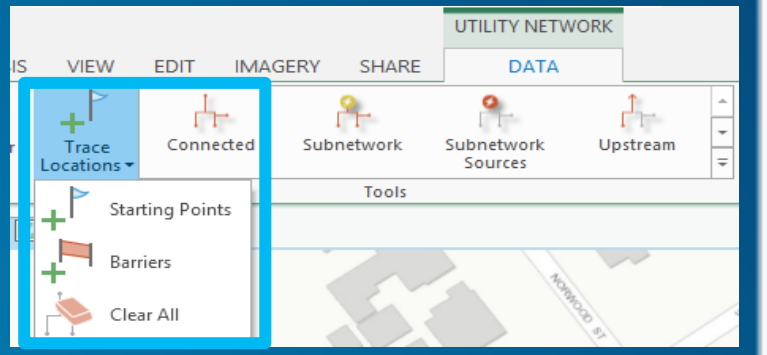
Tracing: Starting Points

- **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**

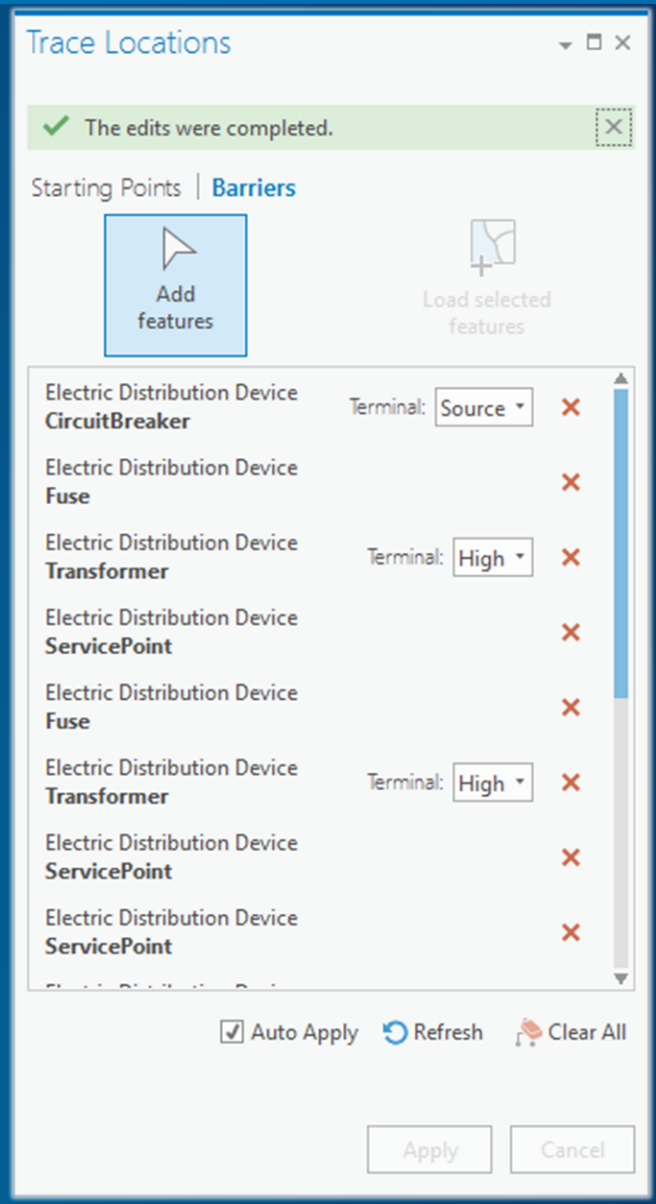


Tracing: Barriers

- **Barriers define locations at which the traversal of a trace should terminate**
  - **Feature on which barrier is placed not included in results**



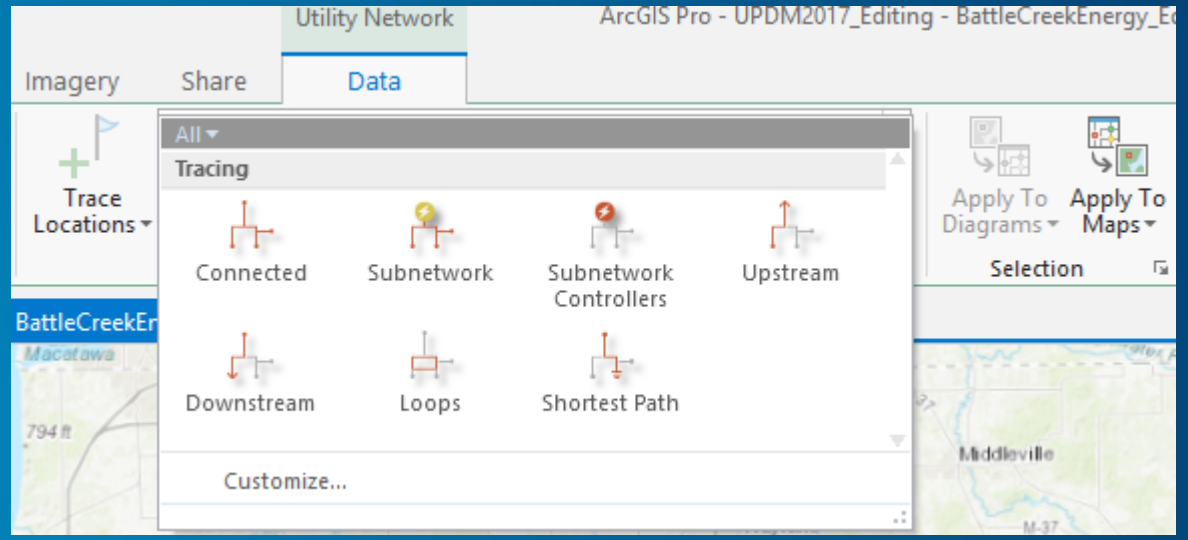
- Starting point
- Barrier
- Connection Point
- Line: Med. Voltage
- Trace Result



  - **May be added or deleted using the Trace Locations pane**
- **Barriers are stored in a feature class in the default project workspace**

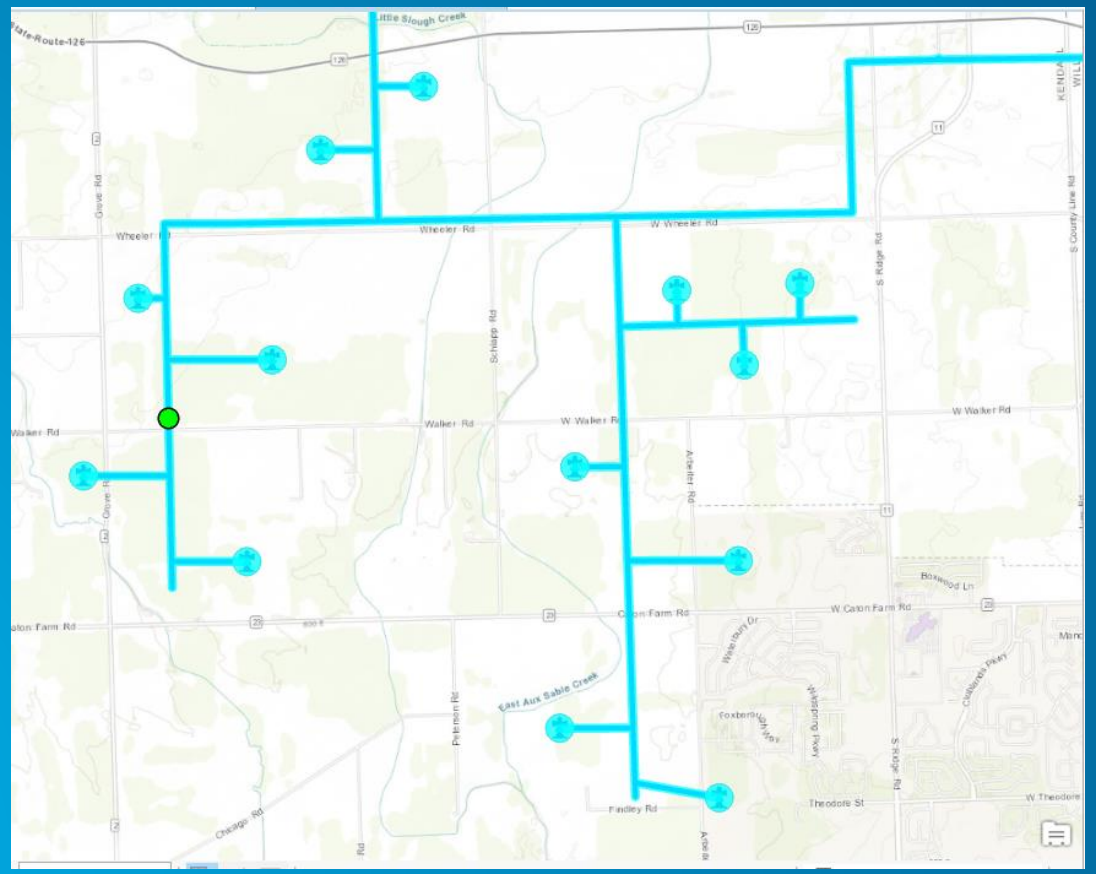
Tracing: Basic Traces

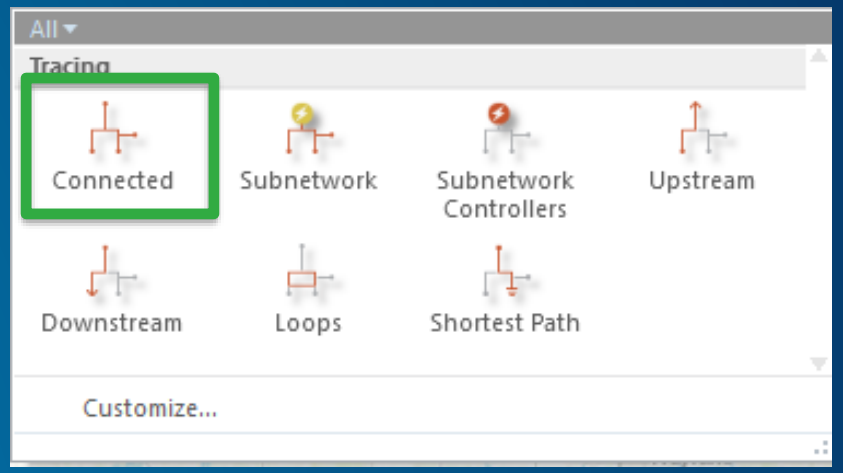
- Connected
- Subnetwork
- Subnetwork Controllers
- Upstream
- Downstream
- Loops
- Shortest Path



Tracing: Connected Trace

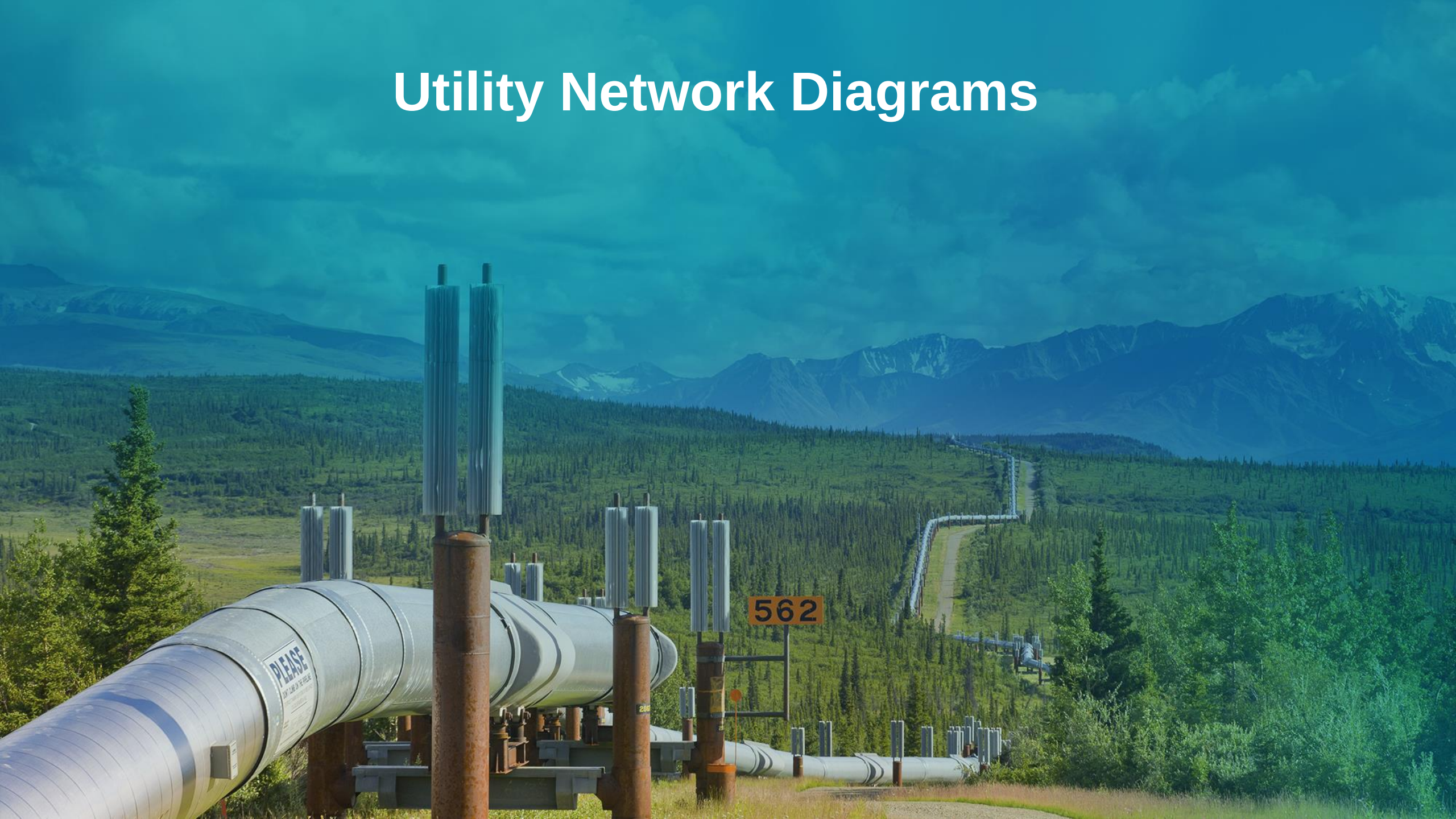
- **Finds all features connected to a given set of starting points**
  - Subnetwork controllers are not required
  - All terminal paths are returned in a terminal device





Demonstration

Utility Network Diagrams

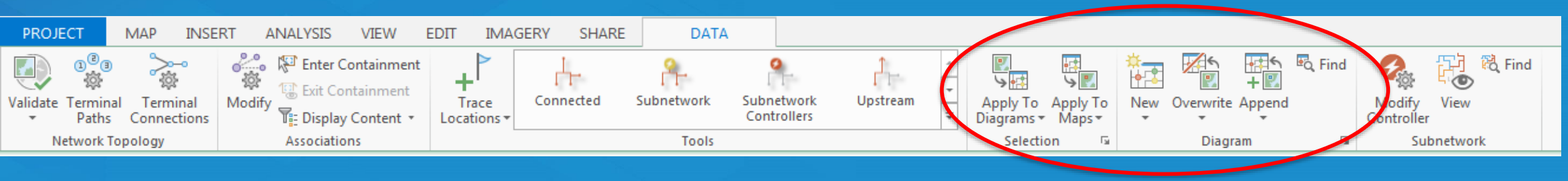


Network Diagrams

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

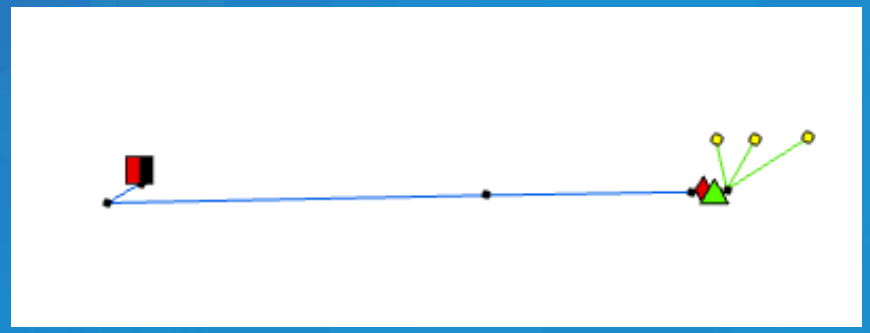
- *NOTE: Although network diagrams are the replacement for Schematic diagrams from the 10.x geometric network world, not all the capabilities from schematics exists in network diagrams. We are currently only supporting data that is in a utility network.



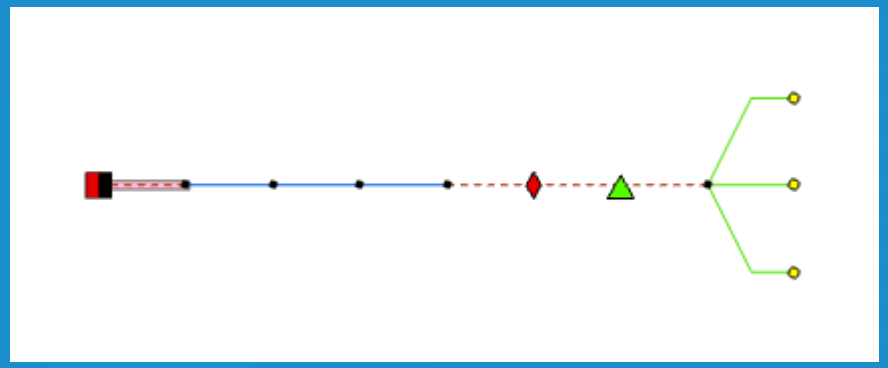
Network Diagrams

- 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

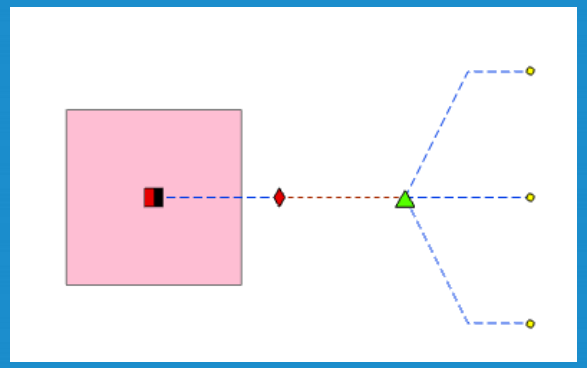
Geo-Schematic



Smart-Tree Layout



Smart-Tree + junction reduction



Demonstration

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Understanding our world.