Blog Series

The Gas Utility Network Management Extension

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About this ebook

The ArcGIS Utility Network Management extension provides new data management features and functionality for multiple industries. The series of blogs in this ebook present a selection of those new features and functionality in a gas utility context.

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Your angel is in the detail

Gas network complex facilities can be more fully defined in the utility network

What if it is really greater goodness that is to be found in having the details of your complex gas network components consolidated in one system of record along with other network data? Think about the improvements to efficiency and productivity that can result when you have all needed data organized in one place and included in your network models. Yes, it's your angel that we believe lies ahead in the consolidated details. That angel can help you more fully realize the benefits available to you by unlocking the potential of the ArcGIS platform.

Bringing data from disparate sources together on a common geographic basis for visualization and analysis is one of the hallmarks of the Web GIS pattern exemplified by the capabilities of the ArcGIS platform. Increasingly, though, while this advance means that they do not have to, many gas utilities are looking to move a broader range of data now stored elsewhere into today's modern ArcGIS platform.

Historically, data has been siloed in different systems for many reasons. In the case of detailed data needed to define complex gas components, one of those is that GIS did not provide the functionality needed to define and store that detailed data. That is changing now. This has many benefits for gas utilities. Among those are making it easier to see a holistic view of the network in whatever level of detail is desired and to analyze it, and facilitating interoperation with other application software that rely upon a published definition of the detailed network. At the same time, it reduces the total cost of ownership by consolidating into one system of record what previously was in multiple systems. In a sense, this advance brings GIS closer to operating just as you operate.

That brings us to the utility network. One of the utility network capabilities getting the most buzz is the capability to more fully define and manage, in real geographic space, the design and operational details of complex gas components, such as regulator stations and compressor stations. The utility network opens up new capabilities in leveraging these details to better understand and operate your gas system

Rest easy

Before we explore this new capability, let us quickly emphasize that the capability to more fully define complex components does not mean that you ever must! So, rest easy. The choice is yours as to whether you elect to take advantage of the new capability and, if you do, when and to what extent. Moreover, if you do elect to add more detail, you can do it incrementally if you wish, rather than in one big project.

Before now

Before the release of the utility network, complex gas components typically were represented in ArcGIS as a point feature. Historically, CAD software often has been used to create precision drawings of gas network complex components. With CAD, what you see is basically what you get – just a picture, not usable data. ArcGIS delivers much more. You still can see the same thing, but what you see is just a representation of the data behind it which you can use in many powerful ways. Now instead of looking at a picture of the internals of a gas facility you can interact and ask questions of the gas facility details. What kind of questions might you be asking of the details? In an emergency operation instead of an isolation trace stopping at the simple representation of a gas facility such as a regulator station, it can now identify the specific critical valves within the facility which need to be closed. If a recall is issued for a specific manufacturer device or fitting, and that device or fitting was installed within a gas facility, those gas facility components can now be identified and reported. Answering these types of questions is not possible when the gas facility internals are just a picture.

How much detail

We increasingly are asked how detailed should the definition in ArcGIS be of a gas network?

There is no one answer to that question. With the ArcGIS platform increasingly supporting the mapping and spatial analytics needs of a growing number of users in a broader range of gas utility functional areas and roles, the answer to that question is evolving.

Here is one way to look at it. The answer to what needs to go into your geodatabase largely depends on what you want to get out of it. That is because each software application has its own specific data requirements. If you want your geodatabase to support one application, then only that application's data requirements need to be accommodated. If you want your geodatabase to support two applications, then the data requirements of both need to be accommodated. And, so on. While some applications share data requirements, generally as the number of applications to be supported increases, so, too, does the breadth and depth of data requirements. The key to your answer lies in understanding the number of applications to be supported and their combined data requirements.

Remember the title of this blog, “Your Angel Is In The Details?” As a rule, erring on the side of more detail is a good thing. It is easier to simplify a more detailed definition than it is to add detail to less detailed one.

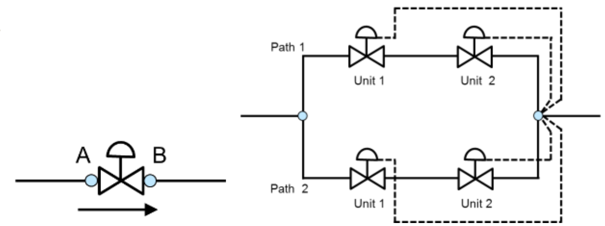
An example

One of the functional areas now more fully exploiting ArcGIS capabilities is gas operations.

Analytics for gas operations often require more granular data than analytics for other functional areas.

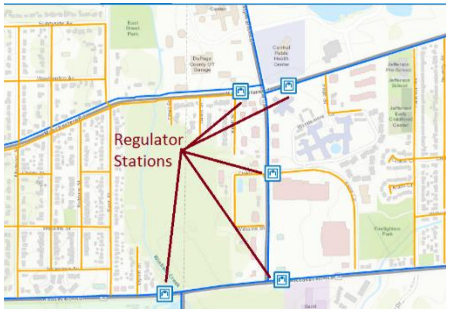
Let’s consider regulator stations. Gas networks typically include multiple subnetworks, each operating at up to a different maximum pressure, with pipe sizes and maximum pressures reducing the closer gas gets to delivery points. Regulators control the safe reduction of pressure or flow from a higher pressure subnetwork to a lower one. A regulator station can be simple, with a single regulator on a single path. Or it can very complex, with multiple regulators and other devices on multiple paths. It also likely contains safety devices. These safety devices may include additional regulators, relief valves, and remote monitoring equipment.

In ArcGIS, a regulator station traditionally has been defined as a point feature. In reality, a regulator station is a complex facility. Now, in the utility network you can define those design and operational details.



Technical discussion

Since gas systems were originally mapped in a GIS several decades ago, GIS professionals have struggled to get the balance right between needed detail and desired cartography. One example of this struggle is the need to manage geographically condensed features like those contained within a gas facility. These details can create very cluttered and hard-to-understand map displays.

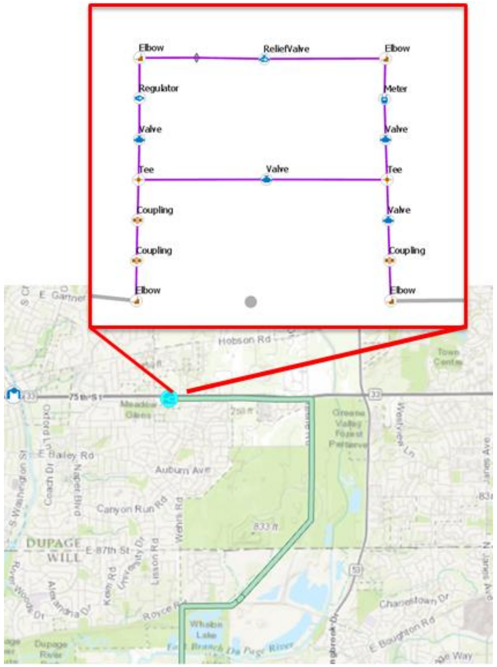


As already stated, these details need to be more than just a picture. They need to be asset records. These asset records need to be spatially reportable so gas companies know where gas devices and fittings are located. Then, add to these gas facility data management requirements the gas operations requirement that these gas facility details be traceable. This is to aid gas ops staff during emergency operations to not only know that a valve in a gas facility needs to be closed, but to identify which critical valve(s) in the gas facility need to be closed. The solution to these problems is the new Utility Network and its container capability.

So what is a container?

A container is an association between the individual features representing the assets internal to a gas facility with the single point feature representation of the gas facility.

Once the container association has been established, the contained assets are hidden from the standard map display. Similar to the legacy picture representation, users are able to click on the simple gas facility representation and see the internals of the gas facility in a separate map window.



What reporting can I do?

The assets contained within a container are geospatial features stored in geodatabase featureclasses. Standard database reporting tools, whether ArcGIS-based or Business Intelligence-based can be used to query, summarize and report these on features. But, what about spatially querying these featureclasses with a standard ArcGIS tool like “Select Features by Location”? This is an additional type of supported reporting, because the utility network provides the ability to precisely place the internal assets at their true geographic location within the gas facility. This is a key point, so let me repeat. Internal assets are placed at their true geographic location!

Can I trace these gas facility assets?

With the utility network, all container contained assets participate in the overall pipe system’s network topology. This means, for instance, that during a gas emergency operation, an isolation trace task can be performed to identify the critical valves within the gas facility which need to be closed for the emergency. This improvement in modeling complex gas facilities additionally provides a better understanding of cathodic protection areas, pressure zones, and system zones.

The ArcGIS Utility Network Management extension container capabilities provides a solution to the gas industry’s growing needs for better management of the details of gas facilities. This ability to manage gas facility internal assets as features instead of pictures, allows gas organizations to provide clear and concise maps, without sacrificing the ability to model individual assets.

Containers provide the angel that gas organizations have been looking for to solve the problem of managing a gas facilities details.

Hierarchies

Organizing your gas network for understanding, visualization, and agility

Moving beyond the traditional hierarchical structure to "where" the industry needs to be

Around the dawn of a new century 118 years ago, the gas industry evolved to a new stage of development. Up to that time, gas networks typically were relatively small, located close to where the manufactured gas was produced, and low pressure. The advent of high pressure distribution systems around 1900 signaled the start of the multi-pressure level gas system era. With this new era came a greater number of valves and regulators, and greater engineering, operational, and business complexity. The era of greater gas system complexity began. System complexity has been steadily growing through the ensuing years, with today's gas networks being substantially bigger, more complex, and more geographically widespread than ever. All indications are that these trends will continue in the years ahead.

Today, answering questions about the asset components of your gas system, their characteristics, and how they operate often requires you to think about your network in different ways.

On the one hand, there is the issue of scope. Depending upon the question, you may need to think about all of your network. Or, perhaps answering the question only requires you to deal with part of it.

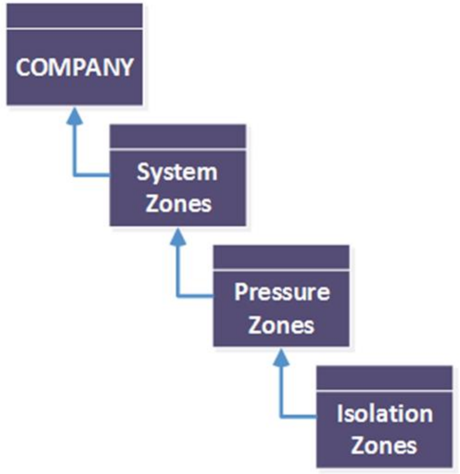
Which part? That may simply be an issue of geography. For instance, "Let's look at assets in this political jurisdiction." Or, it may be an issue of network connectivity or structure. An example of this is "Show me all the network components in this isolation zone."

And, today's question may not be the same as tomorrow's. This makes the ability to easily define new subnetworks and combine different parts for a new purpose essential to business agility.

Traditional network hierarchy

Let's look at long-standing gas industry practice.

Gas networks typically include multiple subnetworks, each operating at up to a different maximum pressure, with pipe sizes and maximum pressures reducing the closer gas gets to delivery points. For years, this led the gas industry to organize network data in a hierarchical tabular structure, where each successively lower subnetwork is subordinate to that above it. Traditionally, this has been a series of tables organized into a parent-child relationship. A typical table organization might look like the following:

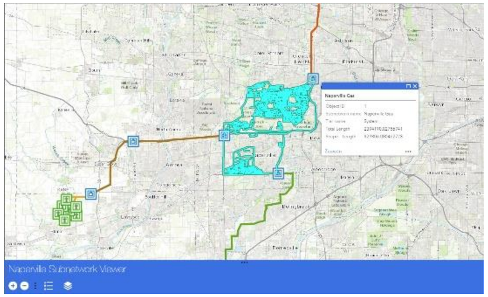


This common hierarchy has served the gas community well over the last several decades. But restricting this organization of the gas system to a tabular structure fails to address the common question of where these zones exist.

The GIS gas community has long been the masters of understanding “where”, but has long struggled with how to visualize an entire gas pipe system without having to wait an unacceptable length of time for the map to draw on the computer screen. This was a minimal issue when most end users viewed the GIS managed gas system via paper maps. But as more gas organizations have deployed web and mobile applications with interactive gas system maps, this issue has increased in priority.

So what is a gas company to do

Turns out the solution to both of these common gas community issues is the new utility network’s subnetwork. This new capability deploys a similar hierarchy structure on top of the gas pipe system as has been traditionally used. But, since the utility network is a part of the ArcGIS Platform these traditional tables are geospatially enabled into polyline features.

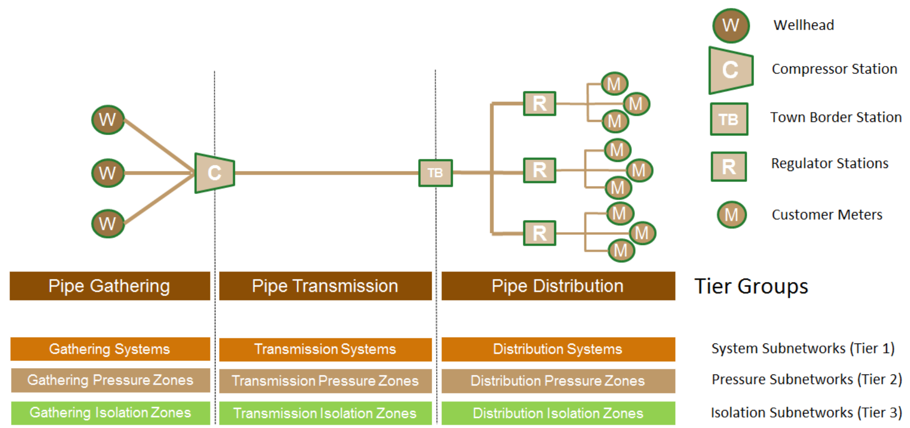


I can see it

The utility network subnetwork capability aggregates the many individual pipe segments into a single multi-part polyline feature which is then stored as a single record in the Subnetline feature class. Similar to the traditional table management structure each subnetline feature class record represents and describes a single system, pressure, or isolation zone. These large but few features can be fetched from the database and drawn very rapidly on the computer screen. With utility network subnetworks’ users of the ArcGIS platform can now see where their hierarchy zones are located and can do so with an interactive map which displays the entire gas system very rapidly.

How are gas Subnetworks organized?

The gas pipe system subnetworks are organized by tier groups and tiers. Each tier group can have its own unique tier hierarchy. There is no practical limit to the number of tiers within a tier group. The default hierarchy included with the UPDM 2017 edition data model divides the wellhead to customer meter gas system into three tier groups. Those tier groups are named: Gathering, Transmission, and Distribution. Each of these tier groups has been given the same tier hierarchy. That tier hierarchy is; System, Pressure, and Isolation. Each tier within each tier group has a unique definition to accurately model the subnetworks.



Do I have to manually maintain these Subnetworks?

The utility network automates the management of the individual subnetwork features within these tiers and tier groups. Mappers responsible for the maintenance of the as-built representation of the gas pipe system simply need to run a single Geoprocessing tool called “Update Subnetwork” to update the subnetworks with changes made to the gas pipe system. Since this is a geoprocessing tool, this update process can easily be incorporated into a nightly batch job further automating the management of subnetworks.

What else can I do with these Subnetworks?

The traditional hierarchy tables used in the past, often had basic attributes such as zone name and some summary attributes such as operating pressure. In the legacy systems these were manually maintained descriptors of the different zones. In the utility network Subnetwork, these summary attributes are maintained by the ArcGIS platform and automatically recalculated every time the "Update Subnetwork" geoprocessing tool is run.

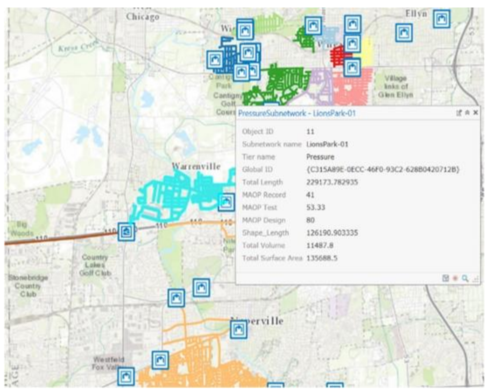
Default summary attributes are included in the UPDM 2017 edition data model. Here is a listing of the default summary attributes for the gas pipe system tiers.

Subnetwork Tier	Summary Attribute	Summary Definition
System	TOTALLENGTH	Sum Shape_Length for all zone pipe segments
System	PIPEVOLUME	Sum PIPEVOLUME for all zone pipe segments
Pressure	TOTALLENGTH	Sum Shape_Length for all zone pipe segments
Pressure	PIPEVOLUME	Sum PIPEVOLUME for all pipe zone segments
Pressure	MAOPDESIGN	Find minimum MAOPDESIGN of all zone assets
Pressure	MAOPTEST	Find minimum MAOPTEST of all zone assets
Pressure	MAOPRECORD	Find minimum MAOPRECORD of all zone assets
Isolation	TOTALLENGTH	Sum Shape_Length for all zone pipe segments
Isolation	NUMBERVALVES	Count Devices of AssetType = Critical Valves
Isolation	NUMBERMETERS	Count Devices of AssetType = Customer Meters
Isolation	PIPEVOLUME	Sum PIPEVOLUME for all zone pipe segments

The geospatial enablement of the traditional hierarchy tables adds a new dimension to the understanding of the zones by addressing the question of where are these zones are located. The aggregation of the zones pipe segments into these geospatially enabled zones also solves the issue of being able to visualize the entire gas pipe system on the map display with the redraw performance that users have come to expect from the ArcGIS platform. The utility network Subnetwork capability resolves two long standing gas community issues by combining the organization and visualization of the gas hierarchy into a set of ArcGIS platform managed features.

Subnetworks

And the answer is…



Using subnetworks for on-demand summarization of information about all or a selected part of your gas system

Regulatory and business stakeholders have been asking summary information questions of gas utility professionals about their systems from the beginning of the gas industry. Some of these questions are cyclical, such as those required to be answered in annual or periodic report filings. Others are ad hoc, asked at various times in response to business challenges or opportunities.

Even in earlier times of smaller and simpler systems, providing complete and accurate answers often was not easy. In speaking today with industry colleagues about data issues, I often think back to William Puryear's comment about the evolution of mapping within the gas engineering department at what now is Baltimore Gas and Electric, America's first gas utility:

"When the territory served and the mileage of mains was so small that the locations and sizes of all mains were matters of common knowledge, the necessity for accurate and accessible records was probably not apparent, and the result was that for many years no adequate records were kept. Even after records were started, they were for a long time merely written descriptions of the work done, and in many cases it was considered sufficient to say that a main of a given size was laid on one side or the other of a certain street in some direction from a given point. In fact, the side of the street on which the main was laid was not always given." He goes on to. describe how they evolved over many years a manual mapping system from there.

Let's consider four points.

One, it is safe to say that quality and consistency of early records, if they were made, varied greatly. There were no real industry standards, and each utility tailored whatever record system they had to their individual preferences.

Two, gas system summary information is dynamic, not static. When a change is made to the gas system, summary information about the part of the gas system in which the change was made changes too.

Three, today's gas systems in many cases are rollups of multiple predecessor gas systems combined through mergers and acquisitions. As gas utilities grew in this manner over time, records did or didn't get passed along and unified.

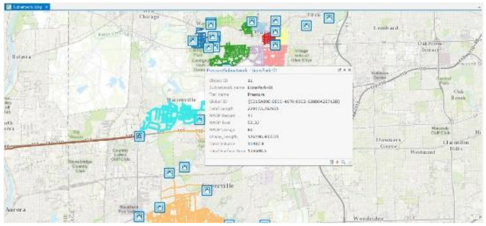
Four, answering summary information questions has long been a manual task. For instance, information such as the pipe volume of a single pressure or isolation zone has been a manual calculation known mainly to the engineers and system control staff. Keeping this information current has been problematic, since it changes every time a construction project is completed for the affected zone. This information historically has not been automatically maintained. Therefore, most engineers have been hesitant to share this information with the rest of the organization out of concern that others will make decisions on potentially out of date information.

In short, gas organizations have a long history of struggling to manage, share and maintain summary information about their gas system. It remains a struggle today. While recordkeeping systems have advanced substantially, legacy data issues persist, and contemporary data issues continue to arise. Networks are larger and more complex. Questions are asked more frequently and are expected to be answered more quickly. The demand by regulatory and business stakeholders on a quicker and more frequent basis for summary information about all or a part of a gas system poses an increasingly steep challenge for gas industry professionals.

In this context, the need for an automated solution to answering summary information questions about dynamically changing gas systems is apparent, and now a solution is here in the form of the subnetworks capability of the utility network. And the answer is…

Technical Discussion

To address this need, the new utility network for gas by Esri provides the ability to configure an automated summarization of gas system information as part of its subnetwork capabilities. For end users such as Cathodic Protection department staff, this means they can now view a CP area's total metallic pipe surface area to aide in determining the correct amperage to set a rectifier too. It also means that system controllers can easily see the total pipe volume of a pressure zone. This will help them in determining how much additional gas can be packed into the pressure zone pipes in preparation for a surge in usage demand such as when a strong winter cold front is about to traverse across the service territory.



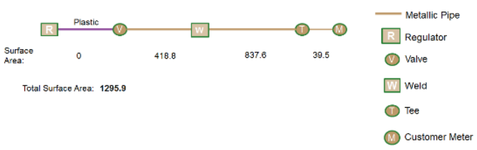
Summarizing for a Subnetwork

Each subnetwork tier can have its own unique set of summary attributes. Summary attributes are user defined fields added to the subnetline feature class to store the desired summarizations. The summarization is limited to only those utility network device, junction, or line feature class features which have been associated to the specific subnetwork feature.

A single summary attribute field can have a different summarization for each unique tier. You can add as many summary attributes to the subnetline feature class as the underlying enterprise geodatabase relational database (i.e. Oracle, SQL Server, PostgreSQL, etc) can support.

What are summary attributes

Summary attributes are user defined fields added to the subnetline. What makes these fields special is that a summarization method has been defined for this field for a specific tier. To understand what this means, let's take a look at how one would summarize the total surface area of only the metallic pipe for a cathodic protection area subnetwork



The first step is to use the geoprocessing tool, Add Field to add the attribute TOTALSURFACEAREA to the subnetline feature class. This summary attribute must be of a data type of short integer, long integer, double, or date.

The second step is to use the geoprocessing tool, Set Subnetwork Definition to define how this summary attribute is to be populated. The specific summarization used to populate the TOTALSURFACEAREA summary attribute, is to ADD the PIPESURFACEAREA attribute values of each utility network line feature associated to the cathodic protection area subnetwork feature. The utility network supports the following methods of summarization: AVERAGE, COUNT, MAX, MIN, ADD, and SUBTRACT. Only those utility network line segment attributes which have been designated as a network attribute can be used for the summarization..

The third step is to use the geoprocessing tool, Set Subnetwork Definition to define the device, junction or line features which will participate in the summarization. The Set Subnetwork Definition geoprocessing tool will limit the features to be summarized to only metallic pipe segments based on the listing of valid utility network line Asset Group/Asset Type unique value pairs. For our PIPESURFACEAREA summarization for the cathodic protection area tier, the list of valid Asset Group/Asset Type unique value pairs needs to define the metallic pipe segments.

What are network attributes

A utility network has a property known as network attributes. A network attribute is a value stored in the network topology. For the Cathodic Protection area example we have been describing the network attribute is PIPESURFACEAREA. This utility network property is defined using the geoprocessing tool, Add Network Attribute.

Network attributes are required to have a data type of short integer, long integer, double, or date. Network attributes are then associated to a utility network device, junction or line feature class attribute. The association between the utility network, network attribute and a utility network feature class attribute is accomplished with the Set Network Attribute geoprocessing tool. While a network attribute can be associated with only one attribute on a feature class, there is no limit to the number of network attributes a single utility network can have. The feature class attribute to be associated to the network attribute must be of the same data type, but it does not have to have the same attribute name.

When are the summary attributes updated

Summary attributes are updated only when the geoprocessing tool, Update Subnetwork is run. This tool can be run by users at the end of their editing workflows. Additionally, since this is a geoprocessing tool, it is very easy to use standard python scripting batch processing techniques to have this process run as a batch process at a scheduled interval, such as every evening.

Pre-defined summary attributes in UPDM 2017 Edition

To help simplify the deployment of the utility network, the Utility and Pipeline

Data Model (UPDM) 2017 edition will come with the following Summary Attributes pre-configured for the utility network.

Subnetwork Tier	Summary Attribute	Summary Definition
System	TOTALLENGTH	Sum Shape_Length for all zone pipe segments
System	PIPEVOLUME	Sum PIPEVOLUME for all zone pipe segments
Pressure	TOTALLENGTH	Sum Shape_Length for all zone pipe segments
Pressure	PIPEVOLUME	Sum PIPEVOLUME for all pipe zone segments
Pressure	MAOPDESIGN	Find minimum MAOPDESIGN of all zone assets
Pressure	MAOPTEST	Find minimum MAOPTEST of all zone assets
Pressure	MAOPRECORD	Find minimum MAOPRECORD of all zone assets
Isolation	TOTALLENGTH	Sum Shape_Length for all zone pipe segments
Isolation	NUMBERVALVES	Count Devices of AssetType = Critical Valves
Isolation	NUMBERMETERS	Count Devices of AssetType = Customer Meters
Isolation	PIPEVOLUME	Sum PIPEVOLUME for all zone pipe segments
CP Area	PIPESURFACEAREA	Sum the PIPSURFACEAREA for all zone metallic pipe segments
CPAREA	TOTALLENGTH	Sum Shape_Length for all zone metallic pipe segments

The utility network subnetwork summary attribute capabilities directly addresses the gas community's long struggle to manage, share and maintain summary information about their gas system. The utility network subnetwork capabilities provide the means to solve the core of this problem, which is the automated creation and maintenance of this summary information. With the management of the summary information automatically maintained by the utility network subnetwork capabilities this information can now be shared throughout the organization with the confidence that it will accurately represent the current state of the gas system.

Improving data quality through a better Rule Base

Correctly assemble a pipe system the first time

As a little kid, I loved playing with Tinkertoys. Tinkertoys were the sticks and sprockets which allowed my imagination to create and assemble all kinds of wonderful things. I could create chairs taller than myself to allow my favorite teddy bear to have a throne to sit upon. The only limit to what I could assemble was my imagination.

Safety and performance considerations do not permit hazardous liquids and gas pipe systems to be assembled in the same kind of easy and carefree manner. Rather, those considerations compel a strict adherence to design and engineering standards and specifications developed through centuries of experience and technical research. At a fundamental level, there are necessary technical restrictions of many kinds. For instance, the type of fitting or device that can be connected to a specific type of pipe. The classic example is that a plastic coupling cannot be connected to a metallic pipe segment. Another example is that a plastic fusion cannot be used to connect two metallic pipe segments. And, the list of fundamentals goes on and on.

Your pipe network data definition needs to be as complete and precise as the real world it models. A rule base as detailed and exacting as the standards and specifications which govern pipe network construction is key to making sure you get this right.

This leads to the question I am going to explore in this blog; How does an implementer of the utility network assemble this rule base?

With the January 2018 release of the ArcGIS Utility Network Management Extension, and ArcGIS Pro version 2.1, a new set of capabilities is being provided to Esri hazardous liquids and gas customers. These new capabilities provide enhanced abilities for improving the quality control of a pipe system through an enhanced rule base. These new capabilities also include new administration tools to help administrators assemble and manage a set of rules to assist the ArcGIS mapper in correctly creating and maintaining the as-built representation of what was installed in the field.

What kind of Rules can I define?

Technically there are five types of rules in the utility network rule base. The five type of rules are: Junction-Junction Connectivity, Junction-Edge Connectivity, Edge-Junction-Edge Connectivity, Containment, and Structural Attachments.

-Junction to Junction Connectivity: Defines which device or fitting features can be connected to each other. For example a metal coupling can now be directly connected to a critical valve.

-Junction to Edge Connectivity: Defines which lines can be connected to a device or fitting feature. For example a Plastic Tee can connect to a polyethylene distribution pipe.

-Edge to Junction to Edge Connectivity: Defines which type of device or fitting is allowed to connect two types of edge features. For example a bare steel service pipe can connect to a coated steel distribution main with a steel 3-way tee.

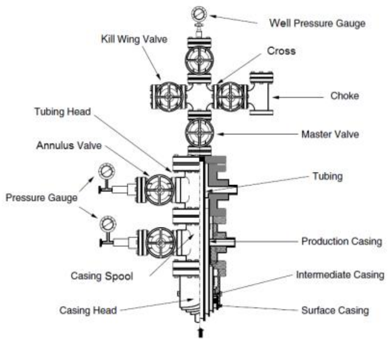
-Containment: Defines which line, device, or fitting features can be contained by a specific type of container. For example a compressor is contained within a compressor station.

-Structural Attachments: Defines which structure junctions can be connected to a device or fitting. For example a pipe hanger can connect to a weld feature. This weld feature denotes the location along a pipe segment where the pipe hanger is welded to the pipe.

Let’s dig deeper into the connectivity rules.

You mean I can connect two point features without an edge?

That is correct. The utility network continues to support spatial coincidence as a means of defining connectivity. But it adds a new capability to define a logical connection between two device and/or fitting features. No more fictitious pipe segments needed to connect a valve to a tee.



A great example of the value of supporting junction to junction connectivity is the wellhead. The wellhead diagram shown above is essentially a collection of valves and fittings. There are no pipe segments in the core construction. With the utility network's new capability to define a logical connectivity association between two point features, such as a flange and a tee, the ArcGIS system can now take a significant step forward in correctly representing this complex assembly.

I could never do that with my tinker toys.

What criteria can I use to define a connection rule?

With the geometric network a connectivity rule was based on a two-value composite key. The two values were the name of the featureclass and its subtype value. Although this technically worked, it was difficult to meet the needs of pipe systems. With the utility network, the composite key has been expanded to a four-value composite key. This four-key composite key is based on the name of the featureclass, its subtype's value (ASSETGROUP), ASSETTYPE value, and its terminal connection. With this expanded composite key, it is now possible to define the following connection:

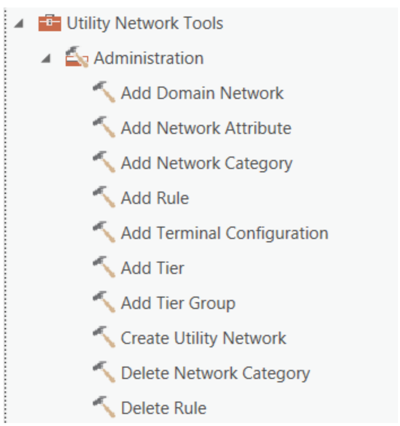
UPDMDEVICE : Valve : Critical : All *can connect too* UPDMJUNCTION : Tee : Metal 4-Way : All

Thanks to this expansion of pipe asset descriptors to define valid connections between assets, it is much easier to define rules in terms engineers and GIS professionals understand. For example, metal tees can only connect to metal pipe segments or other metal fittings and devices.

How are these rules created and managed?

The utility network uses an inclusionary method for defining connectivity rules. This means anything not explicitly defined is invalid. Put another way, once a single connectivity rule is defined, you are committed to the task of defining all valid connections allowed between the pipe system assets.

Administration of the utility network rule base is accomplished within the ArcGIS Pro desktop application using the Geoprocessing tools to be available with ArcGIS Pro version 2.1. Within the Pro Geoprocessing panel is a toolbox named: Utility Network Tools



Within the Utility Network Tools toolbox is a toolset named: Administration. This toolset contains two tools which are used to create and manage rules: Add Rule and Delete Rule. Additionally these tools can be run as python commands. The use of python scripting to create and manage your rule base is significant. Now administrators of publicly traded companies can more easily comply with Sarbanes-Oxley data management requirements. A python script created and tested in the development environment can easily be given to the administrator of the testing or production environment. Allowing that administrator to exactly recreate the rule base which was created or modified in development.

That sounds like a lot of Rules

Yes, for most pipe systems, there will be several thousand unique valid combinations of connectivity between your pipes, devices, and fittings. To simplify the task of defining the rule base, Esri is providing a base data model specifically for the hazardous liquids and gas industry. This core data model will come with over 4,000 rules already defined. Additionally this core data model will be embedded within the 2018 edition of the Utility and Pipeline Data Model (UPDM). This will further simplify the effort required to deploy the utility network for your pipe system.

How do these Rules present to administrators and as-built mappers?

A lot of effort has gone into creating a utility network property page which is both complete and easy to understand. This property page will sub-group the rules into the five types previously listed. Within each sub-group every rule of that sub-group is listed. As shown in the screenshot, the rules are listed in a spreadsheet like layout. This makes for a very easy to read listing of the rule base.

Rules

Junction-Junction Connectivity

Sort By ID (default) Show Default Values

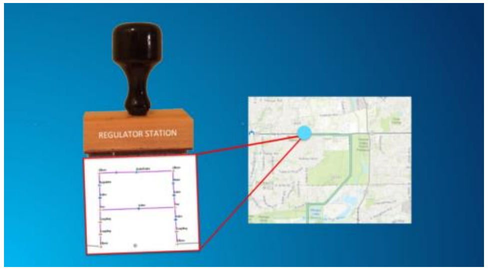
ID	From Class	From Asset Group	From Asset Type	From Terminal	To Class	To Asset Group	To Asset Type	To Terminal
2491	UPDMDevice	Relief Valve	*	*	UPDMJunction	Tee	Metal 3-Way	*
2492	UPDMDevice	Relief Valve	*	*	UPDMJunction	Tee	Metal 4-Way	*
2493	UPDMDevice	Relief Valve	*	*	UPDMJunction	Weld	*	*
2494	UPDMDevice	Valve	*	*	UPDMJunction	Coupling	Metal Coupling	*
2495	UPDMDevice	Valve	*	*	UPDMJunction	Elbow	Metal Elbow	*
2496	UPDMDevice	Valve	*	*	UPDMJunction	Flange	Metal Flange	*
2497	UPDMDevice	Valve	*	*	UPDMJunction	Tee	Metal 3-Way	*
2498	UPDMDevice	Valve	*	*	UPDMJunction	Tee	Metal 4-Way	*
2499	UPDMDevice	Valve	*	*	UPDMJunction	Weld	*	*
2500	UPDMDevice	Wellhead Source Flange	*	*	UPDMJunction	Coupling	Metal Coupling	*
2501	UPDMDevice	Wellhead Source Flange	*	*	UPDMJunction	Elbow	Metal Elbow	*
2502	UPDMDevice	Wellhead Source Flange	*	*	UPDMJunction	Tee	Metal 3-Way	*
2503	UPDMDevice	Wellhead Source Flange	*	*	UPDMJunction	Tee	Metal 4-Way	*
2504	UPDMDevice	Wellhead Source Flange	*	*	UPDMJunction	Weld	*	*
2505	UPDMJunction	Coupling	Metal Coupling	*	UPDMJunction	Elbow	Metal Elbow	*
2506	UPDMJunction	Coupling	Metal Coupling	*	UPDMJunction	Tee	Metal 3-Way	*
2507	UPDMJunction	Coupling	Metal Coupling	*	UPDMJunction	Tee	Metal 4-Way	*
2508	UPDMJunction	Coupling	Metal Coupling	*	UPDMJunction	Weld	*	*

A better rule base

With the release of the ArcGIS Utility Network Management Extension, you now have increased power to control the quality of detailed data defining your pipe network. This builds confidence in your GIS data being an authoritative "digital twin" of your real pipe network. Greater data confidence, in turn, leads to more confidence in your day-to-day use of that data in the performance of business tasks and workflows.

Additionally, the administration of the rule base is significantly easier to assemble and manage than what was previously available within ArcGIS.

You can have your cake and eat it, too



Define a complex facility once. One-click reuse that definition many times.

A study we conducted not too long ago and shared at one of our industry conferences documented a key gas industry trend. At that point, from 1970 the number of gas customers in the U.S. had doubled. In the same period, the number of gas utilities serving 75% of the U.S. market had halved! The result is a smaller number of larger networks and, with employee numbers tightening, the customers-to-employee ratio growing from 344 to 746! These dynamics are one key to the industry's positive performance. They also are key to the need for continuing improvements in employee productivity.

In this context, for years, modelers have been pursuing changes to how gas pipe networks are modeled within ArcGIS that seemingly would move the needle in opposite directions. On the one hand, a variety of regulatory and business drivers have pushed the need for a higher fidelity representation in the GIS of their assets. On the other hand, given the continuing focus on greater productivity, there has been an equal push for improved productivity enhancements.

ArcGIS Pro and the ArcGIS Utility Network Management extension are responsive to these dynamics, delivering an ability to more fully define complex facilities in a highly productive manner. You can have your cake and eat it, too.

For instance, a basic regulator station with a single bypass can easily be comprised of over 20 individual components. With the utility network this facility can have additional configuration requirements to define subnetwork controllers, terminals, and containers. If each component and each utility network configuration were done individually this would be a very daunting task. So, how many clicks does it take to place and configure all of this information? The answer is…. ONE.

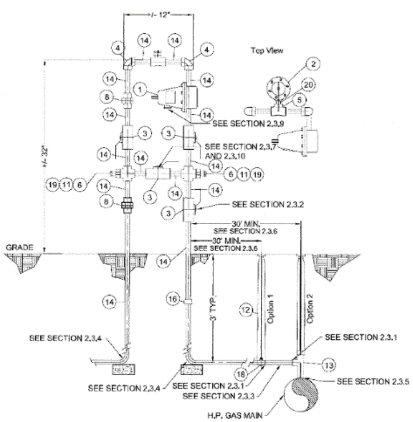
How is a complete regulator station placed with one click?

The short answer is edit templates. ArcGIS Pro provides the ability to create edit templates. These templates can be as simple as pre-populating the attributes for a single asset such as a 4" steel coupling. They can be comprised of multiple features such as 1" plastic service line with an excess flow valve and a meter set. Or they can be very complex such as an entire gas facility such as a regulator station or a compressor station.

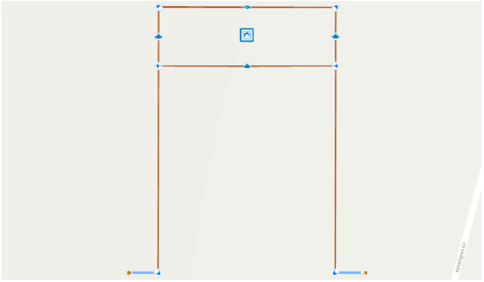
ArcGIS Pro provides the ability to create three types of edit templates. There are edit templates of single features with preset attributes, there are group templates and then there are stamp templates. For this blog I am going to focus on how to use stamp templates to enable an editor to place a 4" regulator station in one click.

How do you create a Stamp Template?

To accurately create a stamp template of a single bypass regulator station, we need to start with a standard design template of how the construction department builds these gas facilities. The diagram below provides such a design.

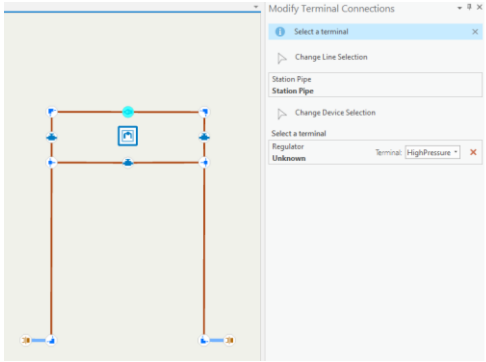


Following this standard construction specification, the standard ArcGIS Pro data creation tools can be used to create the digital twin of the construction specification.

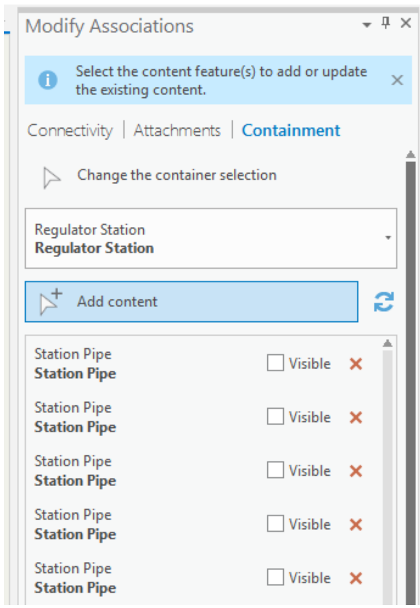


What about those additional utility network configurations?

Now that the digital twin geodatabase features have been created, the additional intelligence of the utility network can be added. Since this is a regulator station, the first step is to use the *Modify Terminal Configuration* tool to define the terminal properties of the regulators and emergency valves.

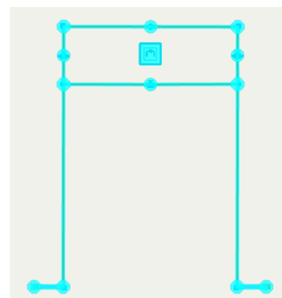


The second step is to use the Modify Associations tool to select all of the regulator station components and associate them with the regulator station assembly feature.

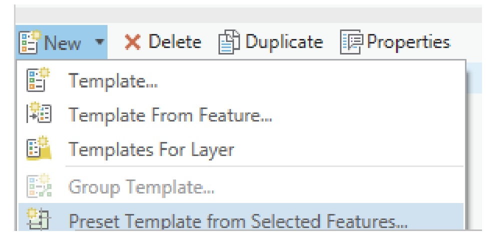


Now that the regulator station template has been drawn within ArcGIS Pro, and its utility network properties have been set, everything is ready for the final step which is to create the stamp template.

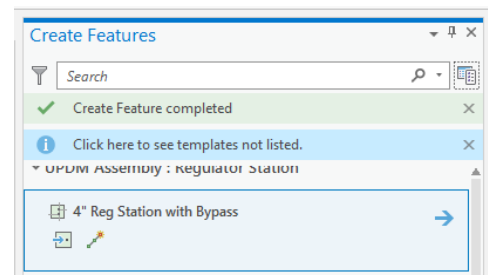
For this next step the selection tools of ArcGIS Pro will be used to select all of the newly created regulator station features.



The final step is to use the manage templates panel to create the template. This is done simply by selecting the "Preset Template from Selected Features" option within the manage templates panel.



Within the Create Feature panel a new template will appear.



Using the basic editing and configuration tools provided with ArcGIS Pro 2.1, a very complex stamp template of a gas facility, such as a regulator station, has been created.

You have made your cake.

This template when used will allow you to place the entire regulator station with its utility network properties pre-populated, in a single click.

And you can eat it, too.

Automating calculations and constraints with Attribute Rules

Improve data quality and editor productivity

Gas utilities continue in an era where the number of gas utility employees is decreasing while the number of customers is increasing. Just over the last couple decades, the customers to employee ratio in the gas industry has more than doubled! This means each gas utility employee is expected to carry a bigger work load.

At the same time, regulatory and business forces are increasing the level of detail required in defining assets and driving data collection and reporting activities from paper-based solutions to digital. These trends are evident in new and proposed regulations like Tracking and Traceability, and in common workflows like weld inspections and daily reporting. How are the gas utility GIS system managers and editors to maintain their productivity with an ever-increasing list of information to manage and attributes to populate? Part of the answer to this challenge is attribute rules.

What are Attribute Rules?

Attribute rules are a new geodatabase capability added with the recent 10.6 release of ArcGIS. They provide the ability to enhance the behavior of a feature class attribute within an enterprise geodatabase. One example of an attribute rule is for the GPSX, GPSY, GPSZ attributes of a gas fitting to be automatically populated with the geometry's X,Y, and Z values when the fitting is initially created by an editor. Another example is to constrain the operating pressure of a pipe segment to a specific range based on its engineering system type and material values. A pipe segment with an AssetGroup = Distribution Pipe and a Material = PE2708 cannot have an operating pressure more than 200 psi. If an editor attempts to submit a pipe segment with an operating pressure of greater than 200 psi to the geodatabase, the geodatabase will reject the edit. The reason the geodatabase rejects the edit is because attribute rules are a property of an enterprise geodatabase feature class.

Another example of attribute rules is the population of attributes such as a pipeline construction Daily Reports TOTALLENGTH. Field supervisors need not worry about this attribute being maintained, or getting out of sync with the entered survey staking from and to measures, because the attribute rules are automatically doing the math.

Is this another ArcGIS Pro only capability?

No. Attribute rules are a server-side capability. They work not only with ArcGIS Pro 2.1, they also work with the current releases of ArcGIS Server feature service editing clients like Portal's map viewer, web application builder web apps and Collector.

How does it work?

The initial release of attribute rules with ArcGIS 10.6 supports two types of rules:

-Calculation rules

-Constraint rules

Calculation rules will automatically populate the attribute based on the defined calculation. Any combination of the record's other attributes can be used in the calculation. For example, PIPEVOLUME can be automatically populated by using the pipe segment's DIAMETER and geometry length to calculate the cylindrical volume.

PipeVolume = 3.14.16 * (DIAMETER/2)^2 * Shape Length

Another more complex example is the collection of a pipe's ASTM F2897 barcode. The barcode can be scanned and captured by standard field data collection applications, such as Collector for ArcGIS. Attribute calculation rules can be applied to parse the barcode, translate the values from base62 to base10 and then write the decoded information to the appropriate attribute fields such as manufacturer, manufacturer model diameter, wall thickness, and material. That is an advanced arcade script, which I will save to discuss in another blog.

Constraint rules go beyond the capabilities of range domains and coded value domains in that they are not limited to being constrained to only the record's subtype values. Any combination of the record's other attributes can be used to define the attributes valid value.

How do I apply Attribute Rules?

Attribute rules are applied using the ArcGIS Pro geoprocessing tool called "Add Attribute Rule." The logic of the rule is written with the Arcade scripting language. One approach to applying attribute rules is to use the following primary steps:

1. Use the Geoprocessing tool "Calculate Field" to create, validate syntax, and test the logic of the arcade script.

2. Use the geoprocessing tool "Add Attribute Rule" to apply the tested and validated arcade script to a feature class's attribute.

Applying Attribute Rules to Construction Daily Reports

An example to introduce this capability is the automating of the tabulation of

Total Length of a Construction Daily Report. Construction Daily Reports are a construction industry staple for communicating the progress of a project to managers and executives. I remember very clearly as a young engineer, having to fill out this form to let my office based project members know what was happening at the construction site. This is usually a single page paper document. In pipeline construction, common information collected in this document would be:

-What task did my crew work on today? (Surveying, clearing, welding, trenching, etc)

-How much was accomplished? (Today, my crew trenched from survey stake 1450+00 to 1650+00)

Converting this type of paper-based form into a digitally-collected form is not difficult. Seamlessly prepping this information into a structure that can be easily and accurately entered by the field supervisor and dynamically consumed by a project's manager's dashboard takes a little more thought and automation. This is where attribute rules can help with the automation. Specifically, with the dynamic calculation of the field crew supervisor's manually entered start and end measure locations. Relying on a user entered polyline geometry is not a very accurate method. Remember that the crew supervisor is filling out this form at the end of the day, most likely while sitting in the construction trailer or in their truck. If the crew supervisor is sitting in the trailer or in the truck, then using a Mobile device's GPS to create the geometry is not a valid option. What is an accepted practice is to denote start and finish based on the survey stakes along the construction path. The stakes are marked with a continuous measurement from the construction project start location. With this understanding what we need is a simple calculation to determine the length of the daily accomplished task based on the supervisor's manually entered start and end measures.

FromMeasure – ToMeasure = Total Length of task completed

In Arcade this would be written as follows:

$feature.TOMEASURE - $feature.FROMMEASURE

To help avoid issues with the field supervisor entering a larger FROMMEASURE than the TOMEASURE the application of an absolute value function to the "total Length of task completed" should solve the problem. The arcade version of that would be written as follows:

Abs($feature.FROMMEASURE - $feature.TOMEASURE)

Next step in this automation is to include some basic situational error handling for a situation where someone after the initial daily report entry, accidentally clears the FROMMEASURE or the TOMEASURE.

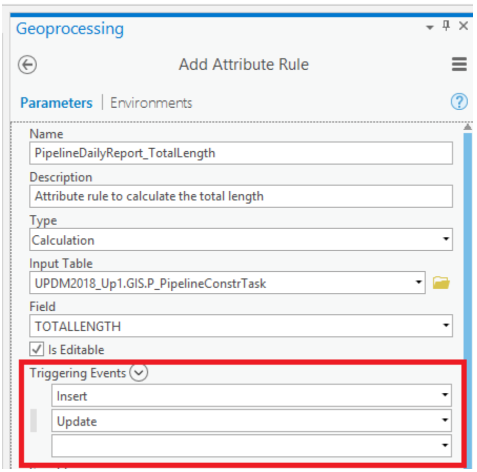
We do not want to lose the calculated TOTALLENGTH. So, the arcade expression gets modified as follows:

```
if ($feature.FROMMEASURE == null) {

return $feature.TOTALLENGTH}

else if ($feature.TOMEASURE == null) {

return $feature.TOTALLENGTH}

Else

return Abs($feature.FROMMEASURE - $feature.TOMEASURE)
```

After testing this with the CALCULATE FIELD geoprocessing tool to test and verify the arcade syntax, it is time to apply this to the geodatabase.

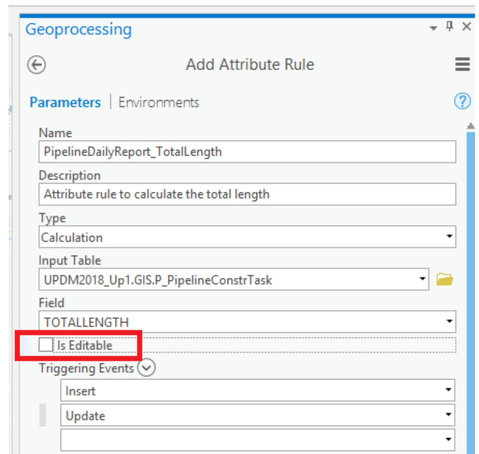
Adding the Attribute Rules to the Geodatabase

Within ArcGIS Pro is a geoprocessing tool called "Add Attribute Rule". Like other schema changes in the geodatabase, you must be the data owner to perform this change. When defining this attribute rule, you define specifically what types of edit changes to the record should invoke the attribute rule. These are called Triggering Events. There are three type of triggering events: Insert, Update, and Delete.



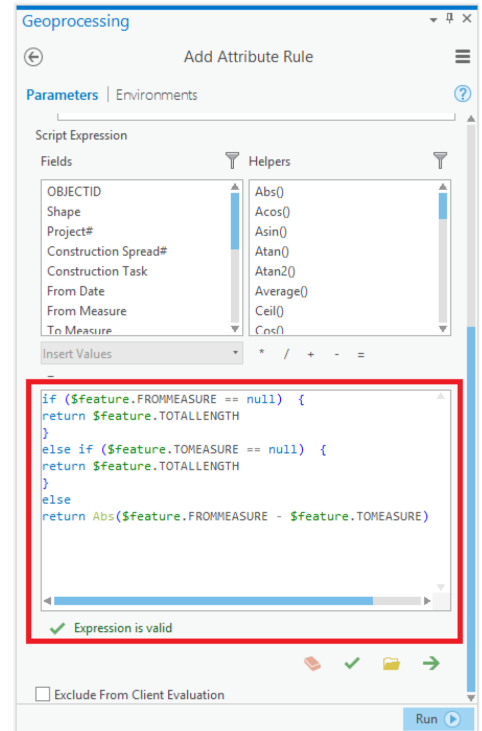
For this rule I will select both Insert and Update.

Another property of the attribute rule is to define whether the field which is being automatically populated should allow editors to manually update the field and overwrite the tabulated value, or should the field be designated as read-only and only the attribute rule itself can populate the field.



For this attribute rule, I will uncheck the “is Editable” option to make this TOTALLENGTH attribute a read-only attribute.

The last step is to load in the arcade script that was successfully tested with the CalculateField GP tool.

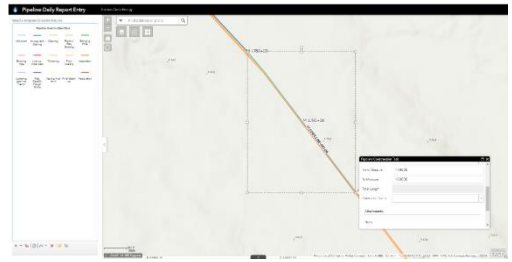


With the attribute rules specified and the arcade script loaded, the tool is ready to be run.

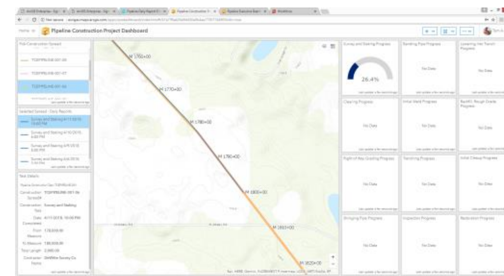
What does the Attribute Rule look like to editors?

Attribute rules are meant to be stealthy. They are not meant to be seen.

For editors, the process of editing just got a little simpler. One field that was a manual user entry field is now an automatically populated field. Notice in the screen shot that follows of my web application builder web application that in the attribute edit form, the field Total Length is greyed out.



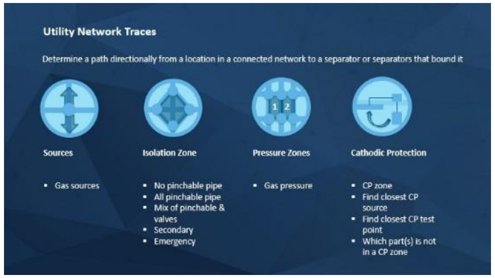
Although my example is not overly complex, the impact of this little bit of automation is significant. With the Total Length now automatically populated with the edit is submitted. Follow-on applications like Dashboards get simpler to deploy with real-time representation of the data. The Dashboard below provides a real-time summary of the progress of a pipeline construction project. The values are tabulated directly from the Daily Reports. Confidence in the summary is greater given that the computer is doing the math. And there is no need for nightly batch processes to run the tabulations, simplifying the setup and administration of this dashboard.



Remember attribute rules work with existing ArcGIS platform clients which can edit a 10.6 or higher enterprise feature service. This includes mobile apps like Collector for ArcGIS, office web applications like Portal's web application builder and map viewer, and desktop applications like ArcGIS Pro.

Attribute rules provide new capabilities to improve the quality of your data, improve the productivity of your editors, and simplify the data entry process through automation. If you have not yet tried attribute rules, you may be missing the opportunity to be the rock star of the month at your company by improving the data entry processes.

Tracing through your pipe system



Finding those key buried devices and paths

A gas utility or pipeline typically transports natural gas or hazardous liquids to customers through a large and complex network of interconnected pipes. In addition to pipe, these networks are comprised of an even larger number of other components, including fittings, valves, regulators, and many more, some of which can affect the flow of the fluid through the pipes. Modeled properly, ArcGIS enables you to create a “digital twin” of all this complexity. This is key as many solutions require that you be able to determine a path directionally from a location in your connected network to a separator or separators that bound it. The utility network provides this capability.

It all starts with location. I find that as I get older, I am more frequently asking myself questions such as: where did I leave my glasses, or where is my phone. Resolving these questions usually entails me wandering about the house until I find those misplaced glasses or phone. Finding these items is not that difficult because I can see my glasses sitting on a table or I can see my phone as it sits on the kitchen counter where I left it.

Now imagine you work for a natural gas or hazardous liquids pipe organization, and all of the assets you are looking for are buried three or more feet below the surface. How do you go about finding a specific valve, fitting, or cathodic protection anode? The short answer is maps. But, maps like traditional paper maps have their limitations in that when looking for a specific valve you must have a pretty good idea of where the valve is located in order to know what map sheet to look at, and where on that busy map sheet to look.

Digital maps are better, in that they allow you to search for a characteristic of the valve such as its assetID, manufacturer, size or type. But, a digital map also assumes you have some knowledge already about the valve you are looking for.

So, what do you do when your question is about the pipe network, and how a specific asset participates in the pipe network? This is where tools which understand how the assets connect to form the pipe network are required. This is where you need tracing tools to know your pipe system.

What type of questions can be answered with a trace?

When managing a pipe system there are many questions that get asked everyday which require an understanding of how the pipe system works. During an emergency, a very common and important question is: what valves do I need to close to isolate a section of the pipe network where damage or a leak has occurred? A common question asked by cathodic protection technicians is where is the nearest CP test point from my current location on the pipe system? Gas engineers who are evaluating a pressure zone ask the question: what are the regulator stations providing gas to this location?

What do I need to do to configure my gas system for tracing?

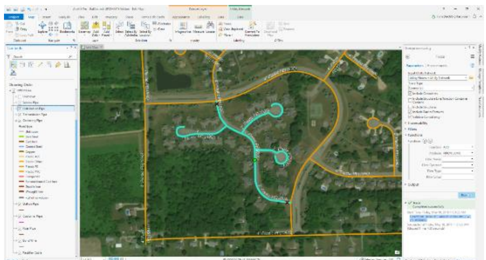
For a software system to be able to answer these common types of pipe system questions, an understanding of how the components of a pipe system connect is required. It is not enough to simply draw a digital representation of the asset on a map, such as is commonly done with CAD software. In addition to drawing the digital representation of the asset on a map, there also needs to be an understanding that the two polyethylene pipe segments which have been butt fusioned together are connected.

This software understanding of connectivity is network topology. Within the Esri ArcGIS platform, our latest version of network topology for utility systems is what we call the utility network.

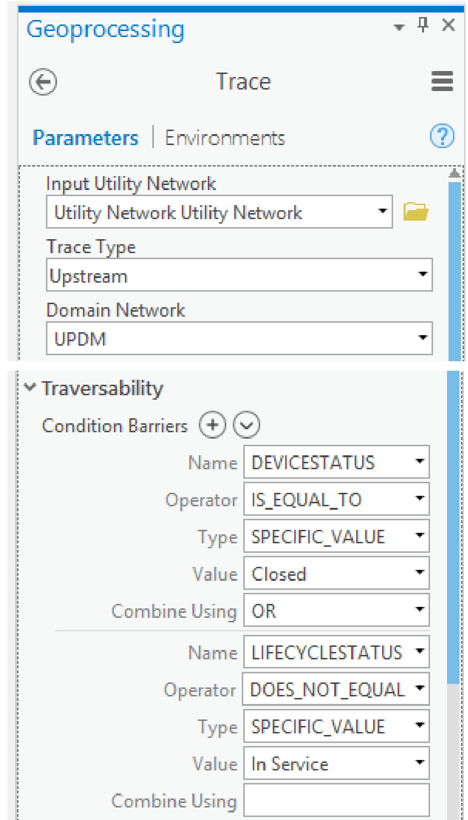
Can I perform a trace in ArcGIS Pro?

Yes. Tracing your network can be performed within ArcGIS Pro version 2.1 or later. Additionally, with the utility network being a service based solution, tracing can also be done with web applications, and eventually will be able to be performed by mobile applications.

Within ArcGIS Pro, the options for configuring a trace have been significantly enhanced when compared to the ArcMap geometric network tools. It is now possible to dynamically answer questions by simple configuration of the properties of the trace tool. For example, if you are trying to determine the amount of gas or liquid lost due to a break in the pipe, you need to know the volume of the portion of the pipe network which was isolated. There is now a function property to the trace tool to allow you to summarize the total pipe volume of the trace selected pipe segments.



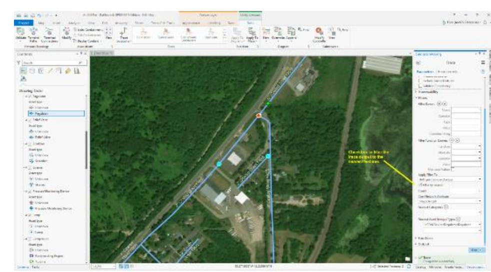
If you need to ask the question, what portion of my pipe system is upstream of a specified location, but only trace on those assets which are in production, and are open to allow the gas or liquid to pass through. The ArcGIS Pro trace tool now supports the ability to use designated asset attributes such as LifeCycleStatus, DeviceStatus, Pincheable, and Insulator Device to dynamically constrain which assets the trace can traverse. This, too, is a simple configuration of the tool's parameters.



Since the trace tool is a geoprocessing tool, your preferred configuration properties can be saved as a model and shared across the organization

How do I configure a trace to find the nearest asset?

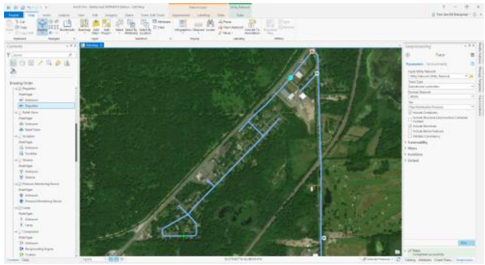
Being able to find the nearest type of asset such as a regulator, valve, or CP test point, is another useful new addition to the capability of the trace tool.



Simply checking a box within the filter options will constrain the trace output to the specified features which are closest based on the distance traversed across the pipe network.

How do I configure the trace tool to find the sources feeding a gas system?

The new trace tool within ArcGIS Pro contains some new trace options, such as subnetwork, subnetwork controller, shortest path, and loops. When a planner or engineer needs to find the regulators feeding a specified location, the subnetwork controller option makes this an easy question to ask of the pipe network.



Tracing with the new utility network solution provided by Esri, is unique in its ability to allow gas and hazardous liquids pipe companies to easily ask questions of their pipe networks. Databases alone cannot answer these questions. CAD systems cannot answer these questions. Even GIS systems which do not include network topology cannot answer these questions. Only a complete GIS system which includes network topology can answer these everyday questions about your pipe network. Only a network topology specifically built for management of utility systems such as a gas or hazardous liquids pipe network can provide the intelligent tools to help you know your system.

About the Authors

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