GIS & Hydraulic Simulation

Getting Them Talking to Each Other

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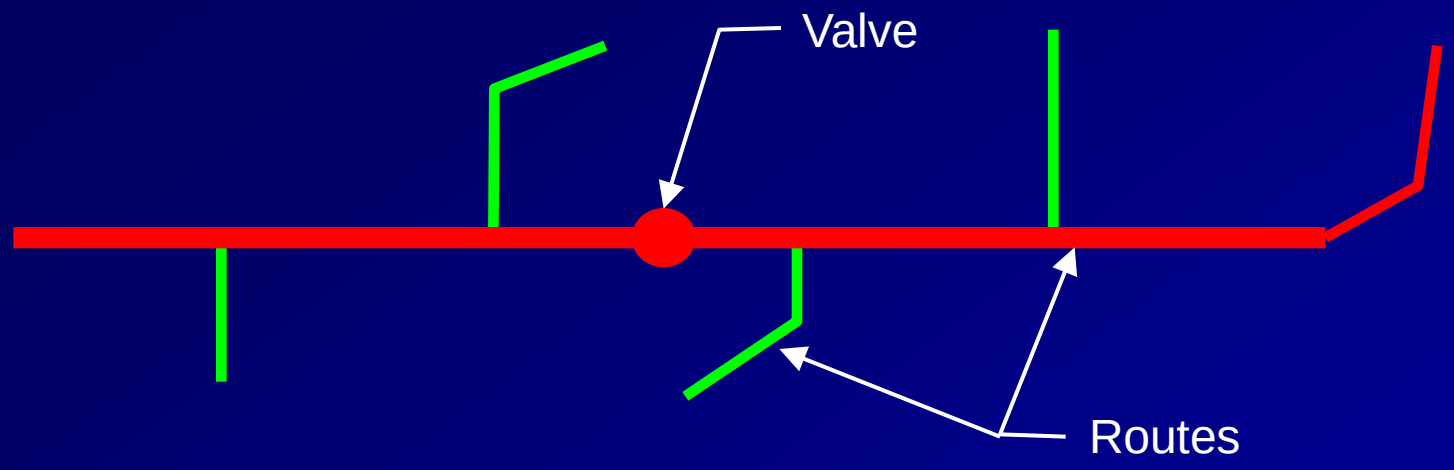
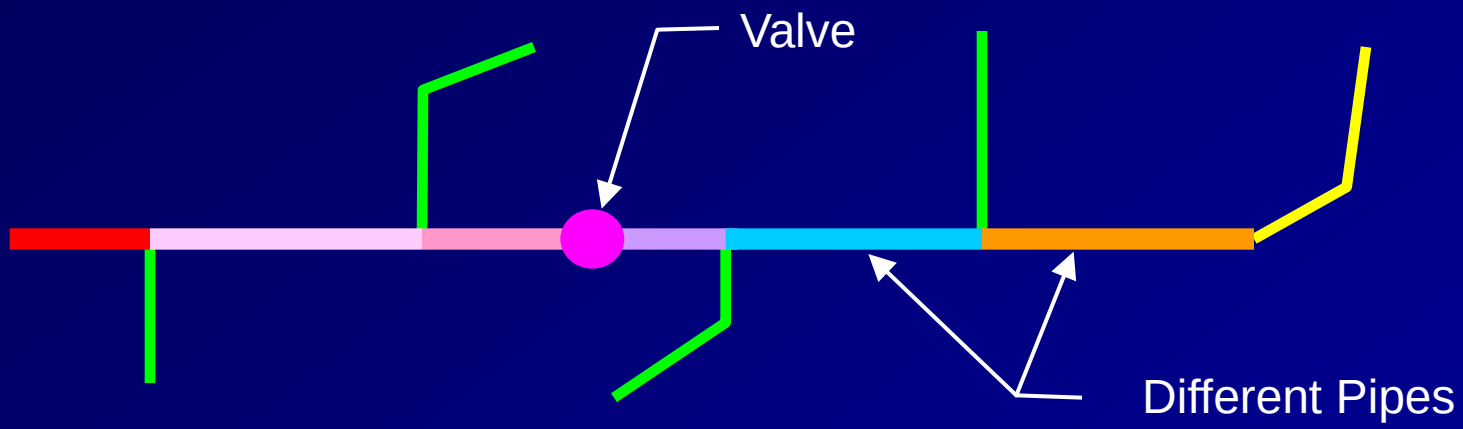
- Wikipedia defines a Geographic Information System (GIS) as a system that captures, stores, analyzes, manages, and presents data that is linked to a location
- Hydraulic Simulation is a software that uses a mathematical model to simulate the behavior of a pipeline network
- Both GIS and Hydraulic Simulation systems look at the same pipeline network but in different ways

GIS View



Typically a GIS system uses routes (pipe) along with events (valves, compressors, etc) along the routes to define a pipeline network

Hydraulic Simulation View



A Hydraulic Simulation model requires that the pipes, valves, compressors, etc. be connected together to form the pipeline network

Goals

- To be able to build and maintain a Hydraulic Simulation model from data in the GIS system
- To be able to display results from the Hydraulic Simulation model in the GIS System
- To be able to use data from one system to verify the data of the other system

Potential Limitations

- Users may like the system or software that they use and may not want to change to another system or software
- The layout and structure of the data used by the GIS system may be fixed or can not be altered significantly because it is being used to support other corporate requirements
- The type and structure of the data required by a Hydraulic Simulation model is usually fixed
- Some of the data that the Hydraulic Simulation model needs may not reside in the GIS system

Data

- Data should only have one owner and this is usually the system or user that is responsible for the overall quality of the data
  - Example: Pipe Efficiency would be owned by a modeler whereas Elevation is obviously GIS data
- Do not confuse use of data with ownership of the data
  - Example: Flow Data is used extensively by a Hydraulic Simulation model but owned by another system such as SCADA

Data

- Data should reside in the system or with the user who owns the data
- It may be easier to “lookup” some data by using existing data rather than creating a new field in the GIS system
  - Example: Pipe Efficiency could be obtained by using an existing Material field in the GIS system to “lookup” a value in an Excel spreadsheet provided by the modeler

Data Recommendations

- Use an Intermediate Data Set
  - This makes the data exchange easier without having to change either system
- Use a static rather than a “linked” method to exchange data between the systems.
  - This keeps the data from “changing” while it is being used by a process.

Data Recommendations

- Establish a unique identifier in the GIS System that can be used to identify objects in the Hydraulic Simulation model.
  - This allows the modelers to communicate to the GIS users about problem areas.

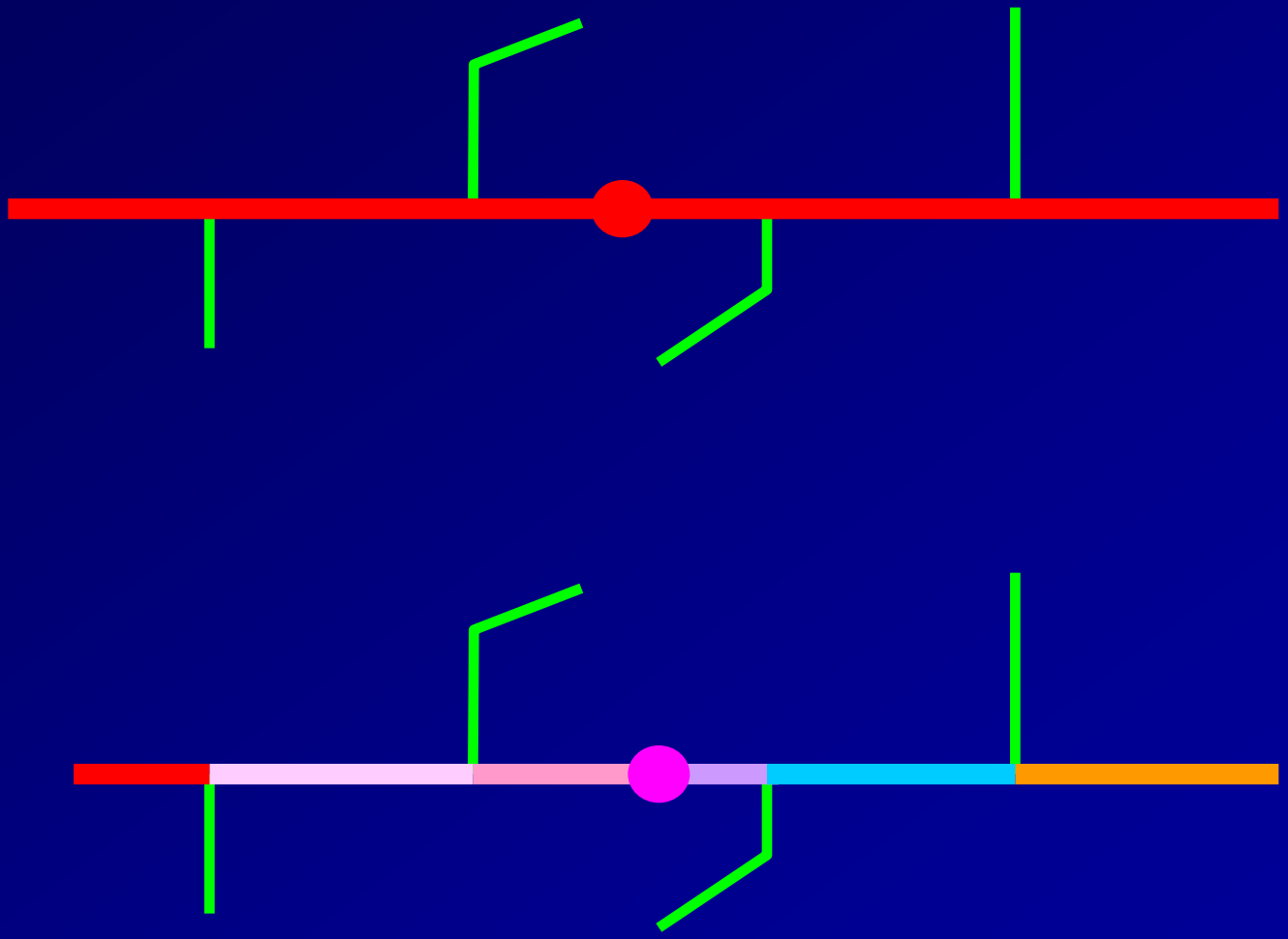
Potential Problem Areas

- Connectivity
- Route Conversion (Pipe)
- Elevation
- What features from the GIS system are needed in the Hydraulic Simulation model
- Valves, Compressors that are typically point features in GIS systems are legs in Hydraulic Simulation model

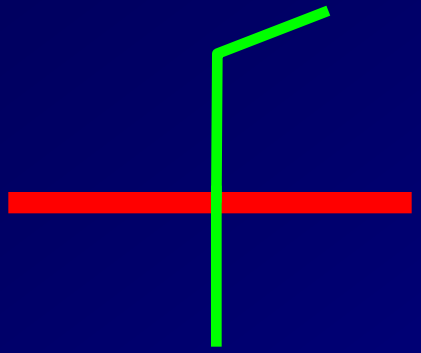
Connectivity

- Two Types – Explicit and Implied
- Explicit – From and To are specified
- Implied – Based upon graphical data (i.e. map coordinates)
- Most GIS Systems use “Implied”
- If using “Implied”, a casual user should be able to determine how the pipeline network is connected

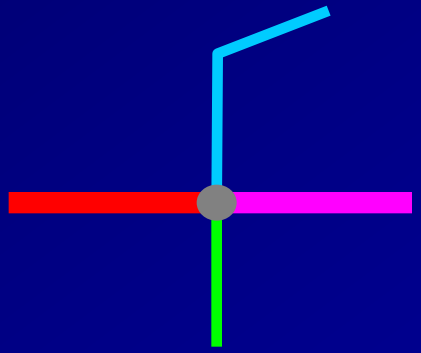
Implied Connectivity

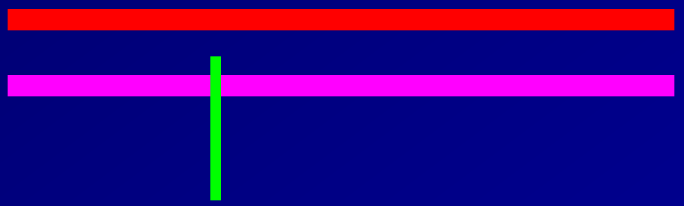


Ambiguous Connectivity



Could Be

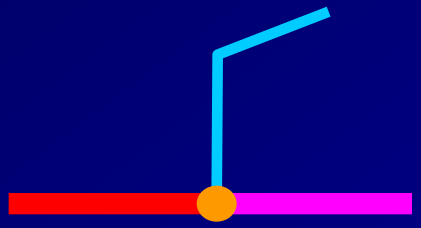




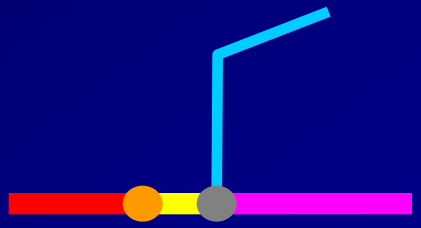
Which pipe is the green pipe connected to?

Valve Placement

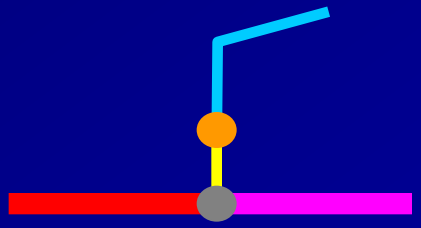
- Valve is placed at the junction of Lateral and Mainline



- Which could be



Or



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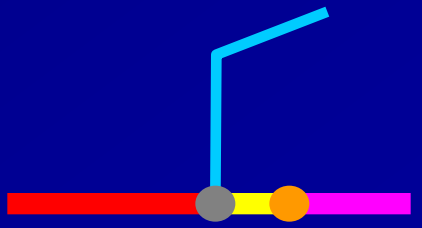
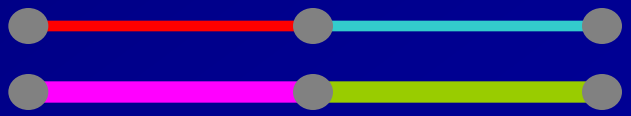


Same Trench

- Multiple pipes are buried in the same trench
- The same GPS coordinates are used for all of the pipes in the trench
- The end result is:

Instead of



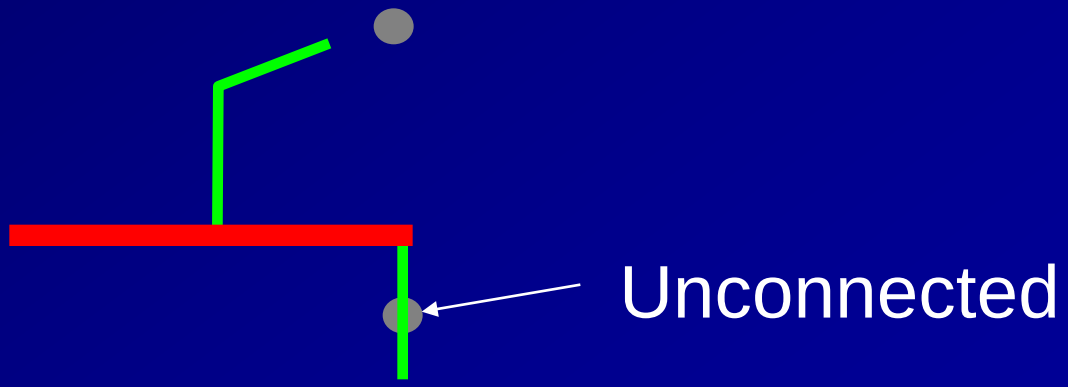
- Usually this is handled in the GIS system by artificially offsetting the pipes

Wells

- Pipe is not extended to the Well

  or

- Pipe is not broken at the Well
- The end result may be unconnected Wells:



Route Conversion (Pipes)

- What is the maximum length of a pipe or how short can my pipes be?
  - Answer: This should be handled by the modeler by using the Hydraulic Simulation software's "Splitting" or "Nodal Reduction" functionality
- Problems that may occur
  - When "Splitting", the unique GIS identifier may get duplicated or left blank
  - When doing "Nodal Reduction", the unique GIS identifier may be lost

Where do I need Nodes in GIS?

- Nodes only need to be created in the GIS system where the modeler wants a named point that is not a Non-Pipe, Receipt or Delivery
  - If the point is a Non-Pipe, Receipt or Delivery then that feature can be used to create a node and name it
- If the point is on a pipe, then a data attribute attached to the pipe can be used to name the nodes at the ends of the pipe.
  - Pipe may have to be broken at the point

Where does the Model need Nodes?

- Where gas is entering or leaving the system
- At the junction of two or more legs
- There is a change in leg type (pipe, valve, etc.)
- Where there is a low or high spot in the pipe. This is highly dependent upon the type of gas being moved
- A modeler may also want nodes where there is significant change in leg properties (i.e. diameter under a road or river crossing)
- Model requirements

Elevation

- Elevation is generally a Node attribute in the Hydraulic Simulation model (i.e. where legs connect)
- Ask your modeler about elevation’s significance in the model. It may not be needed.

Elevation Options

- Add Elevation as two data attributes for pipes (one for each end) and one attribute for all other legs
- Produce a “verbose” data set that “splits” the routes based upon a DEM layer in the GIS
- Produce a 3D dataset with elevation as the third dimension
- Provide a topographical GIS layer that can be used as a Model background

Potential Elevation Problems

- If a pipe is split, either manually or by “Splitting” functionality, then the Hydraulic Simulation software should interpolate the elevations for the new nodes
- If a node is deleted by the modeler, either manually or by “Nodal Reduction”, then an elevation inflection point may be lost
- Provide functionality that allows the modeler to submit a list of coordinates that they need elevation for and get the populated list back to update their models

What needs to be in a Model?

- This is a modeling decision and is based upon the pipeline network being modeled. For example the modeler may want to omit
  - Valves that are never closed
  - Station yard piping / Fittings / Short pipes
- Recommend that the GIS system have a data field for each item indicating whether it is used by the Hydraulic Simulation model or not
  - This will allow these items to be filtered out of the data set during the build

Point Features

- Non-Pipes are generally “point” features in a GIS system and can be converted to legs in the model by generating a second point.
- Generating the second point should involve a “rotation” attribute in the data set so that the legs can be aligned with the pipes
- Some point features such as compressors also have directionality and may need to have explicit connectivity either specified or implied from the data in the connected legs

Recommendations

- Start on a small part of your pipeline network that has the best quality of data, but keep in mind the rest of your network
- Design a process that is flexible and allows for data changes to either system
- Be consistent!

Questions?