Electric Distribution Utility Network Migration Tools Documentation

What's Needed

- ArcGIS Data Interoperability Extension (using one of the following)
  - ArcGIS Pro 2.2.x
  - ArcMap 10.6.x
  - ArcGIS Enterprise 10.6.x
- Source Data
- Water Distribution Utility Network Configuration
- Water Distribution Utility Network Migration Tools
- ArcGIS Enterprise 10.6
  - ArcGIS Utility Network Management Extension
- Utility Network Deployment Tools

	FME 2018.0.0.2 build 18301 can be used in place of the ArcGIS Data Interoperability Extension.

What's Included

In the migration tools download you get the following:

- ArcGIS Data Interoperability / FME workspace (.FMWT and .FMW)
- Sample Microsoft Excel schema mapper file
- Sample XML Assembly definitions
- Sample source data
- Sample target asset package (currently published from Esri Solutions)
- Sample asset package template (schema of the published asset package)
- Sample staging database (sample data that has been migrated)

	The .FMWT file is a workspace template that provides the storage of source files as well as the .FMW workspace itself. This file format is an ideal transport mechanism to provision the utility network migration tools. Either workspace can be used for the migration.

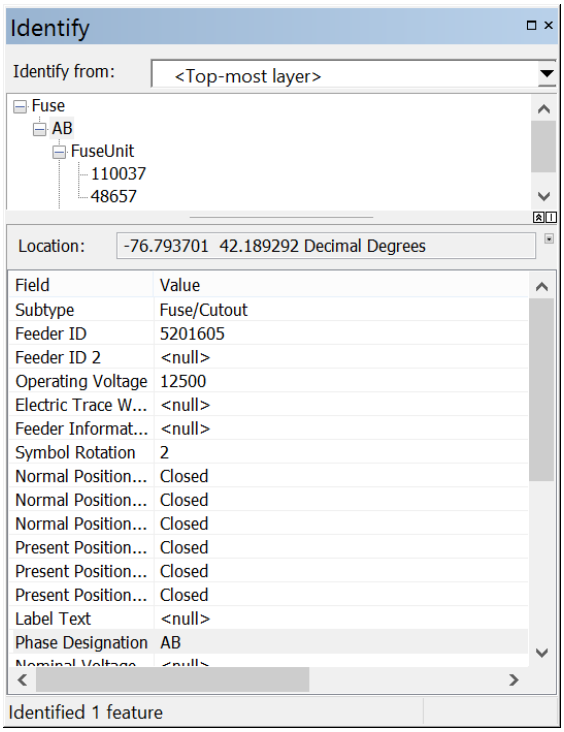
Preparing to Migrate to the Utility Network

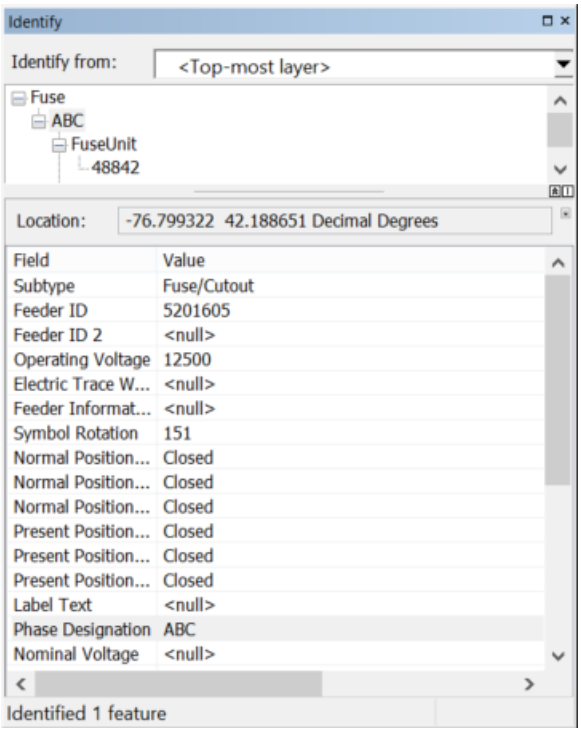
To facilitate a smooth migration to the utility network there should be pre-migration planning, validation, and if necessary data clean-up. Consistent and clean data reduces the likelihood of data migration errors or features loading to the asset package. Esri has provided ArcGIS Data Reviewer checks that can be configured against the source data to identify data issues that need to be resolved prior to the migration. Esri has also provided a template configuration which should be downloaded, configured, and run against the source data prior to migrating the data:

- Water

- Gas
- Electric

Any errors identified by the ArcGIS Data Reviewer checks should be corrected prior to executing the migration tools to mitigate migration errors. Attention should also be given to the consistency of how related records are stored and managed. Related records should be consistently managed; for example, if a fuse point on the electric network is protecting all three phases, the related record should have three-unit records, one for each phase. It should not be also represented as one-unit record with all three phases.





Some of the issues that cause issues, outside of rule violations, are:

- Stacked features (without Z value)
- Self-intersecting lines

Data reviewer may not catch all errors that need to be addressed prior to migration.

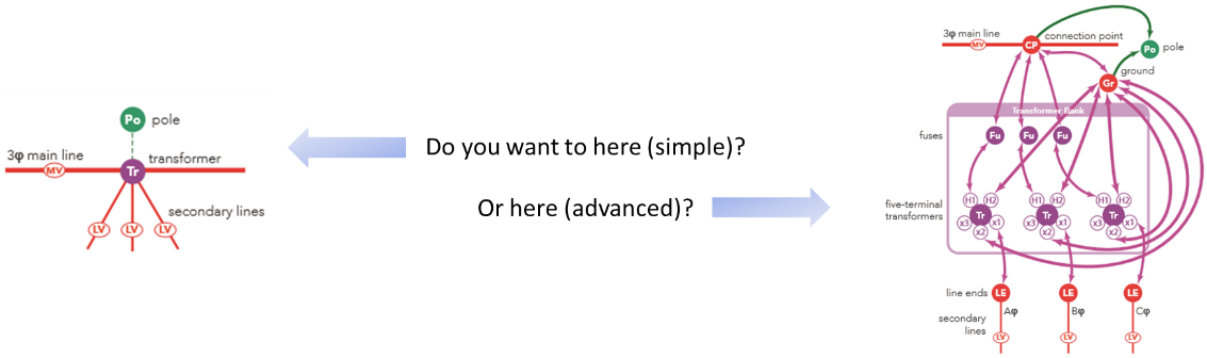
Utility Network Representation

The utility network has the capability to represent network assets in high fidelity, just like they are constructed in the real world. This is accomplished via the utility network information model and the domain specific data models that enable modeling of network relationships down to every terminal.

In planning to migrate to the utility network, you should consider the level of representation you will be migrating to. The granularity of how the data is represented in the target utility network can be categorized into three categories:

- Simple - data migrated in its current form from the geometric network

- Basic - model Esri will provide, includes modeling and representing the real world to support better analytics within and outside the GIS
- Advanced - a step beyond basic to support planning, design and extended modeling within the GIS



How you migrate your data will depend on the quality and robustness of your source data as well as the amount of time and effort you want to put into the overall migration versus addressing a more granular representation post-migration.

For example, you want to represent your pump stations in a more detailed representation, rather than the single point that is in the current source data. With additional work to the migration workspace, you could generate content of a pump station based on defined static assumptions. Conversely, if you have the detail of the pump station, you could modify the migration workspace to accommodate the additional detail that you maintain.

Please review the help documentation for the utility network for the benefits of a more detailed representation of your data with ArcGIS. General reasons include:

- Many of the other systems (ADMS, outage management, modeling packages, etc.) you exchange data with require the more advanced representation. By storing this representation in the GIS you can simplify the data exchange routines with the other systems.
- A more advanced representation in ArcGIS allows for more modeling to be done within the GIS.
- Better accounting of the devices you actually have out there in the field.

ⓘ	Typical electrical utility source data has a network representation. Accordingly, the Electric Utility Network Migration Tools are designed to support a “basic” representation migration.

Asset Package

The Asset Package is a way to model the components of a utility network. Asset Packages can be used to configure a utility network and as an interchange file to import and export the properties of a utility network.

Asset Packages are stored in a file geodatabase and can include the components that model a utility network as well as data to load into a utility network. The Water Utility Network Migration Tools leverage asset packages for data loading.

It is important to understand that while Asset Packages can contain data and can be interacted with by ArcGIS clients, they are not an actual utility network. They are used to configure and interchange data with utility network.

An asset package is supplied with the Electric Distribution Utility Network Configuration that provides a common set of electric distribution network behavior to a utility networks. Users can further refine the asset package to add additional network behavior.

The output of the Electric Distribution Utility Network Migration Tools is also an asset package that can be used to load data into a utility network.

For more information see the Asset Package Reference.

Schema Mapper Spreadsheet

The schema mapping spreadsheet is referenced by the SchemaMapper transformers in the migration workspace of the ArcGIS Interoperability extension or FME workspace file. The spreadsheet has several tabs that map the source ArcGIS schema to the target Utility Network schema. Tabs in the spreadsheet are:

- **Assettypes:** defines the asset group and asset type mappings
- **Domains:** Defines source to target domain and subtype mappings
- **Feature Classes:** These tabs are used to map the source ArcGIS attributes to the target Utility Network attributes.

Limitations:

- ***Nulls****: Microsoft Excel does not handle true NULLs. In cases where a true NULL needs to be mapped to the target add "<Null>" to the cell.*
- ***Case****: the spreadsheets and FME are* ***case sensitive*** *so ensure the case for attributes and values in the source and target mappings match the data you are working with.*
- ***Filters****: simple 'and' filters or joins are used in the spreadsheet to identify which row to use for the schema mapping. For example:*

  ```
  If ArcGISFeatureClass = wControlValve AND VALVETYPE = PC
    then ASSETGROUP = 1 AND ASSETTYPE = 0
  ```

  More complex logic for identifying mappings that might require AND, OR to formulate the mappings might need to be added to the workspace.

	Users will have to review and update the schema mapper excel workshop based on source data and target asset package schema.

Assettypes Tab *– Defines how the source data will map to the target FeatureClass.AssetGroup.AssetType*

- DomainNetworkName – defines the network domain – Structure or ElectricDistribution
- UNFeatureClass—defines the target feature class for the domain network and structure network

- assetgroupDesc—the description of the Asset Group that is presented for the coded value of the Asset Group
- assetgroupDesc—the description of the Asset Type that is presented for the coded value of the Asset Type
- assetgroupValue—the coded value of the Asset Group
- assettypeValue—the coded value of the Asset Type
- terminConfigrationName - look up for terminal types
- FeatureTypeAttr—the variable that the schema mapper transformer in the workspace uses. This will always be: "fme_feature_type" for any mapped values. Every row with a mapped value in the schema mapper spreadsheet requires that "fme_feature_type" be added to the FeatureTypeAttr column.
- assetTypeAttr—constant value that must be added that defines the Asset Type field in the target. This value will always be "ASSETTTYPE".
- assetgroupAttr—constant value that must be added that defines the Asset Group field in the target. This value will always be "ASSETGROUP" and must match the case stored in the target asset package.
- assetTypeAttrDesc—constant value that must be added that defines the Asset Type field in the target. This value will always be "ASSETTTYPEDESC".
- assetgroupAttrDesc—constant value that must be added that defines the Asset Group field in the target. This value will always be "ASSETGROUPDESC" and must match the case stored in the target asset package.

ⓘ	**Note**: For the Electric migration, the AssetType sheet is only used to lookup the asset group and asset type codes based on the Asset Group Description and the Asset Type Description. Asset Group Description and Asset Type Descripition are set in the migration worksace in a series of AttributeCreator transformers – see below. This differs from the 'simple' migration workspaces where the AssetType sheet is used to map to the asset group & type descriptions.

Domains Tab– *Defines source to target domain and subtype mappings. This tab defines how the existing coded values in the source will be translated to the target asset package.*

- ArcGISFeatureClass—defines the source feature class that supplies the data to the target domain/subtype
- ArcGISAttrName—name of the field that stores the source data
- UNAttrName—name of the field that stores the target data
- ArcGISDesc—description of the coded value in the source database that is presented to users through ArcGIS user interfaces
- ArcGISCode—coded domain/subtype value stored in the source geodatabase
- UNDesc—description of the coded value in the utility network that is presented to users through ArcGIS user interfaces
- UNCode—coded domain/subtype value stored in the target utility network geodatabase

- FeatureTypeAttr - The variable that the schema mapper transformer in the workspace uses. This will always be: “fme_feature_type” for any mapped values.

LineToJunctionLookup – this sheet is used to lookup the Junction Asset Type Description based on a devices line connectivity

- LineAssetGroupDesc
- LineAssetTypeDesc
- JunctionAssetGroupDesc
- JunctionAssetTypeDesc

Feature Class Tabs *– Each feature class tab will have the name of the utility network’s information model feature class (minus SubnetLine and ServiceTerritory): Domain>Assembly, DomainDevice, DomainJunction, DomainLine, StructureBoundary, StructureJunction, StructureLine. These tabs are used to map the source attributes to the target attributes.*

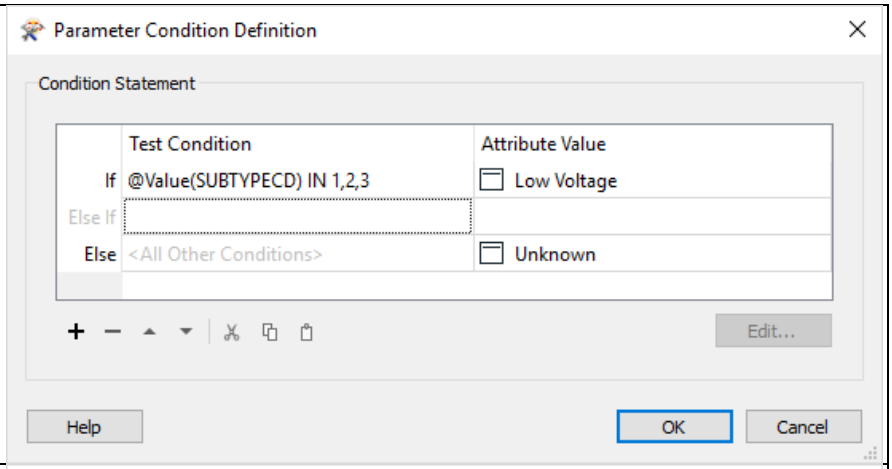
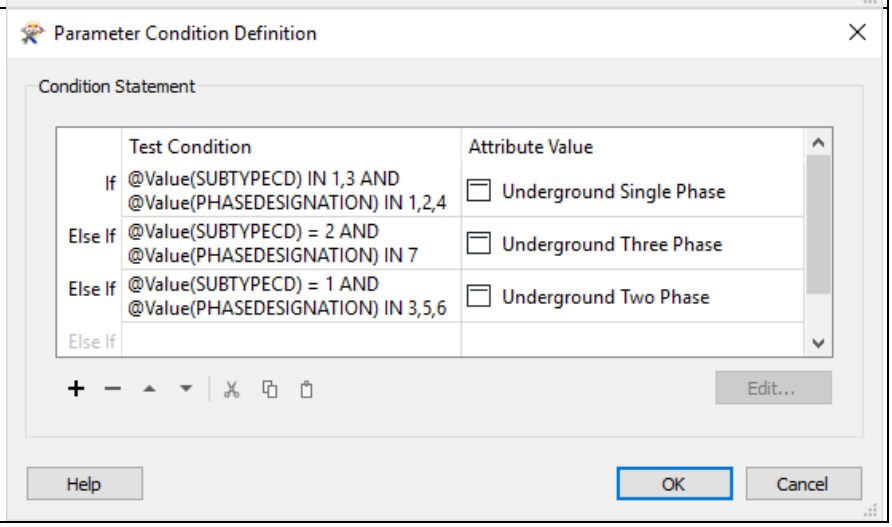
- UNAttrName—name of the source field that is being mapped to the target utility network
- ArcGISFeatureAttr—name of the target field that the source is being mapped to
- UNAttrDefaultValue—default value to be populated in the translation (if any)
- ***Note****: The following fields should be excluded in the mapping as they are managed by the workspace:*
  - *GlobalID*
  - *ShapeLength*
  - *Assetgroup*
  - *Assettype*
  - *Fields that are domain fields should be excluded, or for clarity, flagged as a domain, i.e. LIFECYCLESTATUS (domain mapping), since they will also appear in the Domains tab*

Electric: Asset Group and Asset Type Description Mappings

The complexity of the mappings from ArcGIS to UN for the asset group and asset type descriptions precludes the use of the SchemaMapper. These mappings are carried out in a series of AttributeCreator transformers in the electric migration workspace for each source ArcGIS feature class.

ⓘ	**Important**: The mappings between ArcGIS to Electric Utility Network will vary for each source dataset - particularly with respect to the subtype codes. You should clearly define the mappings from ArcGIS to the UN data model for the asset group and asset type descriptions before you start editing the electric migration workspace

Lines: the mapping for lines usually requires conditional statements based on SubtypeCD and PhaseDesignation. For example, for Naperville sample data, **SecUGElectricLineSegment**:

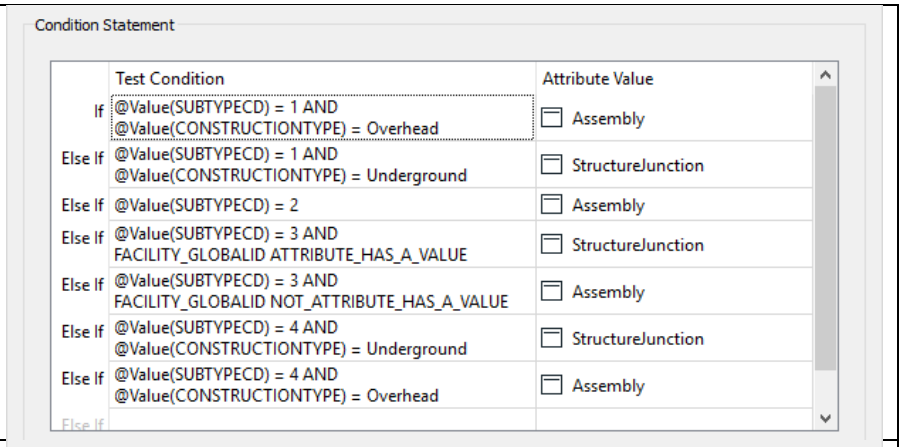
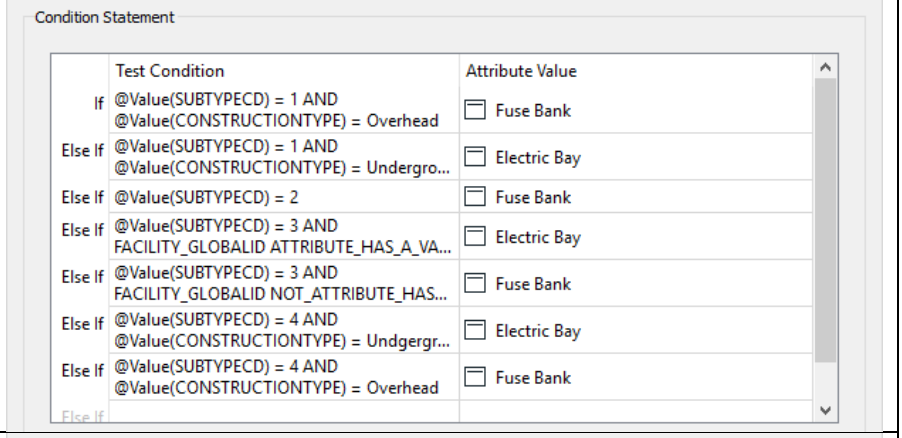
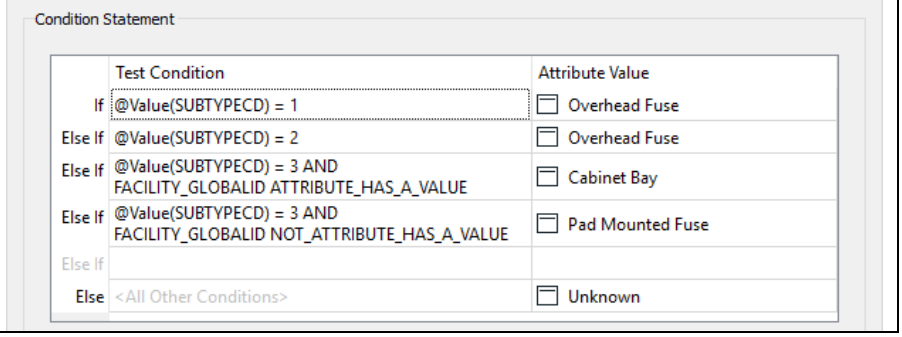
Asset Group Description	
Asset Type Description	

Devices: the mapping for devices usually requires conditional statements based on some or all of the following attirbutes:

- SubtypCD
- PhaseDesignation
- ConstructionType
- HighsideCofiguration

Mappings must be made for both the ArcGIS device feature class (i.e. Fuse) and the associated unit table (i.e. FuseUnit).

For example, for Naperville Fuse feature class:

UN Feature Class	
Asset Group Description	
Asset Type Description	

With similar mappings for Unit Tables: FuseUnit table.

ⓘ	**Important**: The relationship between ArcGIS device and unit table is complex. In summary, the ArcGIS device (i.e. Fuse feature class) is used to create the UN Assembly object. The unit table record (i.e. Fuse Unit) is used to create the Fuse asset contained in the assembly. In some cases, the data in the unit table may not be sufficient to create the asset so the AG device and unit table can be merged to build up the unit table record so the UN asset can be created.

Structures: the mapping for structures usually requires conditional statements based on the SubtypeCD attribute domain:

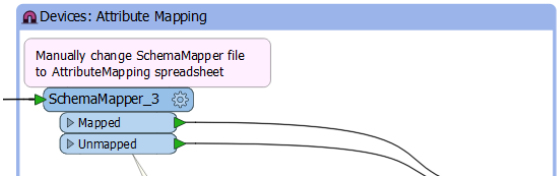
Asset Group Description	Condition Statement Test Condition / Attribute Value If: @Value(SUBTYPECD) IN 3,4,7 → Electric Low Voltage Pole Else If: @Value(SUBTYPECD) IN 1,2,6 → Electric Medium Voltage Pole Else If: @Value(SUBTYPECD) = 5 → Electric High Voltage Pole Else If: Else: <All Other Conditions> → Unknown
Asset Type Description	

Other Mappings: The AttributeCreators set other required attributes used in the migration workspace. These are:

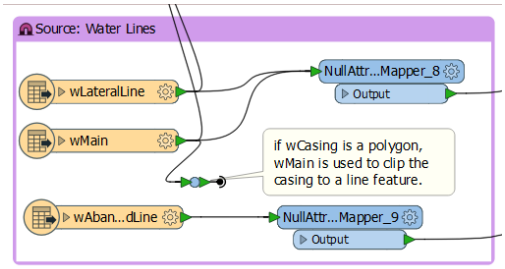
- **_domainNetworkName** - Structure or EslectricDistribution
- **_UNFEATURECLASS** – feature class of the target object i.e. StructureJunction, Device, Assembly, Line
- **ORIGINAL_GLOBALID** – GlobalID of the source AG object
- **_AGFeatureClass** – preserve the original feature class from ArcGIS database

Review the Migration Workspace

In addition to the documentation included here, the migration workspace has many documentation comments and bookmarks within it to support a successful configuration. Some of the comments within the workspace provide guidance on working around known issues:



While others are tips to help with understanding what the workspace is doing, in case more advanced configuration is required:

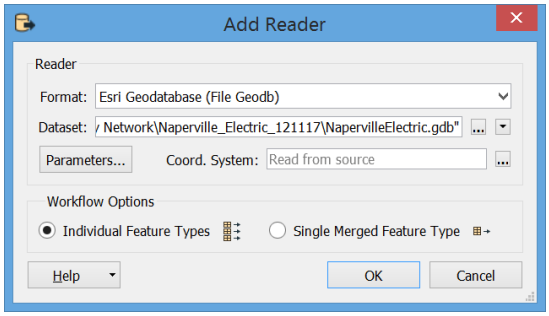


To accommodate the advanced rules defined within the asset package, and to minimize rule violations when loading your asset package into the utility network, there is a workspace transformer process that creates junctions at the intersections of Lateral Lines and Pressurized Mains if they do not already exist. This additional transformer process adds the necessary Water Junctions Asset Group | Asset Type to

meet the connectivity rules for Edge-Junction-Edge and Junction-Edge rules defined in the target Water Asset Package.

Update Source Feature Types

Source features will need to be updated in the migration workspace to support the user's source ArcGIS data model. In the "Readers" menu, select "Add Reader".

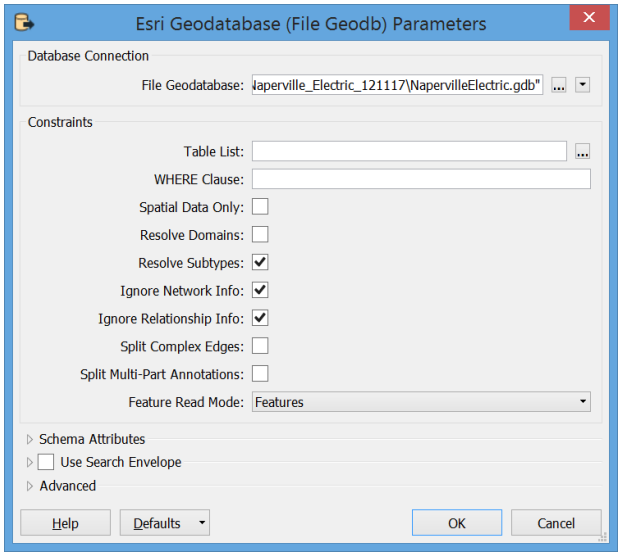


Define the type of source data in the "Format" dialog:

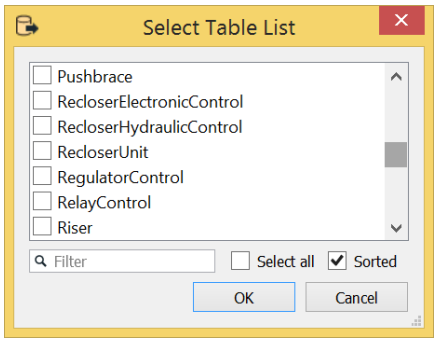
- File Geodatabase
- Enterprise Geodatabase
- Etc.

Then define the location of the source data in the "Dataset" dialog.

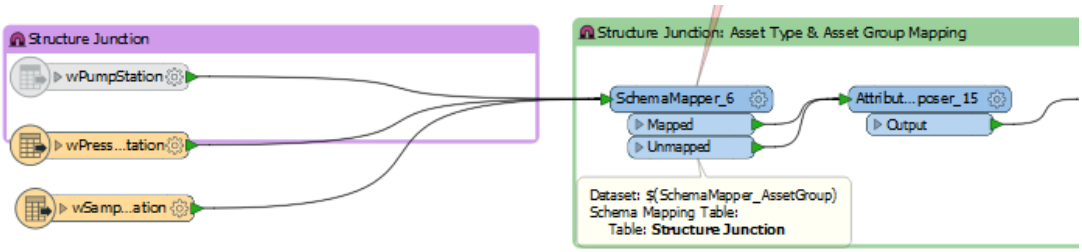
Once the source data has been defined, select "Parameters…" to define what source features will be added to the migration workspace.



Select the "…" next to the "Table List" dialog, this will open a "Select Table List" dialog allowing the user to select the features that will be brought into the migration workspace.



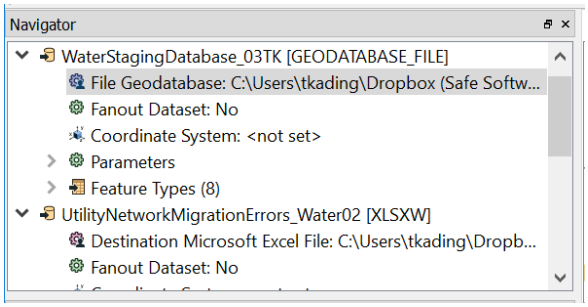
Select all the features that will be migrated to the asset package and select "OK". Then select "OK" in the "Add Reader" dialog. This will bring your source features into the migration workspace. The added feature types will be added to the left-hand side of the workspace as individual feature records. These feature types will be brought in independent of any workspace migration transformers; in other words, they will not be connected to the SchemaMapper transformer. Once the added source features are added to the workspace, the user must then connect the the source feature arrow to the appropriate schema mapping transformers. **Note**: Existing sample source feature types should be disabled by right clicking on the sample source reader in the navigator and selecting Disable Reader. Users may need to iterate through the disabling of sample source features and the dragging and dropping of added source features to the appropriate schema mapping transformer.



Update Target Feature Types

Target feature types only need to be updated if there have been schema changes to the published asset package; for instance, if a new asset group / asset type has been added or a new attribute field has been added. There is a two-step process for updating the asset package being used in the workspace writer:

1) Change the Template Geodatabase—in the Navigator pane select the writer file geodatabase and double click the "File Geodatabase" to change the template. Once the dialog opens, point to the location of the modified asset package. By changing the template, all future runs of the migration tools will use the version of the modified asset package rather than the default version included with the migration tools.



2) Update the Writer—in the "Writer" menu, select "Update Feature Types". When the dialog pops up, select the template that was just updated in step 1. Once the template is chosen, then another pop-up dialog will appear prompting for the location of the asset package that will be used. Update the location to the modified asset package.

Running the Migration Workspace

Prior to running the Electric Migration Workspace you should:

- Ensure source data is clean
  - Topologically consistent (devices lie on line vertices, lines touch at the ends)
  - Unit tables match device feature classes
- You have added your source data reader and updated feature classes
- Updated the writer UN feature classes, if necessary
- Updated the schema mapping spreadsheet
- Updated the asset group and asset type schema mapping in the appropriate AttributeCreators
- Built a small sample dataset for initial testing

Once you are ready, you can run the workspace. It is recommended that you:

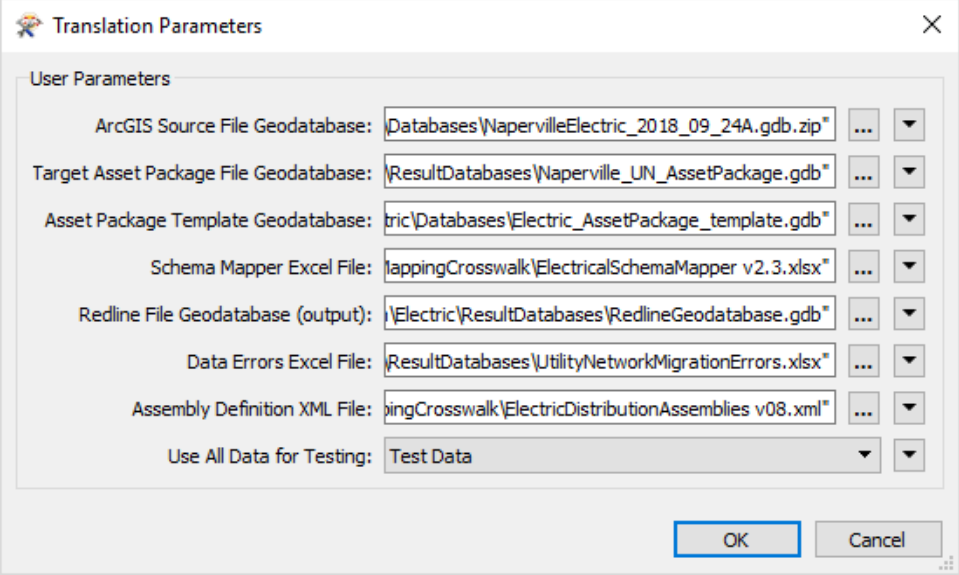
- Run the workspace on a small test dataset. For example, a single circuit.
- Run with the option "Use All Data for Testing": All Data
- By default, the FME Data Inspector will open and show the translation results
- Inspect the resulting Asset Package geodatabase
- Check the error files (red-line geodb and excel file)

The workspace is designed to be run in prompt-mode to help minimize configuration issues. To ensure your workspace is running in prompt mode, select the "Set Workbench to Prompt Before Running" button.

By selecting the Run Translation button, the workspace will prompt the you for configuration parameters:

- Location of "Source Geodatabase" - your source data
- Location of "Target Asset Package File Geodatabase" - migration results.

- Location of “File Geodatabase Template (.gdb)” -
- Location of “Schema Mapper Excel File”
- Location of “Redline File Geodatabase (output)” - error reports
- Location of “Data Error Excel File” - error reports
- Location of “Assembly Definition XML File”
- Option “Use All Data for Testing”: All Data |Test Data



ⓘ	Parameters will vary depending on the domain (gas, water, electric).

Select the “Run Translation” button, and then OK on the parameter dialog to begin running the migration workspace.

Electric Migration Errors

Migration errors are reported to the red line geodatabase and the error spreadsheet. Inspect the data errors and try and trace them back to the source point in the workspace. The error reports give a summary of the feature attributes, GlobalID, error message and the transformer that triggered the error, e.g.:

- AG feature class: APriOHElectricLineSegment
- Error message: WARN: Line: Very short line segment GlobalID: {2C13ED42-2905-4945-B7EB-390575E6F56C} less than 0.06576026909881987. Likely will cause topology errors
- GlobalID: {2C13ED42-2905-4945-B7EB-390575E6F56C}
- Error Transformer: PointOnLineOverlayer_3

Sources of migration errors are:

- Source data quality
    - Poor network topology
    - Mis-matched unit tables
    - Incorrect attribution, i.e. invalid phasedesignation, mis-match of phases on devices & unit tables
- Errors in schema mapping – features will be rejected during schema validation steps
- Errors in the Assembly Definition XML

Addressing Migration Errors

The electric migration workspace is broken into distinct parts (marked by bookmarks) and understanding these sections will aid in debugging errors. Workspace sections are:

- **Source ArcGIS bookmarks**: defines the source data to be read from ArcGIS.
    - **Source ArcGIS: Lines** - Line feature classes
    - **Source ArcGIS: Devices** - Device feature classes & related Unit Tables
    - **Source ArcGIS: Structures** - Structure feature classes
    - **Testing Filters** - Filters to aid testing. These filters let you isolate specific objects (usually devices) for more detailed debugging of your migration workspace. You can enable the testing filters using the parameter *Use All Data or Test Data: All Data | Test Data*
- **Schema Mapping bookmarks**: mapping of source ArcGIS to target UN data model. For each of the major classses of data (Lines, Devices, Structures) there are the separate bookmarks. Within each bookmark there is a separate pipeline for each source ArcGIS feature class:
    - **Attribute clean-up** - Clean-up source attributes (AttributeManager) - remove redundant attributes. Also initializes some attributes.
    - **Uppercase** – FME is case sensitive so all source data is normalized to uppercase so consistent attribute mappings can be used.
    - **Asset Group & Asset Type** – creates the Asset group descriptions and asset type descriptions based on conditional values (AttrbuteCreator) - see the schema mapping

section above. This bookmark also sets the asset group and asset type codes from the schema mapping spreadsheet (DatabaseJoiner -> AssetType sheet). For Devices, there is an additional step (FeatureMerger) that joins the ArcGIS Device attributes to the unit tables.

- **Domain Mapping** – look-up for any domain codes (SchemaMapper -> Domains sheet). For example, PhaseDesignation -> PhasesNormal domain values
- **Attribute Mapping** – rename attributes that are not a domains (SchemaMapper -> ElectricDistributionLines/Devices etc.).
  - **Lines: Junction Defaults** bookmark sets default values for the line end junctions (DatabaseJoiner -> LinetoJunctionLookup)
  - **Devices: Merge Unit Tables** bookmark merges the unit table attribution onto the device features as the list attribute: _unit_table{}

- **Topology –** these sections of the migration workspaces build the topology for Lines, Devices, Structures.
  - **Topology: Lines** bookmarks:
    - **Line / Device Cleaning** – although the source data is supposed to be clean and correctly noded this bookmark ensure that it is.
      - Lines are snapped at a line vertex
      - Devices are snapped to a line vertex
      - Complex edges are split at devices and T junctions
    - **Line End Rotation Angles** – calculate the end of line angles for device placement
    - Line / Device Connectivity – build the connectivity between lines and devices (PointOnLineOverlayer). The output is:
      - Lines: _devices{} list attribute of devices attached to this line segment
      - Devices: _lines{} list attribute of lines connected to each device
    - **Clip & Snap Lines at Assemblies** – clip the lines where UN Assemblies are inserted and ensure lines snap to junctions
    - **Lines; Merge Complex Edges** – merge complex edges that have been split at the PointOnLineOverlayer to ensure there are no duplicate GlobalID's.
  - **Topology: Devices** bookmarks:
    - **Device/Line Connectivity: OH/UG & High/Medium/Low** - gives counts for the number of medium or low lines connected to a device and whether they are overhead or underground objects.
    - **Topology: Junction Connectivity Logic** – logic for setting the UN Assembly rotation and the type of junction based on the connected lines and type of device. Two different patterns for simple devices (two junctions) and more complex devices (>2 junction – usually transformers.

	*May require additional logic for different ArcGIS datasets.*

    - **Devices: Validate Unit Tables** – validate the unit table joins. Depending on the device and PhasesNormal values, the number of unit table records may vary. In addition, some devices require separate assets for each phase (Phase Expansion = Y) and some may only have one, three phase asset, (Phase Expansion = N). For

example, a gang operated switch is a single, three phase asset. A non-gang operated switch has a separate switch asset for each phase.

	*May require additional logic for different ArcGIS datasets.*

  - **Devices/Structures: Merge** – merge the related structure onto the device. Structure attributes have the prefix "STRCT_".

- **Assembly Builder: Create Assemblies & Associations** – builds the UN assembly, devices, junctions and associations.
  - **UN Assemblies: Hifidelity Devices and Associations** - Calls the ElectricDeviceAssemblyBuilder custom transformer that builds the UN Assembly, Devices, Junctions and Associations. The input features to the ElectricDeviceAssemblyBuilder have:
    - **Assembly attributes**: GLOBALID, ASSETGROUPT, ASSETTYPE, PHASESNORMAL etc.
    - **_unit_table{}**: list of unit tables associated with this assembly (_unit_table{}.GLOBALID,
    - **_lines{}**: line connectivity attribution (_lines{}.GLOBALID etc.)
    - **Structure attributes**: STRCT_ prefix (STRCT_GLOBALID etc.)

    The ElectricDeviceAssemblyBuilder custom transformer reads the assembly definitions from an XML definition file

	The ElectricDeviceAssemblyBuilder custom transformer reads the assembly definitions from an XML definition file. You may need to edit this file to add new assembly definitions. Refer to the Esri Electric Utility Network Migration - Assembly Builder XML Documentation for details of defining the assemblies

    Not all devices and associations are be built in the ElectricDeviceAssemblyBuilder. Additional bookmarks are:
  - **Facilities: Create Associations between Facilities / Assemblies** – Create associations between containers such as Switch Facilities and the contained assemblies (i.e. Switch, Fuse assemblies).
  - **Switch Facility: Find Busbar for Switch Facility** – Switch Facilities are generally contain busbars as well as the contained assemblies such as fuses and switch cabinets. This section builds the association between the busbars and contained switch facility and also offsets the switch facility from the busbar line.
  - **Transformer Junctions & Junction Associations** – ensure the connectivity for low side lines to transformer junctions and create the junction / device association.
  - **Tap Junctions: Create Tap Junctions**: create a tap junction at any overhead medium voltage line with three or more lines connecting.
- **Output: Staging Database** – output feature classes to the UN asset package staging database for lines, devices, assemblies, associations structures etc. . Final lookups to complete the UN data (DatabseJoiner for asset group / type codes & association type etc.). Set the output attributes to be upper or lowercase (BulkAttributeRenamer
- **Errors: Lines & Devices Validation:** output errors and warning to the readline geodatabase and error excel file.

Applying the Asset Package to a Utility Network

Once the data has been migrated to the staging asset package, the asset package will need to be applied to the utility network that was staged. Using the ArcGIS Solutions' "apply asset package" tool:

- Add the location of the staging asset package
- Select the domains that will be applied
- Define the target utility network the asset package will be applied to
- Select "Load Data" and "Calculate Spatial Index and Analyze"

This will load the staging asset package to the target utility network.

ⓘ	When applying the asset package to the utility network, the files used to apply the properties of the asset package are written to the "AP workspace" folder; such as the associations and rules.

With the asset package applied to the utility network, run the "Enable Topology" geoprocessing tool. By selecting the "Only generate errors" option, you can validate the quality and suitability of the migration for the utility network.

At this stage, the topology errors identify distinct items that you may need to reconsider:

- Data mapping issues in the schema mapper that result in rule violations
- Bad data that result in rule violations:
    - Stacked features
- Utility network rules that need to be updated to support data

ⓘ	The sample staging asset package and the migration tools themselves have mappings that result in some of the errors described above. This is by design to familiarize you with: ○ Data quality issues ○ Importance of understanding your source data and the target asset package ○ Importance of data mapping ○ Understanding utility network rules

The errors in the staging asset package can be resolved in one of several ways:

- Update the rules in the utility network
- Update the schema mapper spreadsheet by mapping to actual devices rather than "Unknown"
- Resolve data issues in the source data