Correcting GIS Using AMI Data
Big Data Fixing Big Data

Tom Short
Brian Seal
John Simmins
Jared Green

GIS Interest Group
April 22, 2016
Agenda

- GIS Data Quality.
- Finding the feeders.
- Finding the transformers.
- Finding the secondaries.
GIS Errors

- **Types of Errors**
  - Lineage (metadata) – information about the data.
  - Logical consistency – discrepancies in data.
  - Completeness – thoroughness, data gaps.
  - Accuracy (positional and attribute) – lost validity of data or inaccuracies.

- **Sources of Errors**
  - Initial data quality.
  - Poor reference data.
  - Maintenance-induced and ongoing deterioration.
  - Policy.

---

- **Initial Data Quality**
  - Poor quality source data;
  - Incomplete data migration and conversion from paper maps and field data collection.

- **Data Maintenance**
  - Ambiguous definition of data ownership and access rights;
  - Poor data quality control processes / practices;
  - Deferred data update and maintenance.

- **Poor Reference Data**
  - Incomplete or inconsistent metadata;
  - Inferior resolution;
  - Bad collections methods.
What Might be Possible with AMI Data?

- Phase identification
- Transformer identification
- Theft detection
- Mapping connectivity of secondaries
- Auto-generation of secondary models, including impedances
- Finding meters on the wrong circuit (addressing errors)
- Identification of open points on loops
- Identifying transformers with off-nominal taps or ratios

- Quantifying lighting and other unmetered load
- Plotting profiles of primary line voltage at any instant in time
  - Circuit model verification
  - Identification of switched capacitors with blown fuses
  - Identification of misoperating voltage regulators
Circuits on the Wrong Phase from the Substation

- Problem
  - The correct circuits (taps) are not always on the correct phase.
  - GIS is wrong.

- Impact
  - Poor designs.
  - Impacts on loading.
  - Impacts with DR and DER.
  - Outage management impacts.
Automating Phase Identification

- SCADA Voltage Data
- AMI Voltage Data
- Correlating Voltage
- Customer Phase ID
Basic Correlation Algorithm

\[ V_n = k_0 + k_1 V_m + k_2 W_m + k_3 W_n \]

Where:

- \( k_i \) = regression coefficients
- \( V_n \) = substation voltage on phase \( n \)
- \( W_n \) = substation average power on phase \( n \)
- \( V_m \) = voltage at meter \( m \)
- \( W_m \) = average power on meter \( m \)

Matches with \( V_C \) – phasing match
Same Data as X vs. Y
Mc 2412
Substation

- Wrong
- No match
Mc 2412 Google Maps Verification

5th pole east of Carswell Ln
Bottom (blue) phase to transformer
Mc 2412

3rd pole east of Carswell Ln
Both bottom (blue) phase to riser

Seems to confirm the phasing mismatch
Transformer Identification

Problem

– The correct premises are not always on the correct transformer.
– The trans-premise relationship is not always in GIS.

Impact

– Poor transformer maintenance.
– Impacts with DR and DER.
– Outage management impacts.

“I would say that linking the customer to the right transformer and to the right phase is our number one priority. If conflation wasn’t so expensive, we would do that first.”
Preliminary Transformer ID Results

- 7 that were accurately classified
- 1 that was not in the GIS group but was on an unmodeled transformer
- 1 the algorithm missed – there was a lot of distance between this meter and others on that transformer
Transformer Error ID

GIS Transformer Grouping

Transformer grouping with the best correlation
Gaps in Secondary Model

- **Problem**
  - Secondary circuits are missing.
  - Trans-premise relationship missing.
- **Impact**
  - Poor transformer maintenance.
  - Impacts with DR and DER.
  - Outage management impacts.
  - Poor planning.

“The biggest issue with our GIS data is mapping out the secondary network. This is an ongoing issue and we don’t have a good solution.”
Using AMI to Map the Secondary – Bottom-Up Grouping
Corrected for Load

R² = 0.717

R² = 0.949

R² = 0.999

R² = 0.91
Corrected for Load

$R^2 = 0.717$

$R^2 = 0.949$

$R^2 = 0.999$

$R^2 = 0.91$
Basic Algorithm

- Start with a set of meters to be grouped (set $A$), each meter having series of voltage, watt, and var averages captured simultaneously.
- For each meter $i$, solve the regression model paired with every other meter in set $A$.
- Pick the meter $j$ that has the highest $R^2$ value in regressions with meter $i$.
- For the new meter pair of closely coupled meters $i$ and $j$, store the line resistances and reactances for each branch from the regression model. Also find the voltage and real and reactive power at the common point. This forms a new metering point $k$.
- Remove meters $i$ and $j$ from set $A$. Add the new meter point $k$ to set $A$.
- Repeat starting with step two until all meters have been paired together.

\[
V_{\text{drop}} \approx R \cdot I_R + X \cdot I_X
\]

\[
V_0 = V_1 + R_1 \cdot I_{1,R} + X_1 \cdot I_{1,X} = V_2 + R_2 \cdot I_{2,R} + X_2 \cdot I_{2,X}
\]

\[
V_1 = \beta_0 + \beta_0 \cdot V_2 + R_2 \cdot I_{2,R} + X_2 \cdot I_{2,X} + R_1 \cdot (-I_{1,R}) + X_1 \cdot (-I_{1,X})
\]

\[
I_{i,R} = \frac{P_i}{V_i} \quad I_{i,X} = \frac{Q_i}{V_i}
\]

\[
V_{0,\text{estimate1}} = V_1 + R_1 \cdot I_{1,R} + X_1 \cdot I_{1,X}
\]

\[
V_{0,\text{estimate2}} = V_2 + R_2 \cdot I_{2,R} + X_2 \cdot I_{2,X}
\]

\[
V_0 = \frac{(V_{0,\text{estimate1}} + V_{0,\text{estimate2}})}{2}
\]
A Whole Tap
A Whole Tap
Using AMI Data You Can:

- Identify which phase a premise is on.
- Identify which meter a premise is on.
- Build out the secondary both electrically and spatially.
- And much, much, more.....
Together…Shaping the Future of Electricity