Process Improvement of Distribution Protective Relays Coordination
Introduction

- Power system studies are more demanding today
  - Distributed Energy Resources (DERs) pose new challenges
  - Customer demand and load profile is rapidly changing (e.g., electric vehicles, energy storage)
  - Regulatory requirements become more strict
  - Less predictable due to climate change

- A protection department runs hundreds of studies each year
  - Triggered by system changes, unexpected operations, or preventive measures
  - Each study takes several minutes to hours, even a day or two
  - Most of time spent to prepare study rather than evaluation

- Focus of this presentation
  - Improving this process, specifically for distribution protection studies
  - Resolving data quality challenges, right use of software tools and automation, and documentation
  - Taking steps towards autonomous power systems
Distribution protection study process
- Data gathering (model, settings, etc.)
- Modeling (primary system, protection)
- Running studies (short-circuit, etc.)
- Reviewing results
- Reporting
- Repeat!

Examples
- Damage-curve and arc-flash
- Substation relays coordination
- Relays pickup settings comparison with load

These tasks are typically performed manually as separate processes.
Data Integrity for Power Systems Studies

- **Data Availability**
  - Multiple data types needed
  - Different departments own data sources
  - “Data lake” collects all data in one location, for more availability and security

- **Digitization**
  - Convert all records to digital formats
  - Paper records are often inconsistent
  - Digital conversion is not loss-less
  - Automated and manual quality control needed
Data Integrity for Power Systems Studies

- **Quality Assurance**
  - Ensure data quality is acceptable, examples:
    - Accurate connectivity for short-circuit model
    - Updated source impedance model based on transmission network
    - Latest settings are same as the field
  - Large effort right after data conversion
  - Ongoing process: identify, report, and fix

- **Standardization**
  - Helps linking data points, example:
    - Consider system model and settings are available, naming convention helps to place protection
  - Goal is one standard across utility
    - Short-term solution is translation tables
Study Processes, Software Tools, and Automation

Process Optimization
• Accommodate new data sources
• Account for system changes (DER, VVO, etc.)
• Align with software updates

Software Tools
• Many tools used
  Short-circuit analysis, relay software, protection curves, reporting
• Use tools efficiently
  – Review tool functionalities
  – Use interfaces and automation capabilities to transfer data
  – One main tool others as resources

Use of Automation
• Common in transmission studies
• Data availability and quality is a challenge in distribution system
  – Large number of assets
  – Fast system changes
  – Expensive to enhance data quality
• Off-the-shelf solutions don’t exist
  – Due to combination of data sources and process variation
Steps Toward Efficient Systems Studies

- Data integrity

- Process Development
  - Build automation team with diverse skillsets
  - Review current processes, record planned changes, and predict future needs
  - Examine available tools and evaluate potential for improvement
  - Prepare documentation
    - Standards, guidelines, and general practices
    - One-time effort that goes a long way
    - More required today with agile workforce habits

- Automation
  - Gradual integration of automation into processes
Current Processes for System Studies

- User interacts with multiple data sources:
  - Model Database (network model, equipment sizes, etc.)
  - Measurements Database (historical load and fault data)
  - Relay Settings Database

- And multiple tools
  - Short-circuit studies
  - Protection modeling (curves, current/time calculations)
  - Reporting

- One or more steps automated at each example
Implementation Examples
Automation-Assisted Damage-Curve and Arc-Flash Studies

- Automatic parsing and extraction of protective relay settings
- Creating a library of damage curves and protective relay curves
- Automatic drawing of protective device curves and comparing them
- Automatic importing of fault-duties from the short-circuit program
- Automatic parsing and extraction of protective relay settings
- Automatic drawing of protective device curves and comparing them
- Automatic analysis of historical load value, filtering bad data, and estimating load growth

* Not enough margin

✓ Flag ignored in “Switch Mode”
- All functions for damage-curve and arc-flash module
- Automatic detection of substation configuration
- Automatic testing of all contingencies
- Generic study to fall back on if substation configuration is not available
Conclusions

- Data integrity is essential before improving a study process
  - Availability, digitization, standardization, quality assurance

- Process development
  - Build automation team, review existing processes, study available software tools, prepare documentation
  - Efficient use of tools, better use of data sources, and detailed written processes helps
  - Consider new technologies and future needs (DER, energy storage, VVO, electrification, etc.)
  - Think out of the box: implement all scenarios for studies, not only the ones that was possible manually

- Implementation
  - Start with simple steps
    - Such as data transfer and calculations
  - Add/improve at each step
  - Use additional data sources to improve quality
  - Implement fail safe measures for non-essential data sources
Summary and Future Work

- Practical approach to improve a distribution protection study process

- Prerequisites are
  - Data integrity
  - Process development including documentation

- Three examples provided of implemented techniques

- Steps towards adaptive protection systems
Thank you!