Protection Security Assessment and NERC PRC Compliance
A Data Management Perspective

Introduction

The electric utility grid is rapidly changing. The penetration of distributed energy resources (DERs) at both distribution and transmission voltage levels, retirement of conventional energy sources, and system expansion are producing unique protection and control challenges for utility Protection & Control (P&C) engineers.

At the same time, increasing regulatory compliance requirements such as NERC PRC standards, and the simultaneous reduction in experienced staff, are imposing not only technical challenges, but also data management and documentation burdens that tend to take on a utility-wide presence. A utility will therefore need well developed data management and reporting techniques, with as much automation as possible, to efficiently support daily studies and compliance activities. This ensures that P&C engineers are focused on their primary and most important task – to design and maintain P&C systems for reliable operation of the electric grid – and not hampered by data availability and integrity issues.

In this article, Siemens PTI engineers provide their perspective on the data management challenges faced by utility P&C departments, and discuss potential solutions that utilities might be able to adopt to overcome them.

Utility P&C Processes and Data Flow

P&C departments at utilities work with a variety of tools and data sources:

- Short-circuit and protection simulation software: CAPE, ASPEN, CYME, PSS®SINCAL, PSS®E, etc. For special studies, the short-circuit software tool might need to interact with electromagnetic or electromechanical transient simulation programs.

- Relay settings and asset database: PowerBase, IPS, ASPEN Relay Database, CAPE Database, etc. Associated with protective relays are additional data objects such as:
  - Electronic relay setting files (manufacturer-specific)
  - Relay setting templates (spreadsheets, Mathcad script or similar)

- Facility rating information for lines, transformers, and other equipment, stored as spreadsheets or home-grown databases.

- Utility asset database with equipment information for circuit breakers, transformers, etc.
- Planning model of the network, stored in PSS®MOD or planning software, from which the short-circuit model is extracted (not at all utilities).
- Regional short-circuit model returned to the utility by the ISO/RTO for accurate representation of neighboring utility connections.
- Transmission line constants databases containing right-of-way, tower design, conductor, and other relevant information for accurate modeling of transmission line parameters.

Managing the interactions between the tools and data sources is a resource-intensive process, with large portions accomplished manually. A manual process requires several levels of quality checking to assure integrity of the data. Since the operation of critical infrastructure depends on the data management process, automating the interaction between the various tools and data sources is desirable. Siemens PTI’s view of these interactions is captured in Figure 1. Variations are of course possible, and our intent is not to represent all possible approaches that might be adopted.

Figure 1 - Typical Data Flow and Interactions
The items in the diagram are explained below:

1) **Data Sources**: P&C engineers work with different sources of data:

   a) **Relay Asset Database**: The relay asset database (PowerBase, IPS) is typically the “database of record” for protective relay settings. This database actively tracks changes to relay settings, stores the electronic relay setting file for the relay record, and can also be used to create relay test plans.

   Manually extracting the relay information from this database, and entering it into the short-circuit and protection analysis tool can be done, but is a tedious process, resource-intensive and prone to errors.

   An automated technique that allows bi-directional relay data transfer between the asset database and the analysis tool will be extremely useful. This tool can be applied system-wide at specific times, or on-demand.

   b) **Utility Asset Database**: Often, the utility-wide asset database will contain circuit breaker information such as rating, interrupting capacity, interrupting medium, etc. Data for other primary equipment such as generators and transformers can also be found here. If this asset database is the “database of record” for primary equipment, an automated process to pull this information into the planning or short-circuit model will allow model updates and maintenance to take place efficiently.

   c) **Facility Rating Database**: NERC standards PRC-023 (for transmission lines) and PRC-025 (for generators) require that load-sensitive protective relays comply with certain loadability requirements, and not trip the line or generator when experiencing those load conditions. The facility ratings database stores information about the limiting loading condition for each primary equipment.

   d) **Line Constants Data**: Database or source of line constants data (right-of-way, tower design, conductor and other relevant information).

   e) **Short-Circuit Network Model**: A model based on the positive-, negative- and zero-sequence representation of various pieces of equipment in the network.

   f) **Planning Model**: A “master” model that can serve as the model of record, from which the short-circuit model is derived.

   g) **Regional ISO Model**: Model returned by the ISO to the utility after merging in data from neighboring utilities. This model allows the utility to update its representation of the neighboring utilities, within its own model of the network.

2) **Electrical Digital Twin Data Repository**: The data sources described earlier often follow different formats and protocols. There is no standard method for naming and storing the data. Moving the data from the data repository to the applications that need the data is a usually a manual process. To overcome these deficiencies and achieve seamless data movement, Siemens has introduced the concept of an Electrical Digital Twin data model. The data processing module(s) contained in the digital twin data repository possess the ability to understand and communicate with the various sources of data. Once processed, an Electrical Digital Twin data model is created, and this model then becomes the single source of all data needed by any application that needs it.
3) **Applications: Short-circuit Calculations, Protection Simulations and PRC Compliance Studies:** This process is at the heart of the analysis that P&C engineers perform using the simulation tools at their disposal such as ASPEN, CAPE, CYME, PSS®SINCAL, PSS®E, etc. There is ample scope for automating the various studies, using the scripting and automating capabilities of the tools themselves. PRC compliance reviews for standards such as PRC 019, PRC 023, PRC 024, PRC 025, PRC 026, and the newly approved PRC 027 are performed here.

   a) **Electromagnetic Transient Simulation:** For special studies such as evaluating protective relay behavior under electromagnetic transient conditions, the short-circuit/protection simulation process can interface with an electromagnetic transient simulation program such as ATP, PSCAD or EMTP.

   b) **Electromechanical Transient Simulation:** For special studies such as evaluating protective relay behavior under electromechanical transient conditions, the short-circuit/protection simulation process can interface with an electromechanical transient simulation program such as PSS®E.

4) **Protection Analysis and Compliance Management:** The short-circuit/protection analysis tool is used to perform different types of studies – PRC compliance, protection coordination studies and protection security assessments, protective relay settings calculations, etc.

   The outputs of these studies have to be processed, managed, and tracked. Further, compliance reporting, protection security assessment reports, relay settings files, and reports for tracking short-circuit fault duties have to be generated.

   The Protection Analysis and Compliance Management (PACM) process can be used to perform these activities and generate different kinds of reports.

5) **Reporting:** Some of the typical reports created by the PACM process are:

   a) **PRC Compliance Reporting:** Creates auditable documentation as proof of compliance with PRC standards such as PRC 019, 023, 024, 025, 026 and 027.

   b) **Protection Security Assessment Reports:** Reports detailing the results of protection sensitivity and selectivity studies, identifying vulnerabilities in the protection system.

   c) **Relay Setting Files:** Files with relay setting data, calculated by the analysis tools. These files can be uploaded to the relays, and will also need to be uploaded to the relay asset database (2b) for data integrity.

   d) **Short-circuit Duty Tracking Reports:** PRC 027 requires utilities to track the changes to the short-circuit fault duties in their operating footprint. Reports tracking the changes will have to be created, and maintained as evidence of compliance with the standard.

**Automation as a Solution to the Data Management Problem**

The analyses performed by P&C engineers depends on data from different sources such as utility assets, protective relay assets, facility ratings database, line constants data, short-circuit model data and so on. Moving data from the sources to the tools that actually need them is typically performed in a manual fashion – a very resource-intensive and tedious task.

The analysis tools themselves (short-circuit programs, protection simulation programs) have built-in scripting capabilities for automating routine studies, and utilities have taken advantage of these features.
However, in the larger framework of interfacing with varied data sources, and in creating reporting and auditable compliance documentation, utilities still depend on a largely manual process.

Siemens’ vision is to automate as many of the data interfaces as possible – that is, introduce automation at the inter-process level so that data exchange between the sources of data and the tools that need it can take place efficiently and accurately.

The **Electrical Digital Twin Data and Repository** block in Figure 1 and the **Protection Analysis and Compliance Management** block in Figure 1 are examples of process automation. Some of the features that these tools need to be equipped with are:

1. Ability to understand a wide variety of database protocols and data formats (IPS, PowerBase, Cascade, etc.)
2. Ability to communicate with a wide variety of analysis tools (CAPE, ASPEN, CYME, PSS®SINCAL, PSS®E, etc.)
3. Ability to perform high-level protection security assessments based on raw data provided by the analysis tools, but at the same time, drill down into specific relay elements that are the source of the protection system vulnerability
4. Flexible reporting capabilities for generating different kinds of reports and for satisfying compliance documentation requirements
5. A database to store information about all the relevant studies so that the evolution of the utility’s power system, and protection settings can be easily tracked

While the broad requirements that the process automation tools have to satisfy are well understood, the utility-specific requirements and details need a deeper discussion with various utility stakeholders at different levels. One major problem that we have dealt with in the past is the lack of a consistent method for numbering and naming different objects so that an automated approach will work accurately. Often, a company-wide change might need to be mandated by management to take advantage of the benefits of automation.

We are happy to discuss your specific needs, and share additional details of some of our solutions.