Process Improvement of Distribution Protective Relays Coordination

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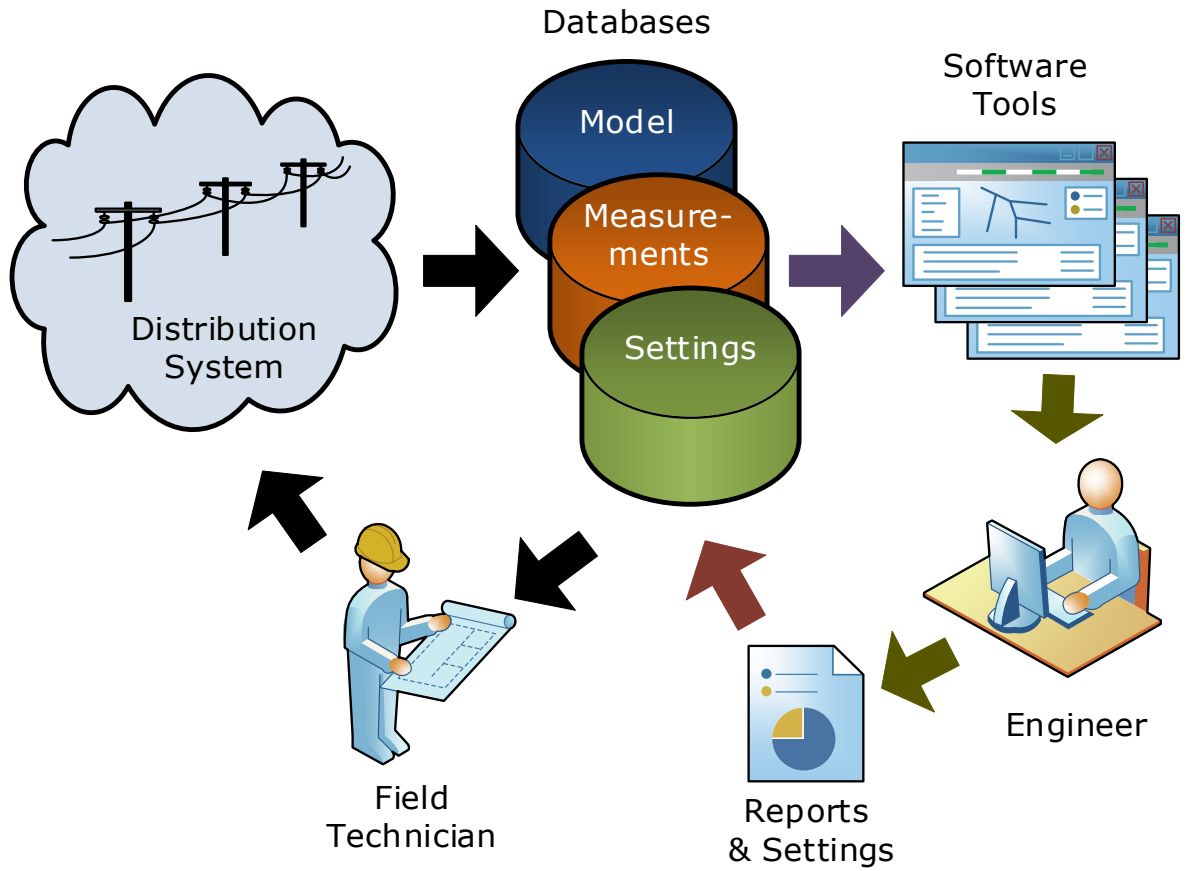
Introduction

- 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

Power System Protection Modeling and Studies

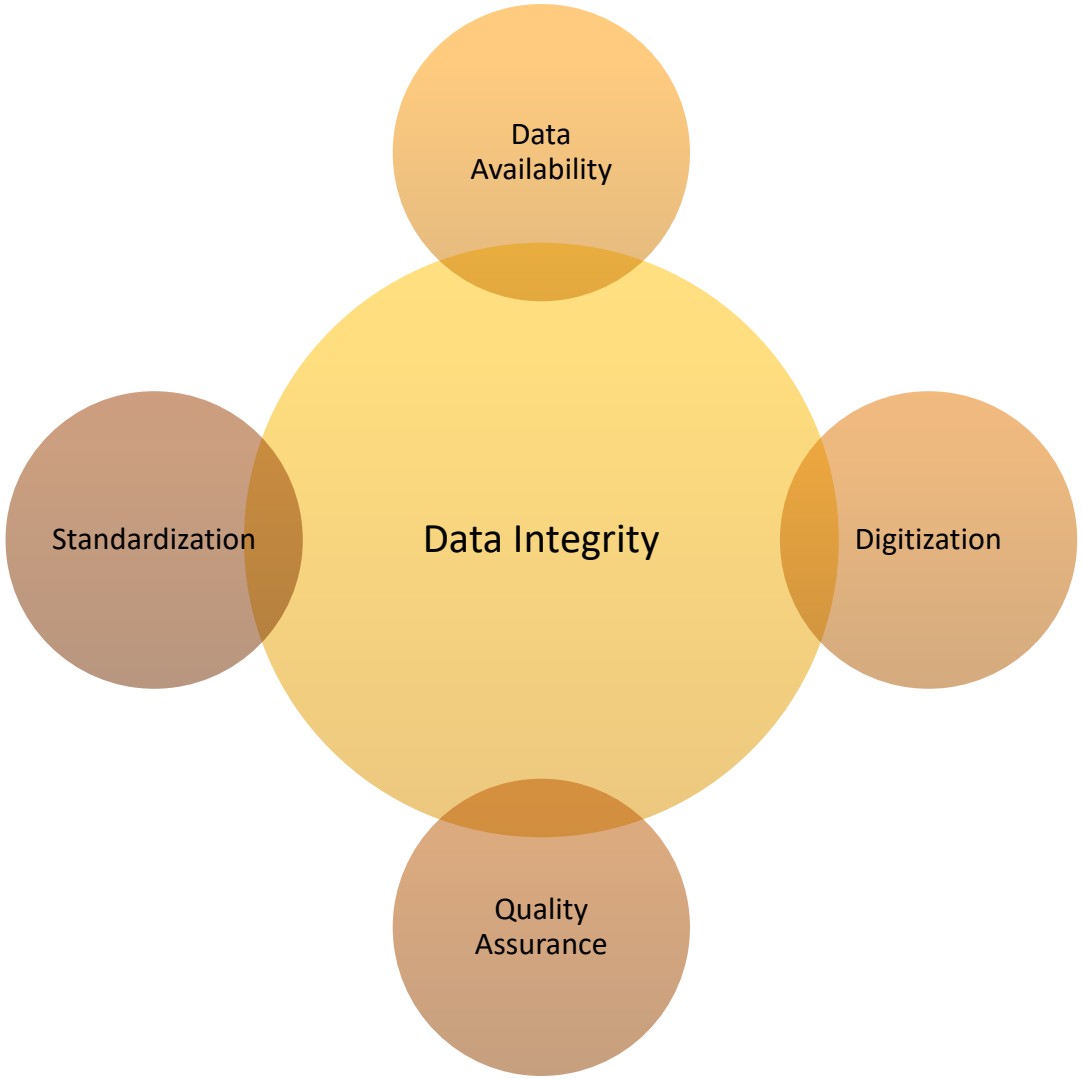
- Distribution protection study process
  - Data gathering (model, settings, etc.)
  - Modeling (primary system, protection)
  - Running studies (short-circuit, etc.)
  - Reviewing results
  - Reporting
  - Repeat!
- Examples
  - Damage-curve and arc-flash
  - Substation relays coordination
  - Relays pickup settings comparison with load



These tasks are typically performed manually as separate processes

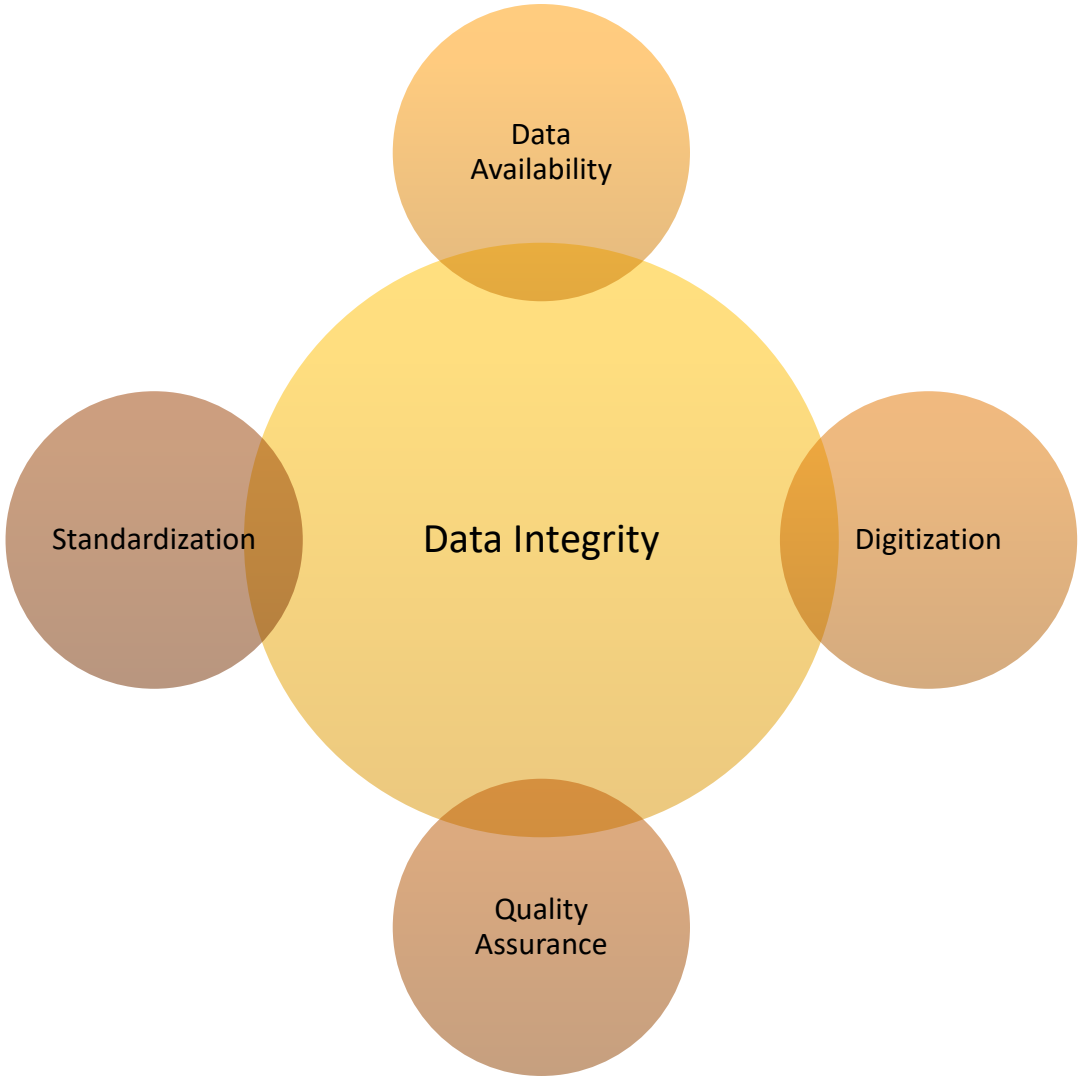
Data Integrity for Power Systems Studies

- 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

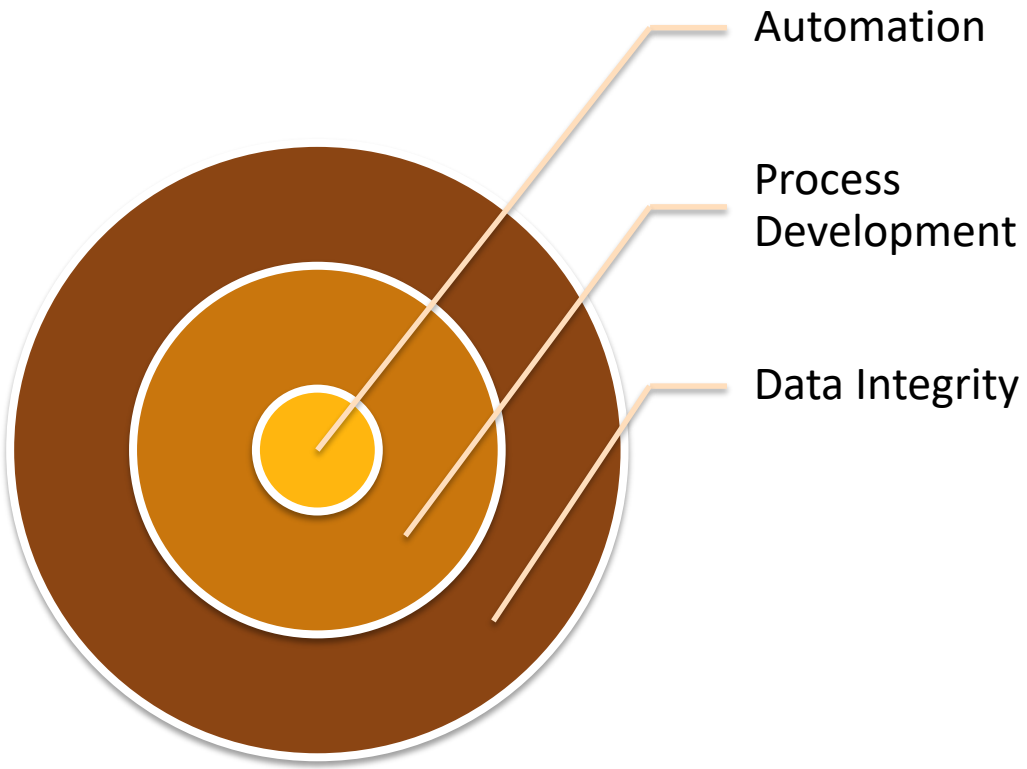
  Short-circuit analysis, relay software, protection curves, reporting
- Use tools efficiently
  - Review tool functionalities
  - Use interfaces and automation capabilities to transfer data
  - One main tool others as resources

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

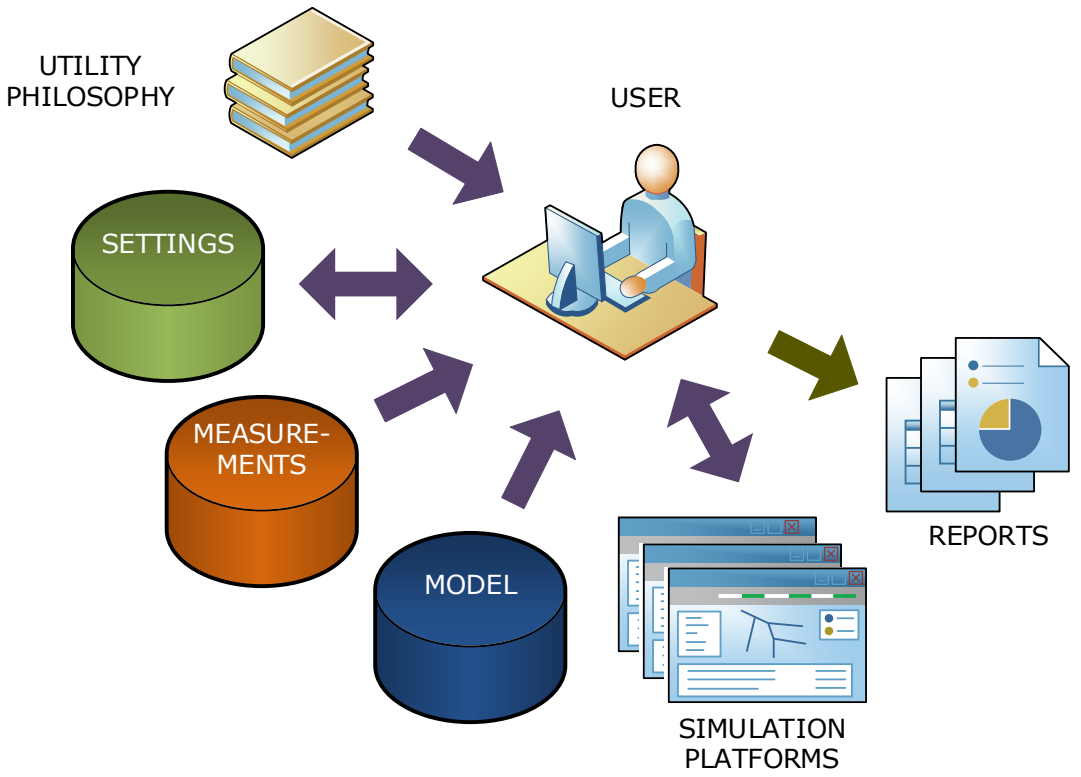
Steps Toward Efficient Systems Studies

- 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 protentional 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

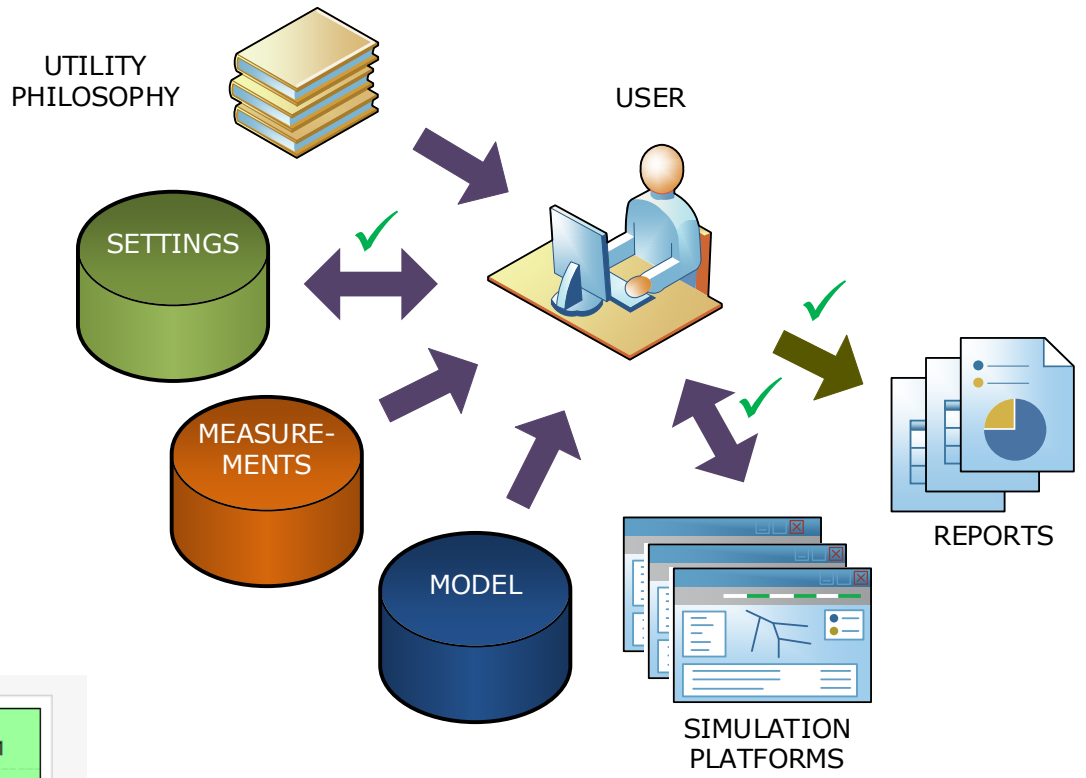
- User interacts with multiple data sources:
  - Model Database (network model, equipment sizes, etc.)
  - Measurements Database (historical load and fault data)
  - Relay Settings Database
- And multiple tools
  - Short-circuit studies
  - Protection modeling (curves, current/time calculations)
  - Reporting
- One or more steps automated at each example

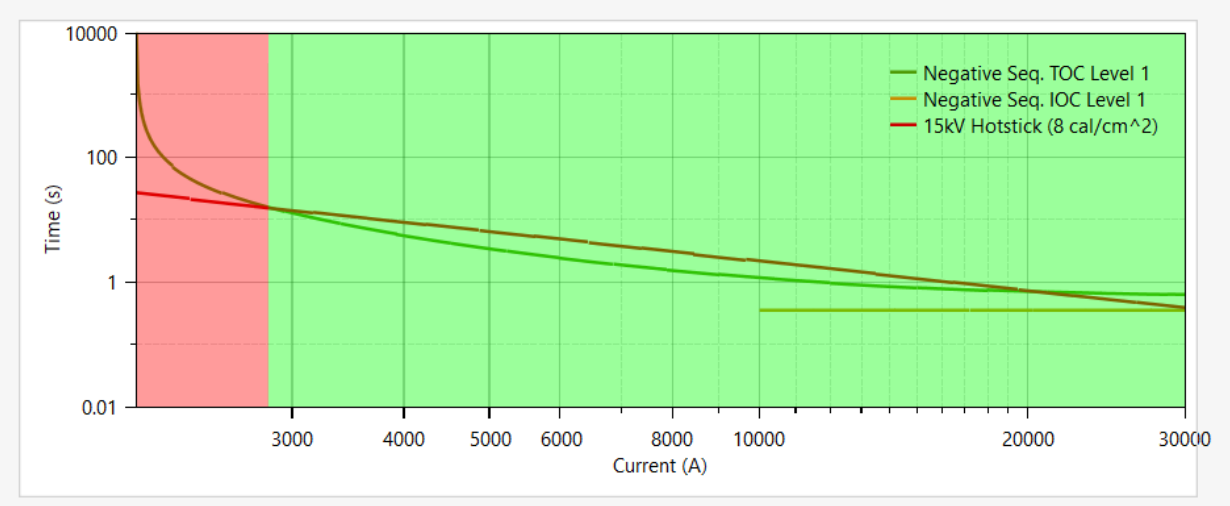


Implementation Examples

Automation-Assisted Damage-Curve and Arc-Flash Studies

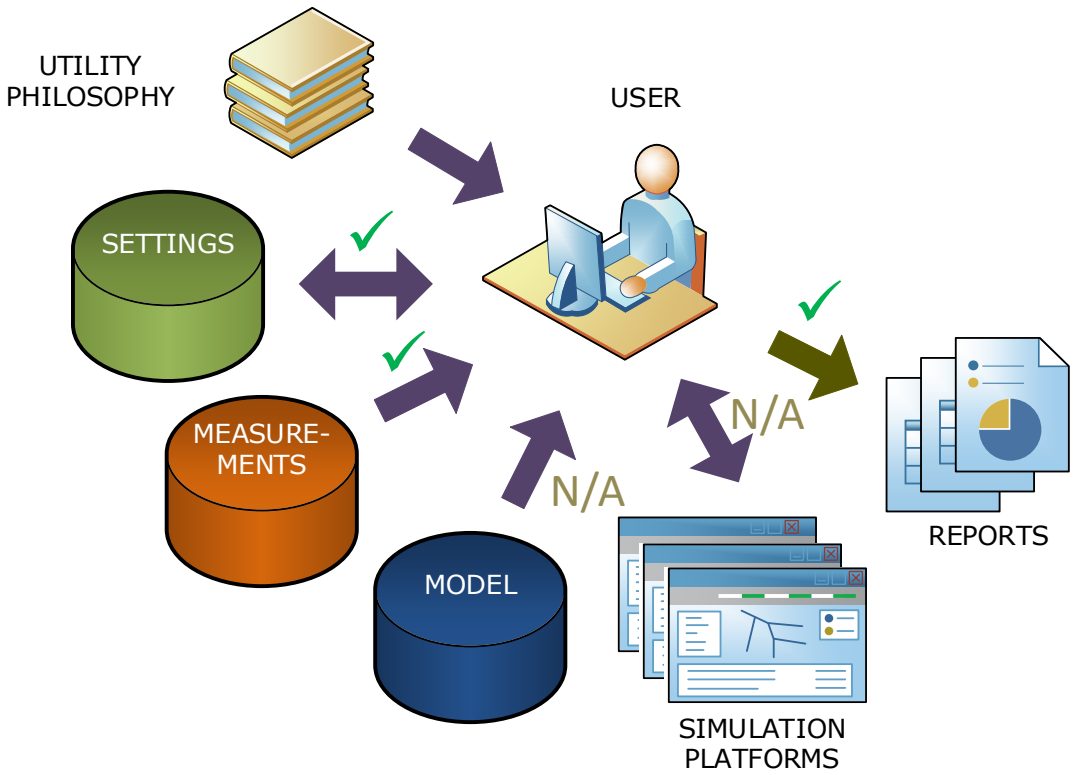
- Automatic parsing and extraction of protective relay settings
- Creating a library of damage curves and protective relay curves
- Automatic drawing of protective device curves and comparing them
- Automatic importing of fault-duties from the short-circuit program

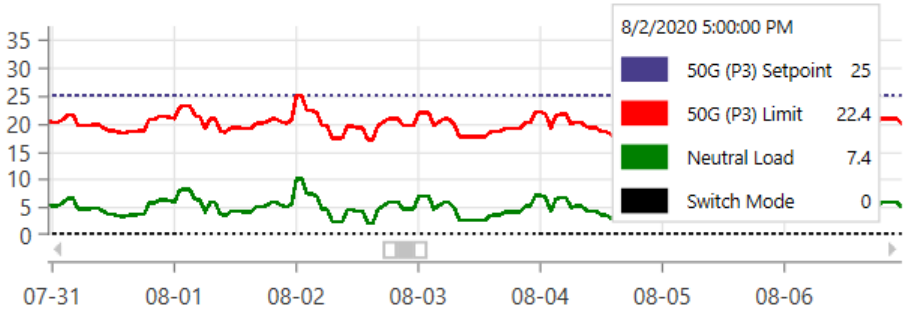




Relay Pickup Settings Comparison with Historical Load Data

- 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





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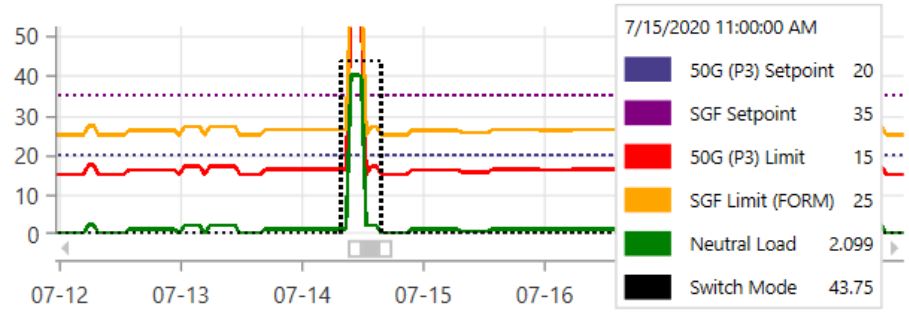

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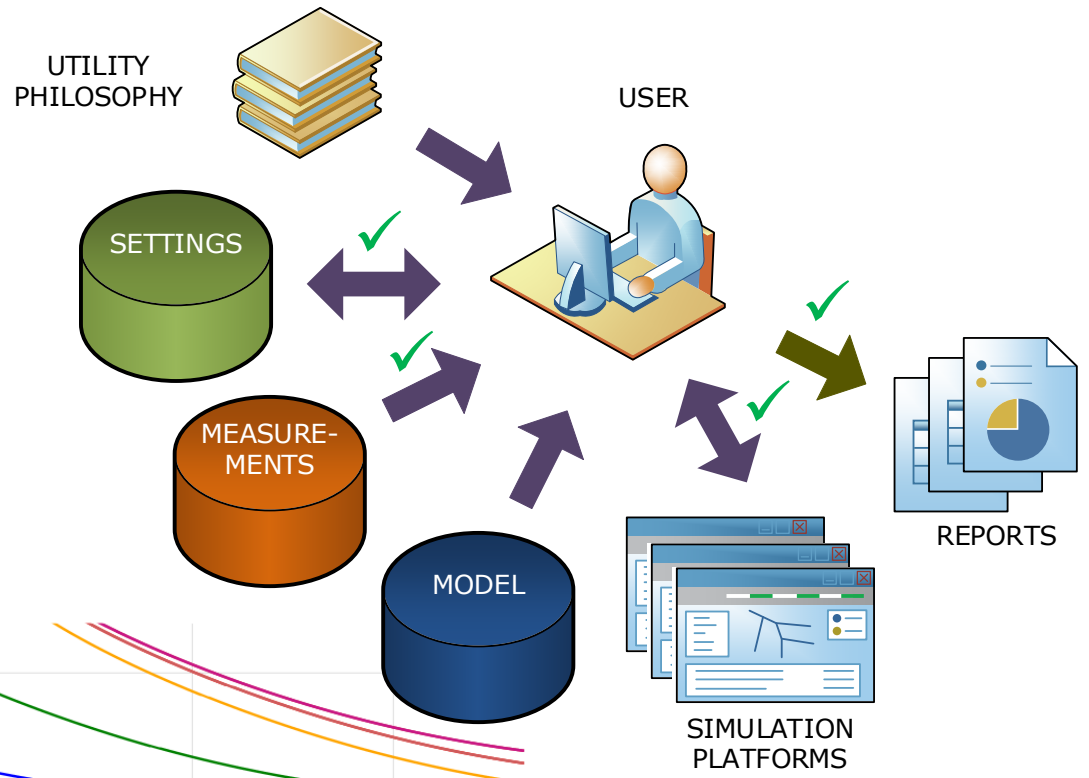
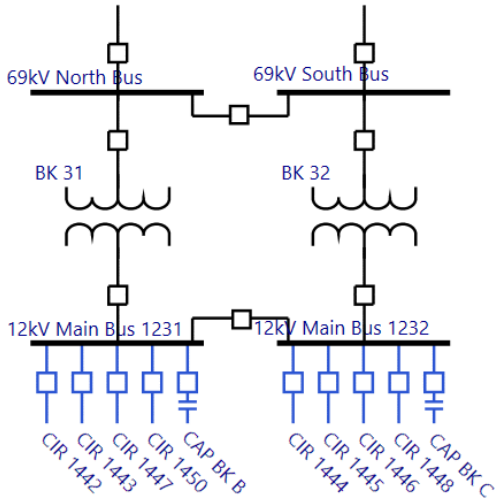
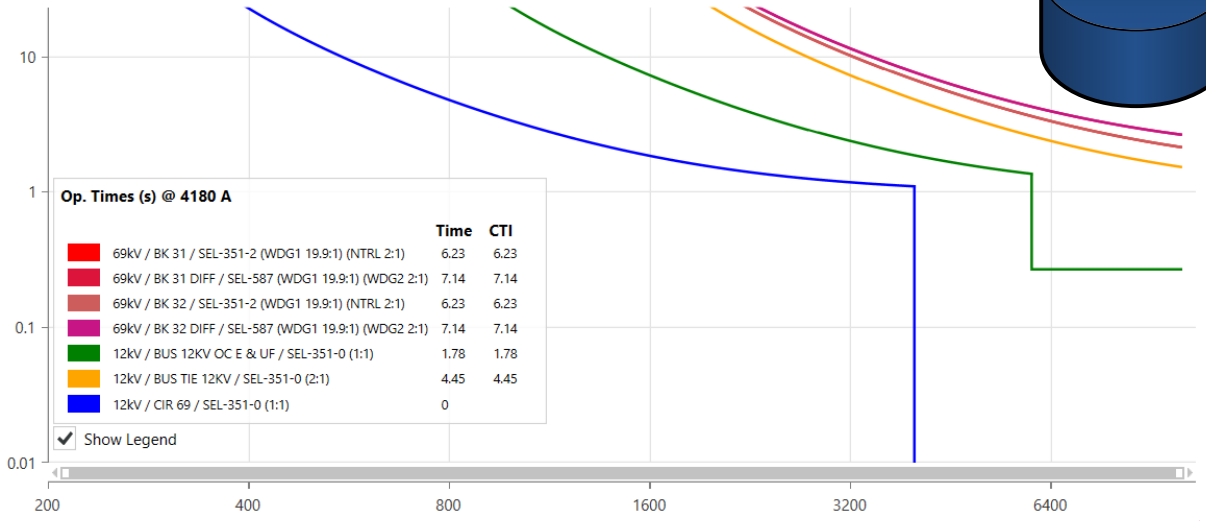
Distribution Substation Coordination

- 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!