Applying Substation Linear State Estimator to Instrument Transformer Health Monitoring and Management: Roadmap

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Executive Summary

- **Instrument Transformers (ITs) and Intelligent Electronic Devices (IEDs) are critical in day-to-day power system operation**
- **AEP proposes a roadmap to establish continuous IT & IED output monitoring at the station level using Synchrophasor-based Substation Linear State Estimator (SLSE) technology to asses the “health” of these devices**
- **The system envisioned would help prevent equipment failures, relay miss-operation, forced outages, and improve employee safety**

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Background

- **AEP exploring and implementing technologies for Asset Health Monitoring**
  - **Transition to condition based maintenance**
  - **Anticipate equipment failures and avoid their associated risks and costs**
- **Monitoring programs for major ($) assets underway**
  - **Transformers and Circuit Breakers**
- **Exploring cost-effective solutions for lower $ assets that can affect system reliability as much or more than bigger $ assets**
  - **ITs and IEDs/Relays**

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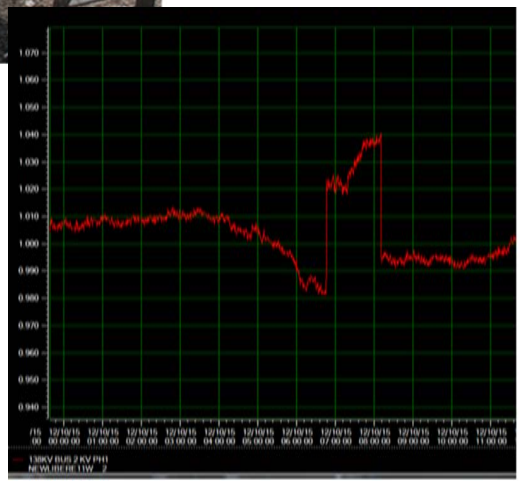
ITs and IEDs

- **Instrument Transformers (ITs)**
  - **Devices used to capture the voltage and current flowing through different paths in a station**
    - **Coupling Capacitor Voltage Transformers (CCVTs), Potential Transformers (PTs), Current Transformers (CTs)**
  - **Many of them located throughout a station**
  - **Measure at full scale and step-down to a level IEDs can accept**
- **Intelligent Electronic Devices (IEDs)**
  - **Receive voltage and current inputs from ITs**
  - **Process these inputs to serve multiple functions**
    - **Protection, Monitoring, Alarming**
  - **Can be end-user configured or programmed**

Problem Indicators

- **Physical**
  - **Leakage of insulating medium (oil or gas)**
  - **Violent destruction**
  - **No apparent issue**
- **Virtual**
  - **Intermittent or chaotic signals or outputs**
  - **Expected output signals deviate vs reference signals**



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Failure Detection Methods

- **Cross checking primary and backup IT outputs for deviation vs one-another**
  - **Requires additional work to determine which one is the "bad one"**
- **Reviewing IT outputs to identify step changes**
  - **Requires additional work to determine if it is truly an instrument issue or a system perturbation**
- **IED internal alarming functions**
  - **Can generate too many notices**
- **After an event occurs, investigating miss-operation or non-operation of IEDs**
  - **Too Late**

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Proposed Approach

- **A Synchrophasor-based Substation Linear State Estimator (SLSE)**
  - **Requires time-synchronized measurements and large amount of local measurements to meet observability requirement**
- **Key Advantages**
  - **Detects and identifies the specific component with the issue**
  - **Automatically accounts for measurements taken during power system perturbations**

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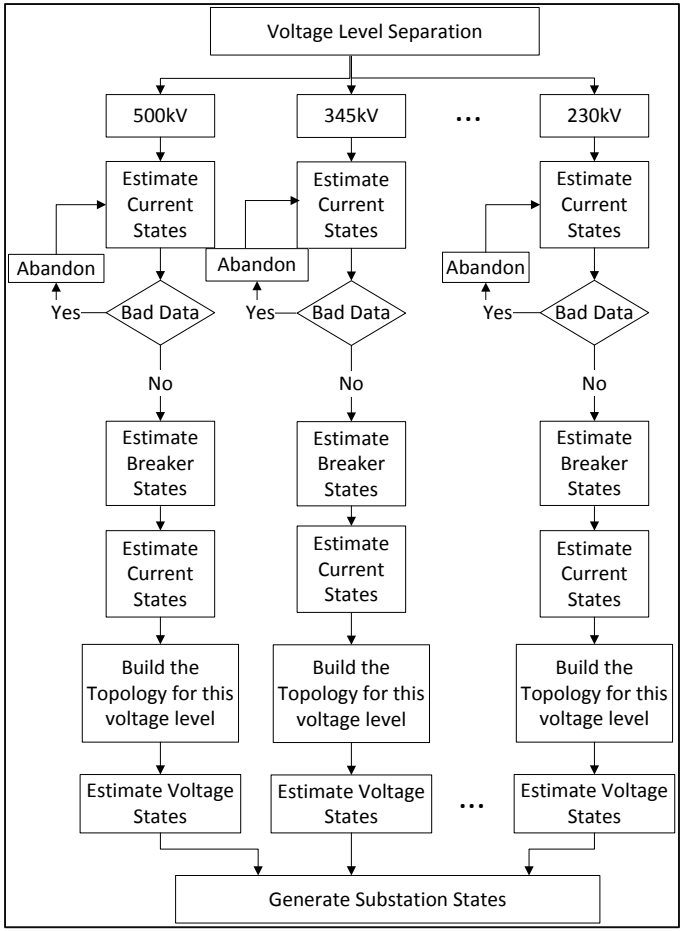
How It Would Work

- **Pre-requisites**
  - **Each station voltage level is handled separately**
  - **Current and voltage handled separately**
- **Steps**
  - **Station current state estimation**
  - **Verify circuit breaker statuses**
  - **Station topology is defined**
  - **Voltage state estimation**
  - **Calculated substation states and station topology feed a “bad data” processor**



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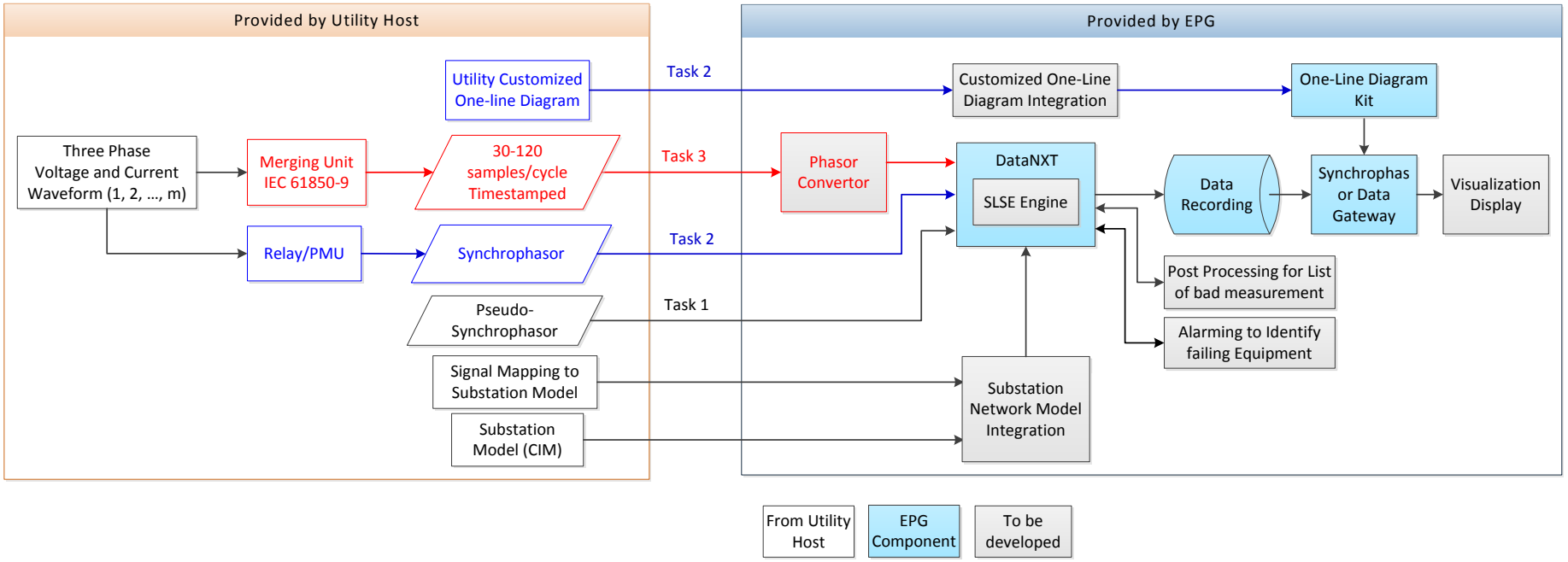
Implementation Roadmap

- **Working with Electric Power Group (ePG) to implement**



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Next Steps

- **Pending notification from DOE on FOA proposal related to “Synchrophasor Applications and Tools for Reliability and Asset Management”**
  - **Develop, pilot, and implement commercially the concept outlined in the paper**
- **Integration of this tool into AEP’s existing Asset Health Center platform**

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QUESTIONS?

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