The Grid Event Signature Library (GESL)

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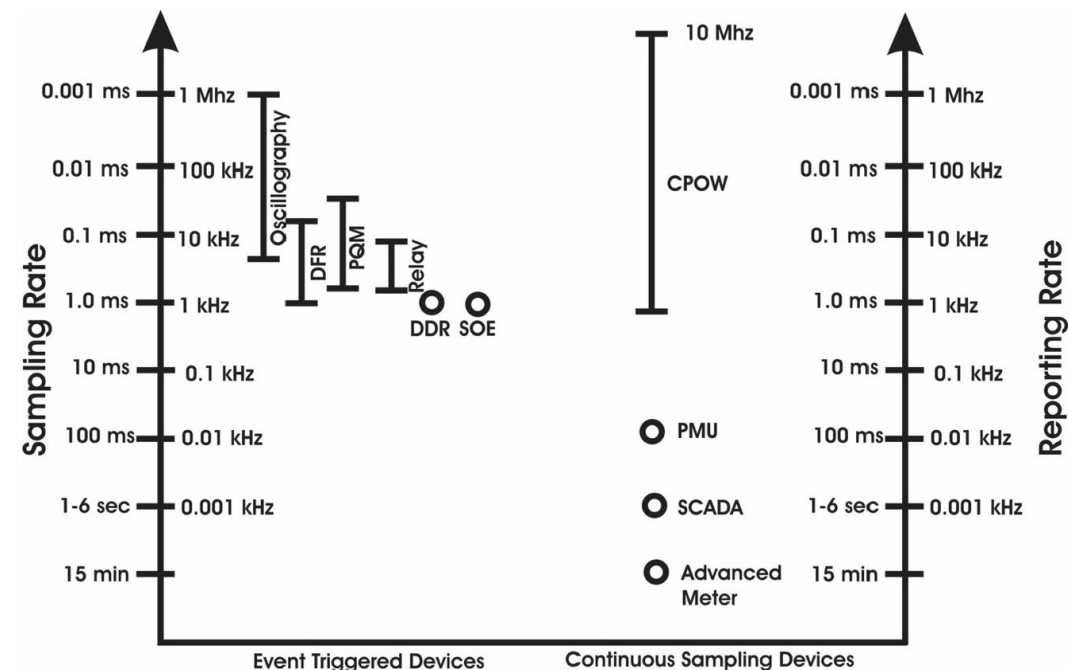
[†] Pacific Northwest National Laboratory

U.S. DEPARTMENT OF ENERGY

Towards more observable grid

- Event triggered measurements
  - Relays
  - Digital fault recorders
  - Power quality meters

- Continuous measurements
  - SCADA
  - AMI (advanced metering infrastructure)
  - PMU (phasor measurement unit)
  - Point-on-wave (POW) measurements

- Event records
  - Outage and maintenance records
  - Device activation records

Grid Monitoring devices by resolution and data continuity[*]

[*]A. Silverstein and J. Follum, "High-resolution, time-synchronized grid monitoring devices," PNNL, Tech. Rep. PNNL-29770, Mar. 2020.
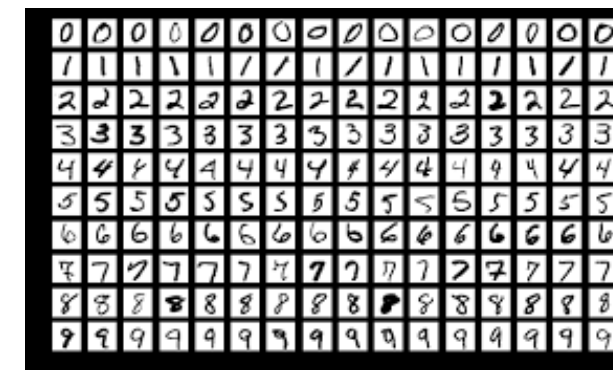
AI/ML-based Grid Health Monitoring

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But still one step away

- Data labeling is critical to AI/ML
  - MNIST
  - ImageNet
  - BTO Building Benchmark Datasets

- Challenges exist for grid events
  - Data is decentralized and inaccessible
    - Limits actionable data available for analytics
  - Data is multimodal and unstandardized
    - Prevents integration of different data sources
  - Data is unprocessed and unvalidated
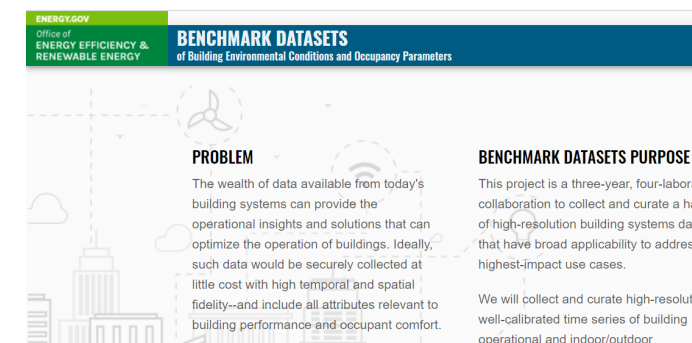   - Lacks critical metadata and proper labeling

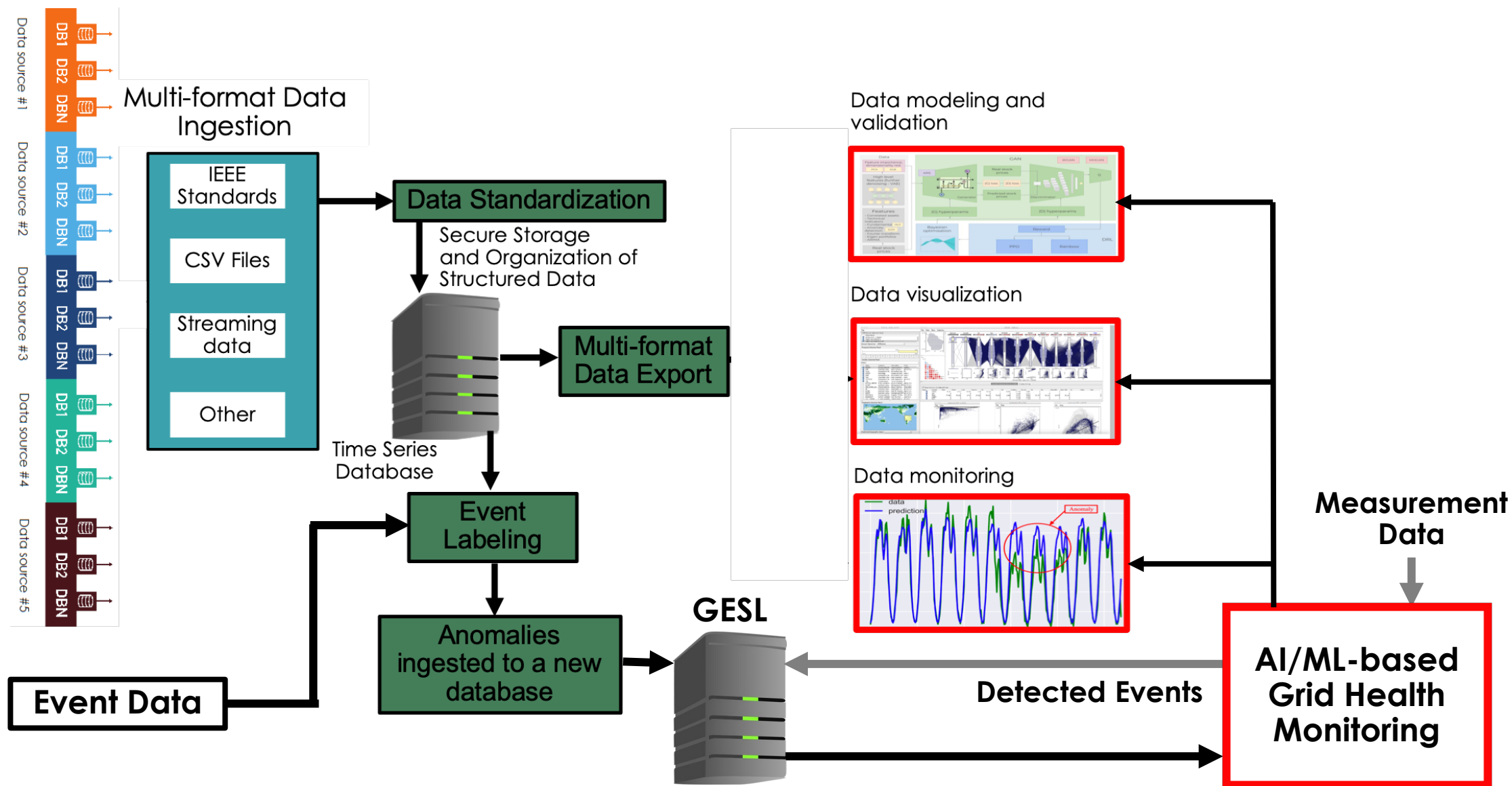THE MNIST DATABASE
of handwritten digits

http://yann.lecun.com/exdb/mnist/

https://syncedreview.com/

BENCHMARK DATASETS
of Building Environmental Conditions and Occupancy Parameters

PROBLEM

The wealth of data available from today's building systems can provide the operational insights and solutions that can optimize the operation of buildings. Ideally, such data would be securely collected with little cost with high temporal and spatial fidelity--and include all attributes relevant to building performance and occupant comfort.

BENCHMARK DATASETS PURPOSE

This project is a three-year, four-laboratory collaboration to collect and curate a hand of high-resolution building systems dataset that have broad applicability to address highest-impact use cases.

We will collect and curate high-resolution, well-calibrated time series of building operational and indoor/outdoor

https://bbd.labworks.org/

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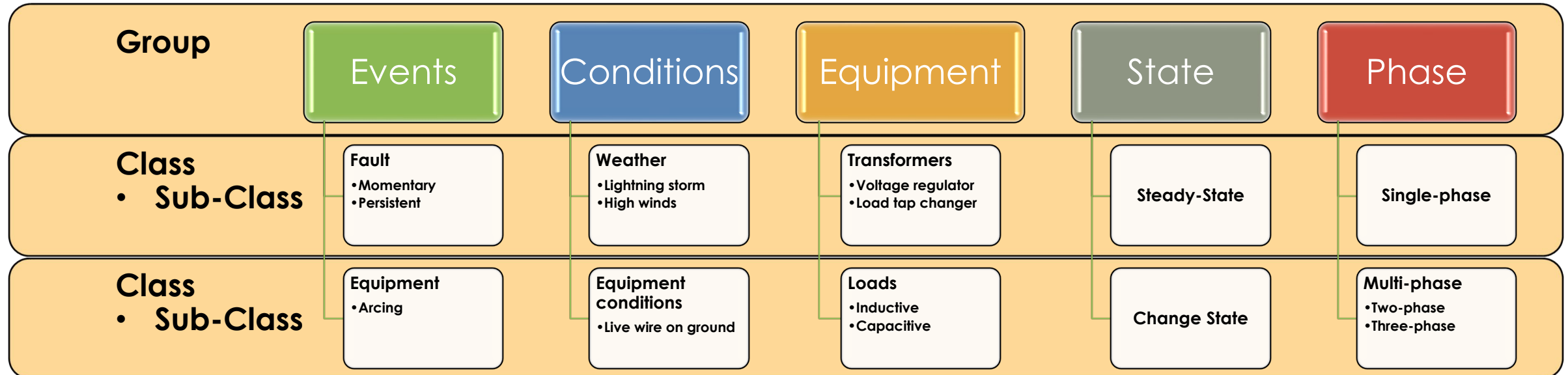# Project Overview

- ORNL, LLNL, and PNNL, funded by DOE Office of Electricity, partnered to develop an open-source <u>G</u>rid <u>E</u>vent <u>S</u>ignature <u>L</u>ibrary (GESL)
  - Measurement data: raw data with signatures yet to be extracted
  - Signature data: labeled events with data provided in specific formats

- Goal
  - Facilitate, tag and fuse data feeds from multiple sources
  - Implement a modular architecture for expandable design
  - Anonymize event sources to enable open data sharing
  - Provide go-to resources for event detection and algorithm validation

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Library Framework

Hierarchical Event Tagging

- Useful for grouping similar types of disturbances
  - Avoids long list of unique disturbance types/conditions

- Flexible & expandable
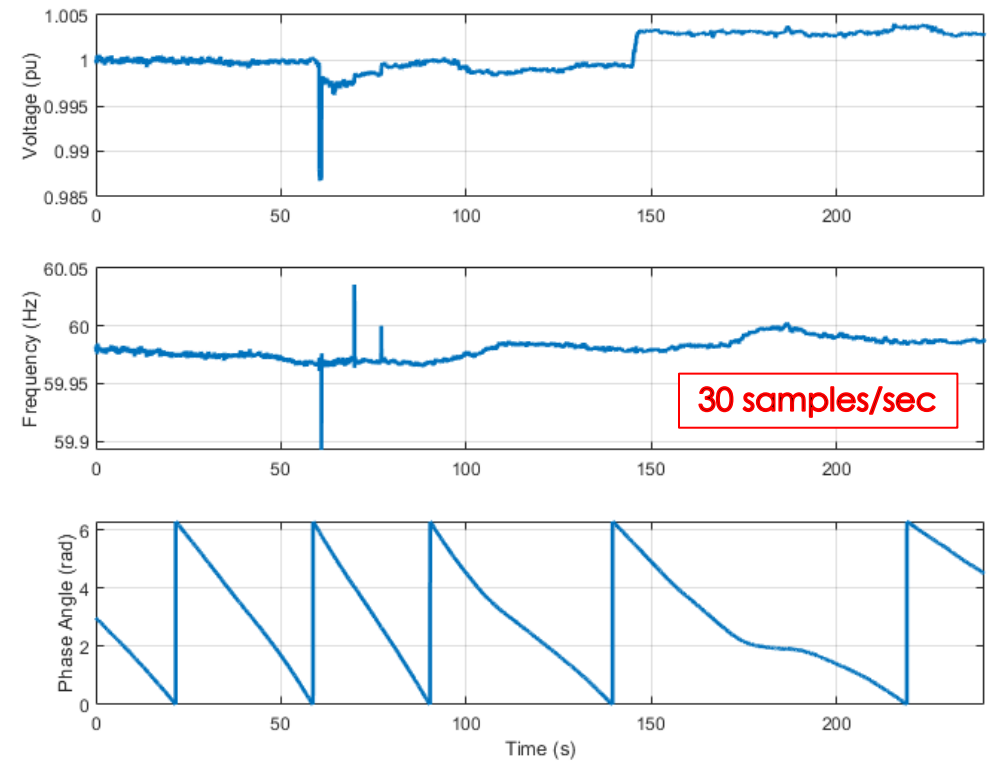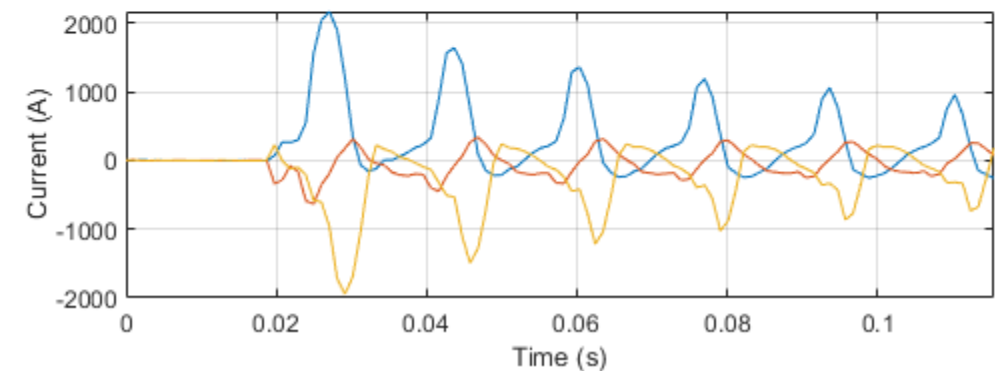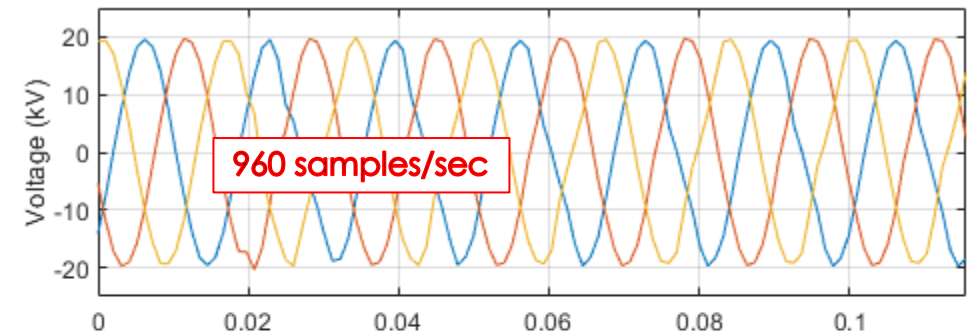 - creating entirely new entry when adding new disturbances

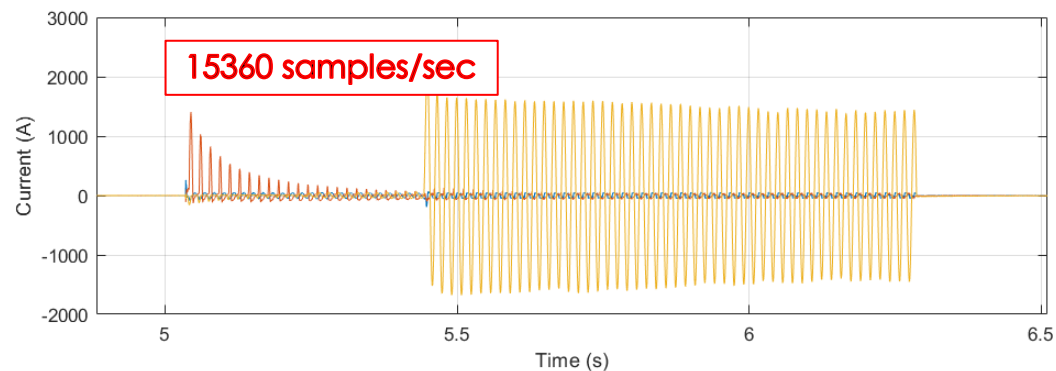| Group	Events	Conditions	Equipment	State	Phase
Class • **Sub-Class**	**Fault** •Momentary •Persistent	**Weather** •Lightning storm •High winds	**Transformers** •Voltage regulator •Load tap changer	Steady-State	Single-phase
Class • **Sub-Class**	**Equipment** •Arcing	**Equipment conditions** •Live wire on ground	**Loads** •Inductive •Capacitive	Change State	**Multi-phase** •Two-phase •Three-phase

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Data Sources – PMU Examples

Distribution level - FNET

Transmission Level - Anonymized

10 samples/sec

30 samples/sec

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Data Sources – PoW Examples

User Interface – https://gesl.ornl.gov

User Interface – Dashboard Search Capabilities

User Interface – Visualization
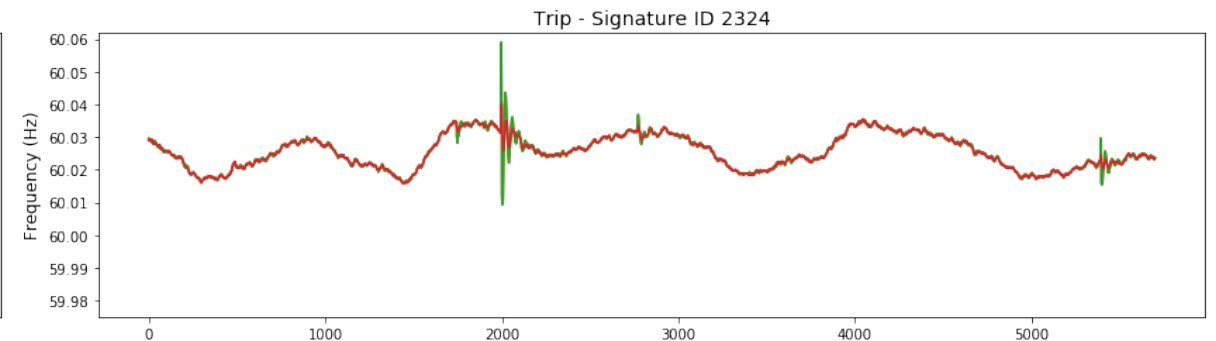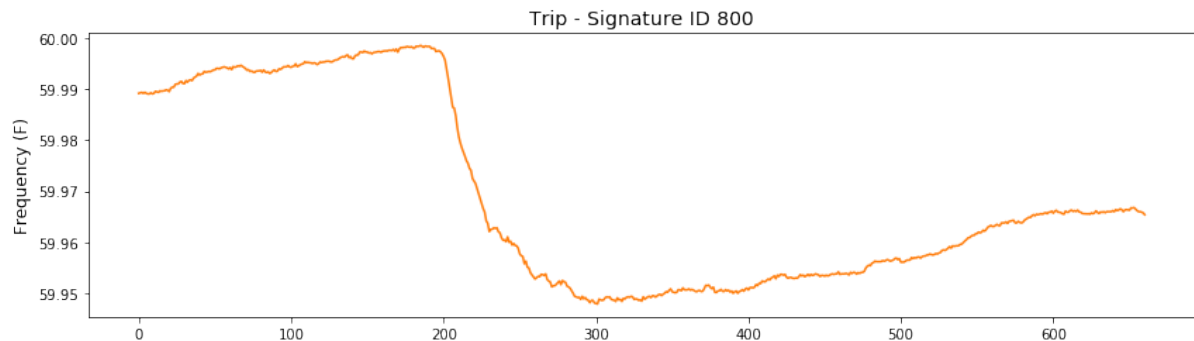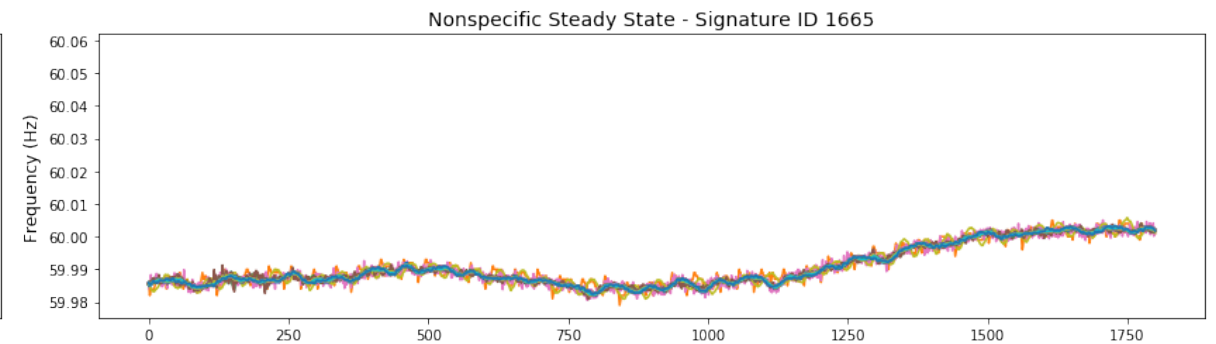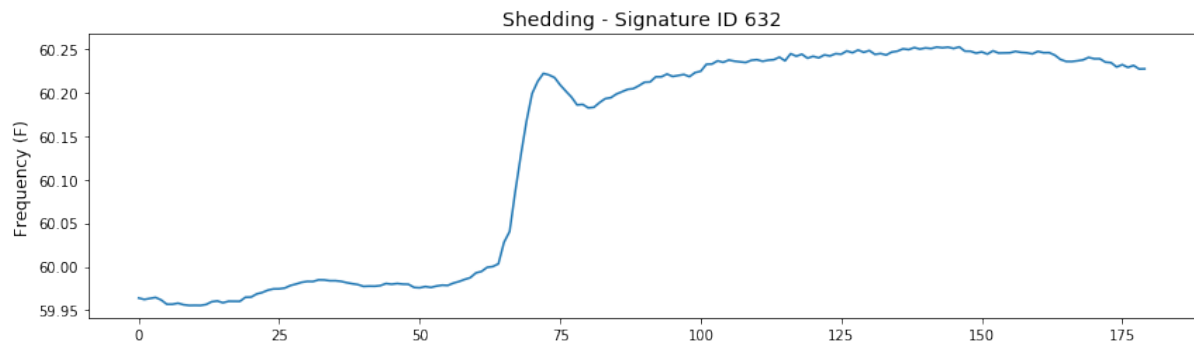
Signature Matching Tool

Signature matching tool for GESL

- Objective:
  to provide a basic functionality to identify unlabeled signatures/unknown events based on the repository of labeled events

- Use cases
  - Identify captured event measurements
  - Classify events from different sensor measurements
  - Identify incipient failures

- Approach
  - Pre-processing of signatures
    - Standardization of signatures
  - Feature extraction
    - Statistical moments, frequency-domain analysis, dimension reduction, etc.

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Classification and device types

- Binary classification of phasor measurement events
- Binary classification yields higher accuracy than multiclass classification
  - Multiclass can be cast as series of binary

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Planned Additions to GESL

- Expanding website design team

- API for accessing/downloading data programmatically

- Inclusion of a user community forum

- Visual analytics capabilities

- "Examples" page for exemplary algorithms developed using GESL data

- Etc…

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Thank you!

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If you are interested in joining our Working Group, please reach out to one of the contacts listed here.

See our panel at the IEEE PES General Meeting in Orlando on July 19!