

Coordination and Augmentation Requirements for AI/ML in Distribution Waveform Analytics

North American Synchrophasor Initiative (NASPI) 2025 Fall Conference

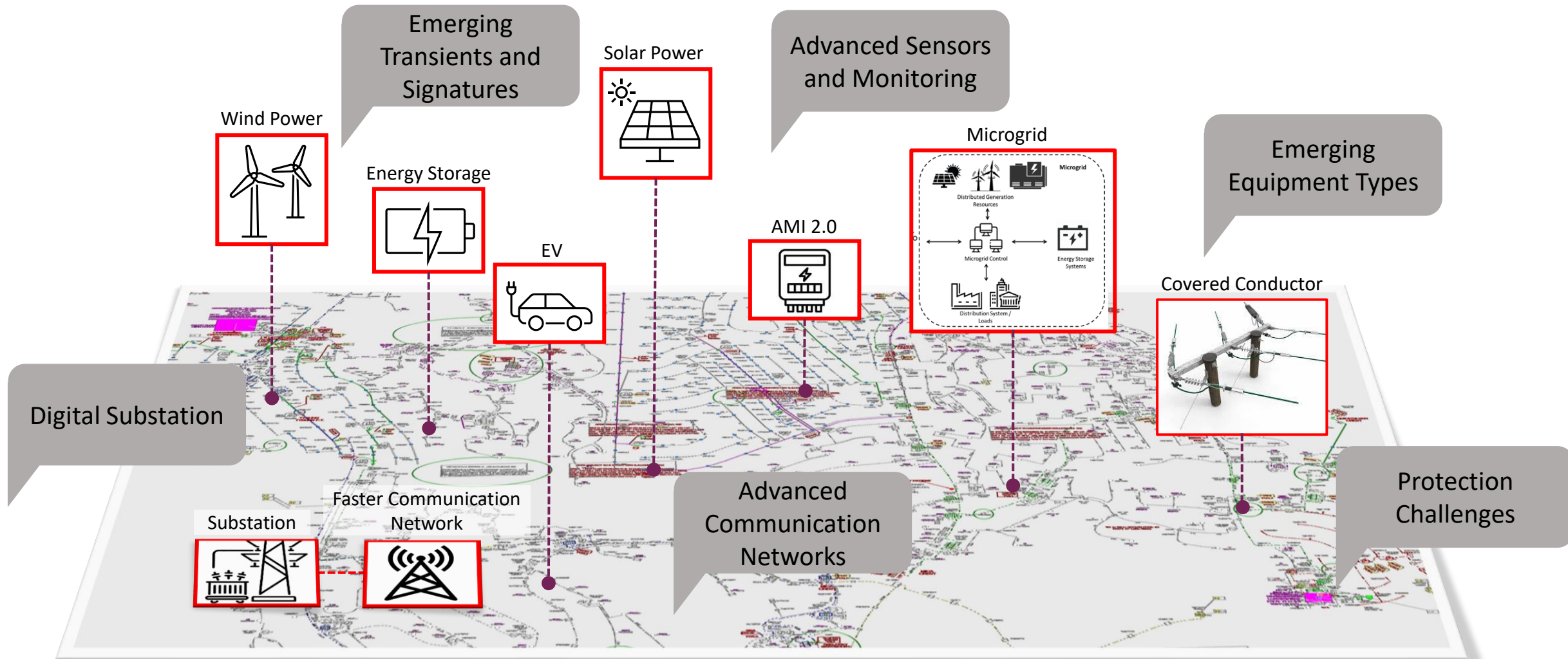
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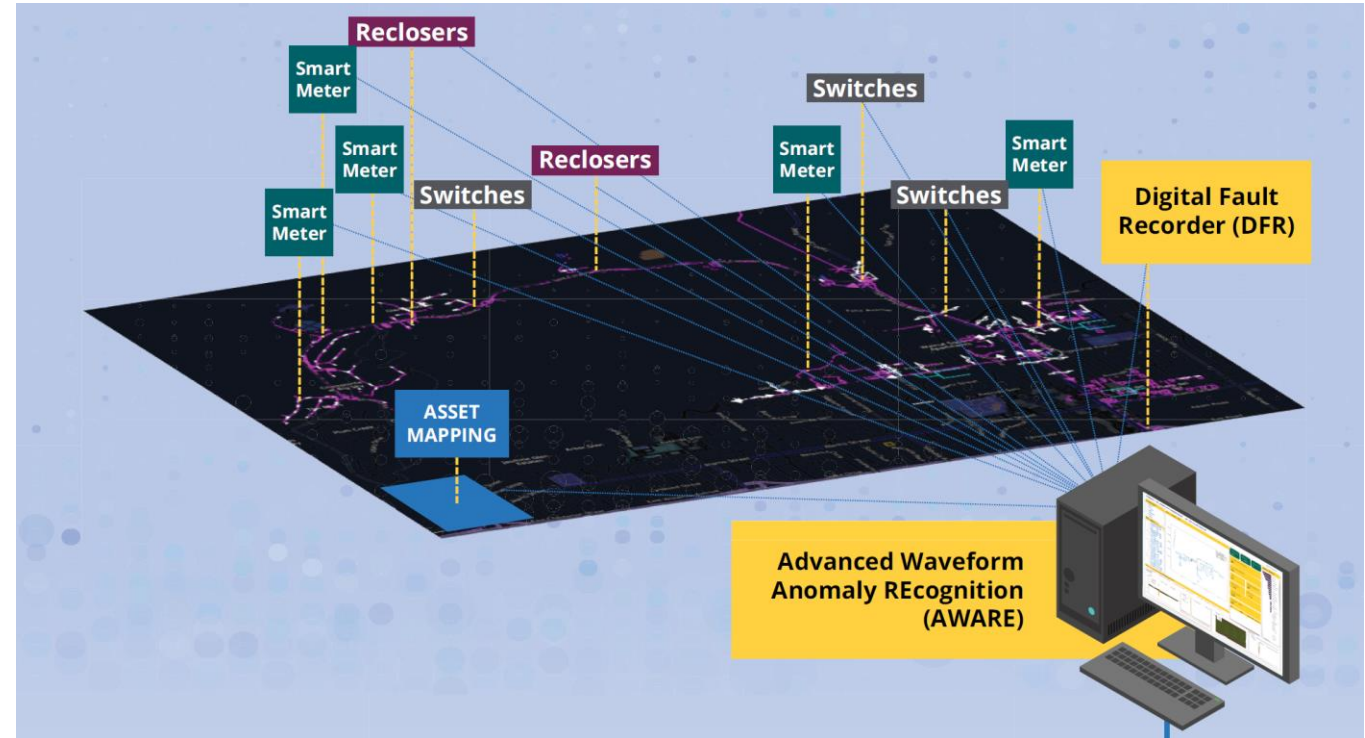
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Emerging Distribution Grid – Visibility and Synchro-waveforms



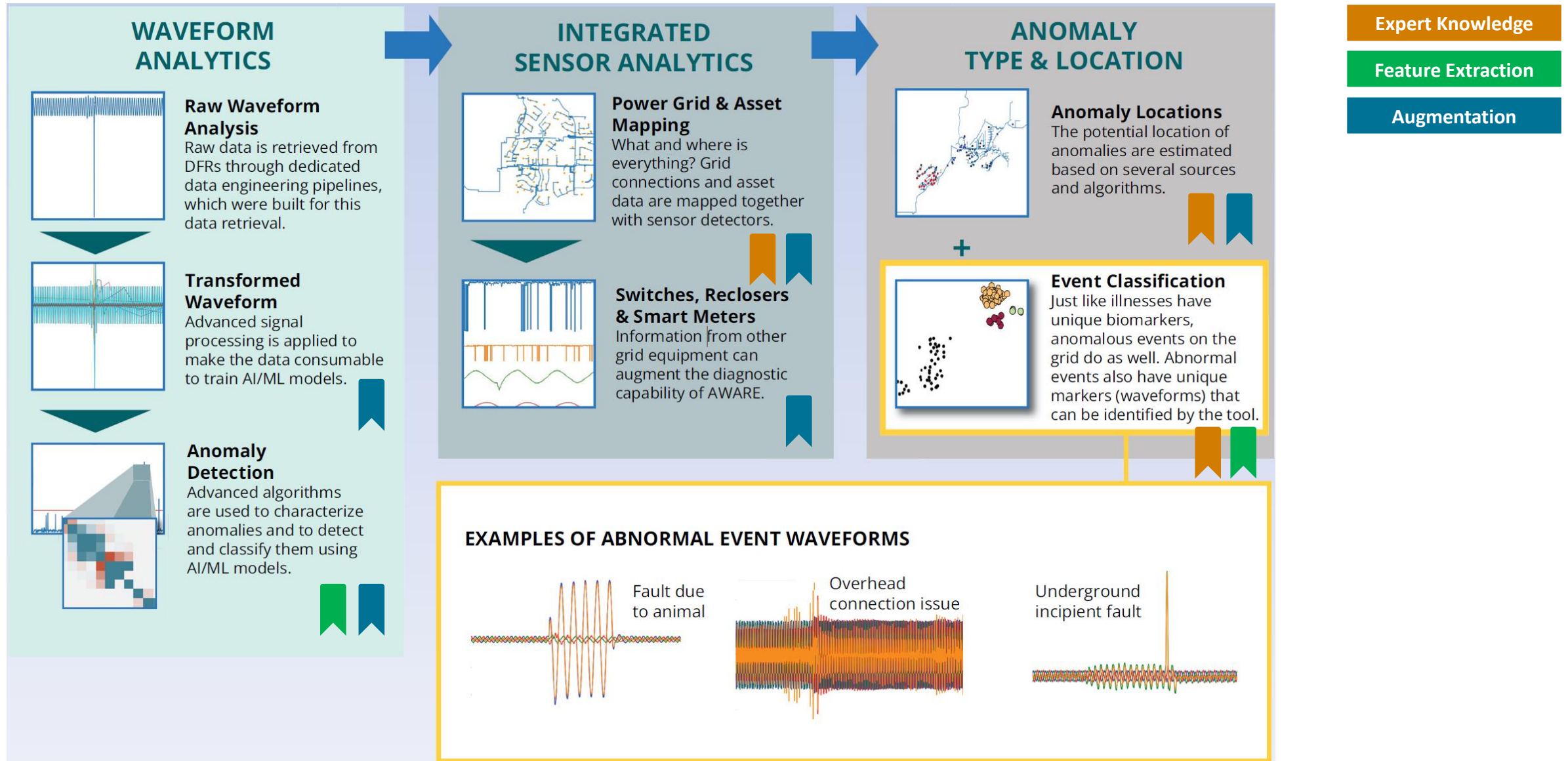
Advanced Waveform Anomaly Recognition (AWARE) at SCE

- **What is it** – In-house suite of advanced fault modeling, signal processing algorithms, and machine learning models designed to utilize high-fidelity waveform recordings at the substation, advanced metering infrastructure (AMI) information, grid models, and SCADA data in real-time to detect signs of equipment failure and estimate their locations to aid fast, proactive, and safe field investigations. A built-in interactive panel features event analytics visualization and circuit layout displays estimated fault locations.
- **What does it do** – The dashboard and alerts are used for fault event analysis and troubleshooting purposes and field operations. These events include incipient faults, UG vs. OH identification, no cause found issues, capacitor bank issues, etc.
- **What are its impacts** – This tool will provide early detection and informed response. This fills a previous operational gap that have not had visibility (e.g. underground signature detection, and incipient faults), additionally improving crew safety and mitigation capabilities.

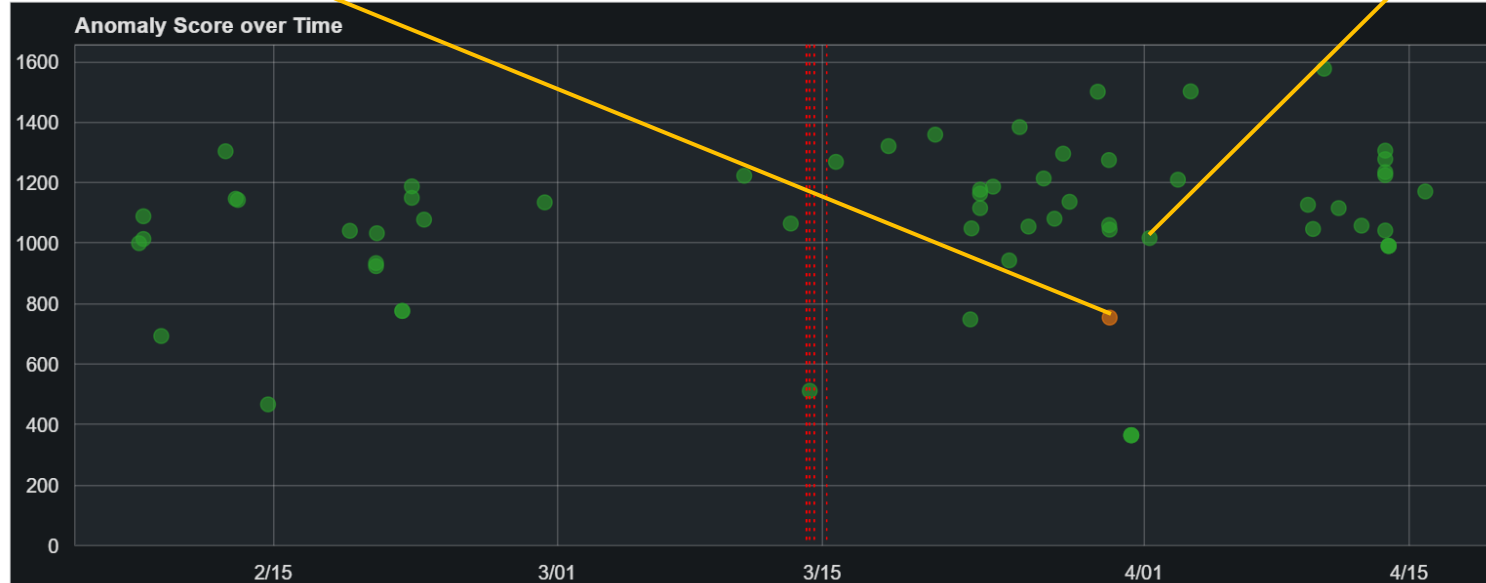
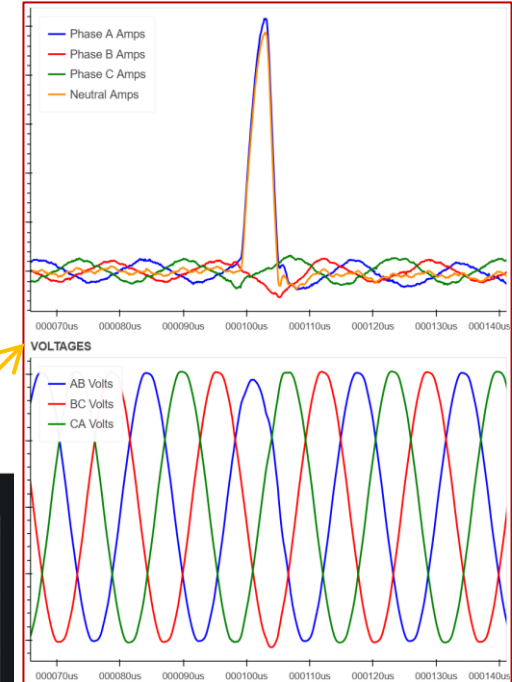
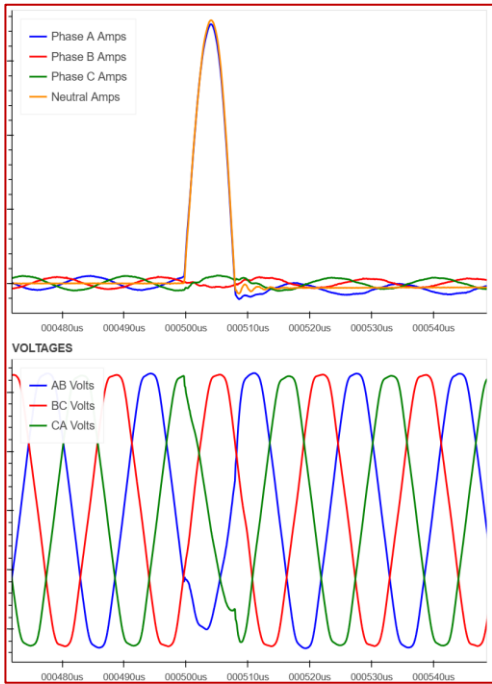


The fault-finding software connects to waveform recorders, grid-edge sensors, grid model, grid device status and metadata in real-time and runs targeted analytics to detect anomalies and estimate their location.

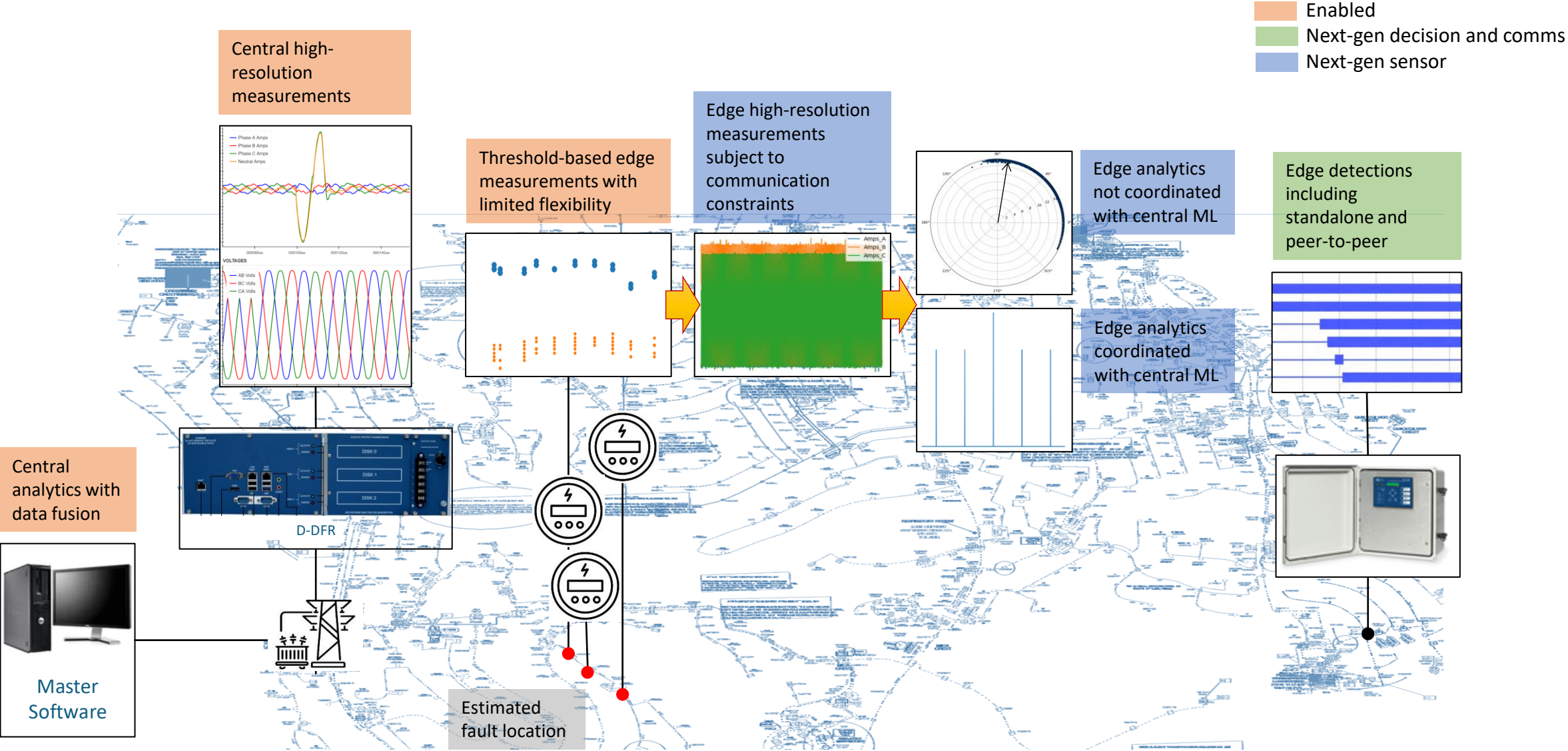
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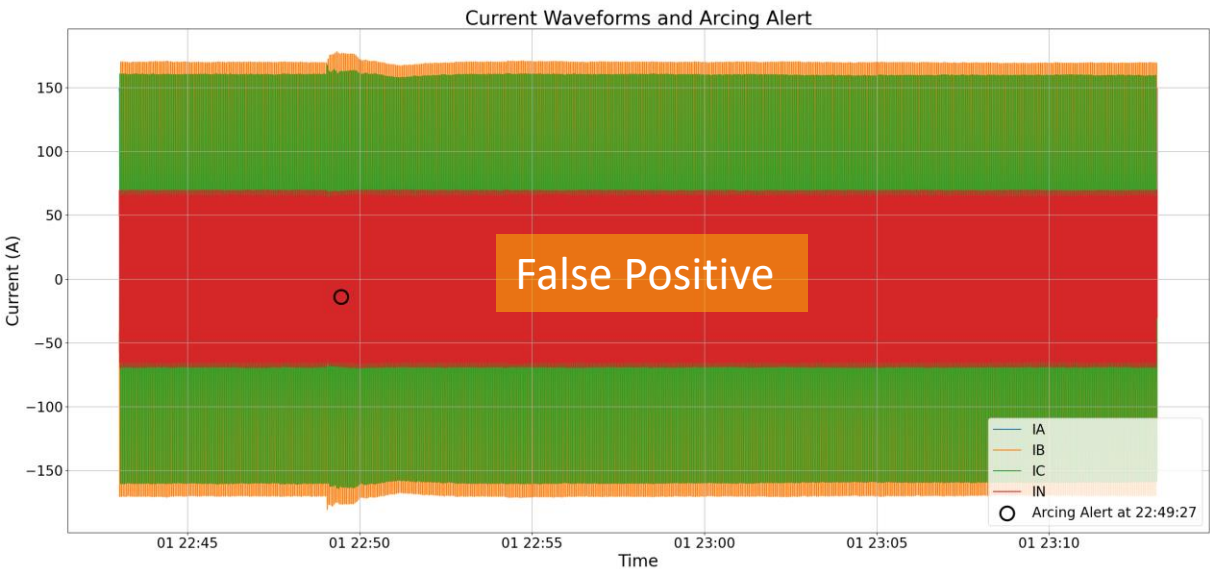
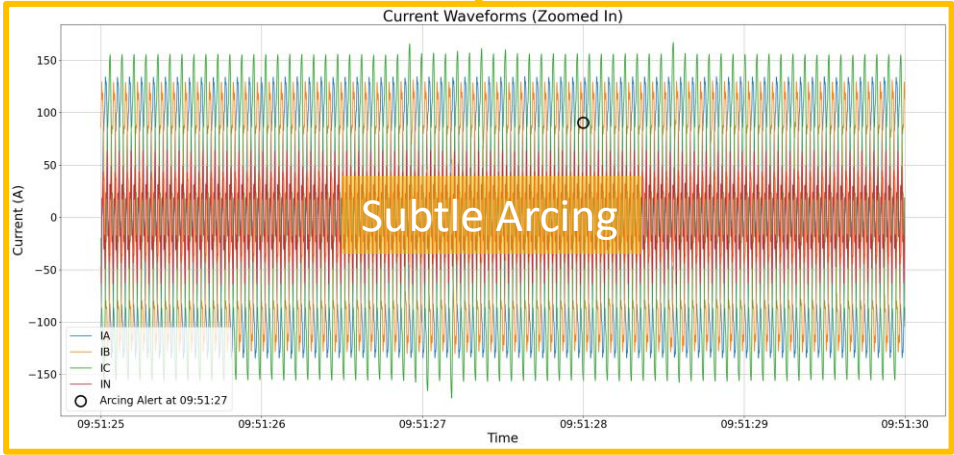
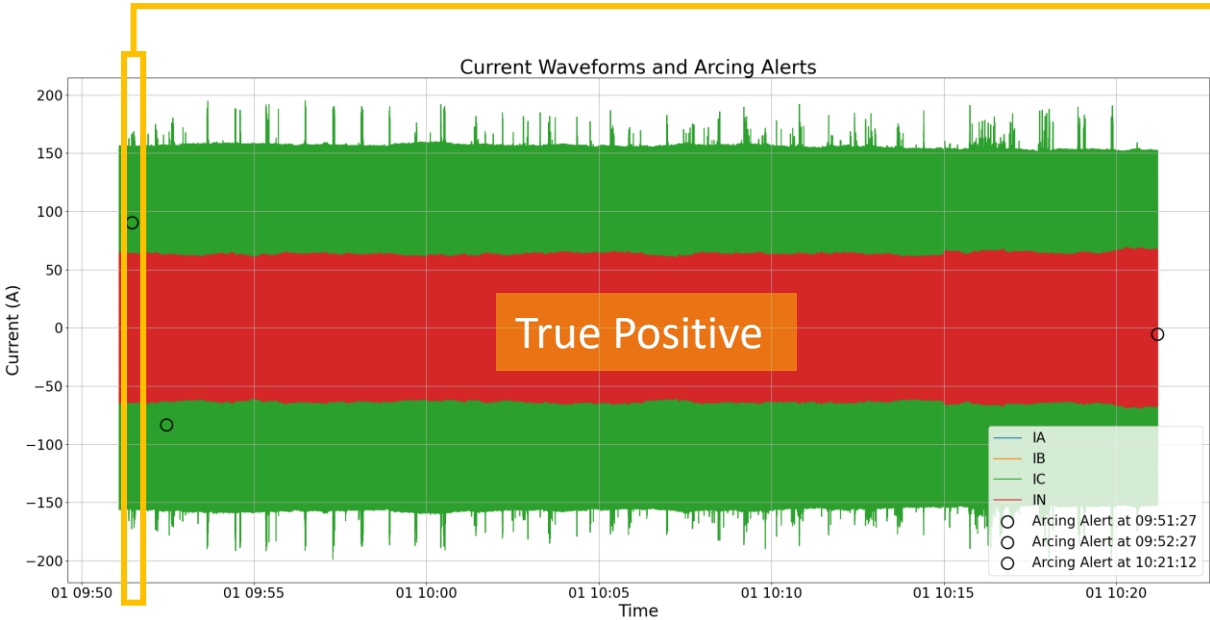
Augmentation – Data Fusion and ML Features



Coordination – Roadmap to Edge Analytics Working with Central AI/ML



Example – Developing Edge Analytics and Central ML



Central ML	Edge Analytics/ML
Process grid-wide data to identify subtle fault trends that may not be apparent at a local level	Rapid detection is crucial to prevent escalation
Access to powerful models	Localized model adaptation
High latency and communication network scalability	Low-latency processing, bandwidth efficiency
Data quality and integrity	Enhanced reliability and resilience
Hybrid coordinated system allows for quick, localized responses to subtle faults while enabling continuous improvement and global optimization	

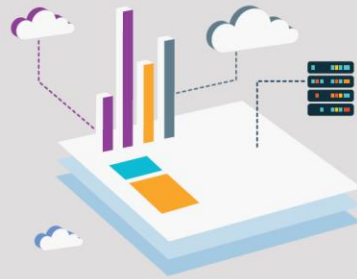
Conclusions

Leveraging five core capabilities to handle real-world data and system characteristics, AWARE sets the standard and serves as a model for applied AI initiatives to succeed in grid operations.



Customized Feature Engineering

Crafting AI/ML features that capture the essence of the event enables AWARE to extract meaningful patterns and relationships from the data, leading to more accurate insights.



Handling Complex Data

Distribution data is rarely clean. AWARE leverages expert- and physics-augmented analytics to enhance performance and maximize achieved visibility.



Minimal Need for Labeled Data

Well-engineered AI/ML minimizes heavy reliance on the labeled signature libraries that are challenging to obtain and generalize.



Complementary Integration

Detection of event location and protection system awareness are key. AWARE's anomaly detection complements traditional protection.



Interpretable Modeling

AWARE's AI/ML is interpretable, enabling transparency that is essential for building trust in machine learning systems and making informed decisions based on model outputs.