GRID MODERNIZATION INITIATIVE

HELICS

1.4.15 - Development of Integrated Transmission, Distribution and Communication (TDC) Models

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GMLC 1.4.15 TDC Models: Extensive industry engagement

- TRC webinar
- TRC in-person meeting

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GMLC 1.4.15 TDC Models: Project Summary

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Project Description

This project aims to enable large-scale TDC interdependency studies through a flexible and scalable, open-source co-simulation platform for the following industry drivers

Project Objectives

- ✓ Provide foundational capabilities for grid planning, operation, and control
- ✓ Engage and educate grid developers on the value of multi-domain planning

Value Proposition

- ✓ There is currently a gap in simulation and modeling technology that inhibits integrated planning across multiple domains
- ✓ Left to it's own devices, the grid community is unlikely to develop capabilities to overcome planning stovepipes (in near term)
- ✓ The DOE plays a unique role in initiating this effort and creating foundational tools that support both research and industry

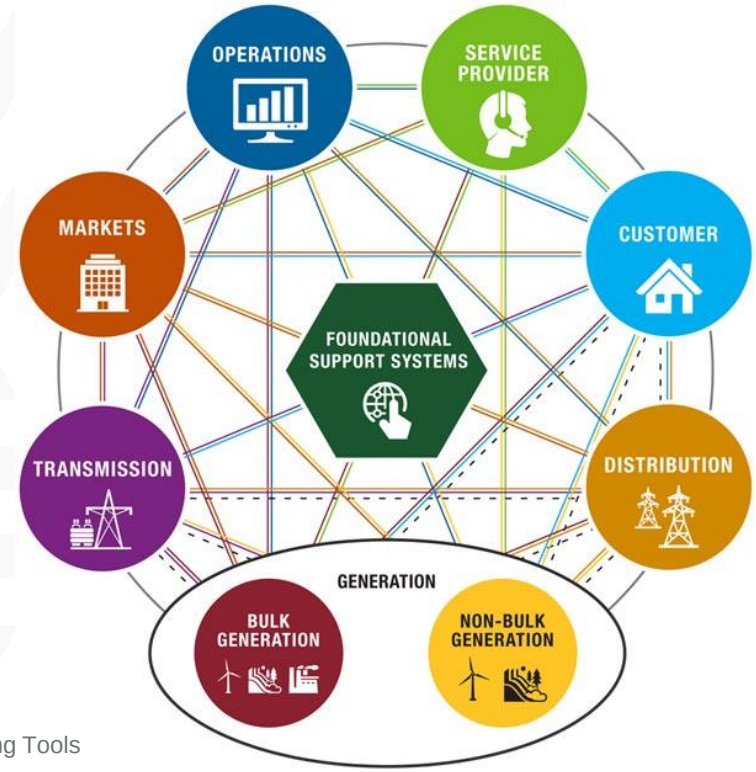

Image from smartgrid.ieee.org

Interdependency resulting in reliability and efficiency issues

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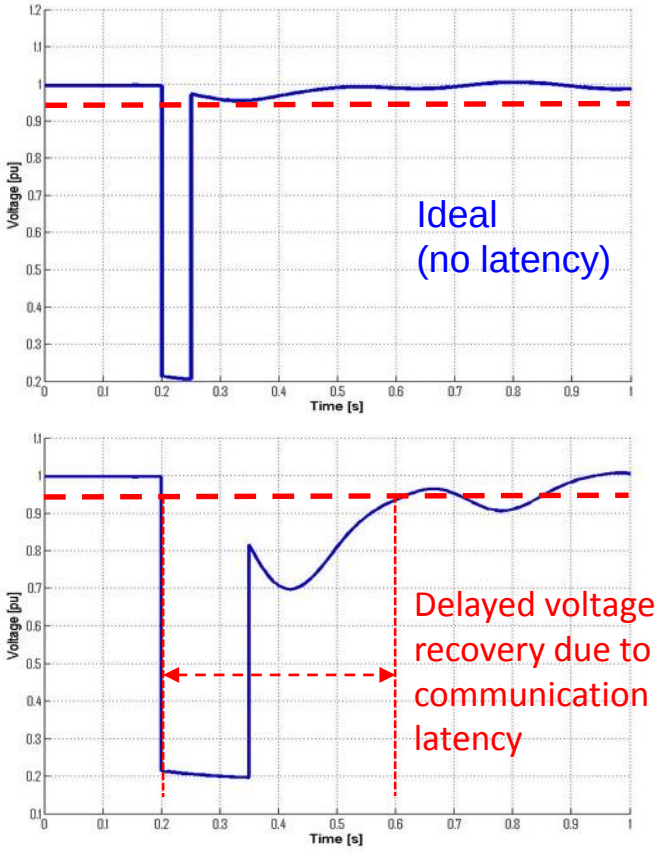
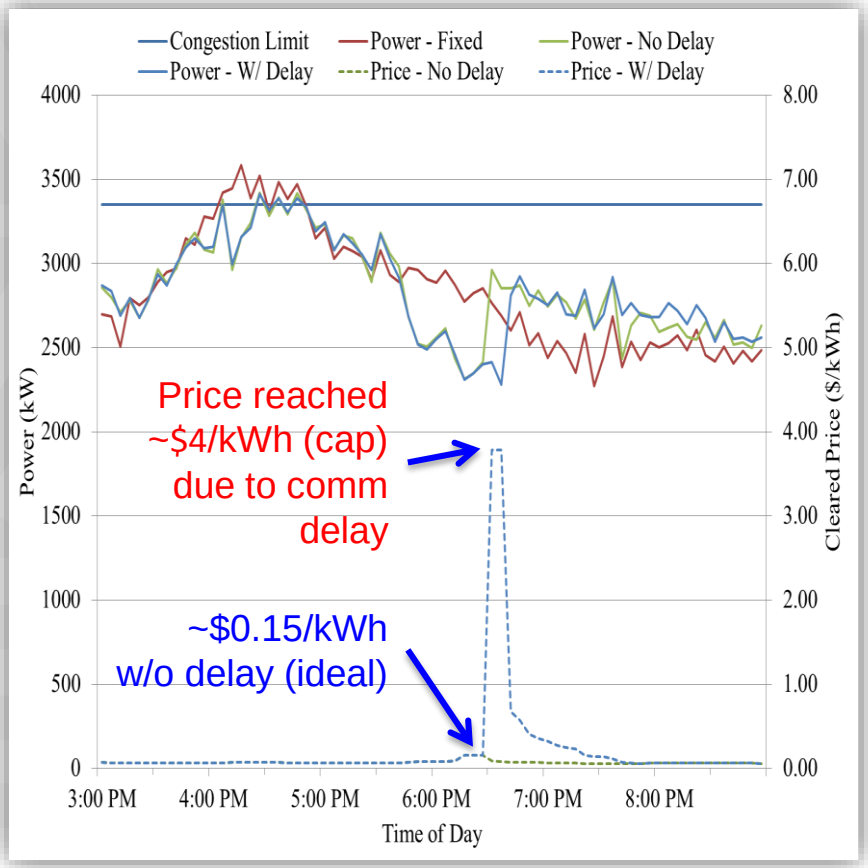
Delayed Voltage Recovery in Wide Area



IEEE 39-bus system with wide control simulated in PST + NS3
Credit: Liang Min, LLNL

Price Spikes in Demand Response (T+D+C)

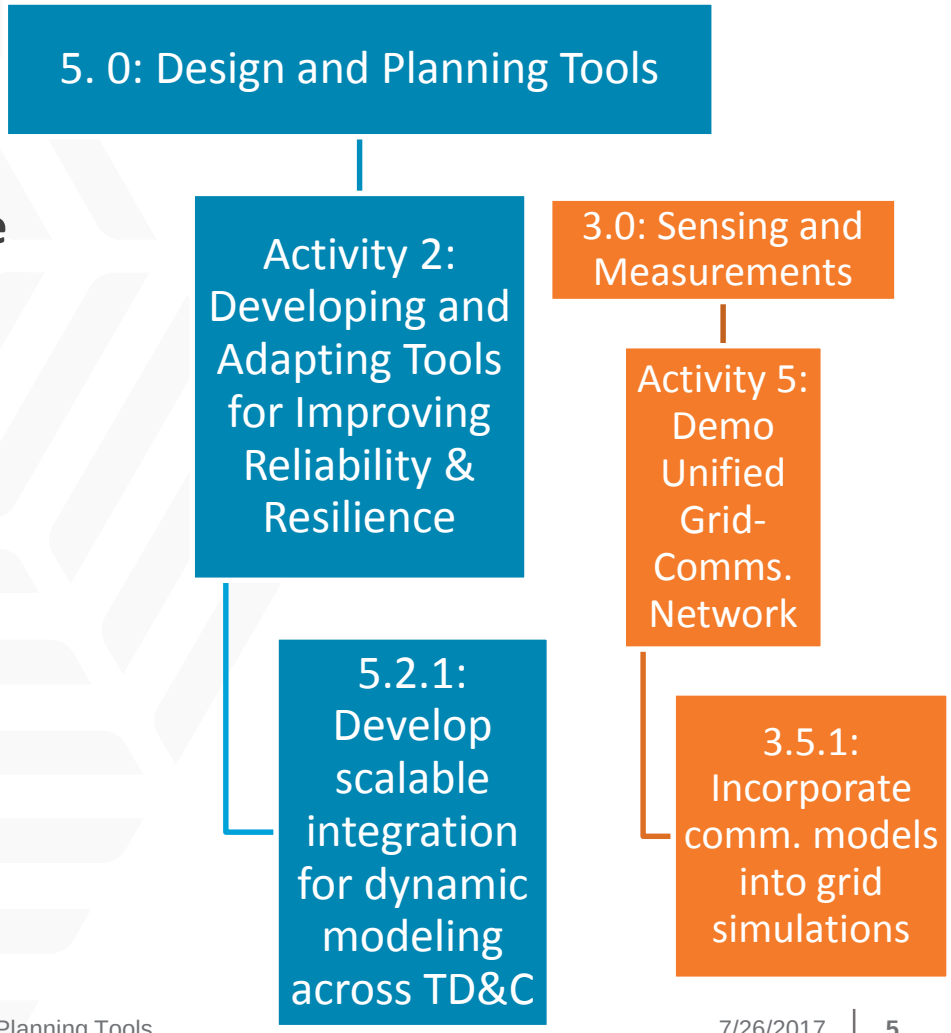


IEEE-13 node system with 900 residential loads simulated in GridLAB-D™ + NS3
Credit: Jason Fuller, PNNL

HELICS supports Grid Modernization Multi-Year Program Plan

A high-fidelity TDC integrated simulation capability will help address MYPP national outcomes:

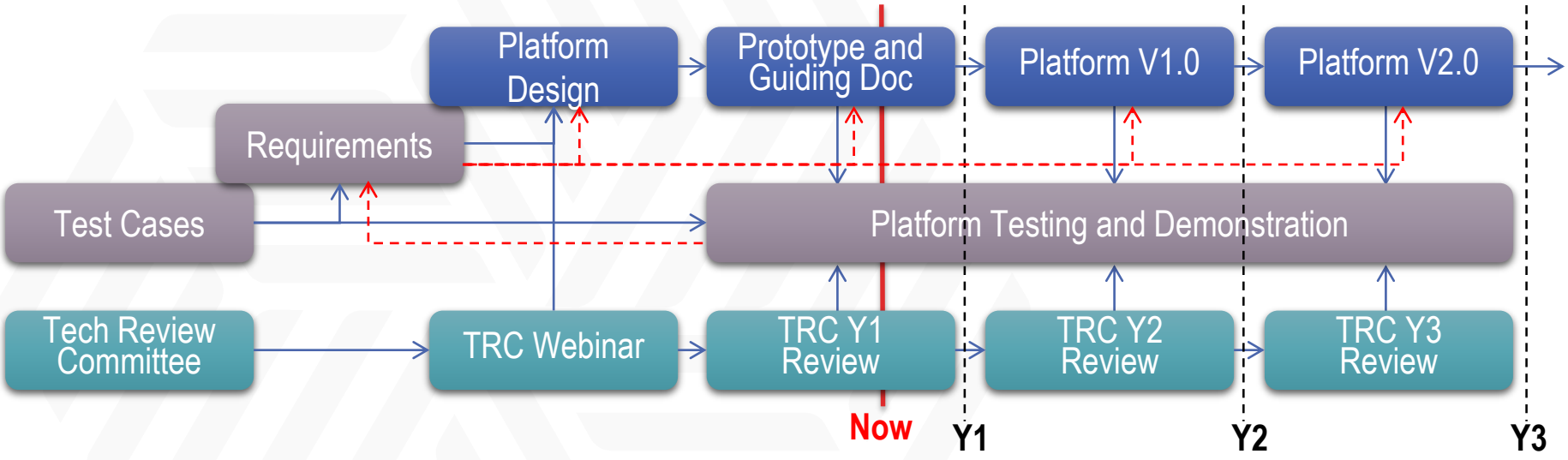
- to **design, with confidence, the future grid** to minimize outages and outage costs;
- operate the grid with a leaner reserve margin and still maintain reliability **through holistic analysis**; and
- increase penetration of DERs by **informing decision-makers with quantified impacts** on the system reliability and economics.



Use-case-driven development of HELICS

Three tracks (use case driven):

TEST CASES, PLATFORM DESIGN AND DEVELOPMENT, OUTREACH



Development plan targets open-source release of the co-simulation platform

HELICS – Hierarchical Engine for Large-scale Infrastructure Co-Simulation

HELICS use cases and features

Support a variety of simulation types:

- Discrete Event
- Time Series
- QSTS
- Dynamics
- Transients

Evaluate systems of unprecedented scale:

- 2-100,000+ Federates
- HPC, including cloud
- But also workstations and laptops

No	Title	Description
1	**Impacts of DER's on Bulk Systems Reliability**	The test case will analyze a combined T&D test system with and without advanced distributed systems with high penetrations of distributed solar PV. Studying the impact on reliability metrics such as the NERC Control Performance Standards 1 and 2 as well as other main metrics can quantify the impacts of advanced distribution systems.

	Domain				Simulation			Comm	
	Transmission	Distribution	Communication	Market	Steady State	Dynamic	Transient	Latency	Packets
DER's on Bulk Systems Reliability	X	X			X				
Load Modeling under high penetration of DERs	X	X				X			
Wide Area Voltage Stability Support Using DERs	X	X	X		X			X	
Voltage and Frequency Ride-Through Settings for Smart Inverters	X	X	X			X			
Real-time Co-simulation of Power Systems and Communication Networks for Transient Assessment	X	X	X				X	X	
Communications Architecture Evaluation for High-Pen Solar	X	X	X		X				X
New Control Paradigm – Centralized vs Distributed to Prevent Voltage Stability Collapse	X	X	X			X		X	
Wide Area Monitoring, Protection, and Control (WAMPAC)	X		X			X		X	X
Impacts of Distributed Energy Resources on Wholesale Prices	X	X		X	X				
Mitigating T/D Interface Congestion Through Demand Side Management	X	X		X	X			X	
Regional Coordinated Electric Vehicles Charging	X	X		X	X			X	
Real-time Coordination of Large Scale Solar PV and Energy Storage	X	X			X			X	

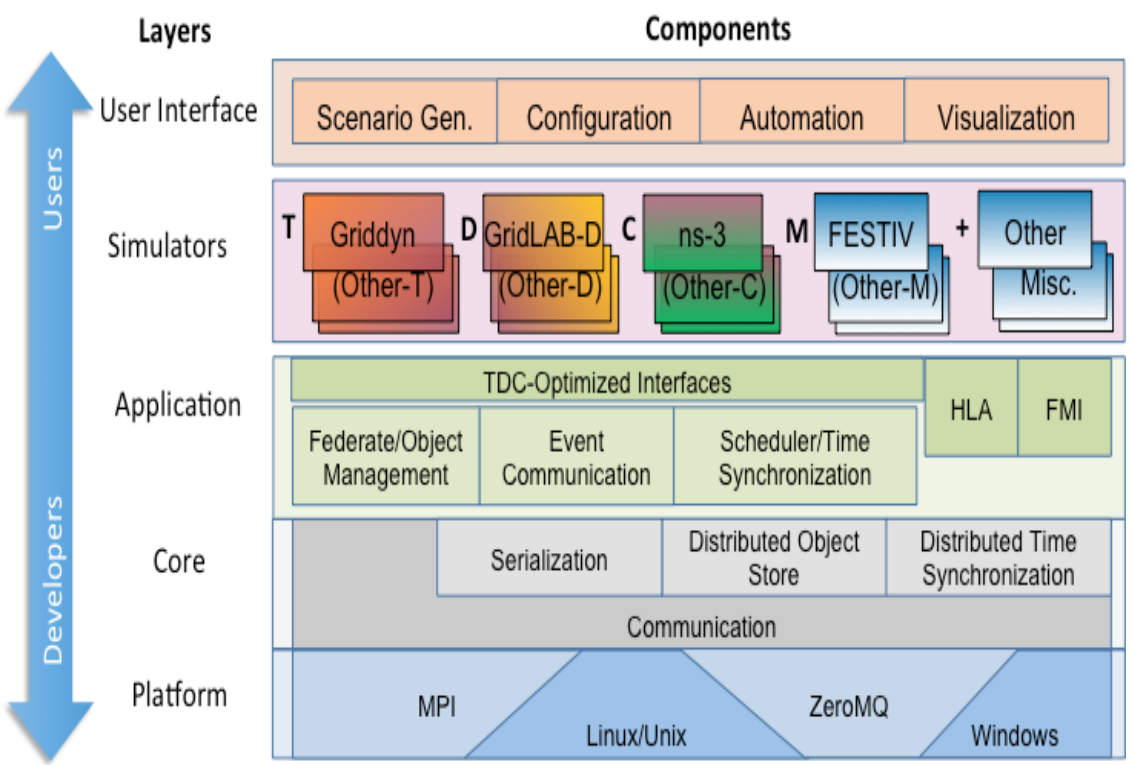
HELICS modular design

Layered and modular architecture to support:

- Laboratory, open-source, and commercial tools
- Interchangeable time synchronization algorithms (depending on use case)
- Reiteration, when necessary

Support standardized interfaces:

- HLA, FMI, etc.
- Tuned APIs for highly used tools (e.g., GridLAB-D, ns-3)



HELICS development status and next steps

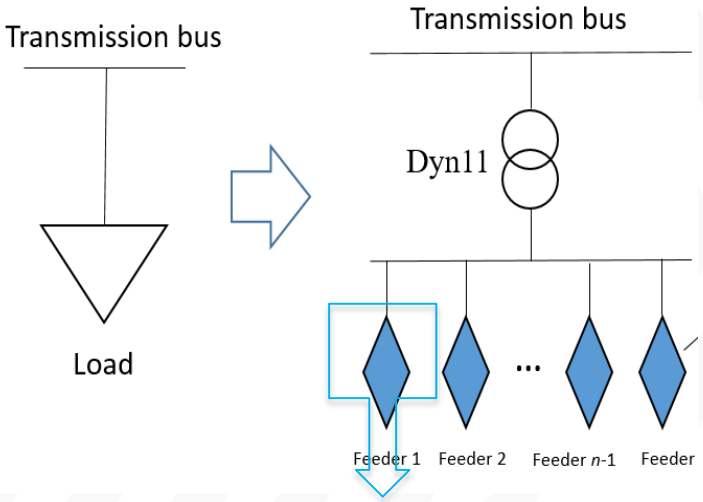
- Developed 12 use cases, with broad coverage
- Released v0.1 of HELICS to the open source in May 2017, including Guiding Document and example use cases
  - Currently securing licensing and copyright agreements
- Held TRC Meeting in May 2017 in Richland, WA

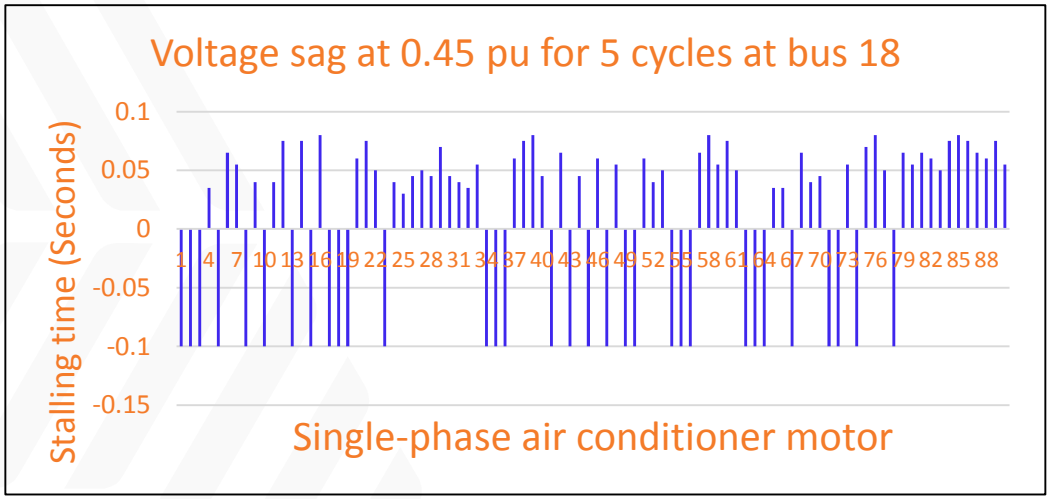
- Add additional simulators as identified by working with other GMLC projects and TRC members
- Implement HPC Platform Layer (MPI-based) to address large numbers of federates
- Develop use cases to demonstrate value and address limits of tool
- Develop (and release) tools to increase usability of tool
- Release subsequent versions to open source (Ver 1, 12/1/2017)

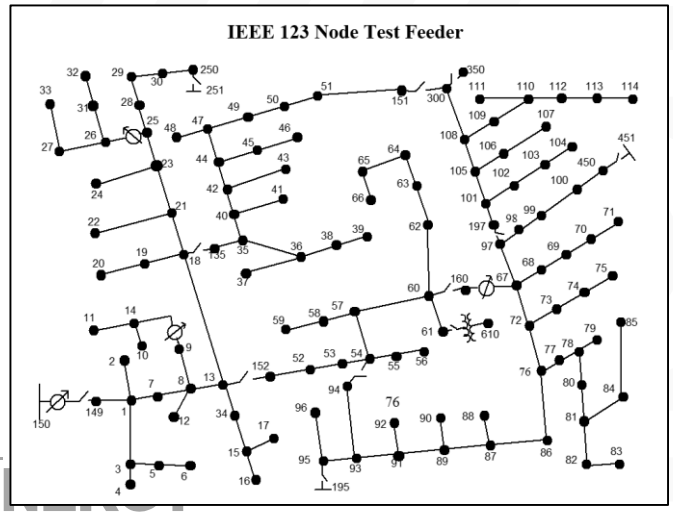
T+D detailed simulation for aggregated load protection modeling

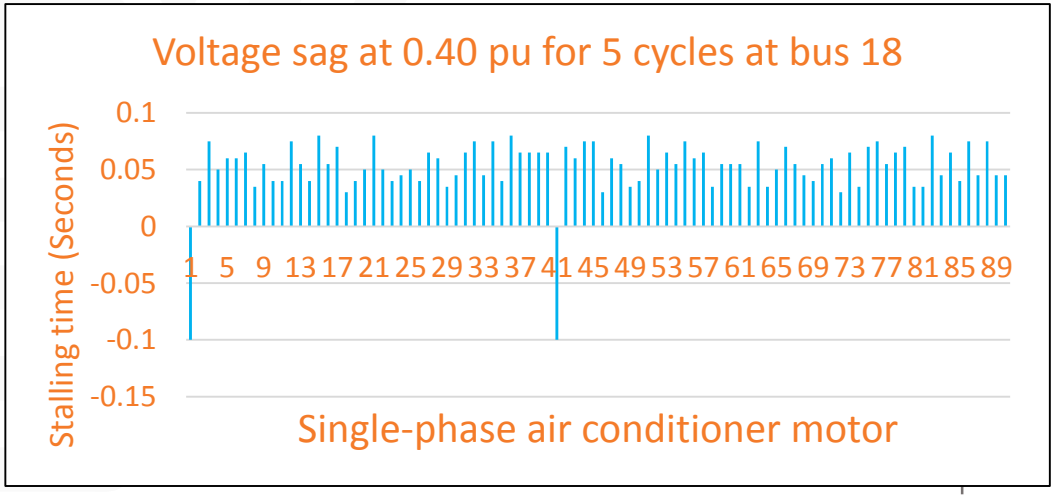
- IEEE 39 bus system + IEEE 123 bus feeders

Credit: Yu Zhang, PNNL









PSLF (T) + PSCAD (D) for FIDVR events

FIDVR = Fault Induced Delayed Voltage Recovery

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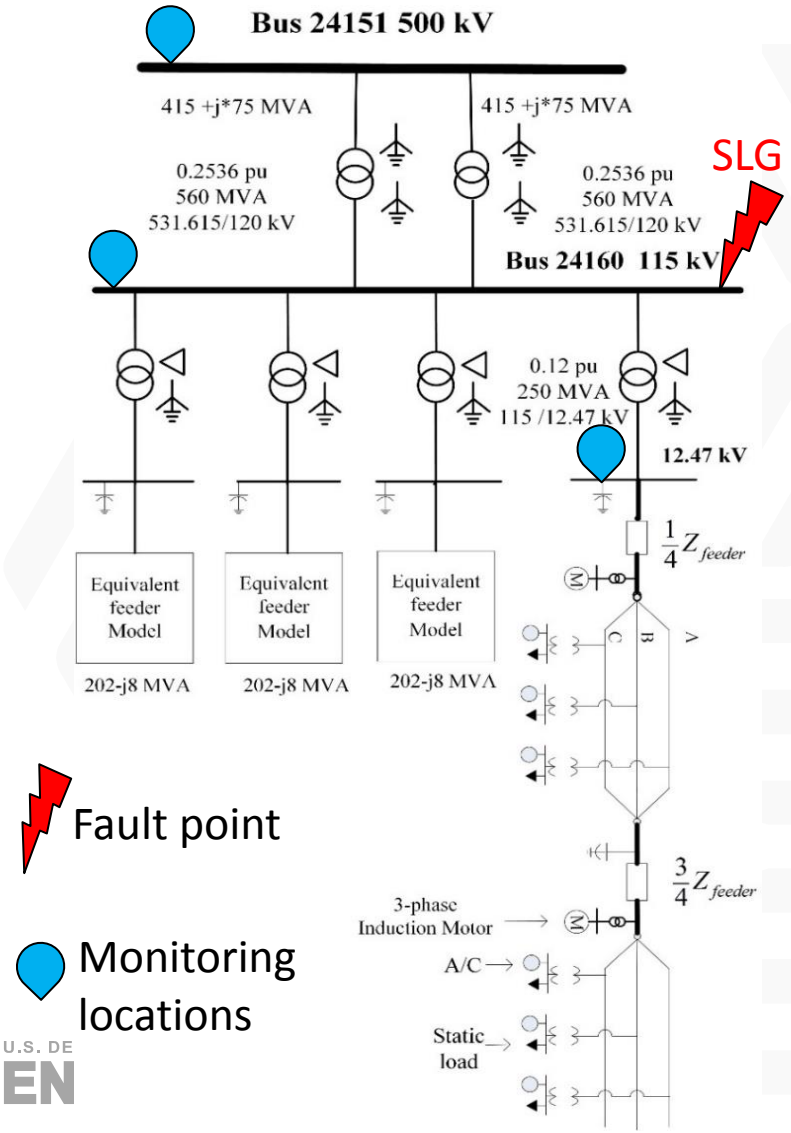
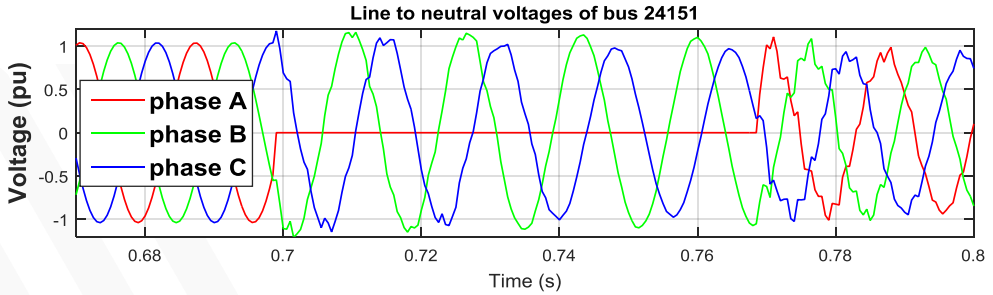
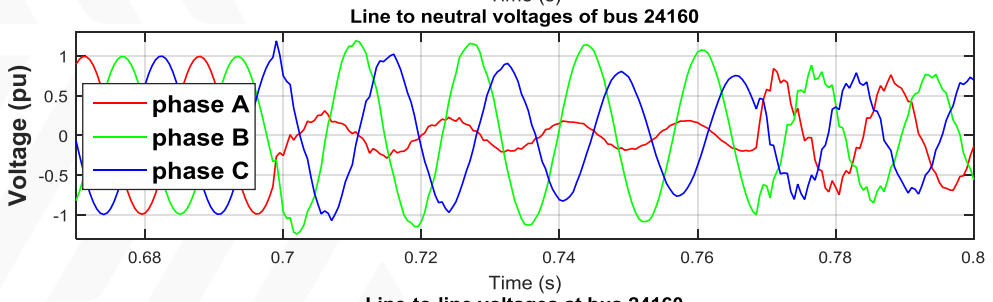
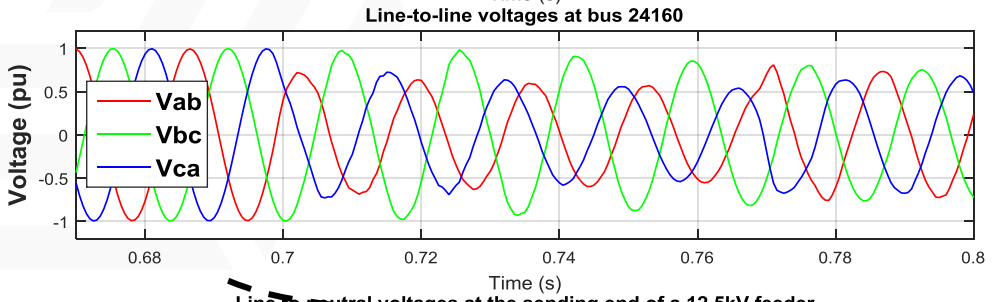
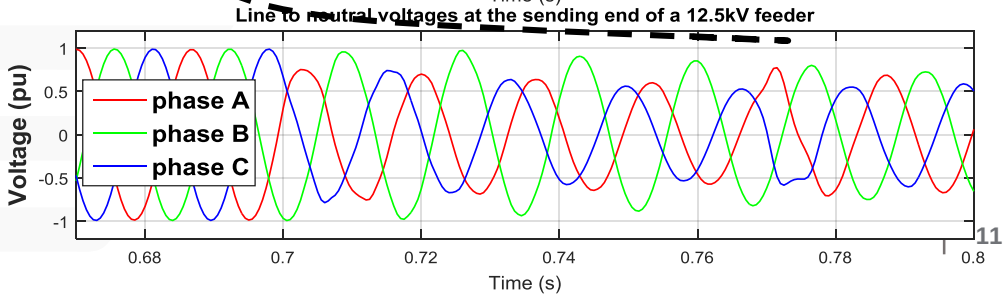
Credit: Qiuhua Huang, PNNL



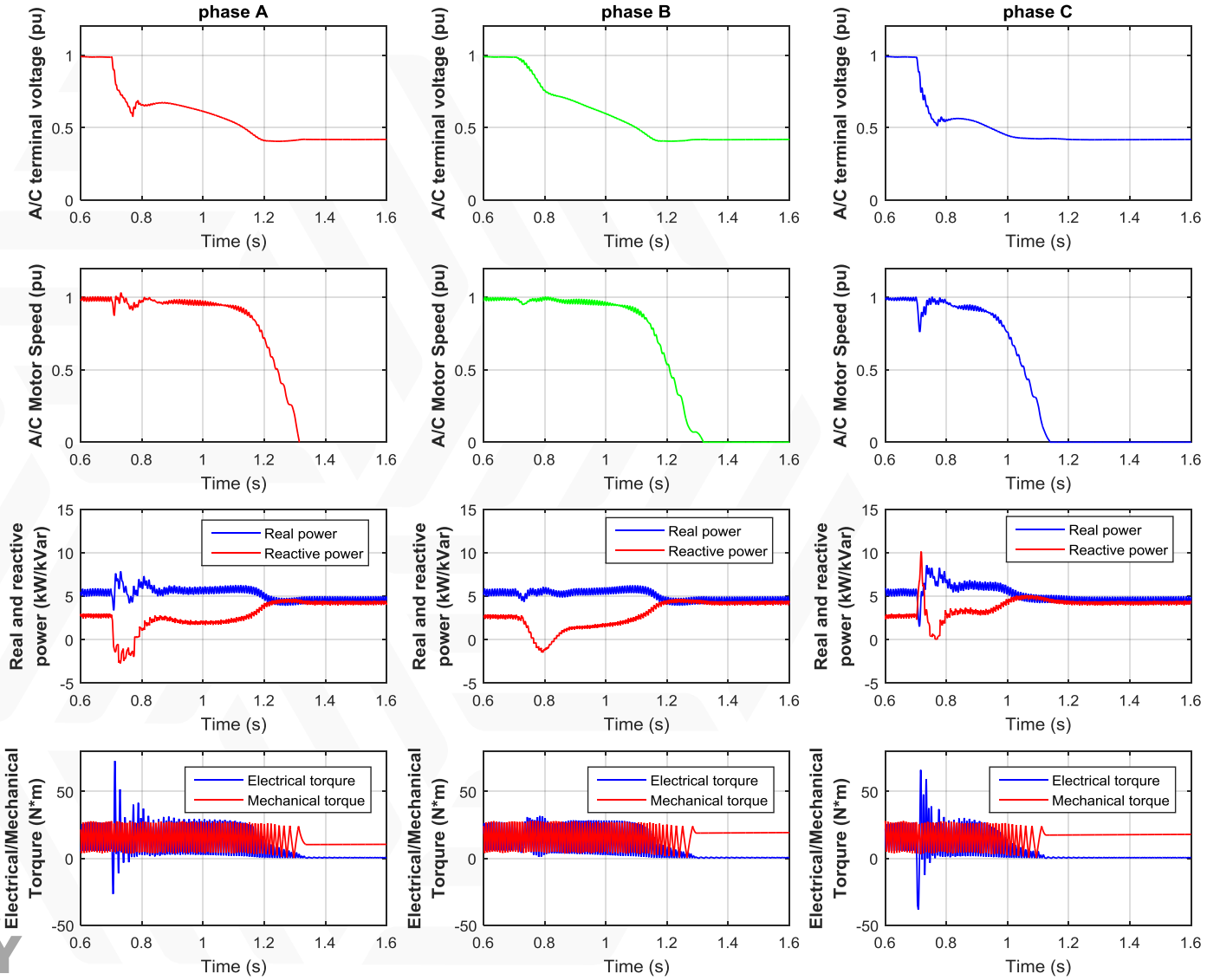




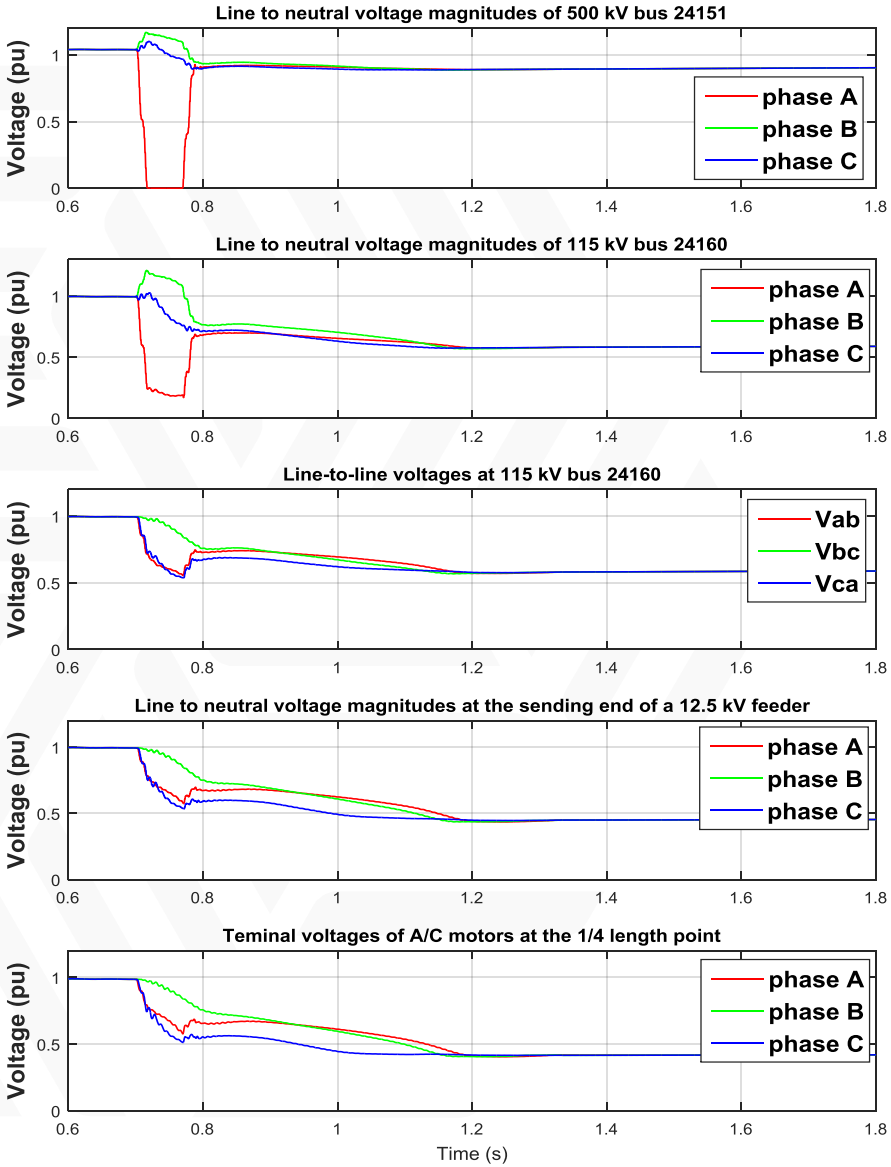




Motor stalling properly simulated



Slow voltage recovery resulted from motor stalling



PSLF simulation results using CMPLDW