2020 Microgrid R&D Program
Peer Review Meeting

Advanced Protection Schemes for Microgrids

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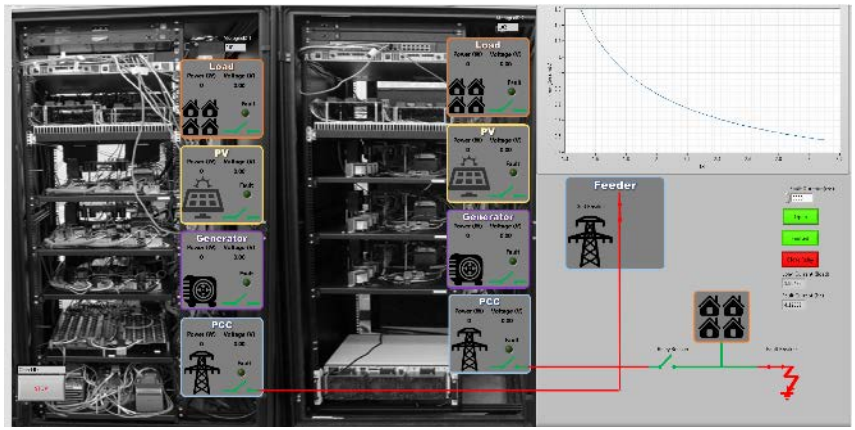
6/10/2020

Advanced Protection Schemes for Microgrids

Objectives & Outcomes

This research project will focus on protection, controls, and communications for the EPB distribution system with multiple networked Microgrids.
The research performed on this project will lead to breakthrough opportunities which will help define interoperability of adaptive systems and protection needs for utilities which may have less robust communications infrastructure.



Technical Scope

The goal of this research project is to leverage and apply the ORNL hardware based adaptive protective relaying system as a solution for many of the protection issues encountered with network connected microgrids on the EPB of Chattanooga electric power distribution system. The adaptive scheme will be tested on the ORNL SI-Grid low voltage A.C. network emulator configured to represent the real physical system including all protection, controls, and communications infrastructure.

Funding Summary ($K)

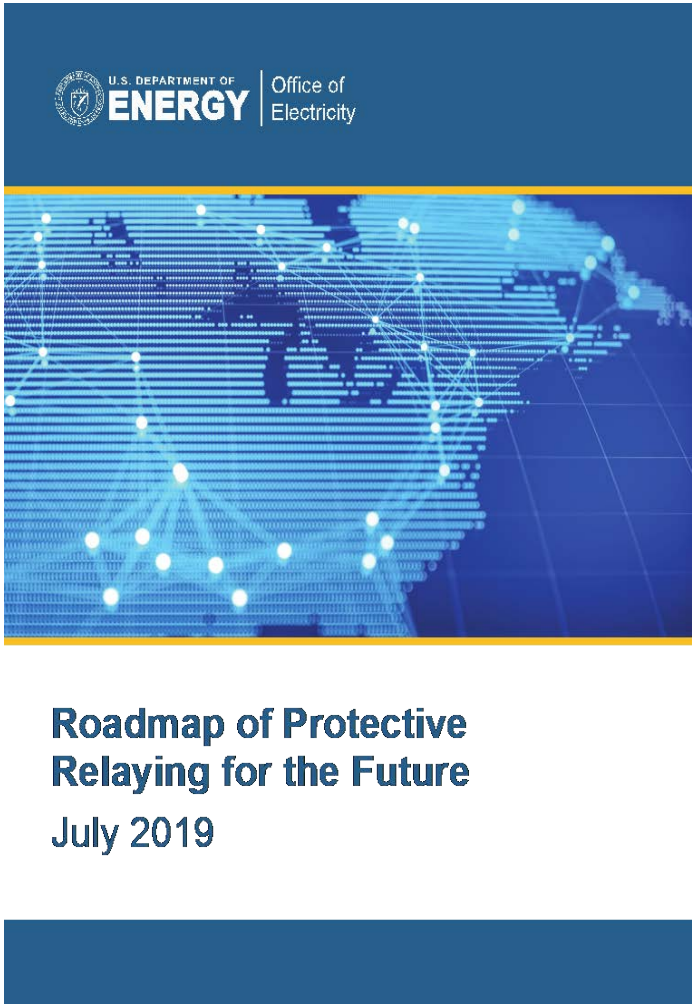
FY19 & prior, authorized	FY20, authorized	FY21, requested
$500k	$500k	$500k

Key Elements to be Addressed in the Ensuing Slides

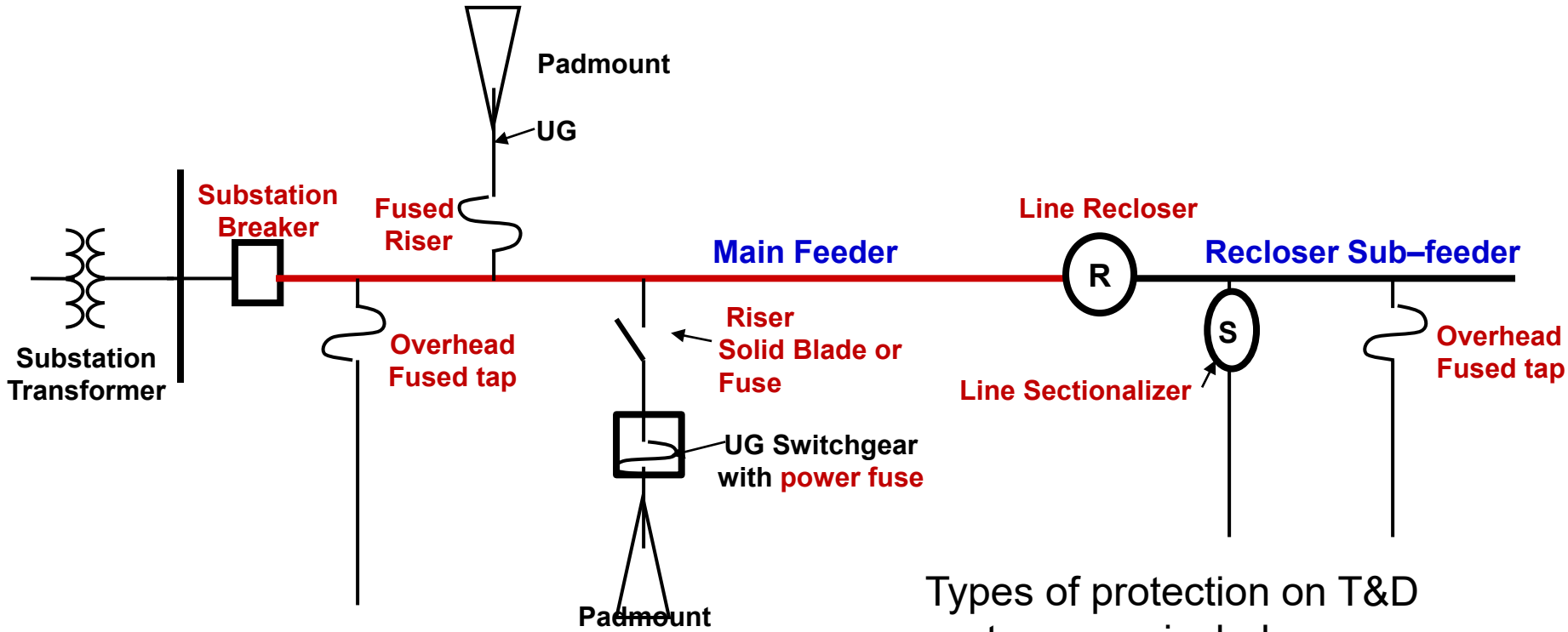
- Significance and Impact
  - The research performed on this project will lead to breakthrough opportunities which will help define interoperability of adaptive systems and protection needs for utilities which may have less robust communications infrastructure. These microgrid protection schemes will yield insight into local and wide area relaying philosophy. Benefits are expected from both philosophies and may result in complimentary hybrid protection systems that are more resilient.
- Approach
  - The goal of this research project is to leverage and apply the ORNL hardware based adaptive protective relaying system as a solution for network microgrids.
  - The adaptive scheme will be tested on the ORNL SI-Grid low voltage A.C. network emulator configured to represent the real physical system including all protection, controls, and communications infrastructure.
- Progress and Results
  - Developed an adaptive hardware-based protective relay with overcurrent functionality.
  - Performed simulations to validate operation of the relay.
  - Developed deployment plan and package for applying the relay on a live system.
- Tech Transfer Activities
- Contact information (Travis Smith, 1 Bethel valley road, Oak Ridge TN 37831, smithtm@ornl.gov., 865 241 5304)

Significance and Impact

- Microgrids present complexities that include
  - Dynamic topology
  - Bidirectional and variable power flow
  - Widely varying short circuit contributions
- Increasing penetration of microgrids and inverter-based generation will require a different approach to protection
- This research will fill many gaps related to these issues



Distribution System Protection Components



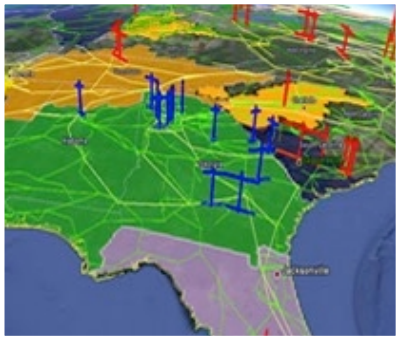
Types of protection on T&D systems can include:

- Overcurrent
- Voltage
- Frequency
- Distance

Problem we are Solving

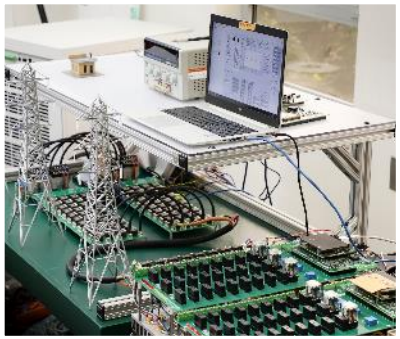
- These devices rely on the magnitude of short circuit current to initiate a trip
- They must be coordinated with each other to ensure the fault is isolated to the fewest number of customers
- Short circuit current alone may not be sufficient to detect a fault on a Microgrid
  - Discrimination between load and fault current is low
  - Small machines and inverters produce low levels of fault current as compared to the grid

Overview Advanced Protection Schemes at ORNL



Protection & Control Modeling

Advanced dynamic protection models used in analysis tools for predictive wide-area imminent fault detection methods and resiliency



Power System Protection Emulation

Power system and protection models implemented in low voltage hardware for testing advanced protection and control schemes

Field Deployment

Develop model driven adaptive protection relay for reliable fault isolation of distribution lateral circuits with varying short circuit contributions and configurations

Adaptive Protection techniques for Network Microgrids

Provide expert analysis based on enhanced models and advanced protection schemes

Increased resiliency through advanced protective relaying

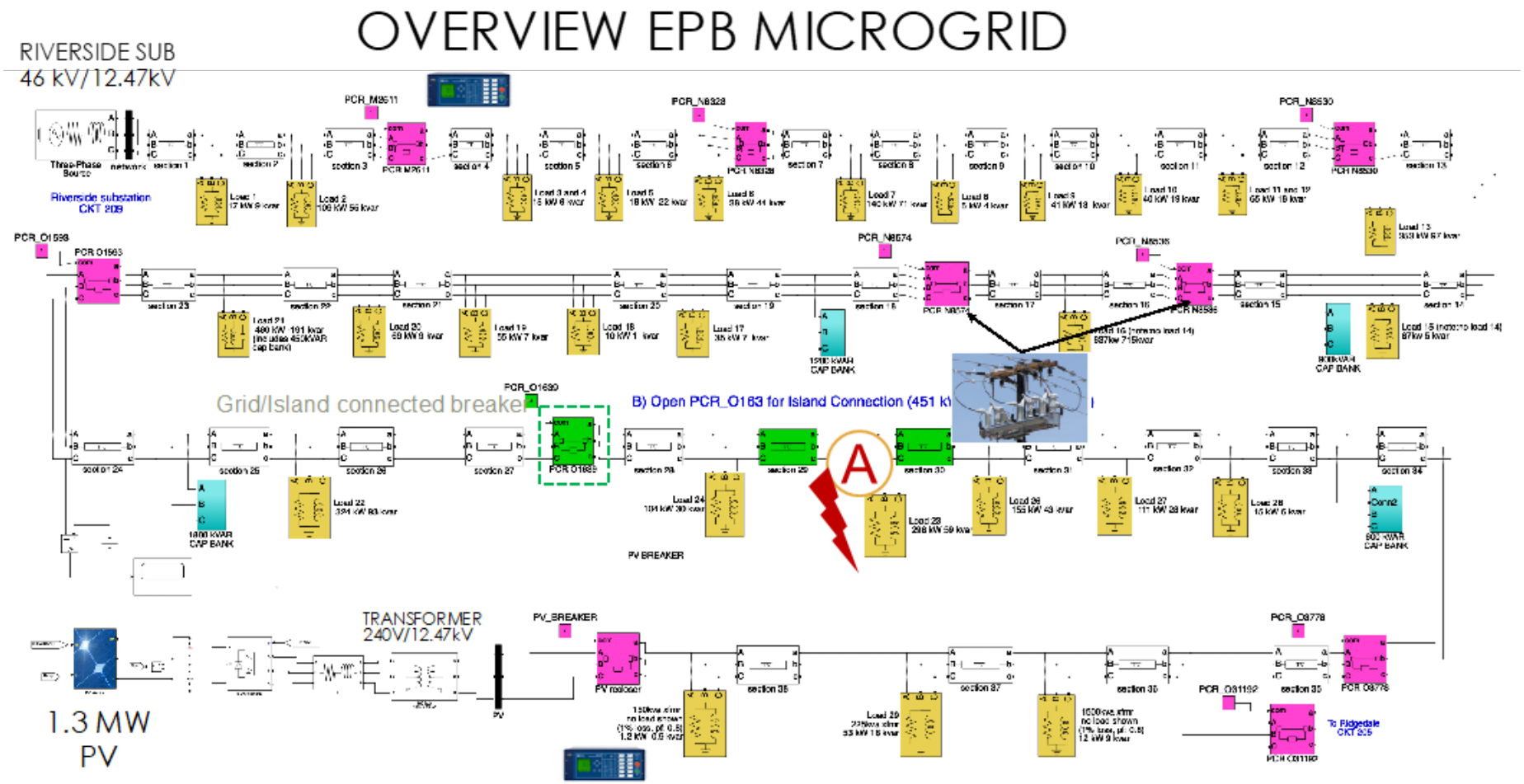
Approach

Task	Date	Status
Modeling	Fall 2019	Complete
Emulation	Spring 2020	Complete
Deployment	Fall 2020	ON-going
Commercialization plan	Fall 2020	ON-going

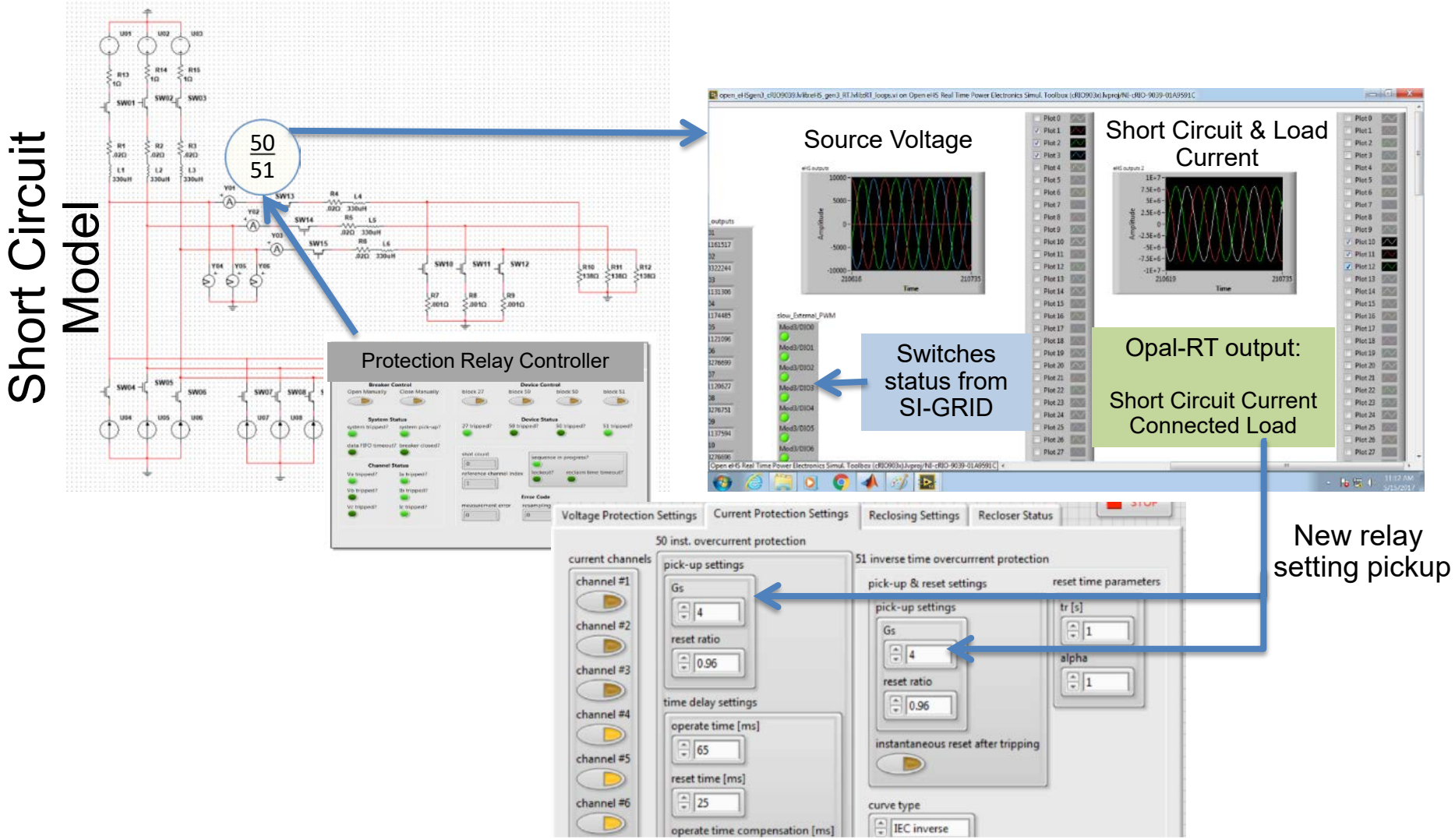
Project Risk and mitigation –

- At this time we do not foresee any issues that will delay progress

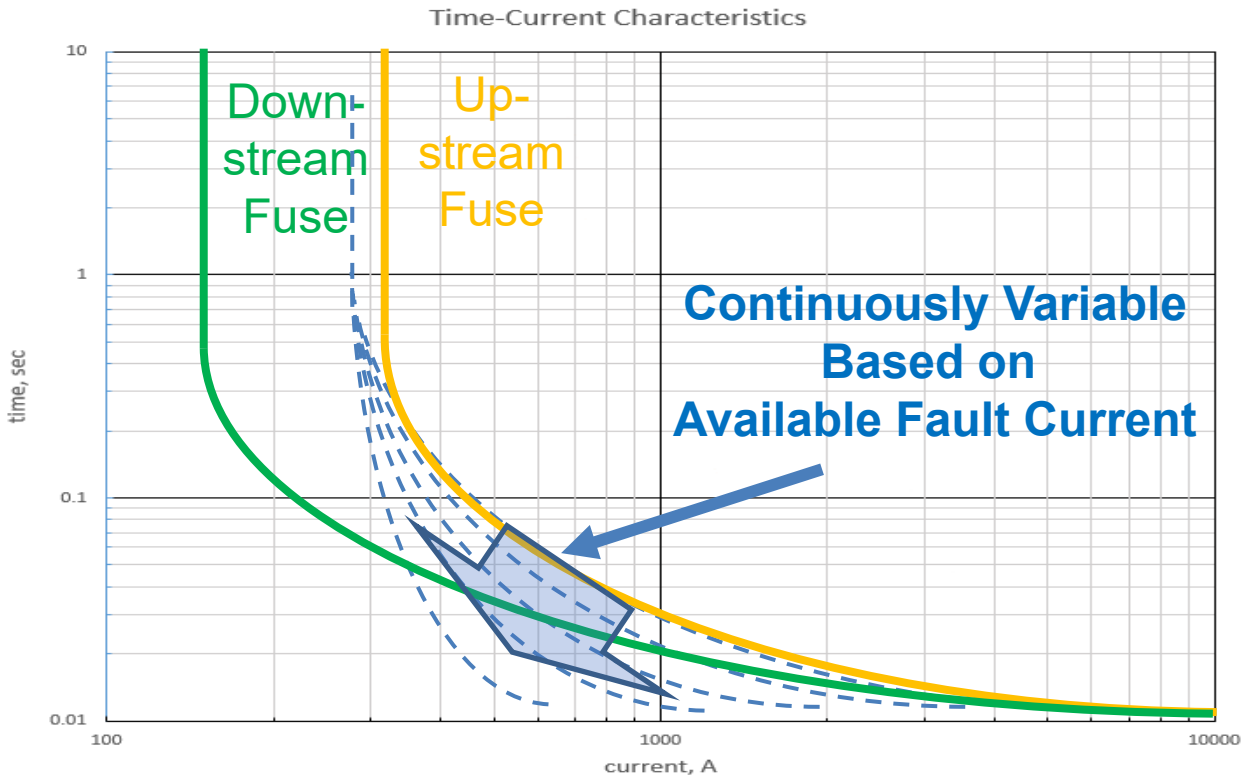
Task 1 - Modeling



Task 1 (cont'd) – ORNL Model Driven Relay



Task 1 (cont'd) - Adaptive Relay Curve



- The Adaptive Relay is designed to continuously adjust the curve shape based on the calculated available fault current.

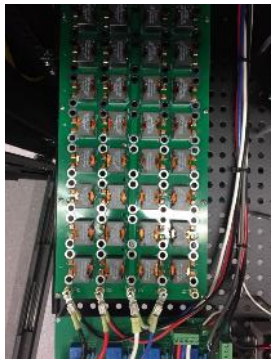
- When the Utility source is not connected it may be necessary to "over reach" the downstream.

Task 2 - Emulation

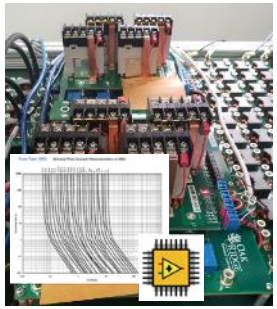
PHIL EMULATOR | **REAL-TIME SIMULATORS**

EPB MICROGRID SIMULATION (Emulator and Real-Time Simulators)

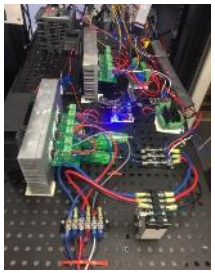
LINE BOARD



FUSE EMULATOR



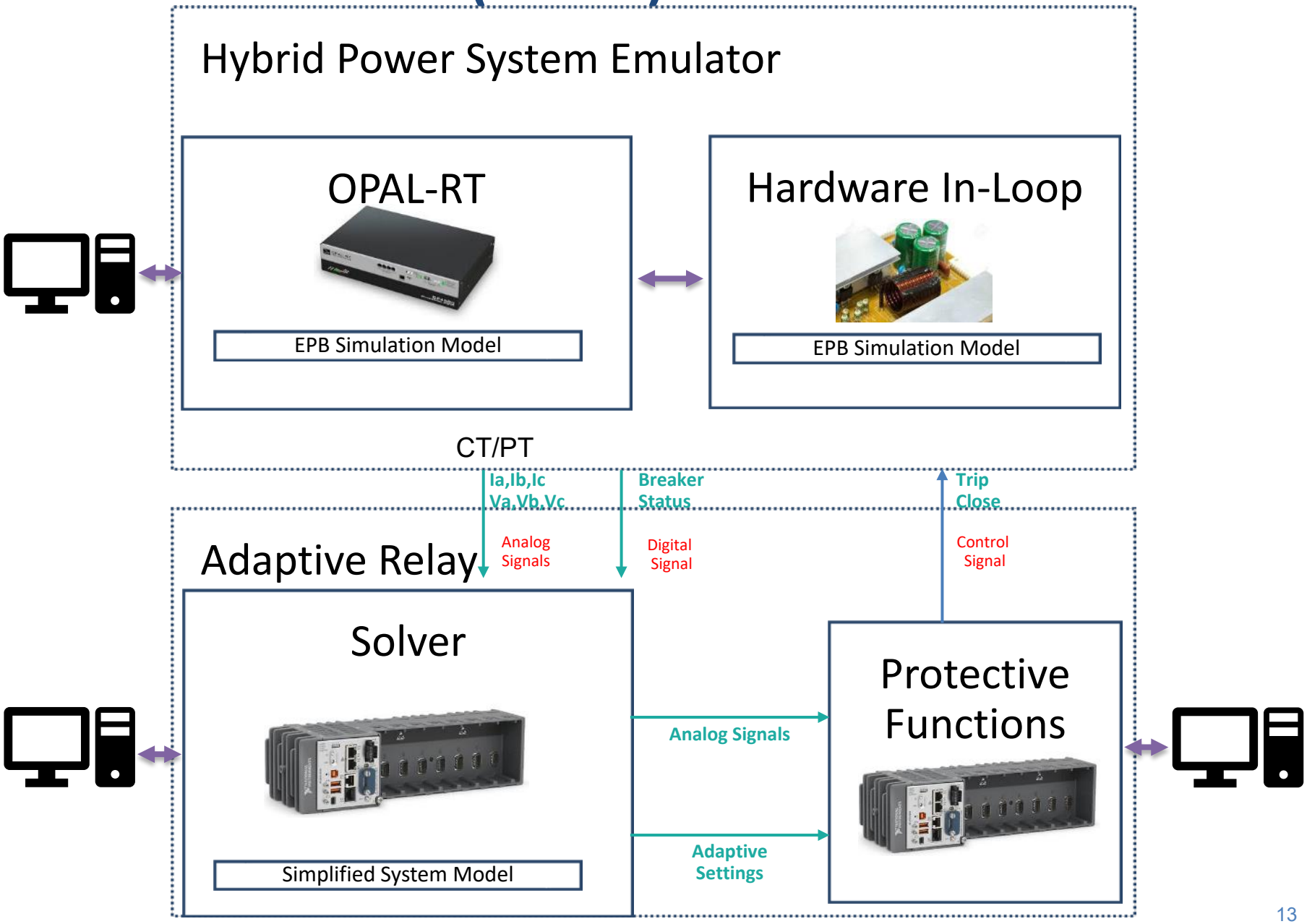
INTERFACES



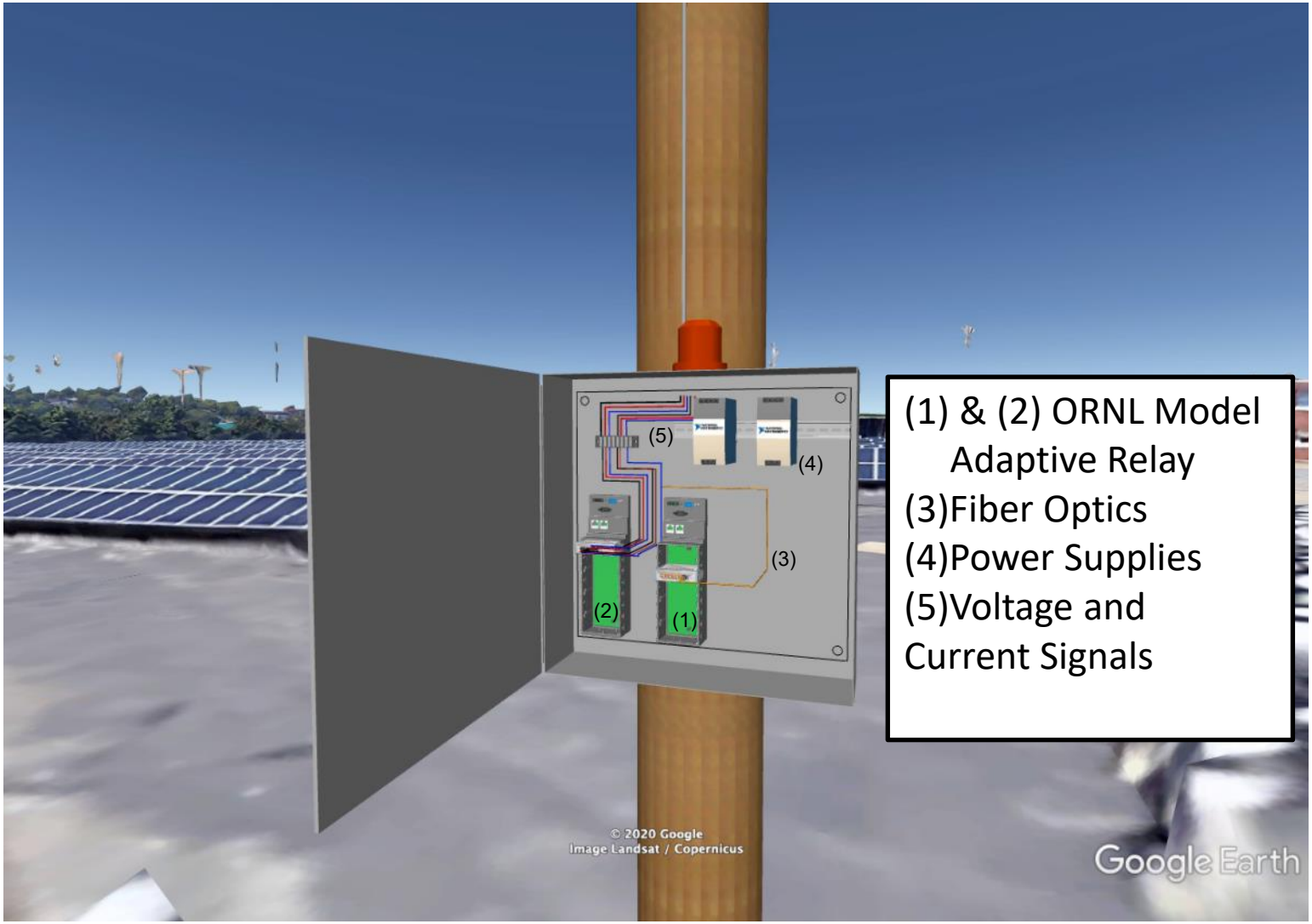
PROTECTION TESTBED

SEL-RELAY 6-S&C INTELLIRUPTERS

Task 2 (cont'd) - Emulation



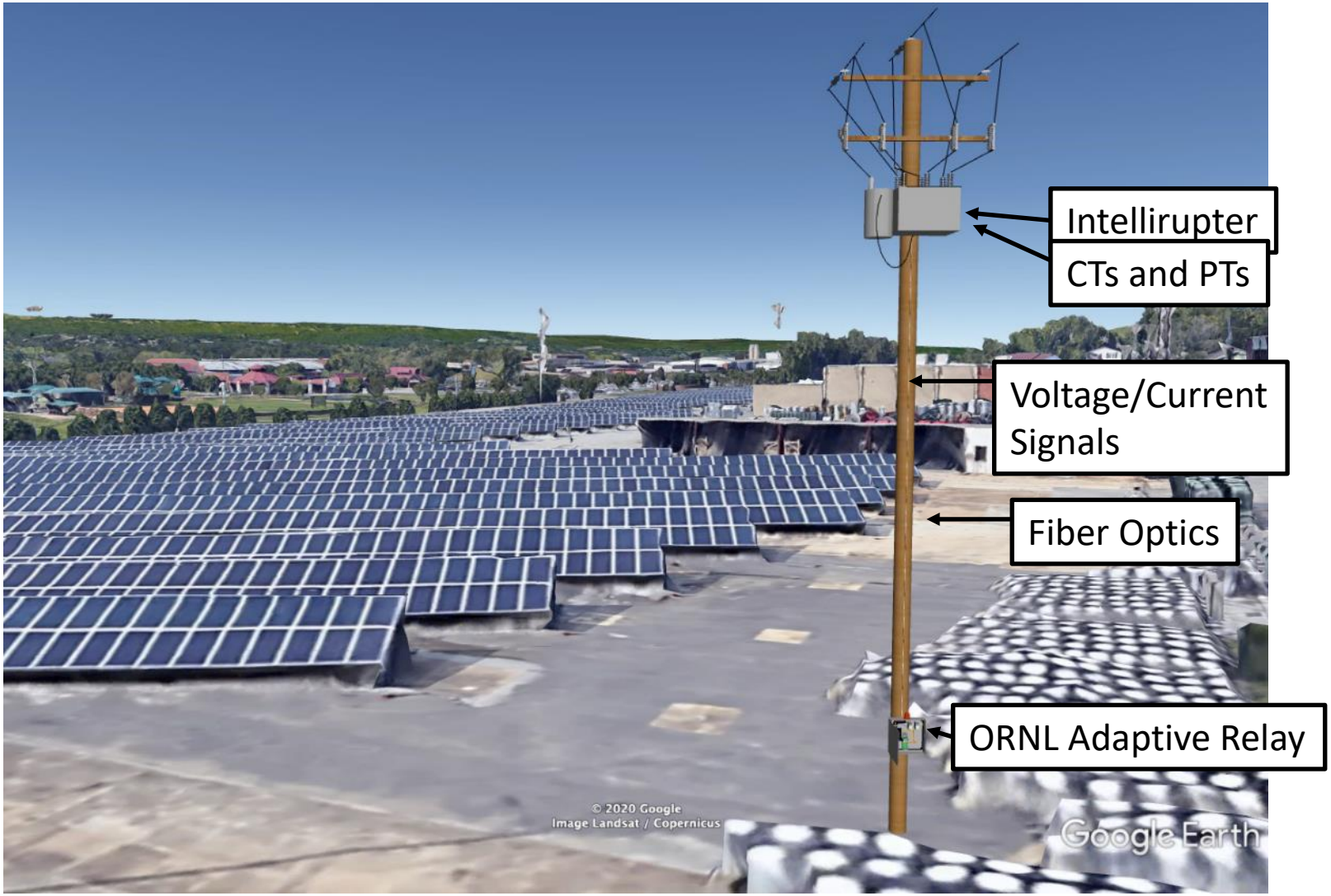
Task 3 - Adaptive Relay Field Deployment



(1) & (2) ORNL Model Adaptive Relay
(3)Fiber Optics
(4)Power Supplies
(5)Voltage and Current Signals

Task 3 – Deployment Location

Task 3 – Deployment Installation



Task 3 - Relay Interface

Task 4 – Commercialization

- Commercialization Plan to be developed by end of FY20
  - Will address applications on systems without EPB's level of communication infrastructure
- Considering options that include
  - open source technology
  - Start up company or partner with existing company
    - Have had conversations with other companies
  - Office of Technology Transitions (OTT)
  - I-CORPS or LABCORPS

Next Steps

Q3 FY20
Tune for Specific Location

Tune the tested adaptive relay package to be used in field deployment to verify interoperability with EPB power system.

Q4 FY20
Field Installation

Field installation of adaptive relay package on EPB lateral circuit. Start collecting and logging operational and event data from adaptive relay package.

Q1 FY21
Report on Lessons Learned

Report on results, lessons learned, and insights gained from deployment package. Expand and incorporate voltage, frequency, impedance protection elements for developing advanced adaptive protection functions within the new relay package.

Future Research Includes the Following

- Develop additional protection elements that include :
  - Voltage
  - Frequency
  - impedance

- Incorporate optical sensing

Project Collaborations

- EPB is the right collaborator for this project due to:
  - Robust communication system that allows for data to be quickly and readily transferred to ORNL as needed
  - Circuits with microgrids already installed that can be used for modelling/emulation and field implementation
  - They capture and record information such as fault waveform signatures that are vital to solving problems with protection on microgrids

Back-up Slides

Include any back-up slides you would like to provide to the peer reviewers and DOE program managers for additional information. The back-up slides will not be shared with others, unless specifically stated by the presenter.