GRID MODERNIZATION INITIATIVE PEER REVIEW

GMLC 1.3.01 – Southeast Regional Consortium

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Sheraton Pentagon City – Arlington, VA

Southeast Regional Consortium
High Level Summary

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Project Description

Create a consortium of utilities, universities, national laboratories, regulators, and industry in the southeast to address grid related technical challenges specific to this region.

Value Proposition

- ✓ The southeast has unique challenges to reliable and resilient energy delivery
  - ✓ Highest frequency of hurricanes in the U.S.
  - ✓ Higher failure rates of coal plants
  - ✓ Growing solar generation
- ✓ Increased resiliency can save billions of dollars each year[1]

Project Objectives

- ✓ Improve distribution system resiliency
- ✓ Increase DER concentration
- ✓ Foster dialogue between regional stakeholders
- ✓ Identify technical challenges in the SE
- ✓ Develop advanced sensing, communication, and controls to improve the visibility and recovery speed of the SE power grid
- ✓ Transition technology from national laboratories and universities to industry

[1] "Economic Benefits of Increasing Grid Resilience to Outages," Executive Office, August 2013.

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Project Team

Project Participants and Roles

- **Savannah River National Laboratory**
  - Lead for wireless sensor network development
- **Oak Ridge National Laboratories**
  - Lead for distributed control, TSN, and optical sensors
- **University of North Carolina Charlotte /CAPER**
  - Modeling and sensors
- **Clemson University**
  - Optimization of restoration plan
- **Duke Power**
  - Provide technical details of distribution feeders.
- **Chattanooga, TN Electric Power Board (EPB)**
  - Time sensitive network testing
- **National Instruments**
  - Distributed control hardware and software
- **SmartSenseCom**
  - Passive optical sensors

PROJECT FUNDING			
Laboratory	FY16 $	FY17$	FY18 $
SRNL	$200k	$300k	
ORNL	$220k	$280k	

Southeast Regional Consortium
Approach

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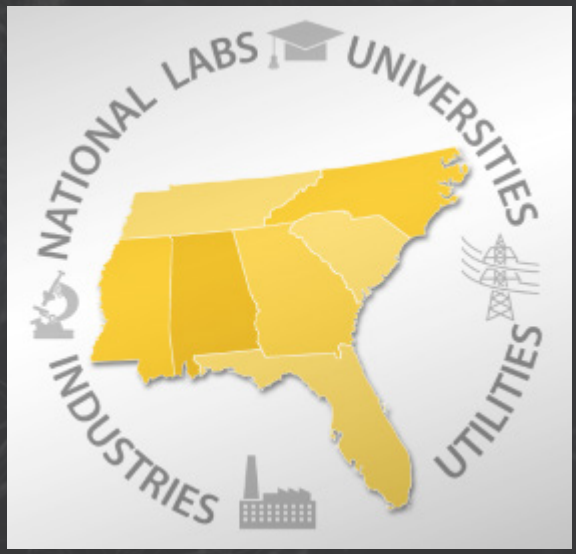
Project Overview

- Develop tools for control, communication, and situational awareness to improve the resilience of the SE grid to low frequency – high impact events like hurricanes.
  - Dual Channel Wireless Network
  - Restoration Optimization
  - App Based Distributed Controls (CSEISMIC)
  - Time Sensitive Networking (Deterministic Data)
  - Distribution Step Distance Protection using Optical Sensors
- *Working with utilities and universities to develop and demonstrate these technologies.*



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Approach

SRNL Resiliency Project

Project Description

To improve resiliency through a terrestrial and satellite based communication system for sensors on the grid and develop a tool for utility companies to improve their response to high impact low frequency events such as hurricanes. The program will determine all damaged location, optimize the order in which needed to be restored, and optimize first responders scheduling.

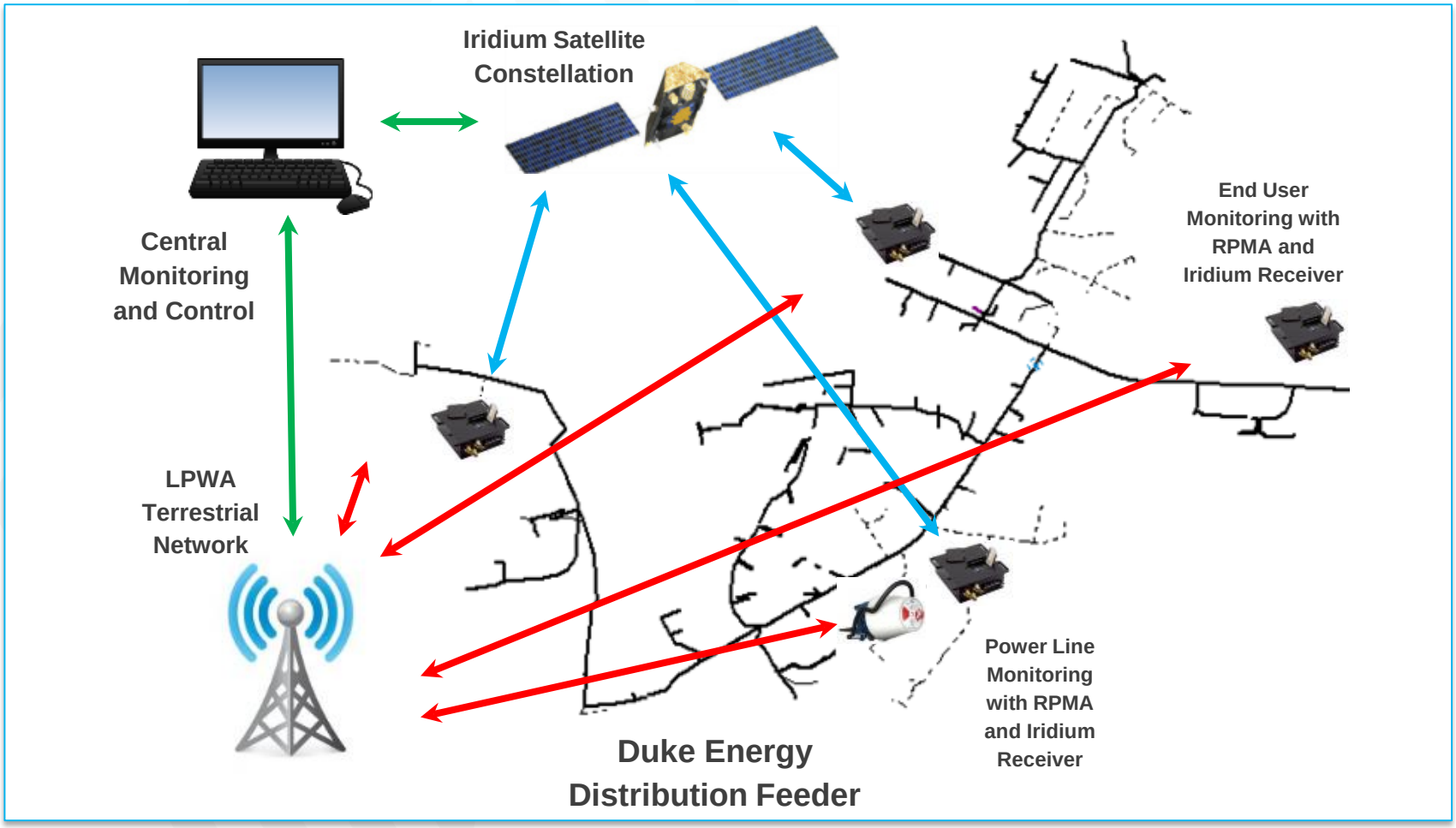
Project Participants and Roles

- Savannah River National Laboratory – Lead for wireless sensor network development
- University of North Carolina at Charlotte – Fault location through AMI and first responder scheduling
- Clemson University – Optimization of fault restoration sequencing
- Duke Power – Provide technical details of distribution feeders

Expected Outcomes

- ✓ Single iteration program to determine first responders scheduling
- ✓ Demonstrate cyber-resilient dual mode wireless control network
- ✓ Demo wireless and scheduling at UNC Charlotte Campus

SRNL Dual Wireless Network Demo



SRNL Overview of Restoration Optimization

SRNL develops demo network with cyber-resilient dual mode wireless control network which feeds data to UNCC

UNCC develops algorithm for detecting fault locations using AMI data.

UNC CHARLOTTE

Clemson develops optimization damage restoration scheduling

DSS

UNCC develops algorithm for scheduling utility crews to prioritized loads

UNC CHARLOTTE

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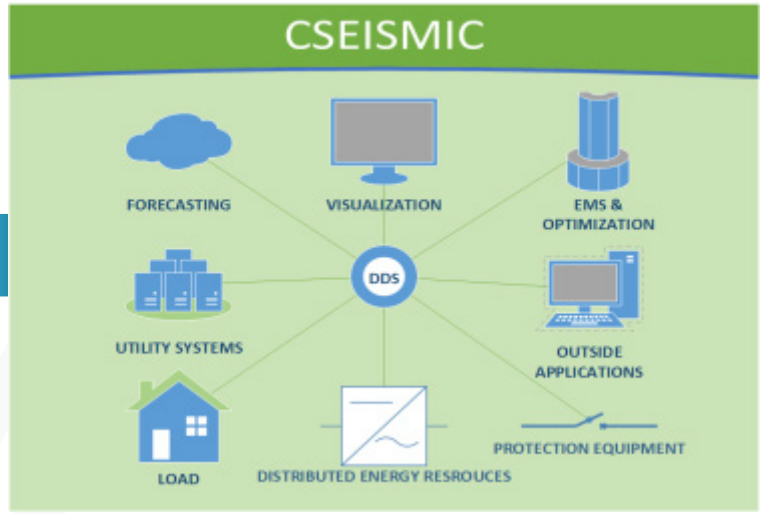
CSEISMIC Distributed Control Platform

- Apply to a site-specific model (EPB Control Center microgrid.)
  - *App Based Energy Management*
    Forecasting, Resource Optimization, Dispatch, Load Shedding
  - *Protection*
    Relay Coordination
  - *Resiliency*
    Seamless islanding and resynching
  - *Communications*
    IEC 61850 (Substation Automation Systems)
  - *Inverter controls to support microgrids*
    V/F, P/Q, Droop with multiple sources (PV/Energy storage)



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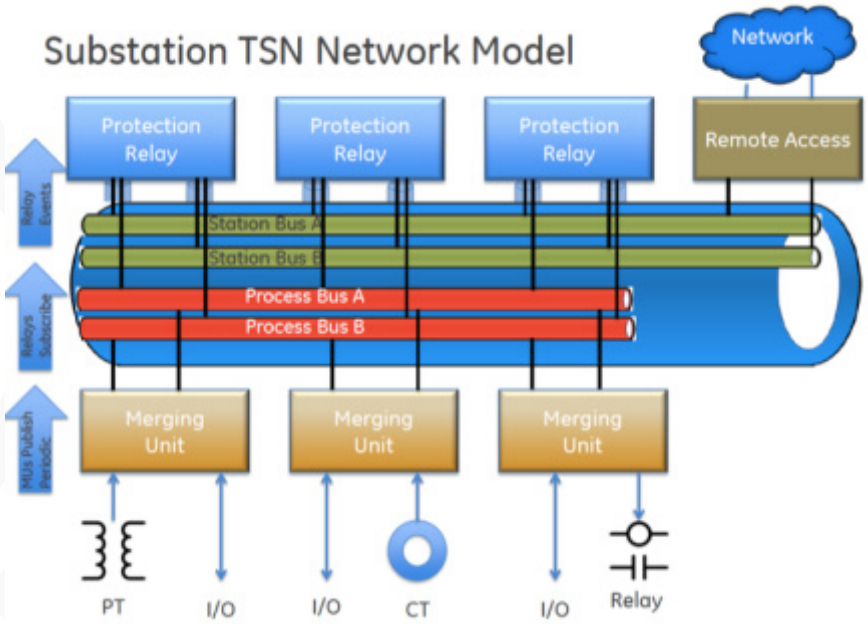
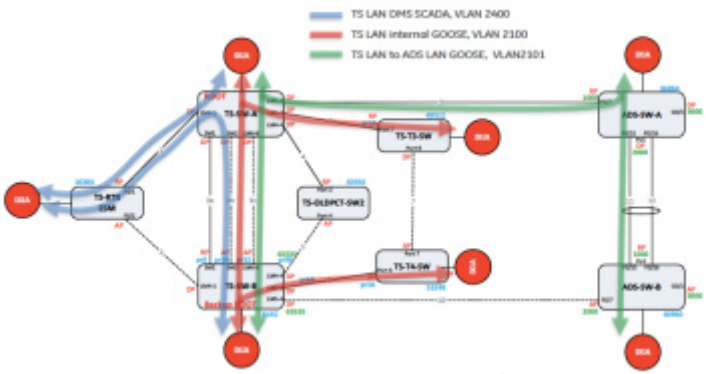
Approach

Time Sensitive Networking

- Microsecond Deterministic Data Transfer
- Low Latency / High Availability
  - *Increases distributed control and sensing capabilities for the grid.*
- *Approach*
  - *Deploy TSN network on an existing fiberoptic network in Chattanooga, TN*
  - *Test latency and data availability*
  - *Test impact on existing SCADA traffic*

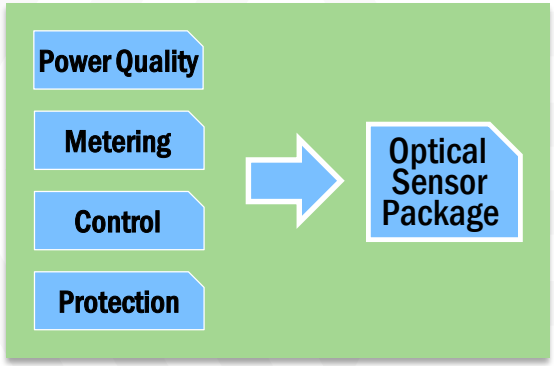


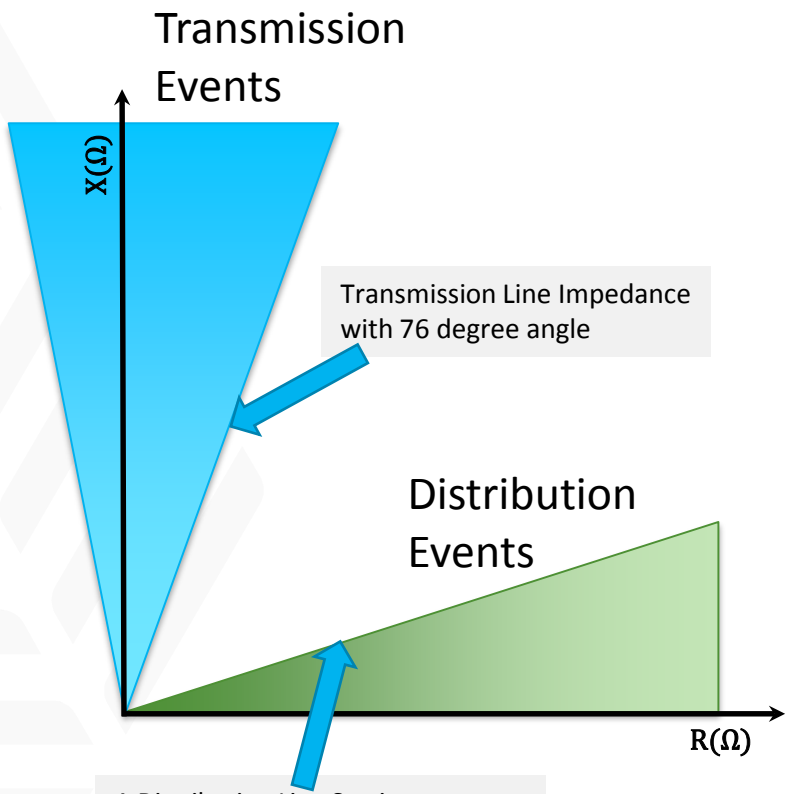
The TSN architecture will rely on multiple VCs/VLANs to differentiate the measurements/control traffic in consort with the TSN network manager.



Step Distance Protection

- Impedance based fault localization and protection
  - Currently used only in transmission systems
  - Allows bi-directional power flow
- Approach
  - Use high resolution isolated optical current and voltage sensors to test step distance protection for distribution
  - Develop and test hardware in the loop distribution step distance protection relays
  - Test using standard Doble test sets





Southeast Regional Workshop

March 22nd-23rd, 2017

- Held at the Zucker Family Graduate Education Center in North Charleston
- Organizations that attended:

DOE OE ISER, DOE SR, Duke Energy, Santee Cooper SCE&G, Southern Company, Electric Power Board EPRI, General Electric, Resilient Power Systems Clemson University, UNC Charlotte, NC State, ORNL SRNL, PNNL

- ORNL and SRNL had presentations and posters associated with Southeast Projects
- Focus of the Workshop was on Grid Resiliency and Restoration
- SCE&G and Santee Cooper gave presentations on the impact and recovery of Hurricane Matthew
- Several areas of future collaboration between SRNL, ORNL, universities, and the SE utilities were discussed

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Accomplishments to Date

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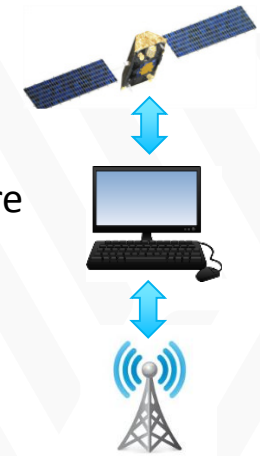
Dual-Channel Terrestrial and Satellite Wireless

- Detect fault locations with Advanced Metering infrastructure
  - Using information coming from SRNL hardware and simulated outages
- Schedule first responders due to fault location and priority

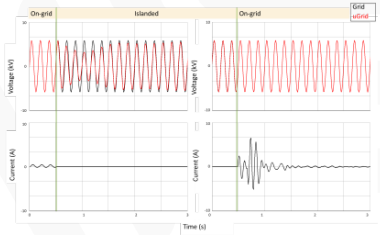


Time Sensitive Networking

- Deployed TSN network on EPB fiberoptic network
- Tested performance with extended grid state IoT sensors
- Showed no impact on SCADA traffic

CSEISMIC App Based Distributed Controls

- Developed HIL simulation and testbed for EPB microgrid
- Integrated CSEISMIC with device controllers
- Demonstrated seamless islanding and re-synch



Optical Step Distance Protection for Distribution

- Created a relay model for HIL testing
- Characterized sensor performance
- Integrated with Doble test sets for HIL testing

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Key Project Milestones – Milestones dates need to be approved by DOE OE

Milestone (FY16-FY18)	Status	Due Date
Complete Design of Design of Wireless Sensor Network	Complete	9/30/2016
Hold Southeast Region Workshop	Complete	3/30/2017
Documentation of optimization for restoration of at least one distribution feeder	Complete	12/31/2016
Report detailing the development of the Geographic Information System with Duke Energy's Distribution Feeders	In Progress	5/31/2017
Complete Demonstration of Wireless Sensor Network at Duke Facility	In Progress	6/30/2017
Report detailing test results of time sensitive network hardware and protocols	Complete	3/30/2016
Document functional verification of CSEISMIC distributed controls	Complete	3/30/2016
Document design and testing of optical step-distance protection	Complete	3/30/2016
Finish integration of distributed controls on EPB site-specific infrastructure	Complete	12/31/2016

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Next Steps and Future Plans

Time-Sensitive Networking

- Use TSN for EPB SCADA traffic
- Use TSN for IoT substation sensor data
- Test distributed controls over TSN network

Distribution Step Distance Protection

- Deploy optical sensors at EPB in parallel with existing relay CT's and VT's
- Compare speed and accuracy of step distance protection with existing relays
- Test fault localization accuracy using optical sensors
- Test optical sensors as phasor measurement units

CSEISMIC

- Deploy CSEISMIC on the physical EPB microgrid
- Test forecasting, optimization, and islanding/re-synching

Dual Channel Wireless/Restoration Optimization Algorithm Development

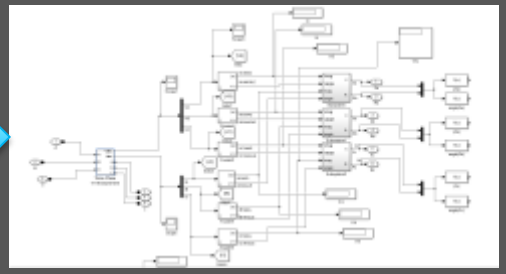
- SRNL, UNCC and Duke Energy will demonstrate the dual wireless sensor networks on various grid sensors at the UNCC Campus
- The Restoration Optimization Network will be demonstrated simulating power outages in the Southeast
- SRNL to compare performance of 24KV Smart Sense with ORNL low voltage sensor

BACKUP SLIDES

Step-Distance Protection with Optical Sensors

- Developed a software relay model (physics and relay logic)
  - Can't interface with existing analog hardware relay inputs
- Create a hardware in the loop test setup
- Using Doble test sets to simulate distribution faults
- Incorporated with the ORNL software defined low-voltage microgrid testbed

Relay Model

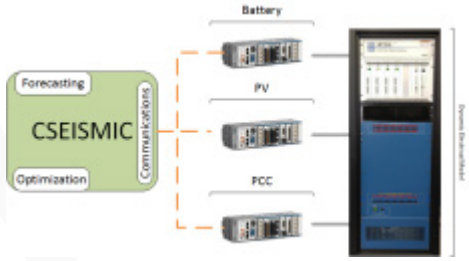


Doble Test Set

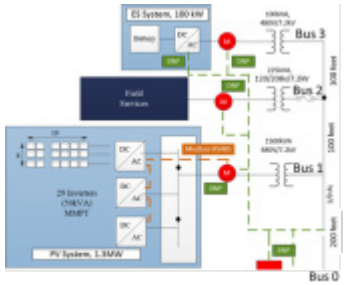
SI-Grid HIL Testbed

CSEISMIC

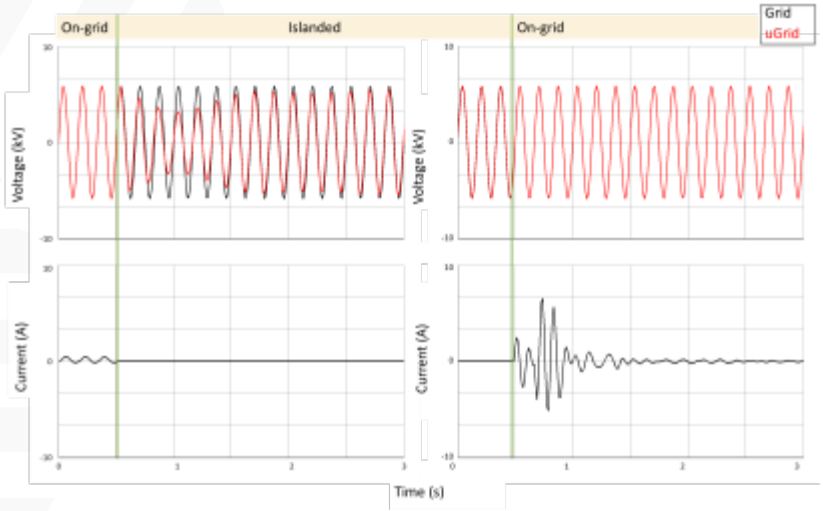
- Created a detailed model of the EPB Control Center, Flow Batteries, Solar Arrays, Inverters, Loads, and Busses
  - Power flow implemented in RTDS
  - Batteries, Solar, Inverters, Batteries, and Loads are implemented using FPGA's
- Deployed the app based CSEISMIC distributed controller on the microgrid
- Tested controller functions
  - Demonstrated seamless islanding and re-synching
  - Demonstrated online battery management



Microgrid master controller consisting of an EMS and SCADA and IED controllers are implemented in hardware.



EPB Control Center Microgrid



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Accomplishments to Date

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Time-Sensitive Networking

- Deployed a TSN network between two substations and the control center using the Chattanooga, TN Electric Power Board SCADA fiberoptic network.
- **Demonstrated no impact on existing SCADA network traffic**
- Using TSN network for extended grid state monitoring and remote drone operations

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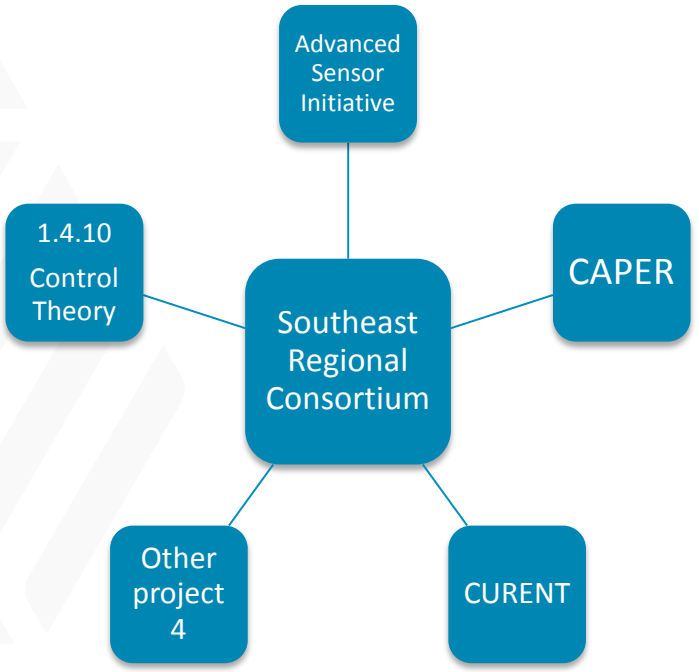
Project Integration and Collaboration

Describe how this project relates to other GMLC projects both Foundational and Program-Specific (From Project Negotiation Document)

The Southeast Regional Consortium presented our work at a regional workshop organized by the consortium to a group of 16 regional stakeholder.



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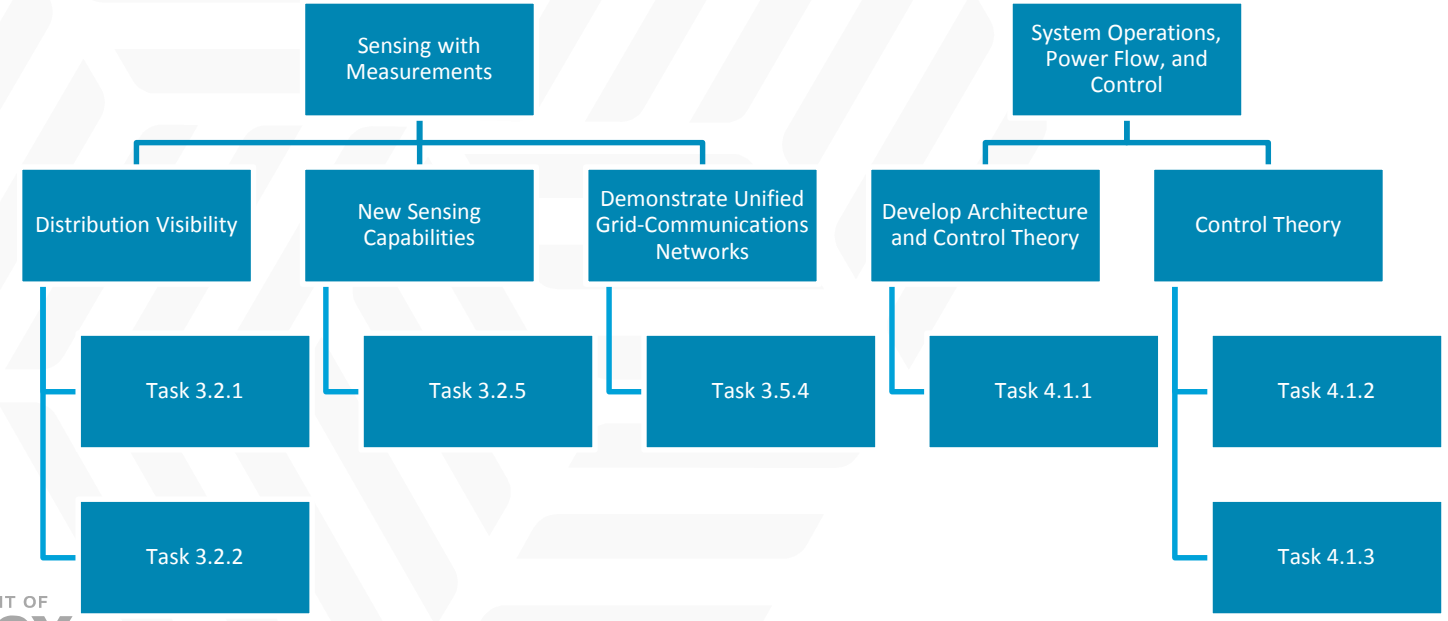
Relationship to Grid Modernization MYPP

This regional consortium is designed to facilitate the flow of information and technology between regional stakeholders to:

- Increase TRL levels of laboratory technologies from 3-4 to 5-6
- Transition laboratory technologies to industry for demonstration, testing, and validation
- Develop collaborative research project to address specific stakeholder needs.

The laboratory demonstrations under this project support the following MYPP goals



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Response to December 2016 Program Review

Recommendation	Response
Reach out to other Category 1 Project to look for synergy	All Cat 1 PI were invited to the South East Workshop held in Charleston. Staff from PNNL, ORNL, and SRNL discuss areas of future collaboration

Restoration Optimization

- Detect fault locations with Advanced Metering infrastructure
  - Using information coming from SRNL hardware and simulated outages
- Schedule first responders due to fault location and priority