

# Synchrophasor based Tracking Three Phase State Estimator and its Applications

DOE Advanced Synchrophasor Research Funding

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**V. Centeno**

*Virgilio@vt.edu*

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Center  
for Power and Energy  
Engineering

 **VirginiaTech**  
*Invent the Future*

# Project Objectives

Develop analytical tools for the implementation of a Synchrophasor-Based-Tracking three-phase state estimator for Dominion's 500 kV System.

Develop the transducer calibration techniques required for the proper implementation of the estimator

Develop analysis and visualization tools required for the application of the estimator to unbalance detection and intelligent islanding in the Dominion 500kV System

# Project Budget

Phase	Virginia Tech		Dominion Virginia Power		Quanta Technology		Total per Year
	DOE	Cost Share	DOE	Cost Share	DOE	Cost Share	
1	\$219,380	\$82,841	\$150,000	\$153,448	\$294,740	\$75,690	\$976,099
2	\$214,408	\$87,515	\$200,000	\$195,717	\$82,165	\$21,060	\$800,865
3	\$66,206	\$67,770	\$250,000	\$255,136	\$22,890	\$22,450	\$684,452
Total	<b>\$499,994</b>	\$238,126	<b>\$600,000</b>	604,301	<b>\$399,795</b>	\$119,200	<b>\$1,499,798</b>
	<b>\$738,129</b>		<b>\$1,204,301</b>		<b>\$518,995</b>		<u>\$961,627</u> <b>\$2,461,416</b>

Year	2009				2010				2011				2012			
Quarter	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
<b>Task 1</b> <b>Project Management</b>																
<b><i>Phase 1 – Analytical Studies</i></b>																
<b>Task 2</b> <b>Establishment of study system database</b>																
<b>Task 3</b> <b>Tracking Three Phase State Estimator</b>																
<b>Task 4</b> <b>Tracking Three Phase State Estimator Applications</b>																
<b>Task 5</b> <b>Three Phase Estimator Display Development</b>																

# Phase 1. Analytical Studies Tasks

## Task 2: Establishment of study system database

- a) Non-disclosure agreements
- b) Establish a study system model

## Task 3: Tracking three phase estimator

- a) Develop algorithms and software for the three-phase tracking state estimator for the 500kV system
- b) Develop algorithms to determine the optimal placement of Synchrophasors for full observability of the three-phase system.

# Phase 1. Analytical Studies Tasks:

## Task 4: Three Phase estimator applications

- a) Develop procedures and measurement sequences to estimate the magnitude and phase error of instrument transformers
- b) Develop real time tools for the detection and analysis of unbalanced conditions
- c) Develop real time tools for the detection and identifying of islanding scenarios.
- d) Develop three-phase estimator visualization tools.

# Phase I: Dominion

## ***PMU Installation at:***

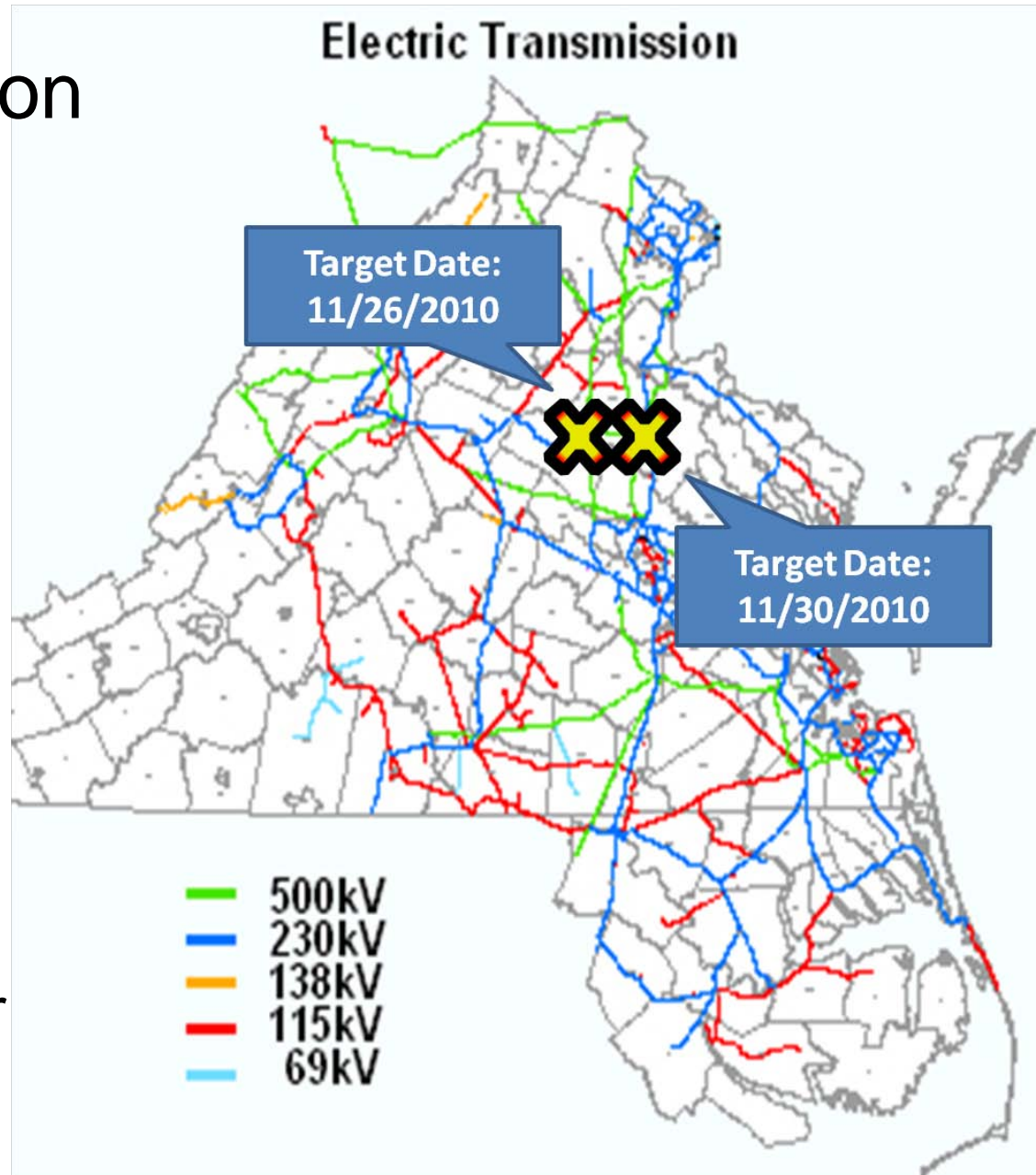
North Anna

Ladysmith

(generator stations)

Development  
architecture for data  
concentration and  
calculation

Purchase and  
installation of  
synchrophasor vector  
processor.



Year	2009				2010				2011				2012			
Quarter	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
<b><i>Phase 2 – Pilot and Prototype Studies</i></b>																
<b>Task 6</b> <b>PDC/Server System Integration,</b> <b>specification and selection</b>																
<b>Task 7</b> <b>Tracking Three Phase estimator</b> <b>Lab testing and demonstration</b>																



## Phase 2: Pilot and Prototype Studies

- a) Select a Dominion substations and test performance of the algorithms and measurement sequences to determine the magnitude and phase error for instrument transformers.
- b) Use Dominion's full system model to test the performance of:
  - 1) Three-phase estimator algorithm
  - 2) Unbalance detection and tracking algorithm
  - 3) Islanding algorithms and enhanced optimal PMU placement
- d) Use the 3-phase estimator to test the performance of the visualization tools developed for the estimator.
- c) Determine the minimum requirements and select the commercial data concentrator needed to implement the three-phase tracking state estimator in Dominion Virginia Power's 500 kV system.

# Phase II: Dominion

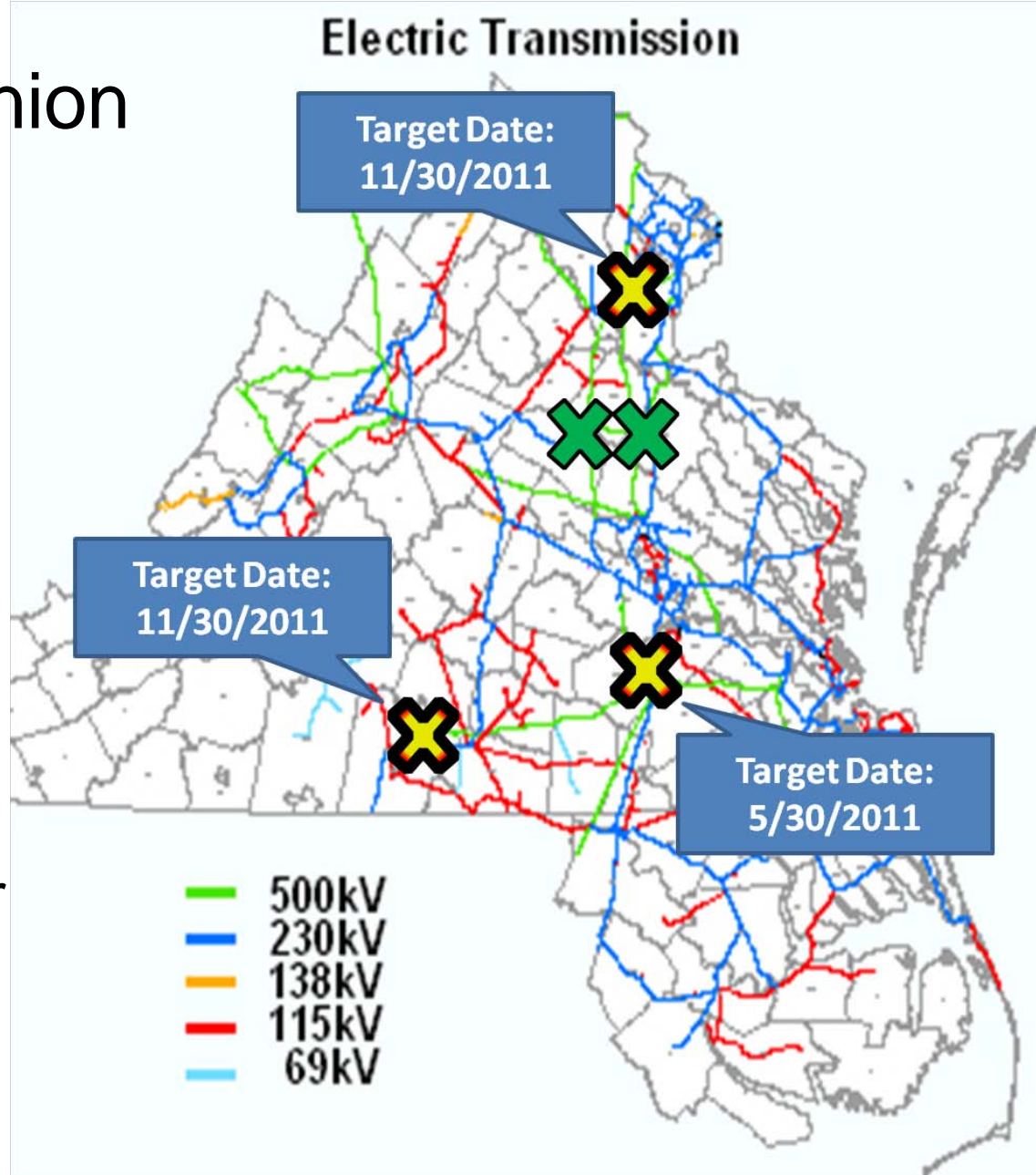
## ***PMU Installations:***

Carson Substation  
Bristers Substation  
Clover Substation

## ***Other Activities:***

Purchase and preliminary setup of visualization server for tracking estimator

Database licenses



Year	2009				2010				2011				2012			
Quarter	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
<b><i>Phase 3 - Full Scale Demonstration</i></b>																
<b>Task 8 PDC field verification and installation</b>																
<b>Task 9 Tracking estimator field installation and verification</b>																

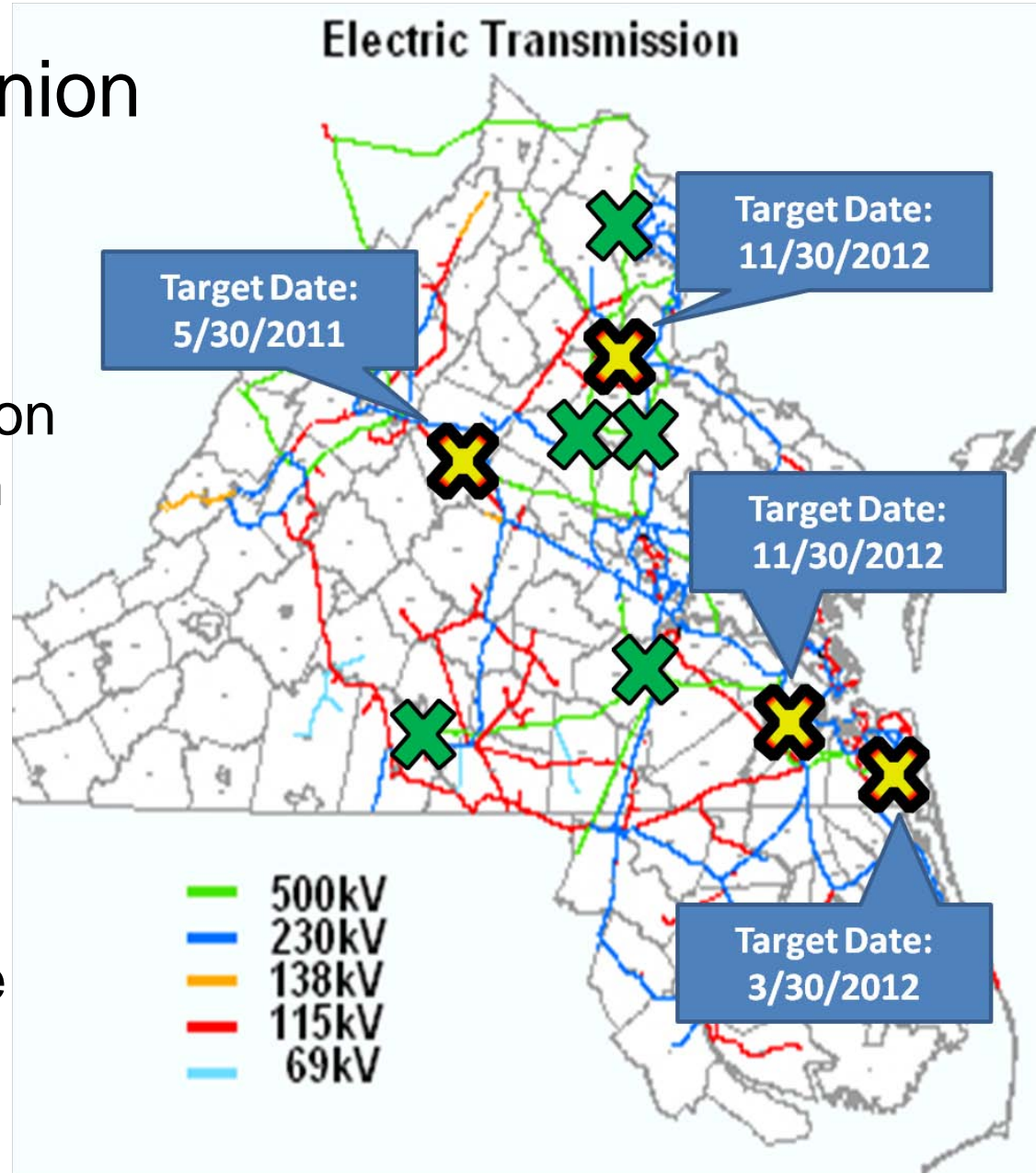
# Phase III: Dominion

## ***PMU Installations***

Fentress Substation  
Cunningham Substation  
Chancellor Substation  
Septa Substation

## ***Other Activities:***

Testing and  
commissioning of  
Tracking Estimator  
Visualization Software



# Project Team

## Virginia Tech

Arun Phadke, PI

Jim Thorp, Virgilio Centeno - Co-PIs

## Dominion Virginia Power

Mathew Gardner, PI

Richard Purdy, Mark McVey, Terry Fix – Co PIs

## Quanta Technology

Damir Novesel, PI

Yi Hu, David Elizondo - Co-PIs

¿Preguntas?



- Three-Phase Estimator Interface and Displays Development
  - Stand alone applications, completely separated from the existing EMS/SCADA system
  - System Display Application. Display phasor measurements on a one-line diagram of Dominion's 500 kV transmission system and identify transmission network elements that operate in unbalance conditions.
  - Tabular Display Application. List power system elements that operate under unbalanced conditions.
  - System Islanded Display Application. Observe the separated system and capture its behavior.
  - Trending Display Application. Show the trends of unbalance conditions of the system and their relationships to the season, time of the day, etc.



- Ensure that the PMU, PDC and Application Server components are integrated to function as one system.

