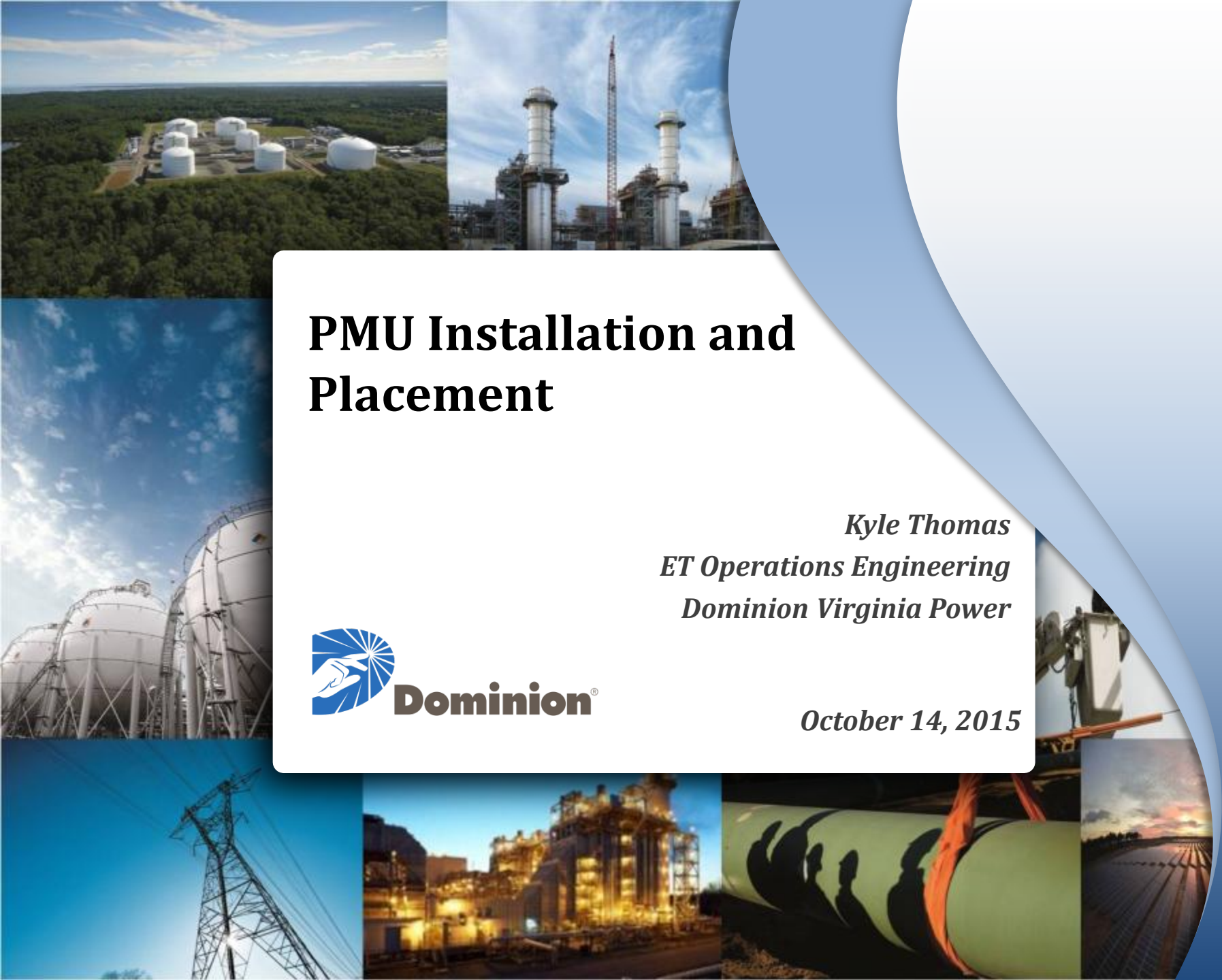

PMU Installation and Placement

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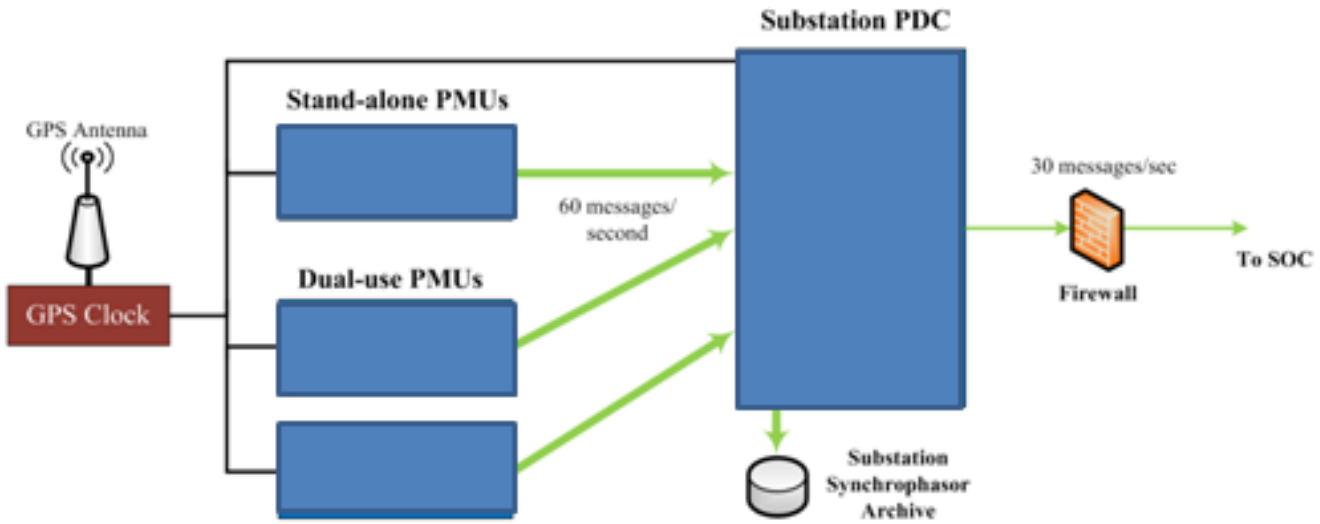
October 14, 2015

PMU Installation

Architecture Design

- **Stand-alone PMUs**
- **Dual-use PMUs**
  - DFRs
  - Relays
  - PQ Meters
- **Clock synchronization**
- **Data resolution**
- **PDC Architecture**
  - Include substation PDC?
    - Local storage
    - Down-sample
    - Reduce open ports from substation
  - Central PDC
- **CIP versus non-CIP determination**



PMU Installation

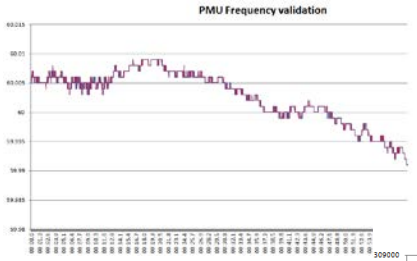
Inside the substation control house

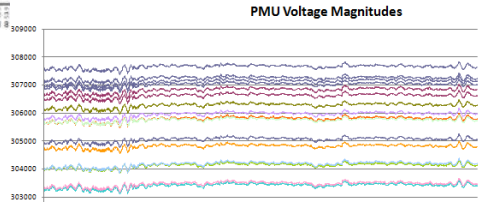
- **Wiring to the PMUs**
  - Connecting measurements:
    - Voltages (single phase vs. 3-phase)
    - Currents (single phase vs. 3-phase)
    - Digitals (ex: circuit breaker status)
    - Analogs
  - Communications
    - Ethernet, fiber, serial, etc.
  - Time Synchronization
    - Satellite clock, direct antenna, PTP, etc.
- **PMU Settings**
  - Standard setting templates
- **Phasor naming conventions**
  - Owner conventions versus ISO/RTO conventions

PMU Installation

Commissioning

- **Commissioning is a key step to ensuring field installation is complete and correct**
  - Connect PMU stream with stream reader
  - Capture and store small set of data to check (1 minute to 5 minutes)
- **Items to validate:**
  - Timestamps
  - PMU Status word
  - Phasor magnitudes
  - Phasor angles
  - Frequency & dfdt
  - Any digitals and analogs





Status Word = A000 (HEX)

Data Invalid

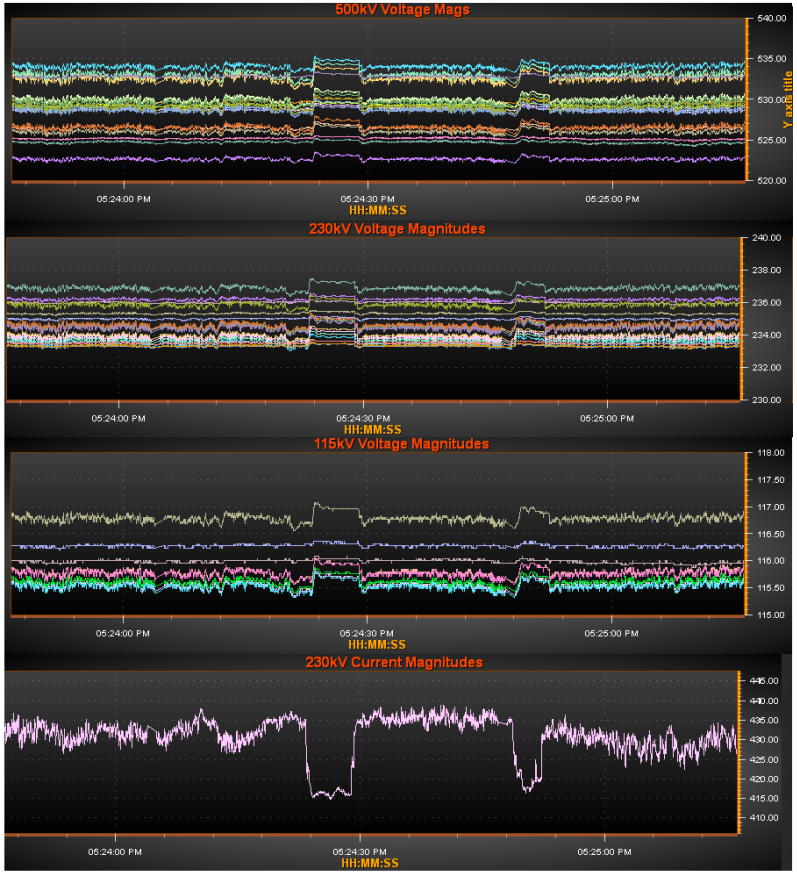
PMU not GPS synchronized

Good Timestamps	Bad Timestamps
04/22/2014 10:10:10.000	04/22/2014 12:12:12.000
04/22/2014 10:10:10.033	04/22/2014 12:12:12.050
04/22/2014 10:10:10.066	04/22/2014 12:12:12.077
04/22/2014 10:10:10.100	04/22/2014 12:12:12.123
04/22/2014 10:10:10.133	04/22/2014 12:12:12.143

PMU Placement Strategies

PMU locations can enable the use of applications and tools

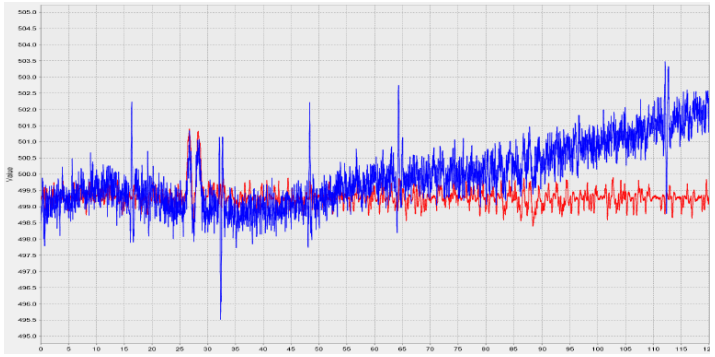
- **Place PMUs at locations critical to your system**
  - EHV substations, then work on lower voltage levels
  - Critical flow paths
  - Grid interconnections
  - Nuclear plant interfaces
  - Unique system locations (FACTs devices, Arc furnaces, etc.)
- **Real-time Applications**
  - State Estimation
  - Oscillation Monitoring & Analysis
  - Inter-Area Mode Monitoring & Analysis
  - Angle Difference Monitoring
  - Blackstart and System Restoration
  - Remedial Action Schemes
  - Major Interfaces – IROLs & SOLs
  - Renewable Energy Resource Integration
  - Voltage Stability and Control

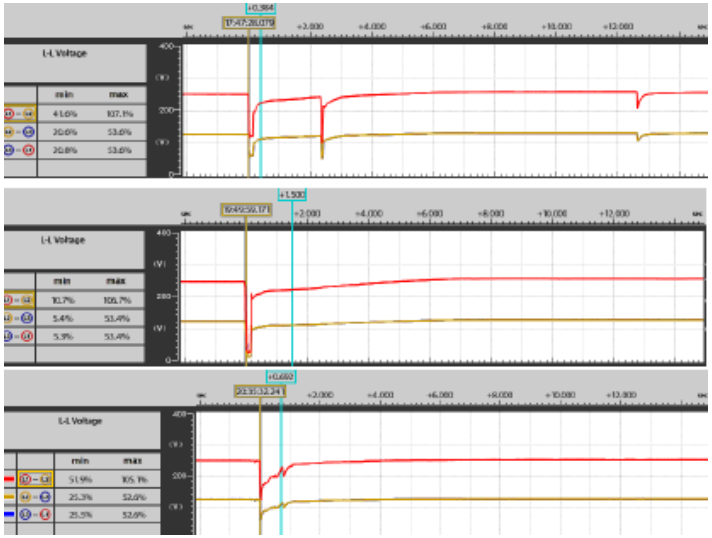


PMU Placement Strategies

Offline Applications

- **Generator Model Validation**
- **System Model Validation**
  - Large power plants and generating units
  - Dynamic reactive power resources (ex: FACTs devices)
  - HVDC terminals
  - Automatic controls such as Under-Load Tap Changers (ULTC), phase-shifting transformers, and switched shunt devices
- **Load Model Validation**
  - Cohesive load zones – capture aggregate load response
  - Major system loads – large industrial or block loads
- **Disturbance Monitoring & Event Analysis**
  - PRC-002-2
- **Frequency Response Analysis**
- **Distribution System Monitoring**





PMU Installation and Placement

- **Optimize PMU Placement by finding any applications that utilize the same system locations**

- **PMU Standardization – rapid deployment, locations dependent on project locations**

- **Two great resources:**
  - "Guidelines for Siting Phasor Measurement Units", NASPI RITT
    - *https://www.naspi.org/File.aspx?fileID=518*
  - "Reliability Guideline: PMU Placement", NERC Synchronized Measurement Subcommittee (SMS)
    - Currently in progress

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