DOE/OE Transmission Reliability Program

Powerline Conductor Accelerated Testing (PCAT)

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Topics to Address

- Recap on what is PCAT and why is it here?
- Previous Capabilities & Challenges
- Status of Current Upgrades & Test Results

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Recap - History: Powerline Conductor Accelerated Testing Facility – Why is it here?

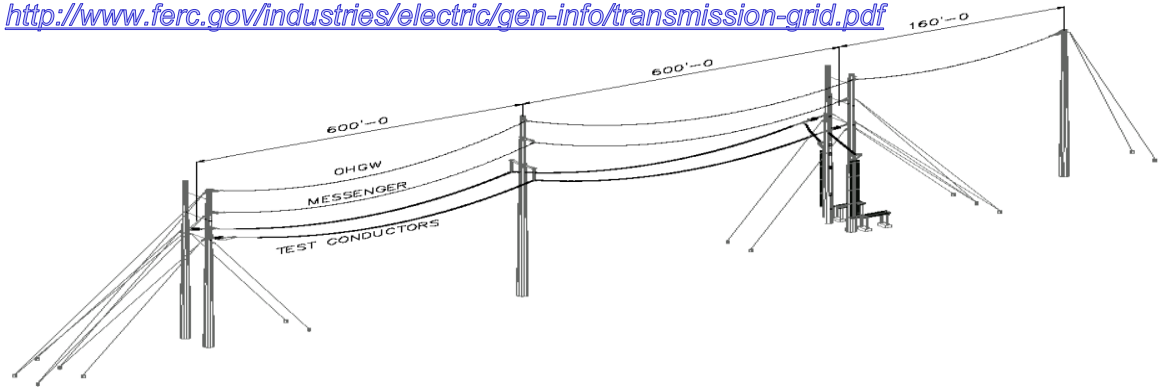
2002 - National Transmission Grid Study

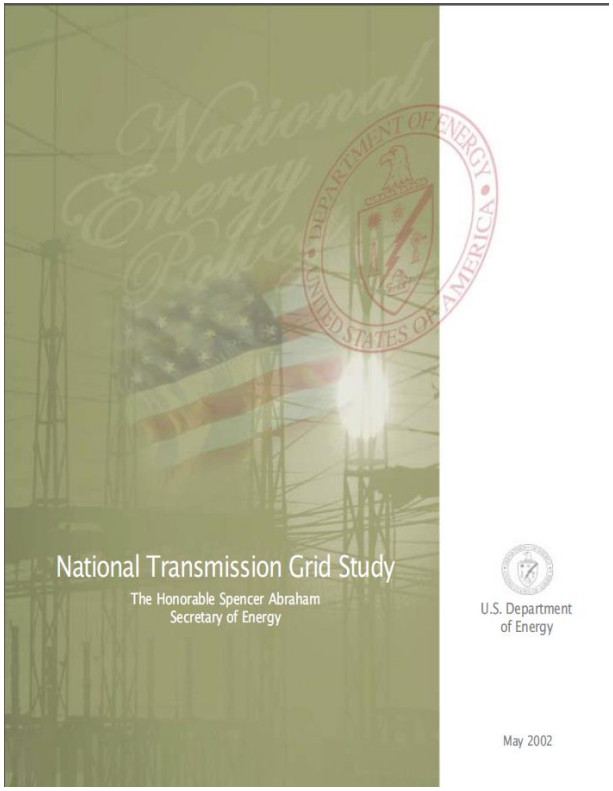
- One of the 51 Recommendations -

"DOE will develop national transmission-technology testing facilities that encourage partnering with industry to demonstrate advanced technologies in controlled environments.

Working with TVA, DOE will create an industry cost-shared transmission line testing center at DOE 's Oak Ridge National Laboratory (with at least a 50 percent industry cost share)."

http://www.ferc.gov/industries/electric/gen-info/transmission-grid.pdf





Originally built for the 3M Composite Conductor development, now available for any manufacturer to validate their product.

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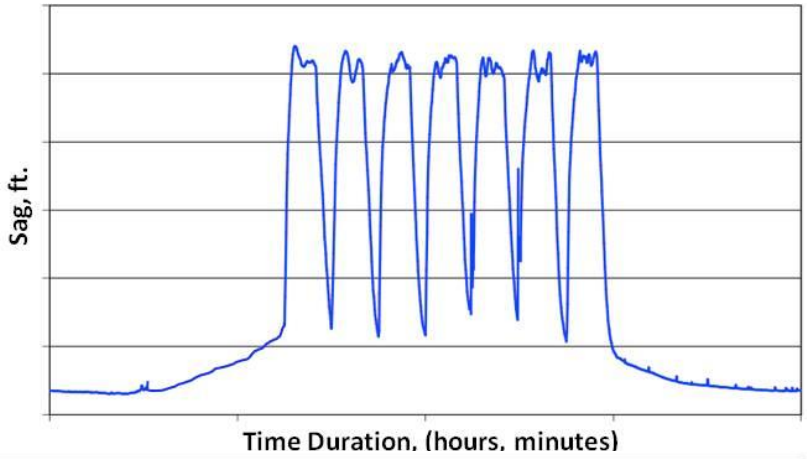
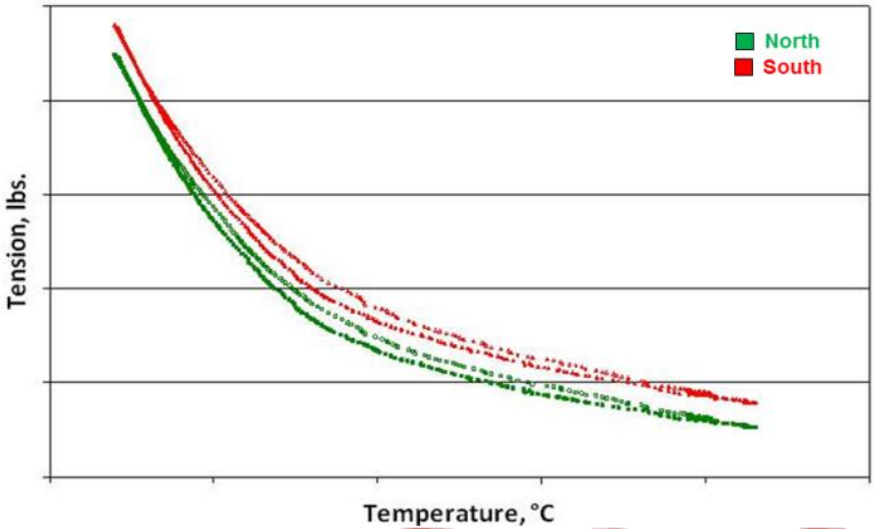
Recap: Past Accomplishments

- PCAT has been in operation for over 10 years
- The PCAT facility has been used to test many different conductors and sensors:
  - 3M 477 kcmil ACCR
  - 3M 675 kcmil ACCR
  - Southwire 1113 kcmil ACSR FO
  - Power Donut2
  - 3M 1272 kcmil ACCR
  - 3M 795 kcmil ACCR
  - Southwire C7 Overhead Conductor
  - Others





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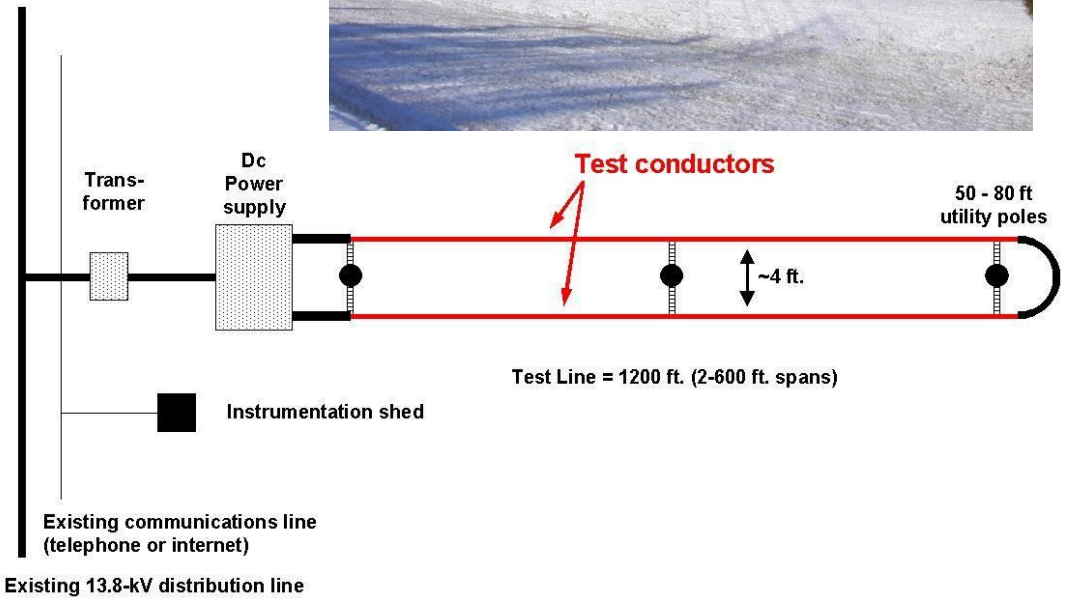
Recap - Capabilities: Powerline Conductor Accelerated Testing Facility

- Testing Capabilities
  - Thermal / Mechanical Cycling
  - Current / Temperature Ramp
  - Current / Temperature Steps and Hold
  - Controlled current testing
  - Controlled temperature testing
- Facility
  - 2400 feet of conductor
    - two 600 foot spans
    - 3 towers
  - 0 to 400 Vdc
  - 0 to 5,000 Adc
  - Conductor and accessories
  - Tested up to 300°C
    - can go higher if needed



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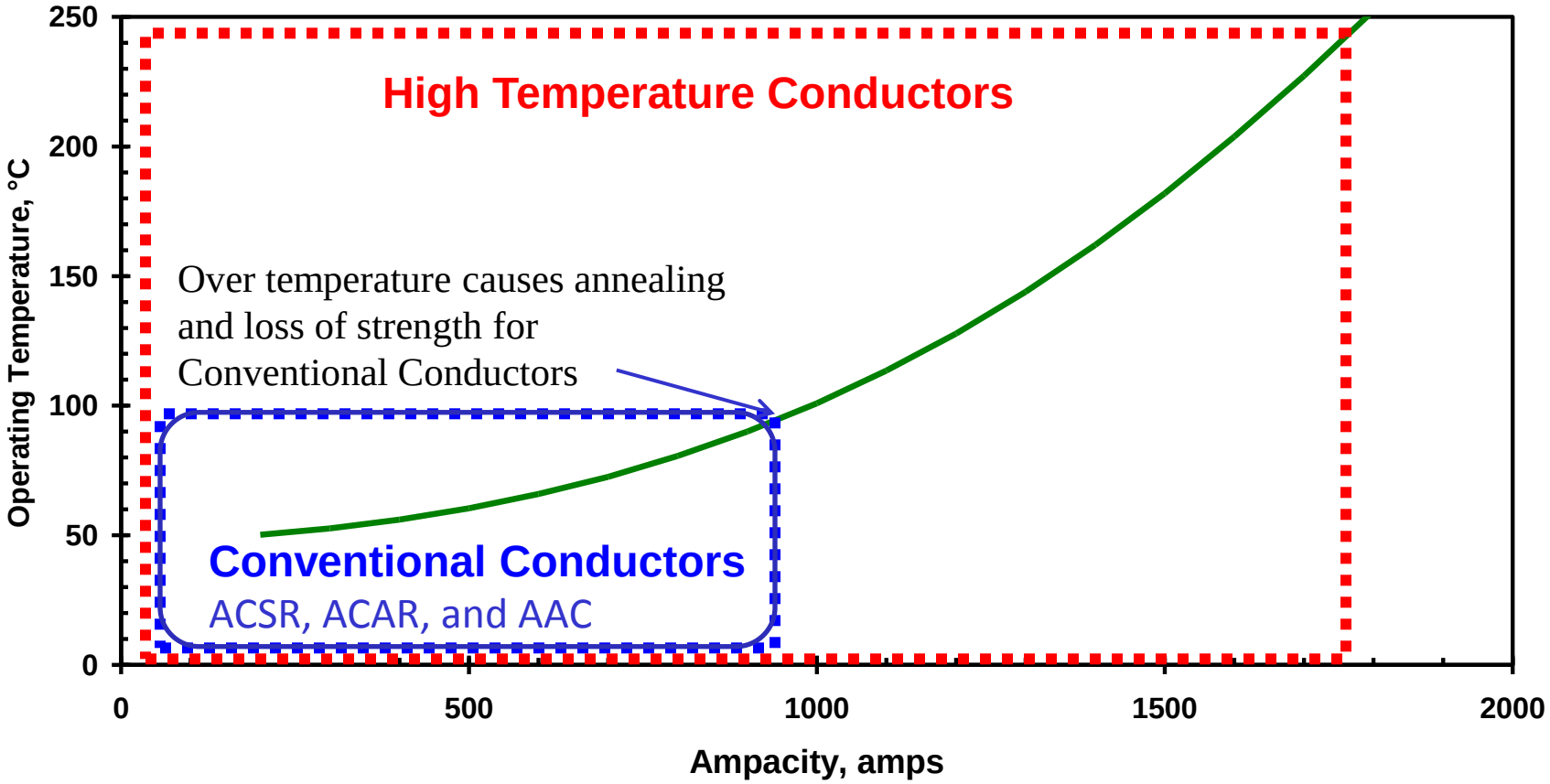
Recap: Driver of higher operating temperatures is higher current ratings



Need to test / verify new conductors over entire operating range

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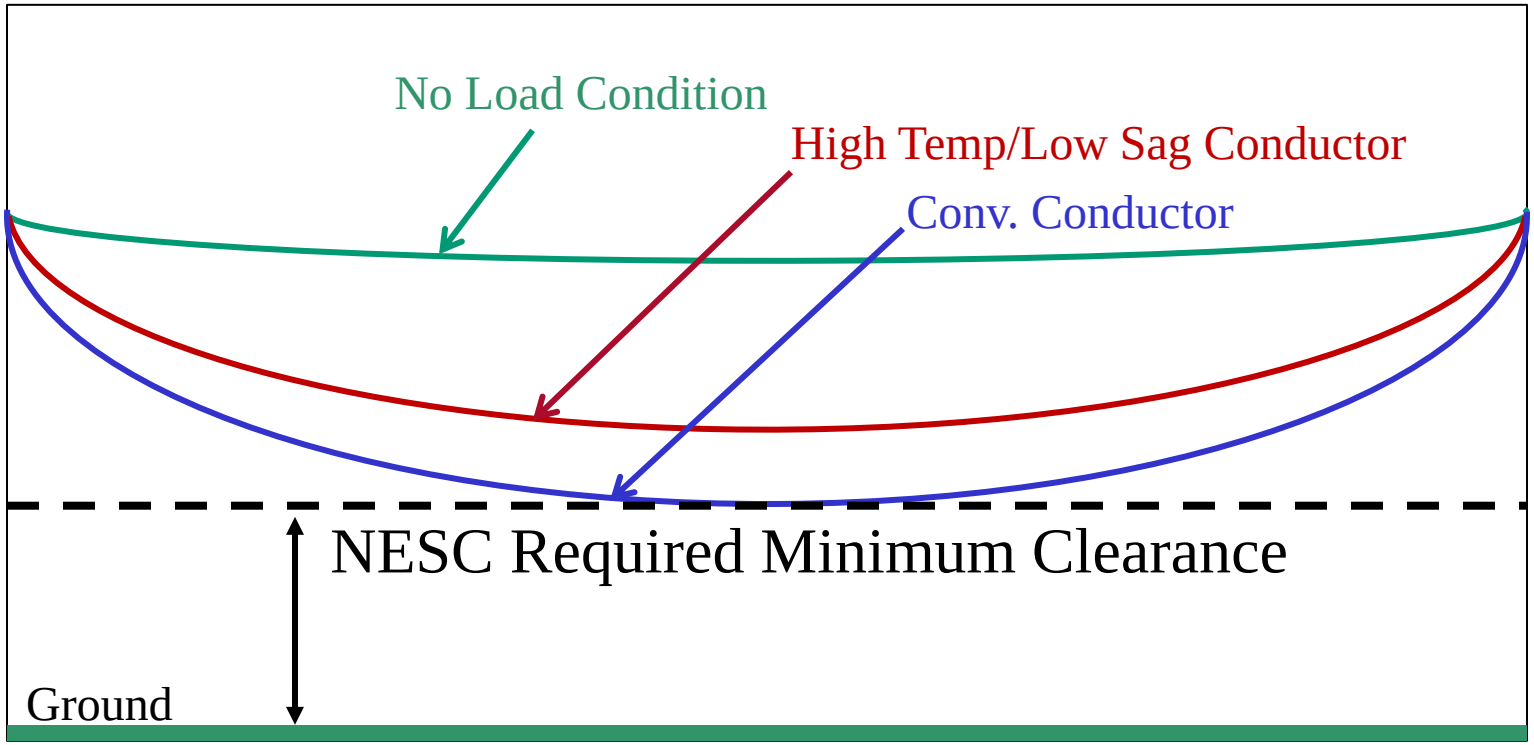
Recap: Benefit of a high temp/low sag conductor



More ampacity while still meeting the National Electric Safety Code (NESC) required minimum clearance

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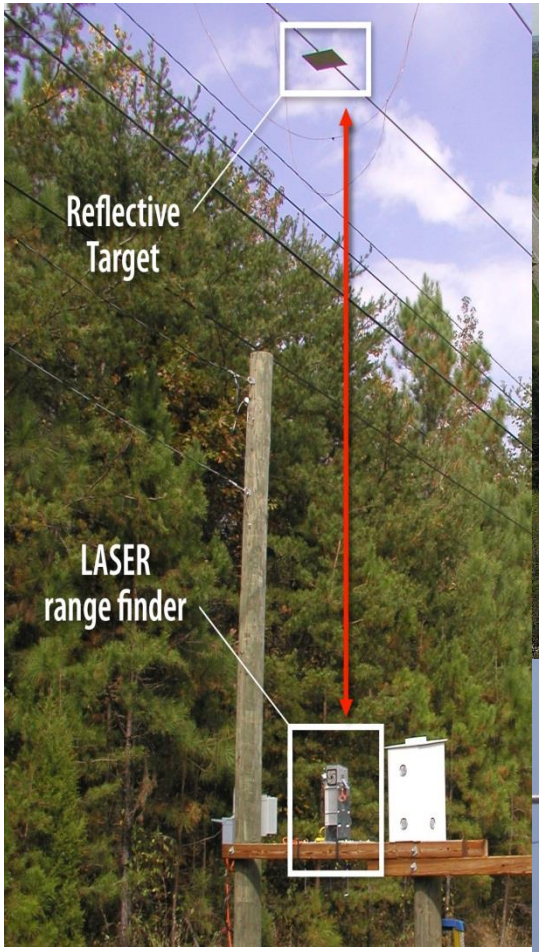
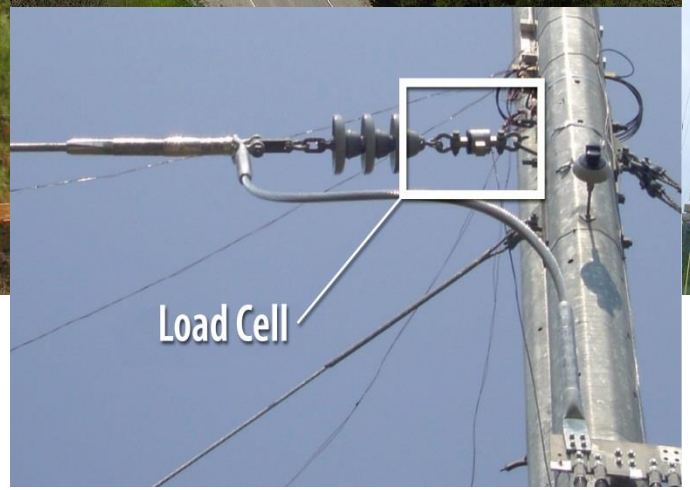
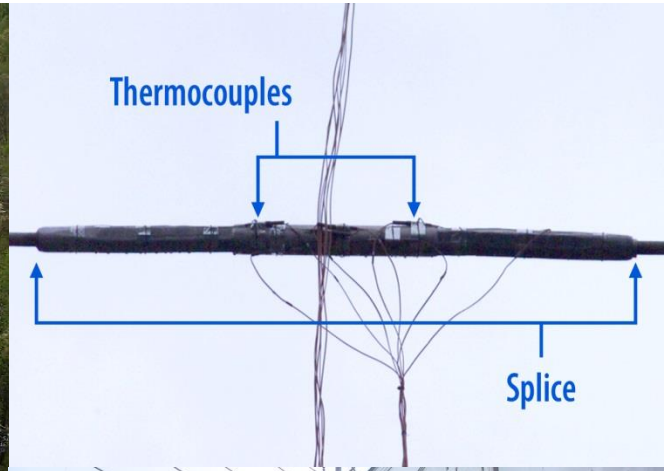
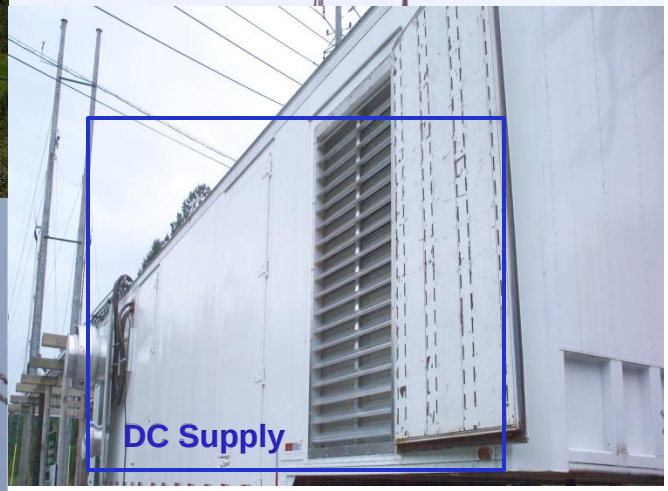
Recap: Existing Infrastructure









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Recap: Conductors are installed by TVA using conventional industry practices

Typical installation is ~ 3-4 days

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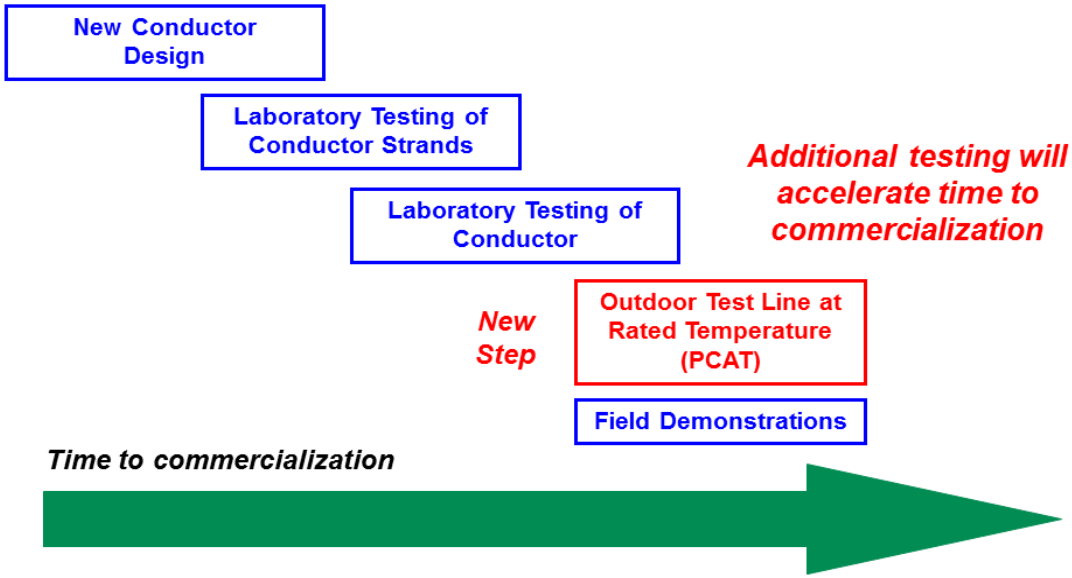
Where PCAT fits?

- PCAT provides a unique transmission conductor testing facility to augment utility field tests and demonstrations
- Each conductor test undertaken in collaboration with industrial partner



How is PCAT Unique?

Who else does this in the US?

- Other Facilities:
  - KEMA – No Overhead testing in US
  - NEETRAC – Primarily indoor
  - EPRI – Charlotte is indoor, Lennox could add outdoor testing, but currently not present

Only facility in North America where there are realistic spans, realistic environment, and realistic loads

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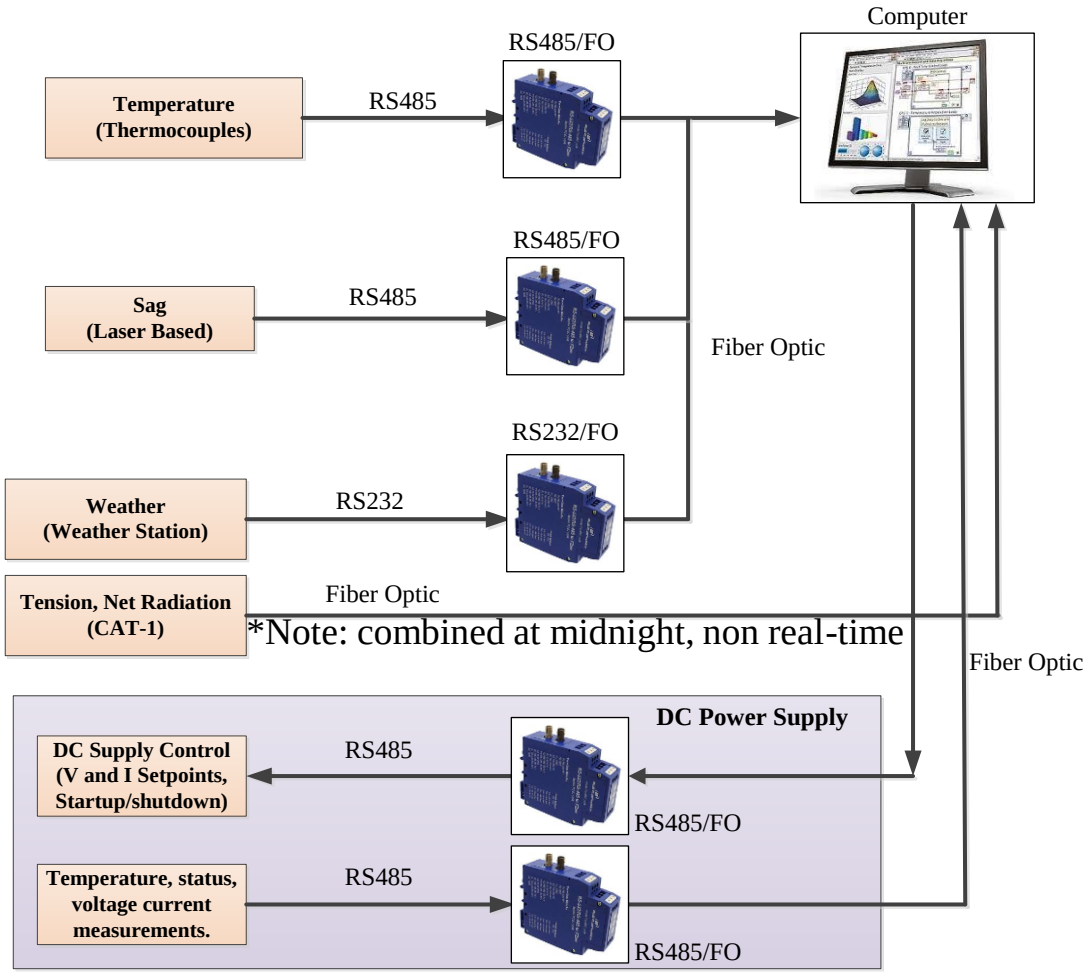
Historical Data Collection – Visual Basic

- Conductor/accessory temperature
  - Surface contact or conductor core
  - Upto 128 thermocouples
- Applied current and voltage
  - Measured by power supply
- Conductor sag
  - Laser at mid-span
- Conductor tension
  - Load cells on both circuits
- Weather
  - Ambient temperature, wind speed, wind direction
  - Conductor net radiation sensor
- PC-based data acquisition system
  - 10 second polling, 1 minute data archive



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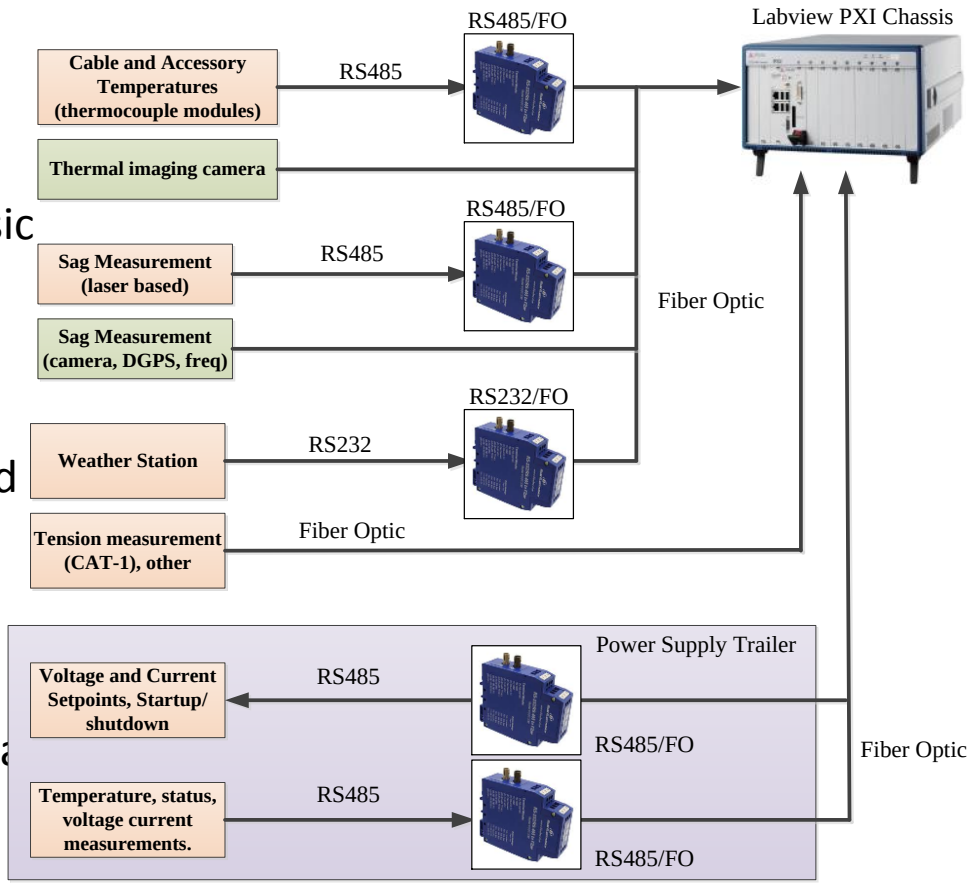
Historical Challenges to Testing

- Lightning strikes have damaged many sensors
- System lacked flexibility to adapt test plans and analysis to meet specific vendor needs:
  - Legacy software was in Visual Basic, original programmer has since retired.
- Measurement resolution
  - Inability to investigate short duration phenomena
- Inability to detect bad data
  - Unable to validate measurements using multiple sources (diverse measurement technologies)
- Conductor Right-of-Way Encroachment
  - Tree limbs were in close proximity to conductor including touching at times

Current Activities

- Rehabilitating PCAT Data Acquisition, Controls, and Visualization:
  - Replaced broken, obsolete and inflexible parts
  - Transitioning control from Visual Basic to LabVIEW.
  - Integrate new sensors including thermal imaging of conductor
  - Integrate continuous CAT-1 data feed
  - Implement real-time remote monitoring and warning system
- Continue testing
  - Installed and currently testing Genera Cable ACSS Drake 795 Conductor
    - One side coated, One side non-coated



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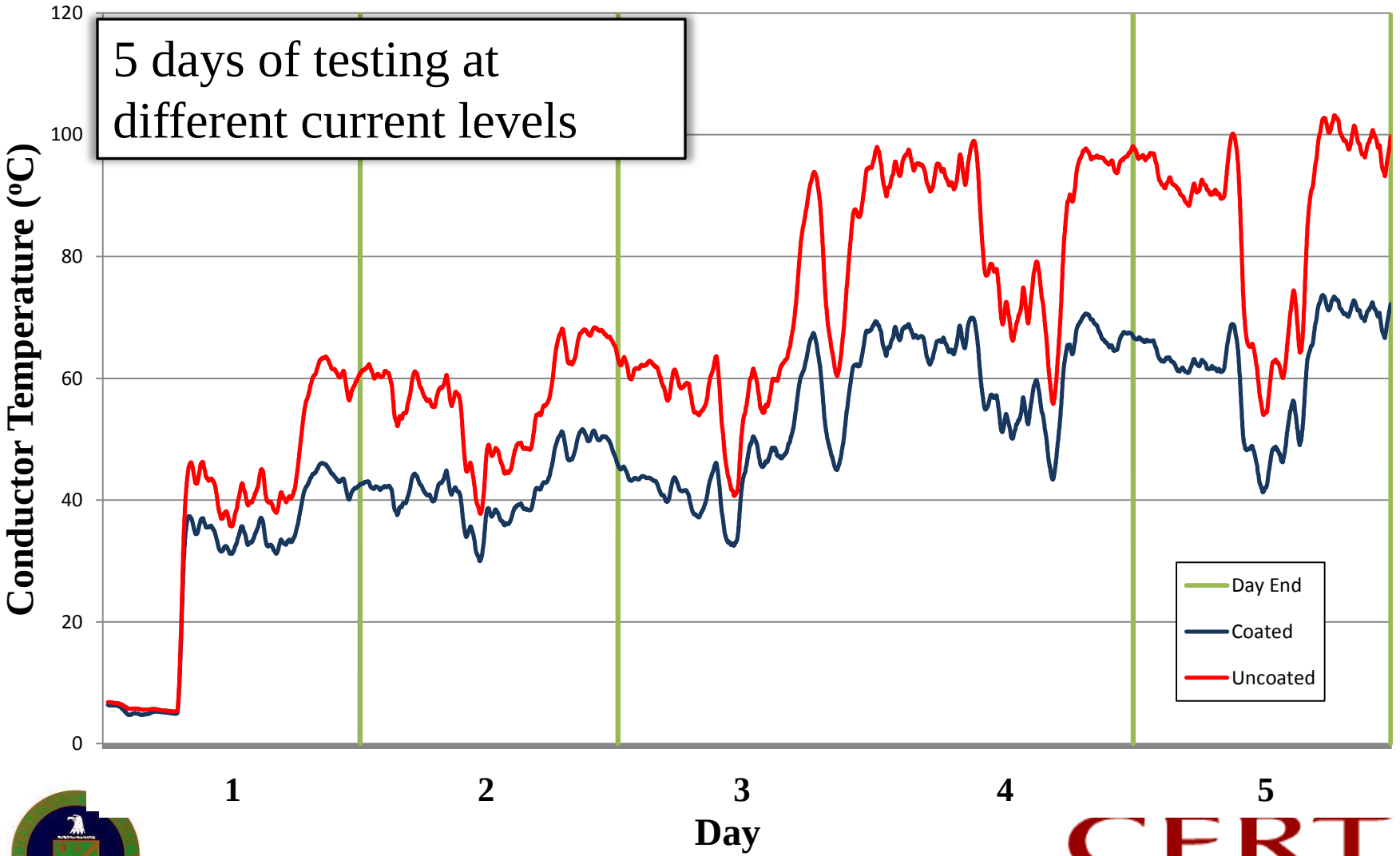
General Cable Test Results



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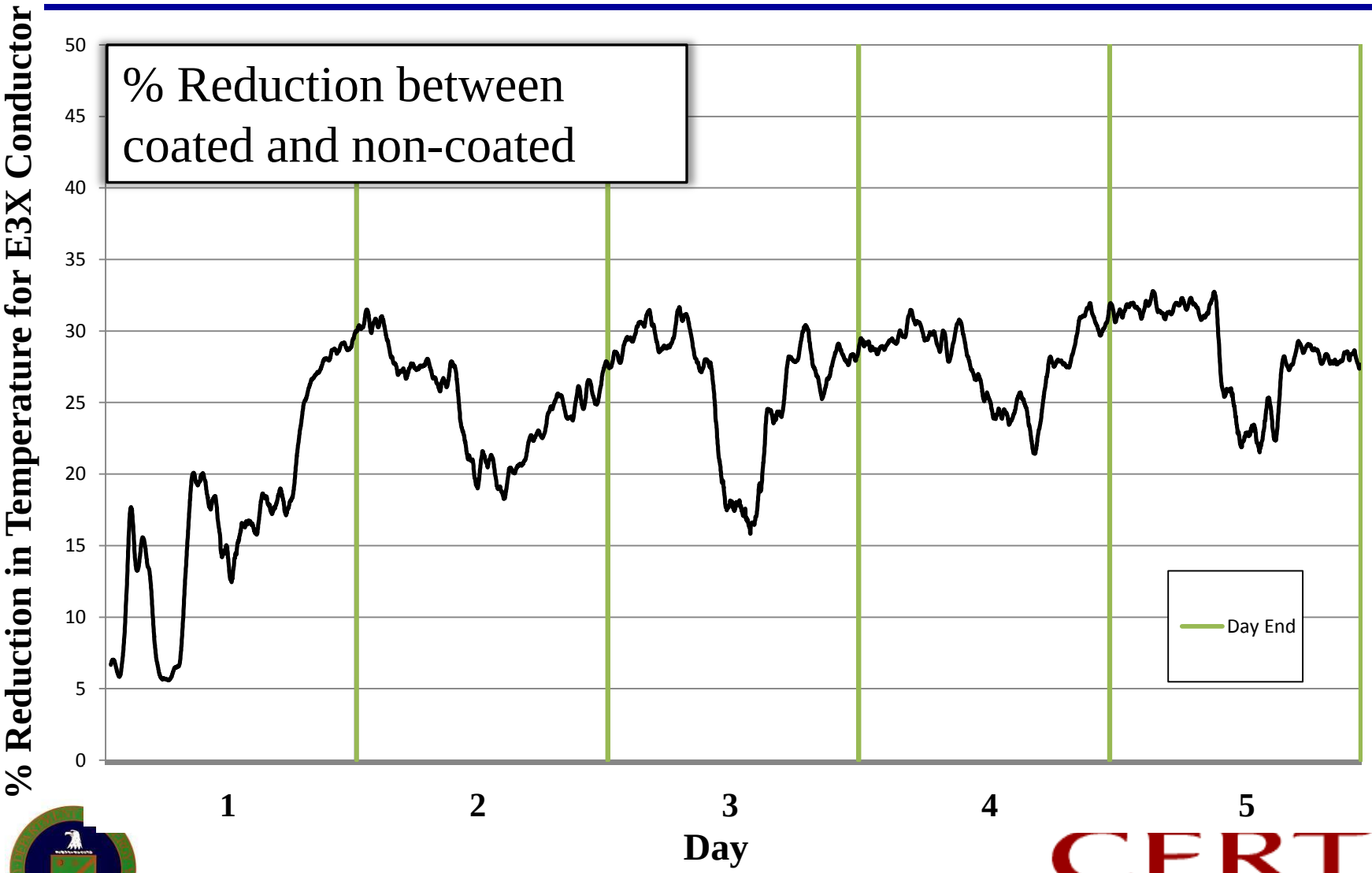

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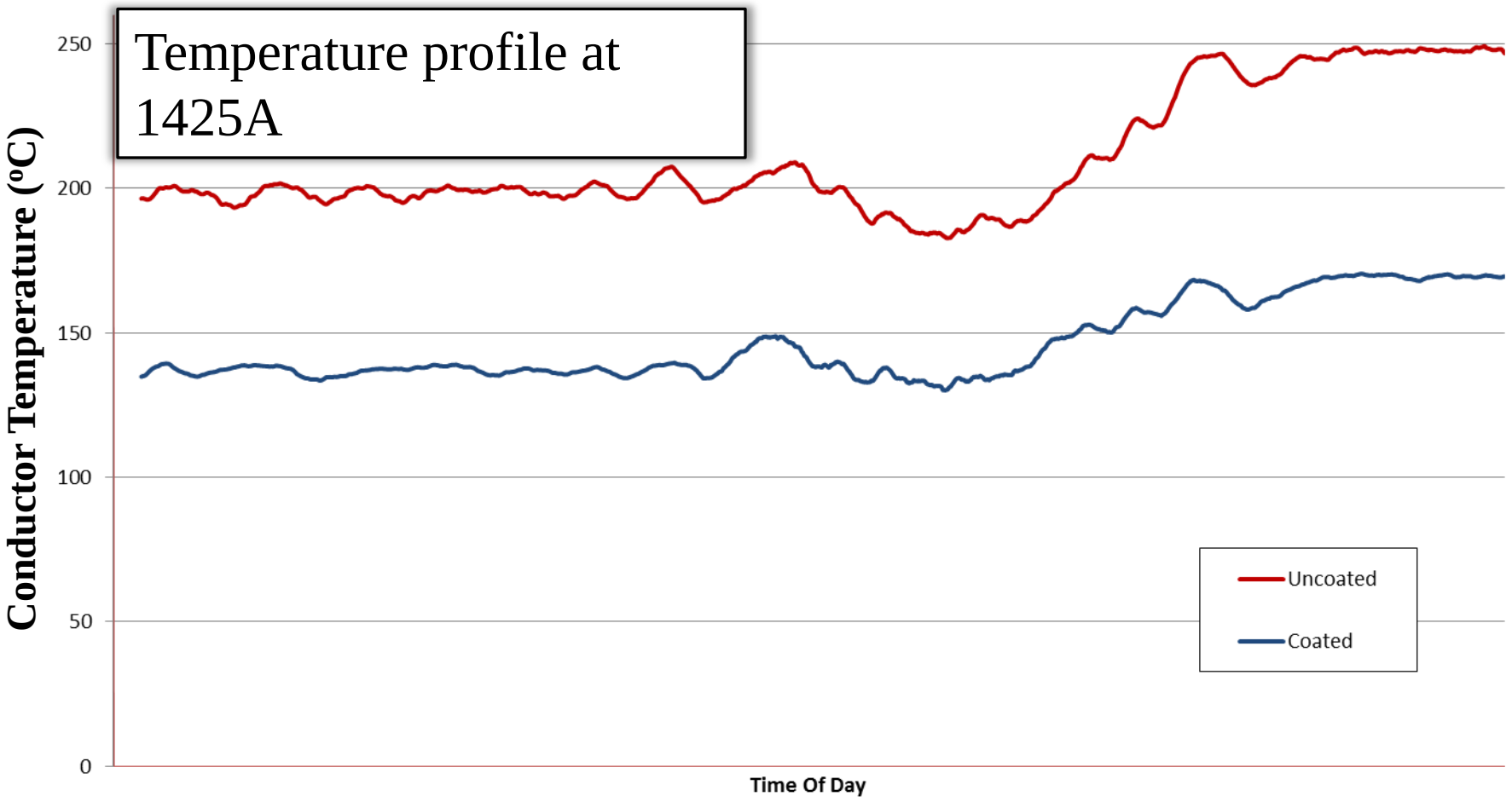

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General Cable Test Results

Conductor: ACSS Drake 795kcmil

Ambient Temp (°C)	Wind Velocity (ft/s)	Uncoated Conductor (°C)	Coated Conductor (°C)	% Reduction	Differential Sag (ft.)
9	1.1 - 3.6	90	72	**20%**	0.5
8	0 - 4.7	119	90	**24%**	0.7
8	4.4 - 5.7	125	94	**25%**	0.9
6	0.2 - 3.2	166	125	**25%**	1.5
6	0.4 – 4.8	200	150	**25%**	1.6
4	NA	240	174	**28%**	2.25
2	2.1 - 2.2	275	190	**31%**	2.85

20-30% Reductions in Operating Temperature and Sag for Coated Conductor vs Uncoated Conductor

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Right of Way Clearing

- Current Right of Way was encroaching on the conductor
- At times would have tree contact with conductor
- Cleared a large Right of Way (~15’) for the Conductor to ensure uninterrupted testing

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Thermocouple Upgrade

- Thermocouple modules all updated to I-7018-R modules
- Every channel individually checked to ensure valid identification and labeling
- Added open circuit thermocouple detection to the module enabling identification of unused thermocouples

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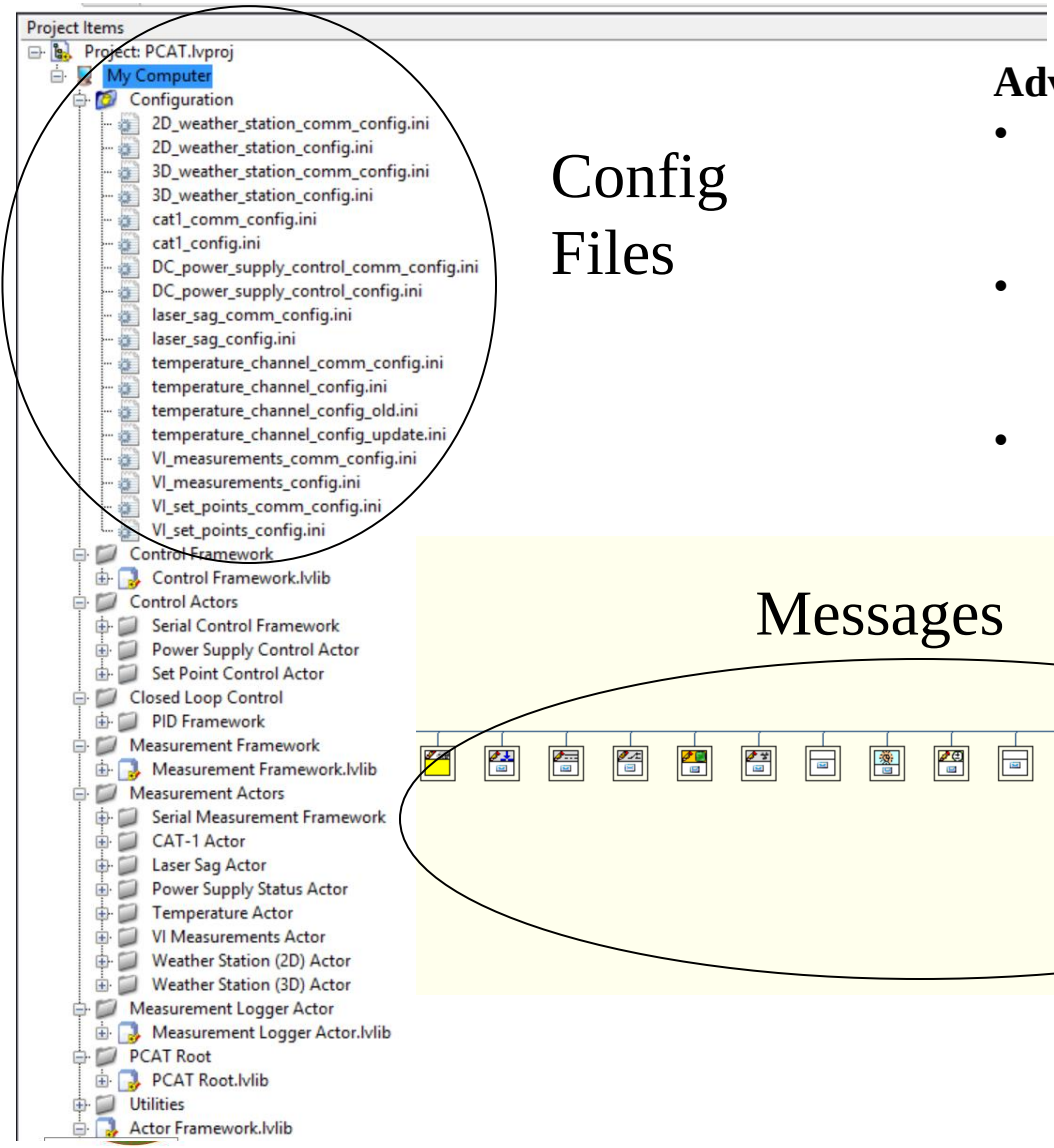
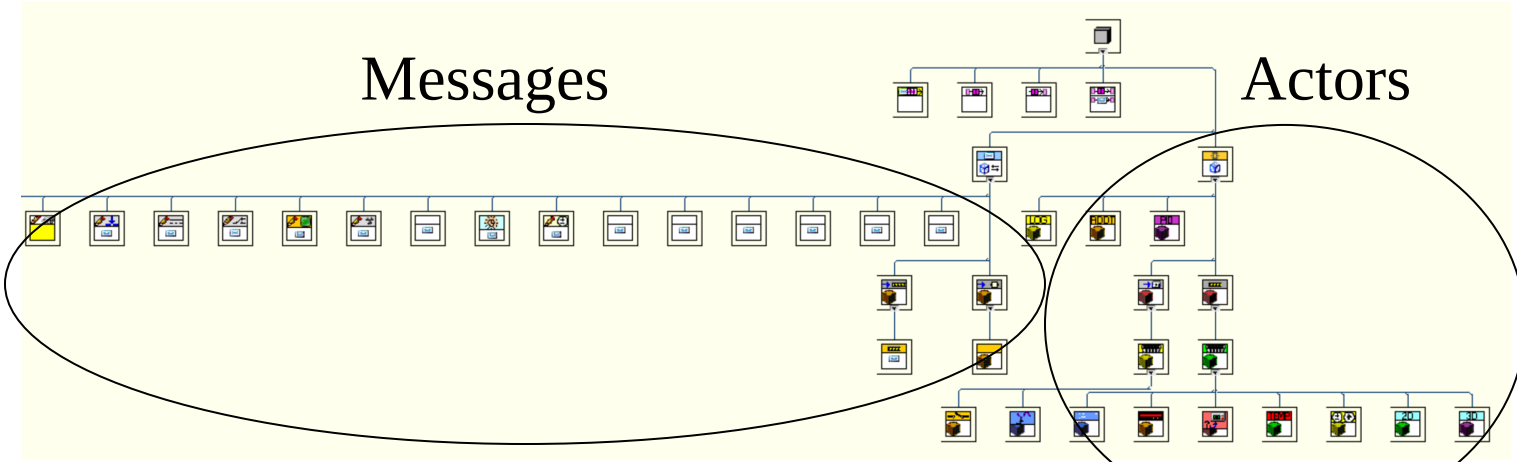
PCAT LabVIEW implementation using Actor Framework



Config Files

Advantages

- Measurements, processing, and controls performed asynchronously and in parallel
- Allows adding new measurement or control capabilities without affecting current functionality
- Enables rapid development of additional measurements and new controls



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Initial Thermal Investigation

- Roadside tracker with 2 FLIR Tau 2 Longwave Infrared (LWIR) cameras (640 by 512).
- 9 mm lens with focal length providing a 70 degree horizontal view angle.

Selected Thermal Camera

- Purchased A310f 15° FLIR Camera
- Currently integrating with LabVIEW front panel, followed by embedded image processing for sag and temperature analysis

Planned Installation Site, 2nd at other end once validated

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Additional sensors

- Material Transfer Agreement has been executed with UC Synergetics to implement their ThermalRate System
  - Plans to expand into a CRADA
- Plans to install the system during June and incorporate into the LabVIEW data feed
- Will provide feedback on any beneficial features

Risk Factors

- Glitches during cutover to new control system.
  - Have minimized risk by paralleling the serial connection to keep it connected to both sets of controllers.
- Unfavorable weather conditions
  - Because sustained bad weather is not predicted, this is only a minor risk to the schedule.

Proposed FY16 Activities

- Continue conductor testing
- Finish integrating additional sensors
- Enhance Real-time controls

- Expand PCAT test capability to include alternating current
  - Add a DC to AC inverter stage to the current infrastructure
  - Conduct additional testing including:
    - Perform conductor testing of steady state and transient conditions at grid frequency accounting for all the effects of the AC EM field
    - Test and experiment with measurement devices and auxiliary equipment including:
      - Dynamic Line Rating Devices
      - PMUs
      - CTs
      - VTs
      - Other devices intended for ac powerline applications
    - Test and experiment with different power flow control devices
      - Smart Wire
      - Power Donut
      - ORNL's Continuously Variable Series Reactor (CVSR)
      - Others
    - Investigate the impact of AC EM field on different devices/objects along the right-of-way

Q&A

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