National Laboratory/University Perspective on Existing RD&D

GridWorks RD&D Planning Workshop

Panel #1
Technical Status of Cables and Conductors Today
October 20, 2004
9:30 – 10:20 am

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Hyatt Regency O'Hare
9300 West Bryn Mawr Avenue
Chicago, Illinois

University/National Lab's Involved in Conductor RD&D

- Looking for testing facilities and relevant projects
  - University Research Capabilities
    - www.ece.umr.edu/~power/PEEC/main.html

- Georgia Institute of Technology – NEETRAC
    - National Electric Energy Testing Research and Applications Center
  - www.neetrac.gatech.edu/
  - Overhead Conductor Assessment & Hardware Conductor Analysis

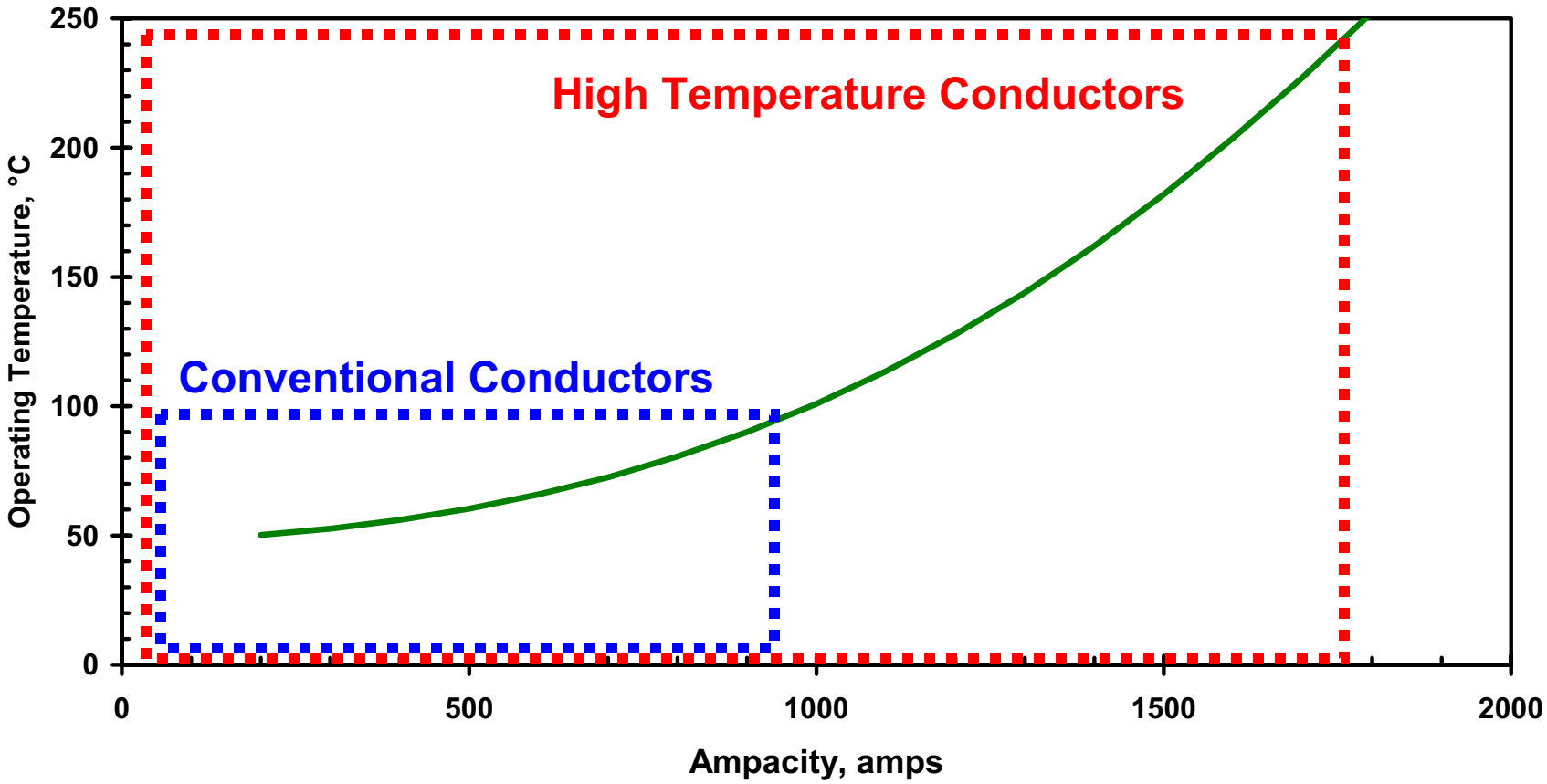
- Mississippi State University - High Voltage Laboratory
  - www.ece.msstate.edu/research/hvl/
  - Aging of insulated cables and overhead crossarms / insulators

- Oak Ridge National Laboratory – PCAT
    - Outdoor Powerline Conductor Accelerated Testing
  - www.ornl.gov/sci/oetd/facilities.htm
  - Overhead conductor/accessory testing at rated current/temperature

New conductors are available and being developed to improve on today's conductors

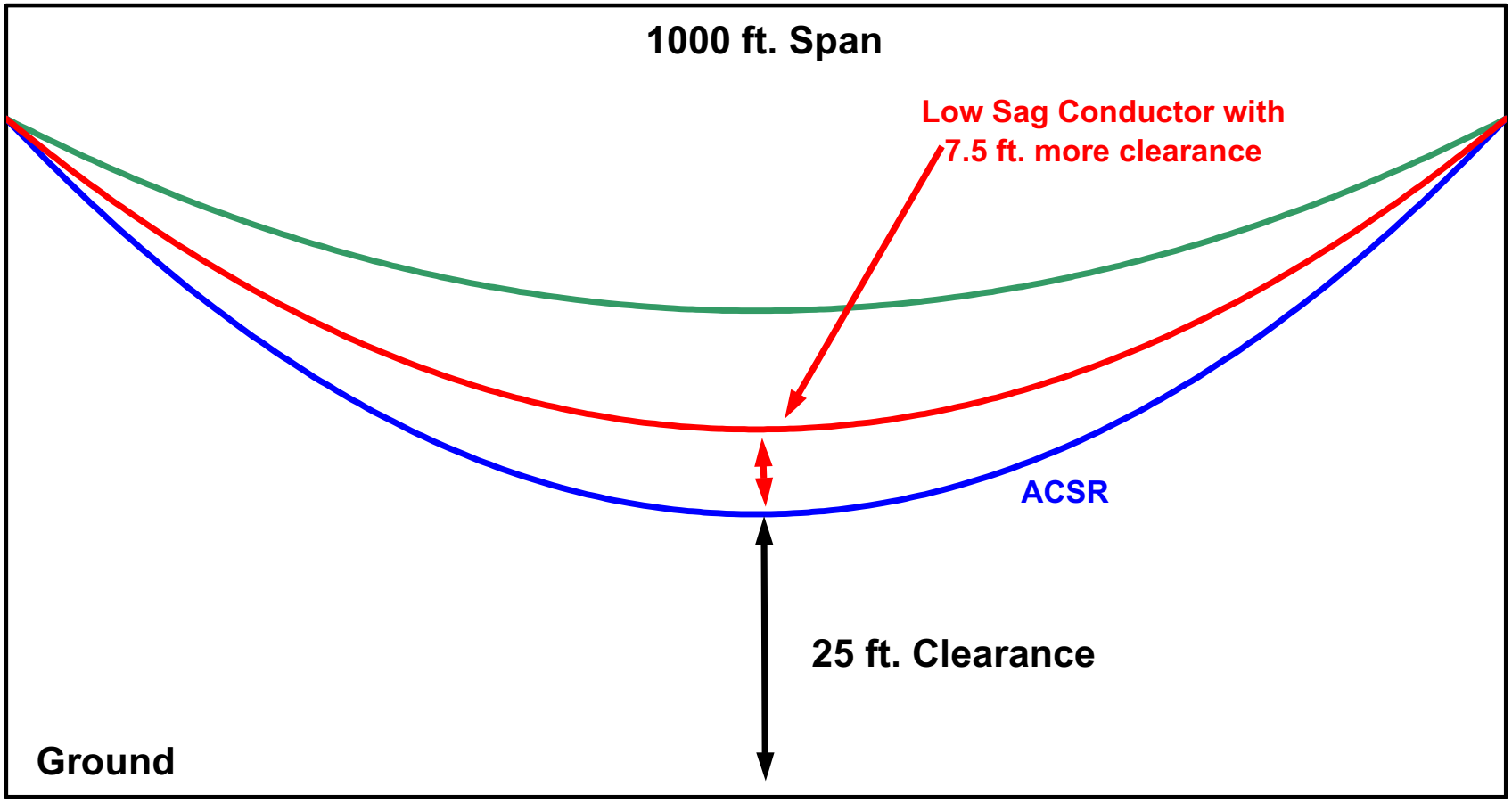
- #1 – Conductor Operating Temperature Limits Allowable Current
  - Raise operating temperature of aluminum by
    - Fully anneal the aluminum – lower strength
    - Add small amount of zirconium to aluminum – retains strength
- #2 – Conductor Sag Limits Allowable Current
  - The solution is to replace steel with a different material having a lower coefficient of thermal expansion (CTE)
- #3 Trapezoidal Shaped Wires
  - Pack more aluminum into same conductor diameter
  - More aluminum means more current
- #4 Gap Conductor
  - Reduce sag by using only the steel to hold conductor
  - Build a gap between steel core and aluminum

#1 Benefit of Higher Operating Temperatures is Higher Current Rating

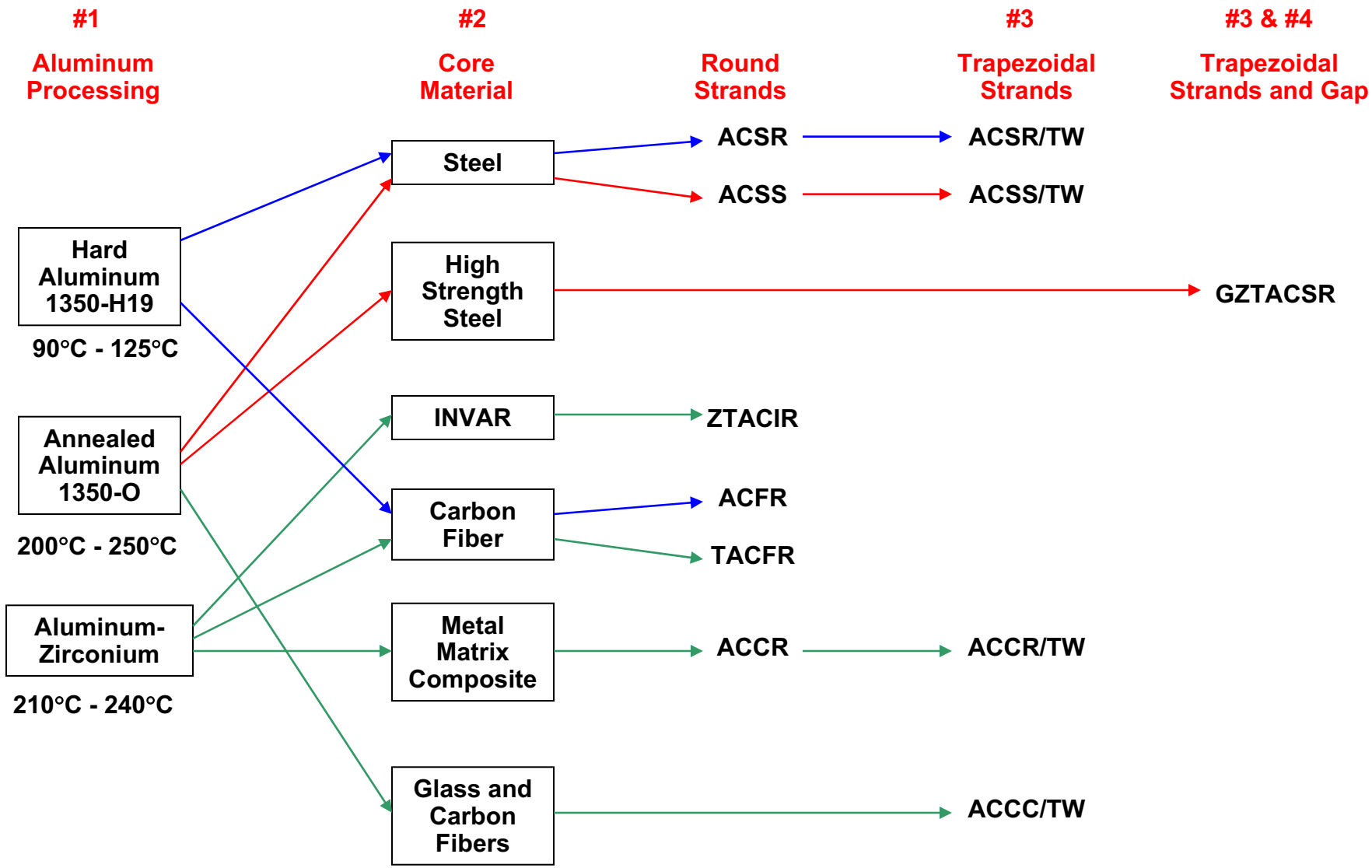


Need to test / verify new conductors over entire operating range

#2 Benefit of a Conductor the Expands at One-Half the Rate of ACSR



Conductor Road Map



Bringing a New Conductor to Market

New Conductor Design

Laboratory Testing of Conductor Strands

Laboratory Testing of Conductor

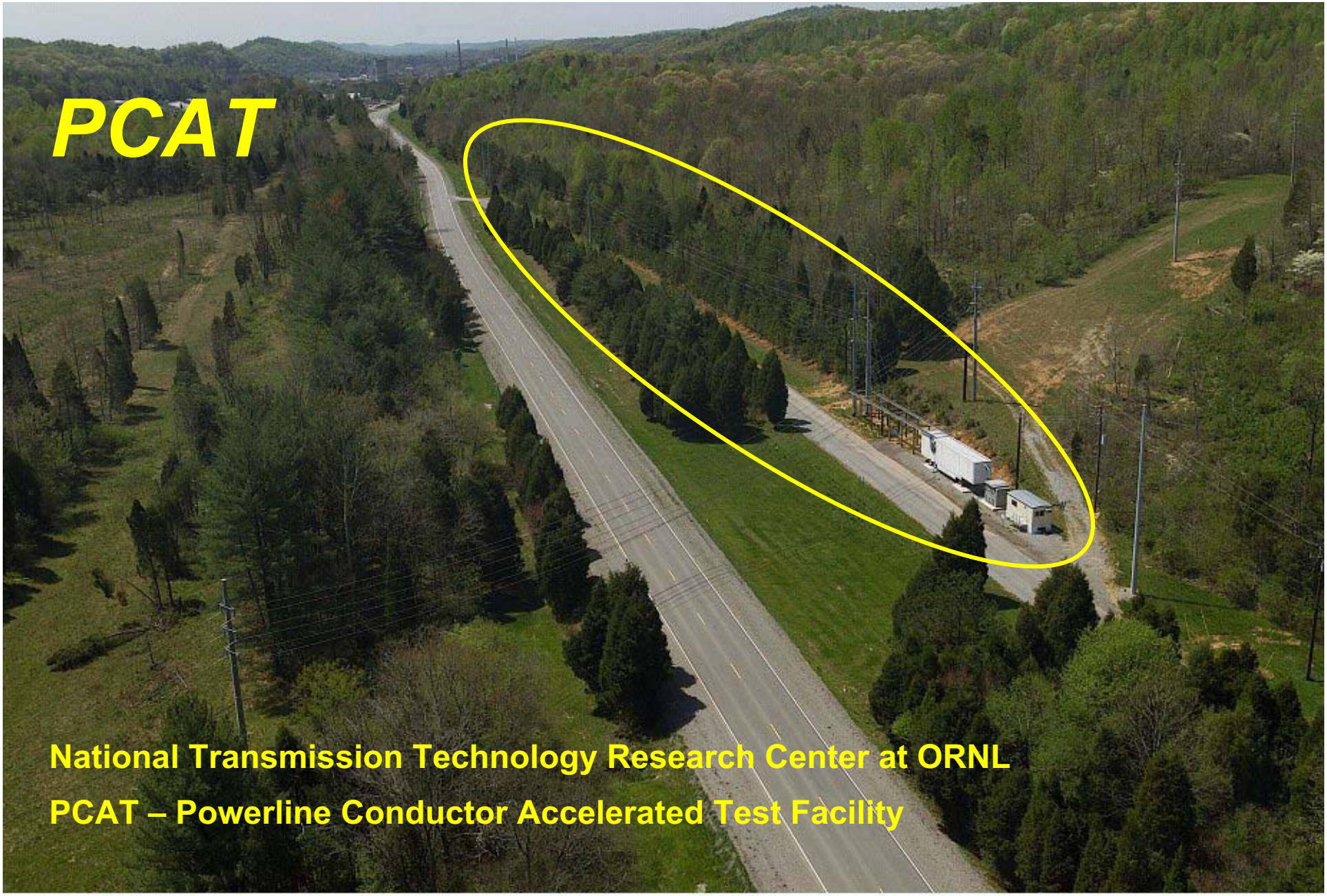
New Step

Outdoor Test Line at Rated Temperature (PCAT)

Field Demonstrations

Additional testing will accelerate time to commercialization

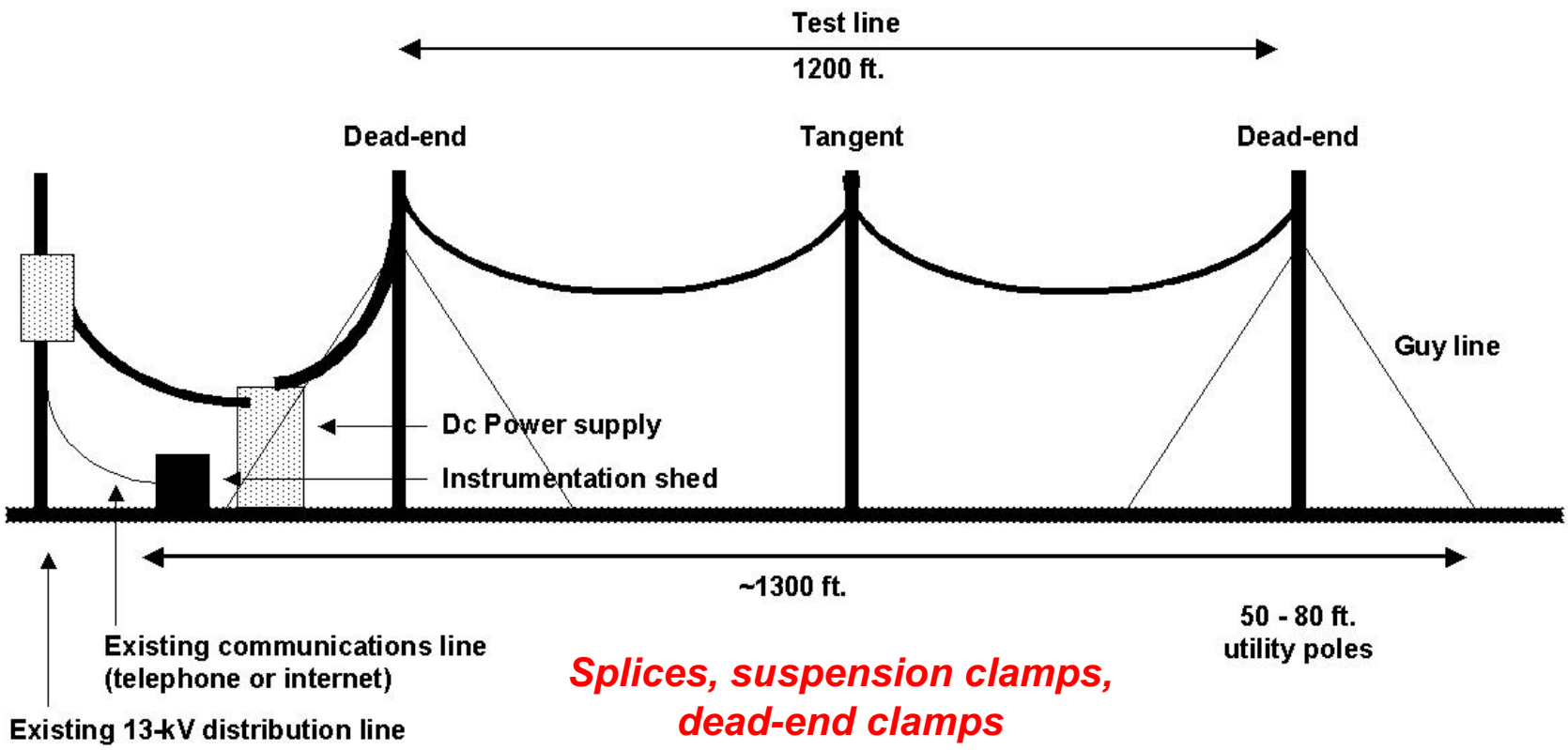
Time to commercialization


PCAT
National Transmission Technology Research Center at ORNL
PCAT – Powerline Conductor Accelerated Test Facility

PCAT - Profile View of Outdoor Test Line

PCAT - Powerline Conductor Accelerated Test

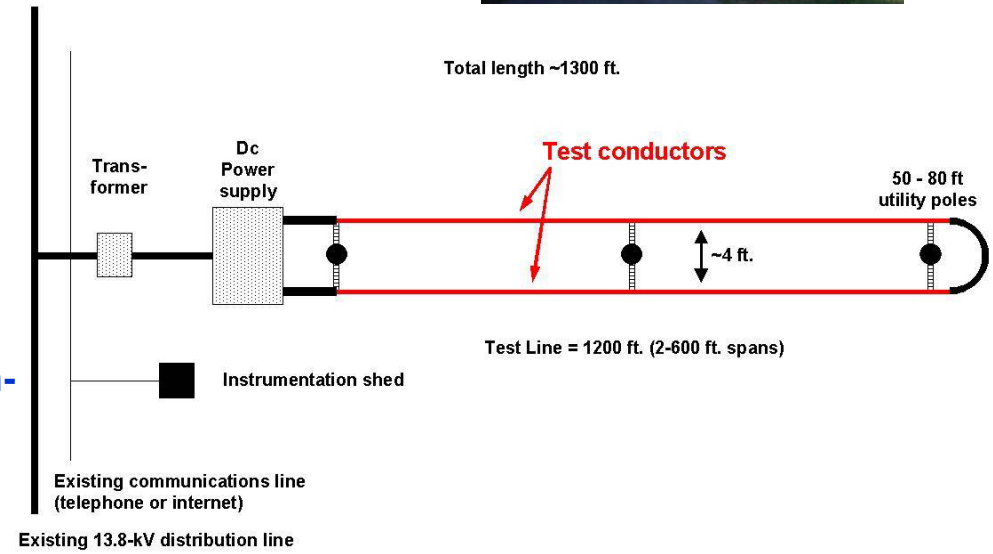
Initial Concept for Test Facility Developed with 3M Company



Splices, suspension clamps, dead-end clamps

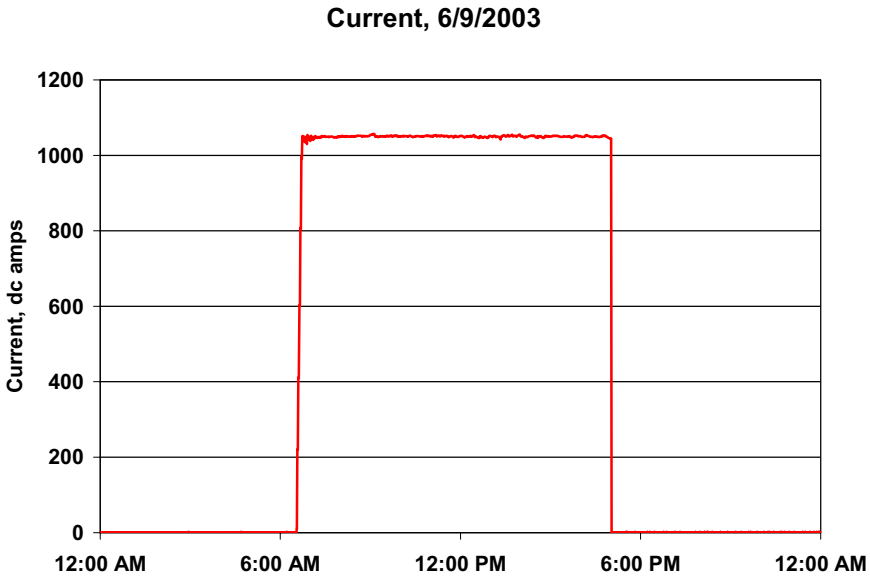
T1. PCAT – Facility Capabilities

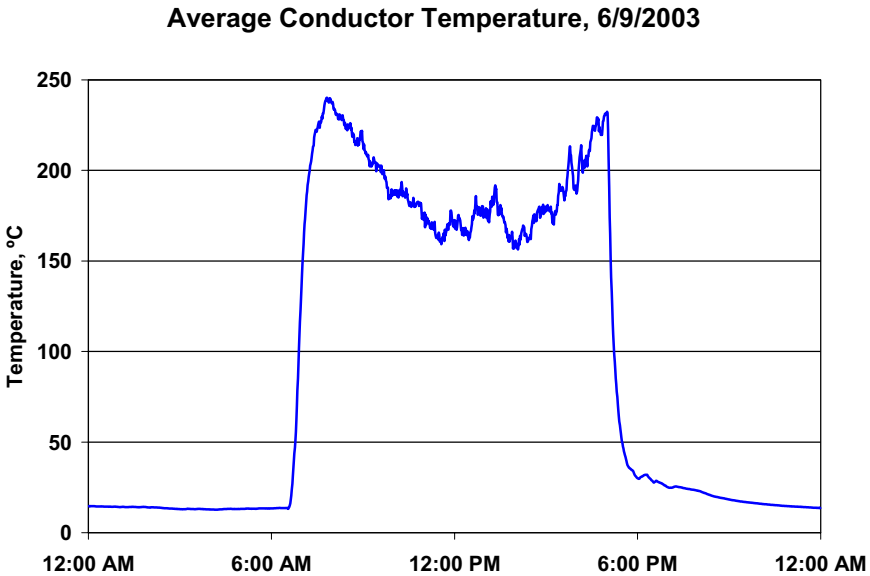
- Testing Capabilities
  - Controlled current or temperature testing
  - Conductor and accessories
  - Up to 300°C
- Example tests
  - Constant Current or Constant Temperature
  - Thermal / Mechanical Cycling
  - Current / Temperature Ramp
  - Current / Temperature Steps and Hold
- Capabilities
  - 2400 feet of conductor
  - 2 – 600 foot spans
  - Low Voltage, 0 to 400 Vdc
  - High Current, up to 5,000 Adc
- National Transmission Grid Study, U.S. DOE, May 2002, www.ntgs.doe.gov
  - One of the 51 Recommendations
  - "DOE will develop national transmission-technology testing facilities … at DOE 's Oak Ridge National Laboratory.*"

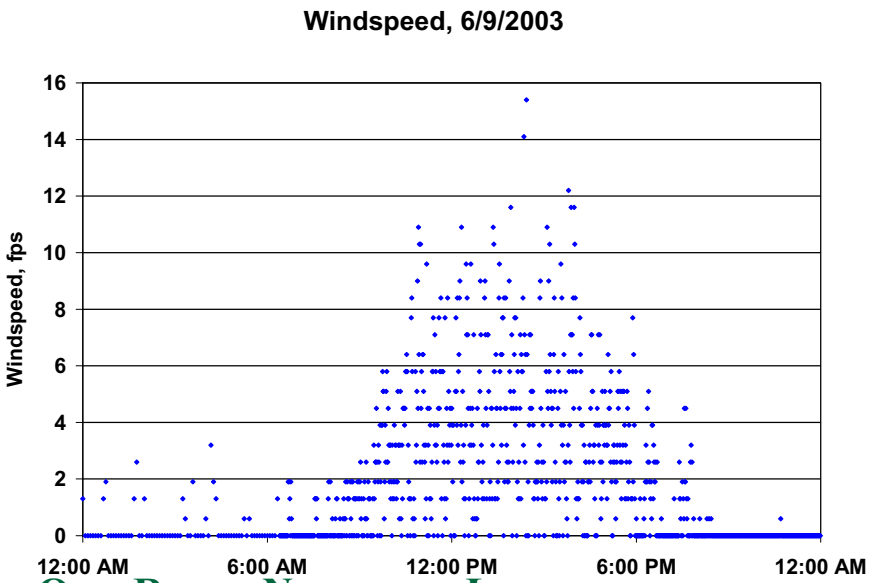


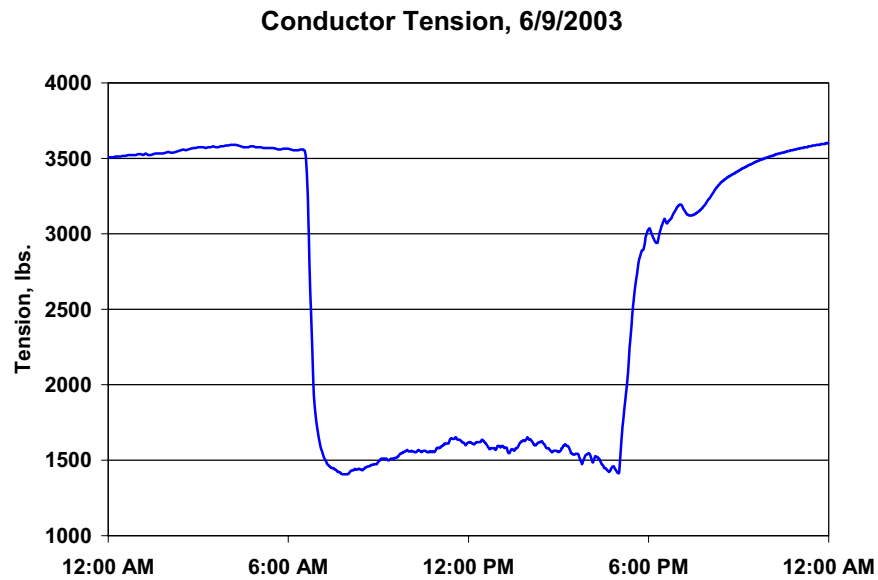
Click To Start Movie of Conductor Sag

Example run shows wind cools the conductor





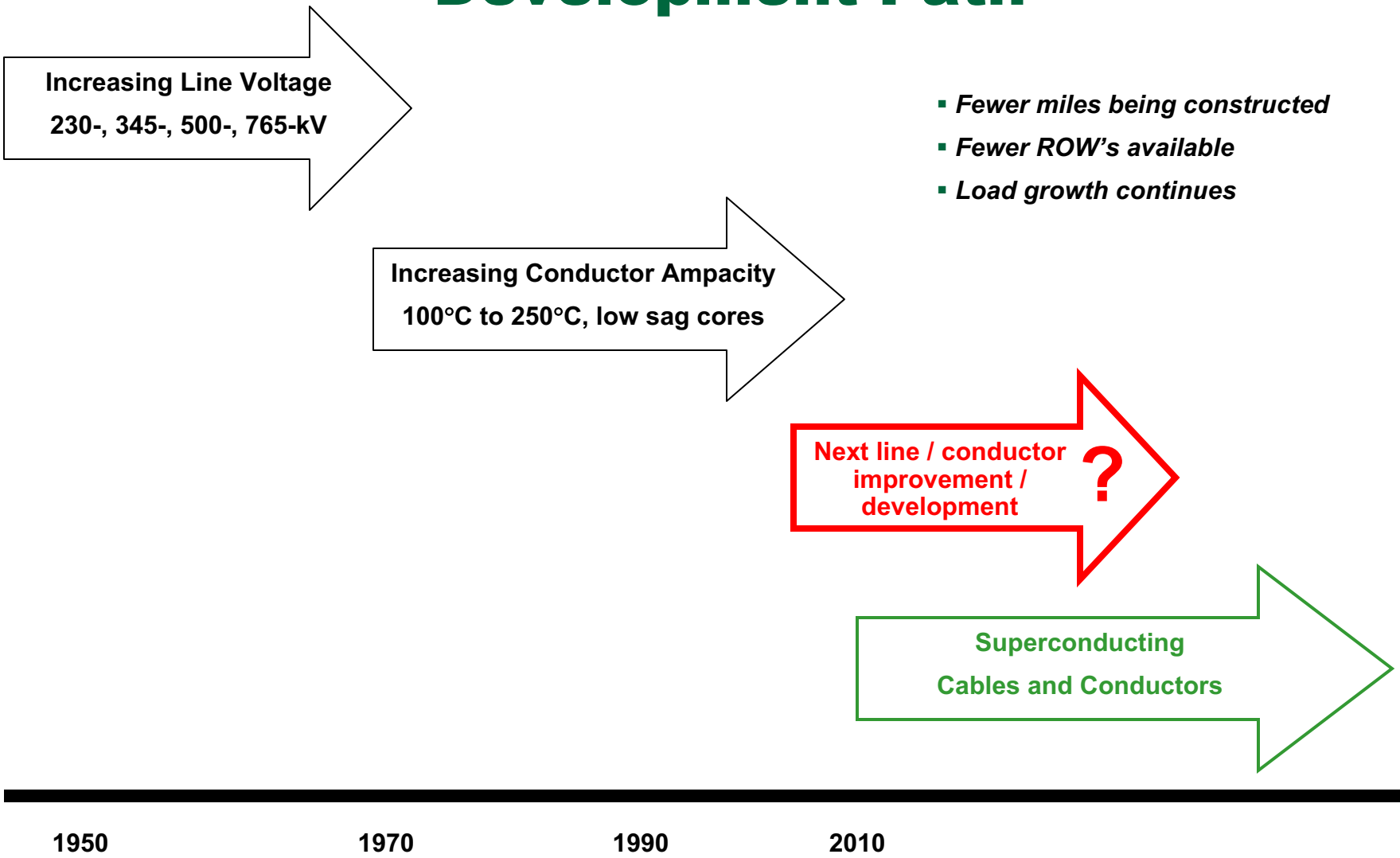




Thus far, four Conductors Have Been Tested At ORNL and Two Conductor Monitoring Devices

1. Aug. 2002 - Oct 2003 – 3M 477 kcmil ACCR
2. Nov. 2003 to Apr. 2004 – 3M 675 kcmil ACCR
3. Apr. 2004 to Aug. 2004 – Southwire 1113 kcmil ACSR with embedded optical fiber
   - Also tested, Power Donut2
4. Installed Aug. 2004 – 3M 1272 kcmil ACCR

Transmission Line / Conductor Development Path



- *Fewer miles being constructed*
- *Fewer ROW's available*
- *Load growth continues*

RD&D Needs for Conductors

- Need to better utilize 115- to 230-kV lines
- Conductor monitoring hardware and techniques
  - Optimum utilization of existing assets
  - Need to monitor more than one span
- Materials Research
  - Higher Strength Conductor Reinforcements
  - Lighter Weight Conductor Reinforcements
  - Lower Thermal Expansion Materials
  - Higher Elastic Modulus Materials
  - Higher Operating Temperature Materials
  - Nonmagnetic Materials
  - Surface Treatments and/or Coatings on Conductors
  - Higher Electrical Conductivity Materials

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