

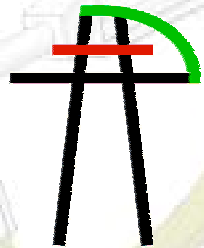
# SAGGING LINE MITIGATOR (SLiM)

TECHNOLOGY TO INCREASE LINE  
PERFORMANCE, RELIABILITY AND SAFETY

For:

**Power Engineer's Line Conference - 2005**

Hailey, March 2005



**Power  
Transmission  
Solutions, Inc.**



**Material  
Integrity  
Solutions, Inc.**

# Problem Statement

---

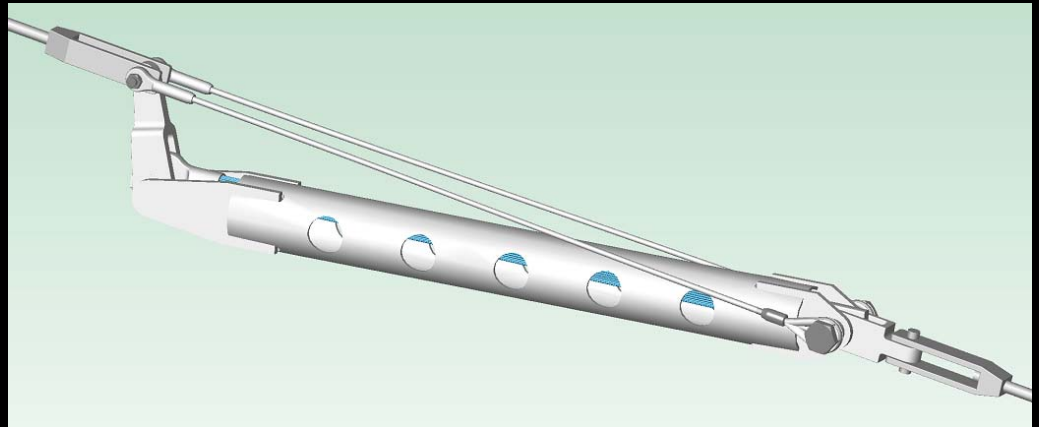
- Excess sag limits line ampacity
- Safety/reliability issues
- Economic impact
- Survey Results
  - Majority of respondents acknowledged sag problems on their system
  - Primarily an issue with 115-230 kV lines
  - Most sag problems < 5 ft.

# Current Approaches

---

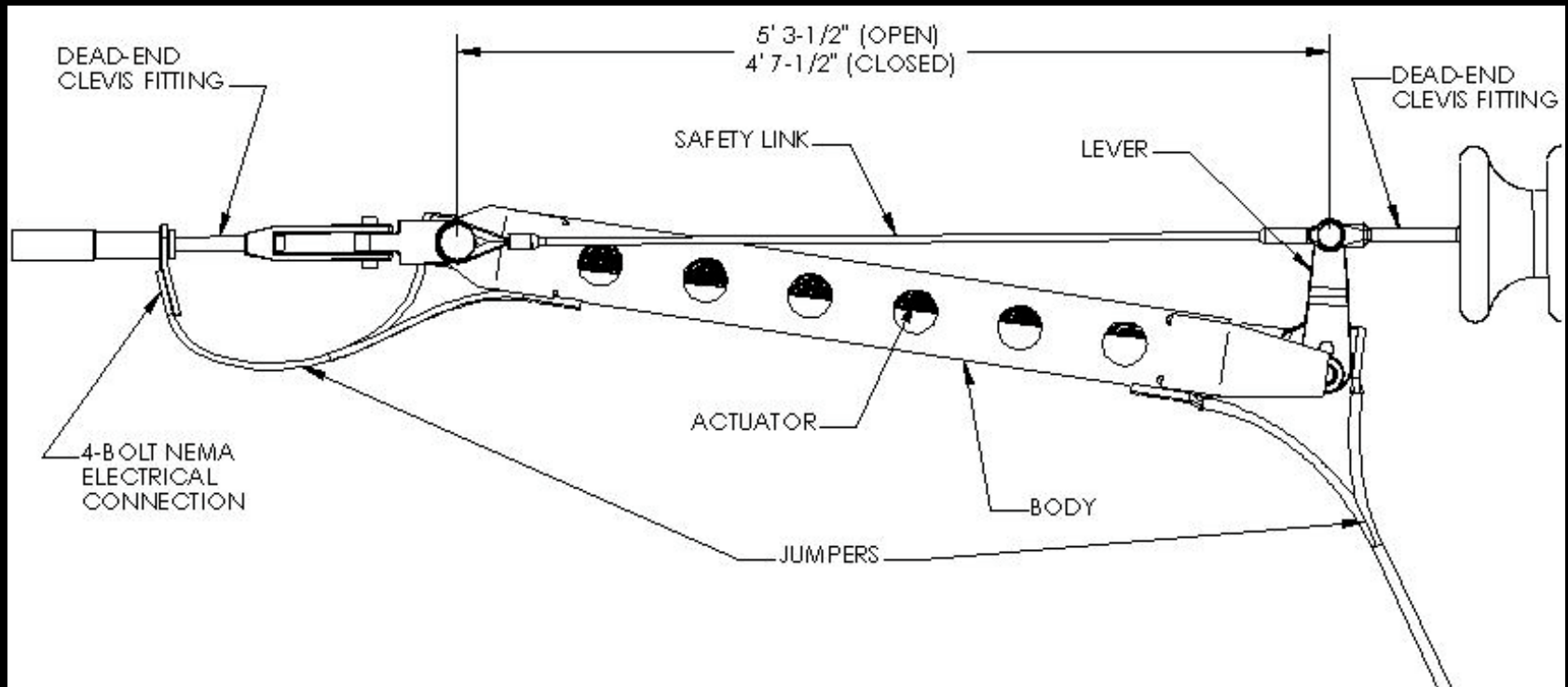
- Increase tower height
- Decrease tower spacing with intermediate structures
- Re-conductor
- Construct new, parallel lines
- Real-time load rating

... or SLiM



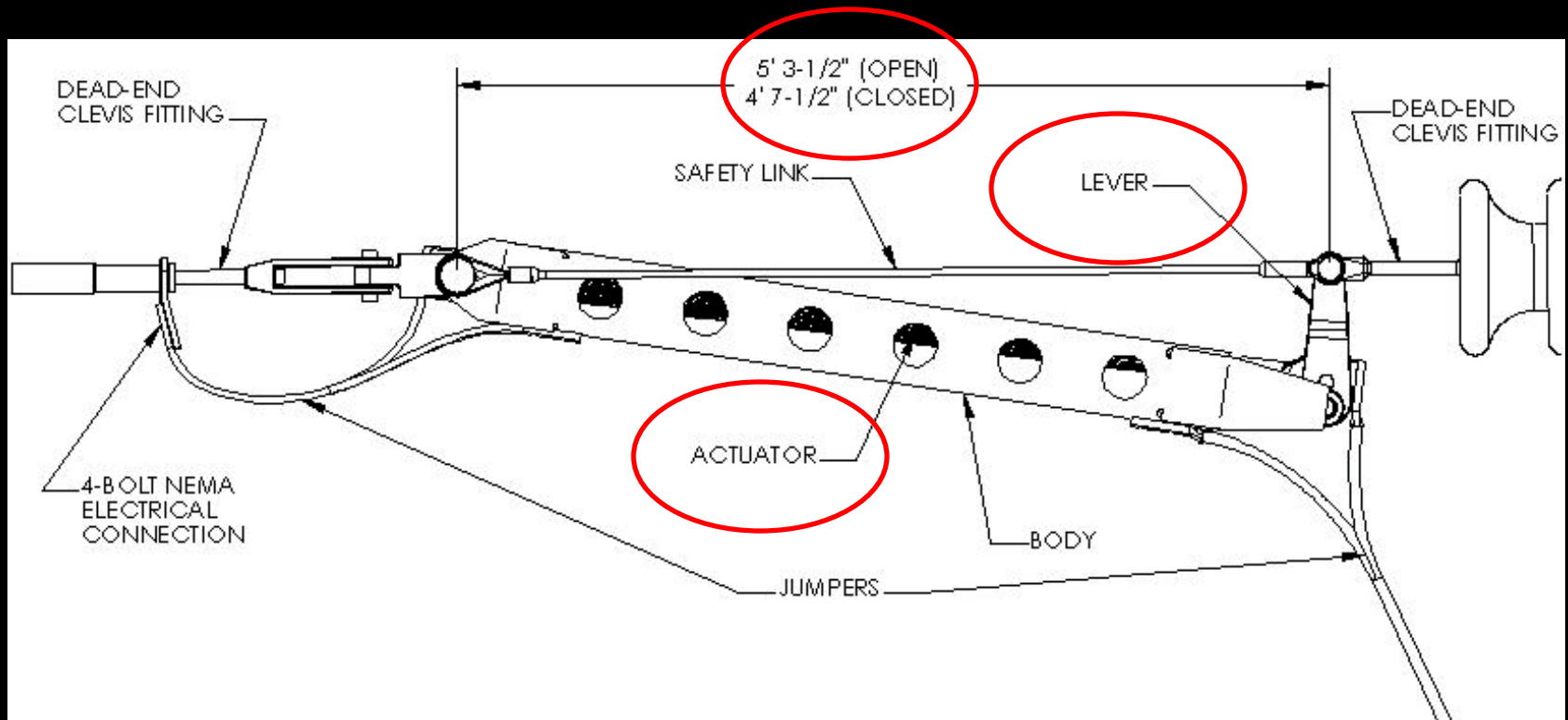
# What is SLiM?

## Sagging Line Mitigator



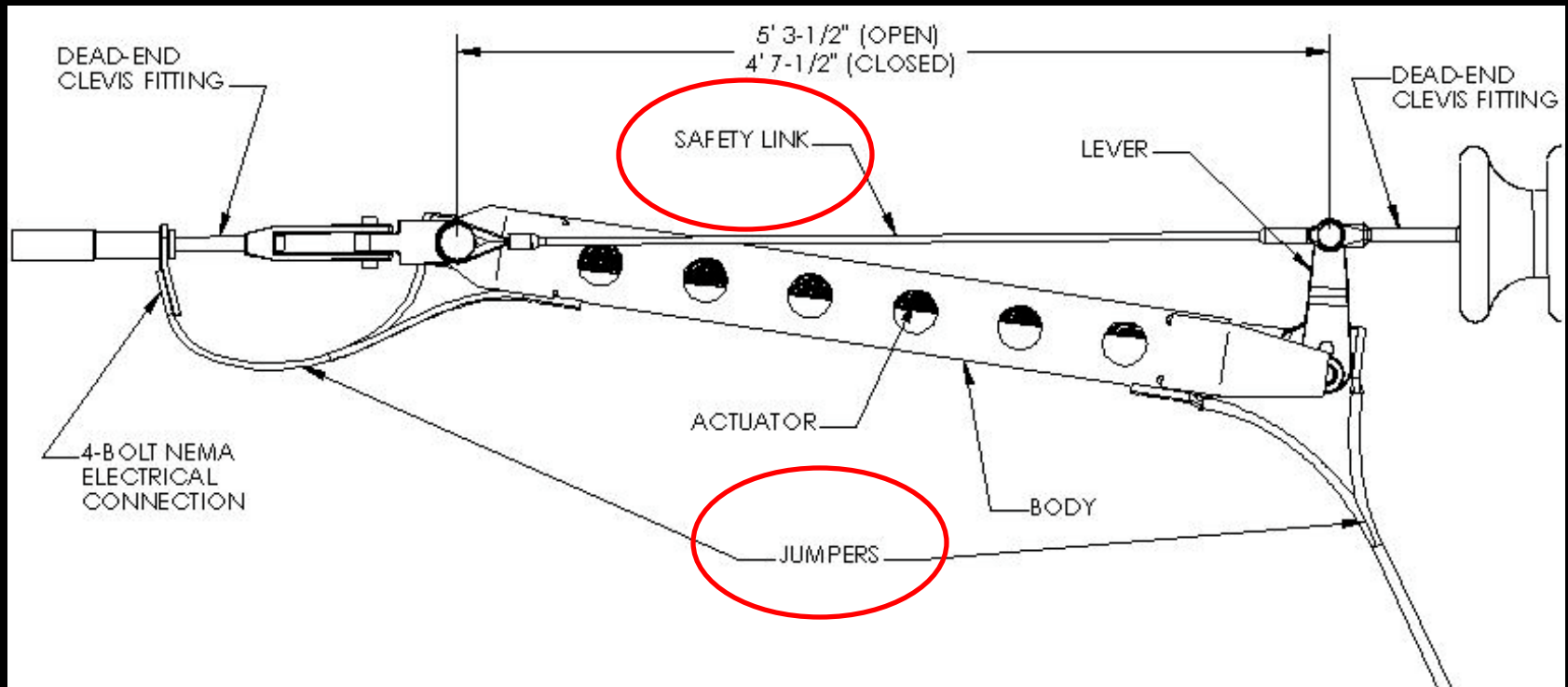
# What is SLiM?

## Sagging Line Mitigator



# What is SLiM?

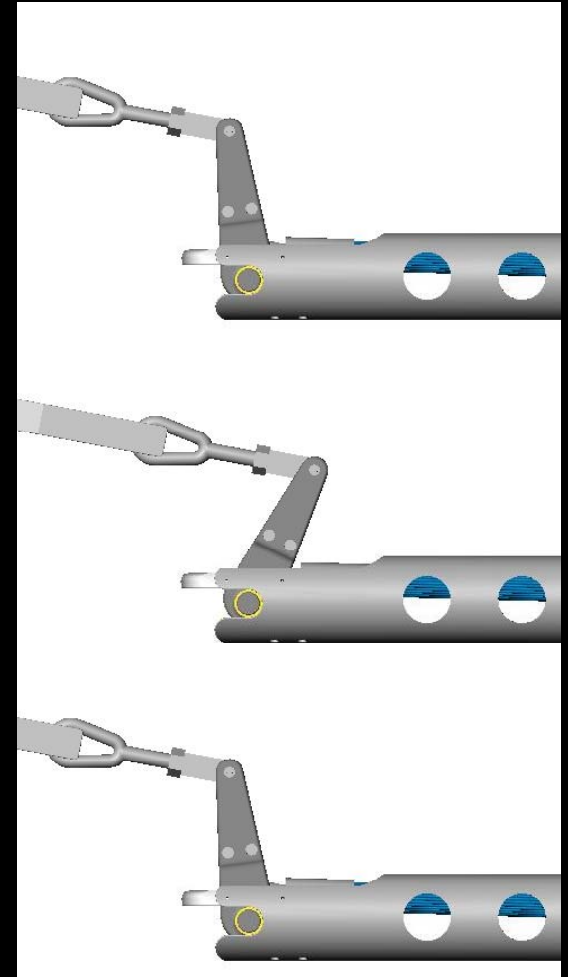
## Sagging Line Mitigator



# How SLiM Works

---

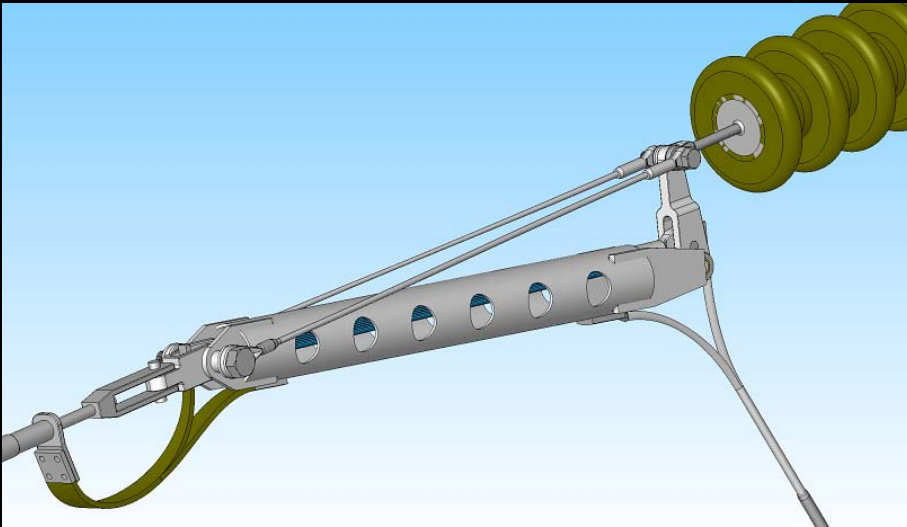
- A portion of line current passes through SMA actuator.
- Actuator shortens when heated.
- Lever arm magnifies actuator change.
- Line tension extends actuator when cool.



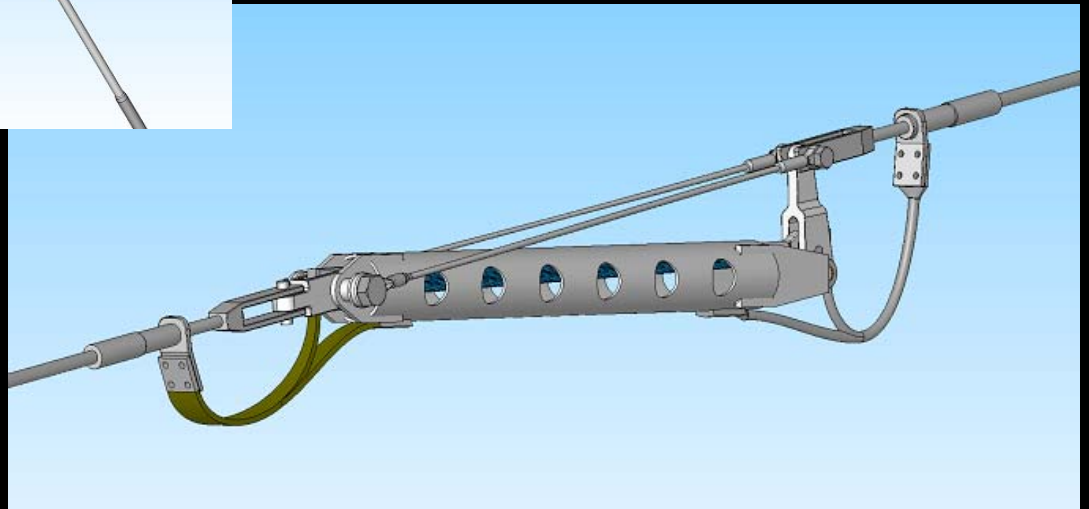
# Installation Configurations

---

Dead-End Installation



In-Line Installation



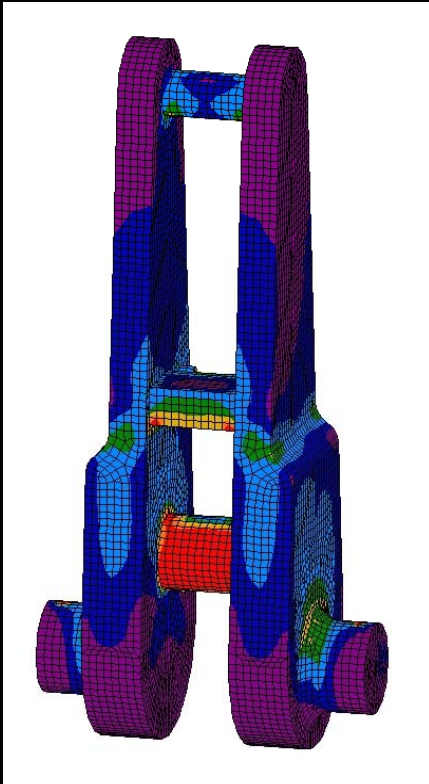
# Important Points

---

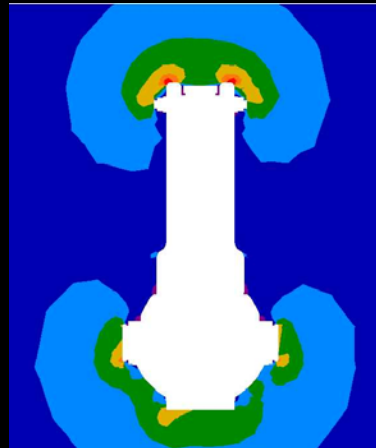
- High temperatures cause the SLiM device to change shape and decrease effective conductor length.
- Passive device using state-of-the-art shape memory alloy.
- Fixes the problem of excessive sag at high temperature.
- Application at suspension point or in span.
- Effect cascades through adjacent suspension spans.

# Simulations

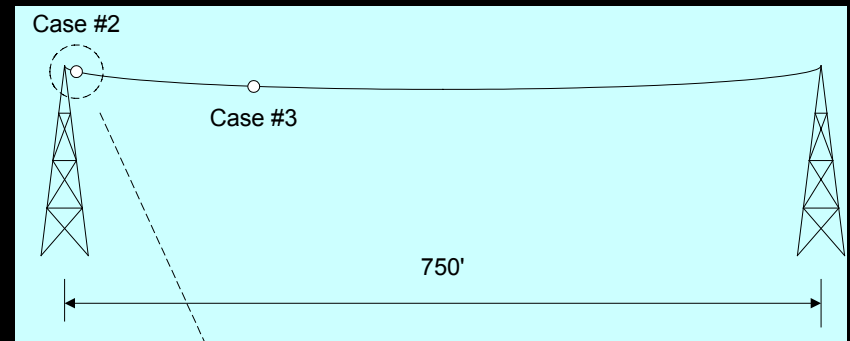
## Stress Analysis



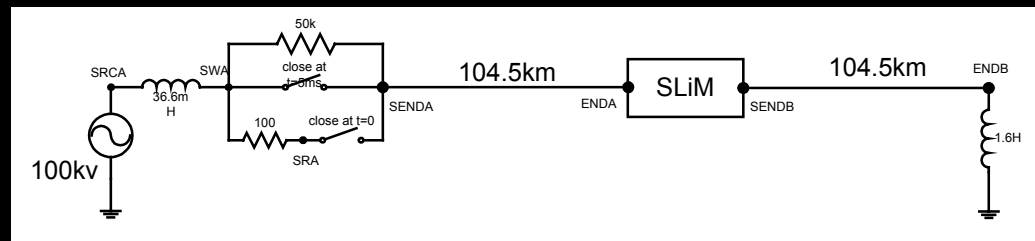
## Electric Field Density



## Vibration Analysis



## Effect on Line Transients



# Component Testing

---

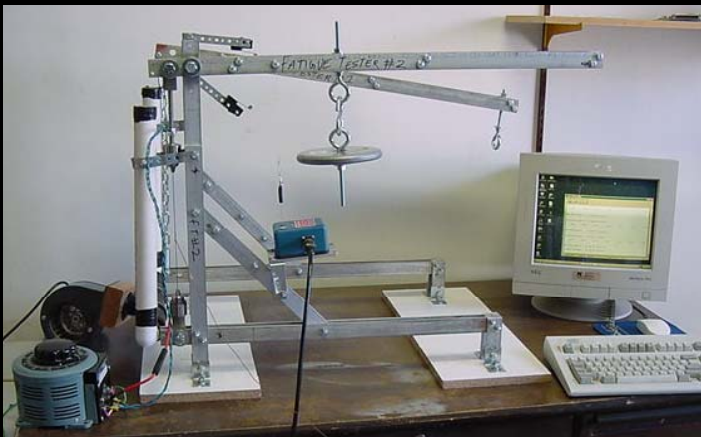
## MECHANICAL LOAD



## CORROSION

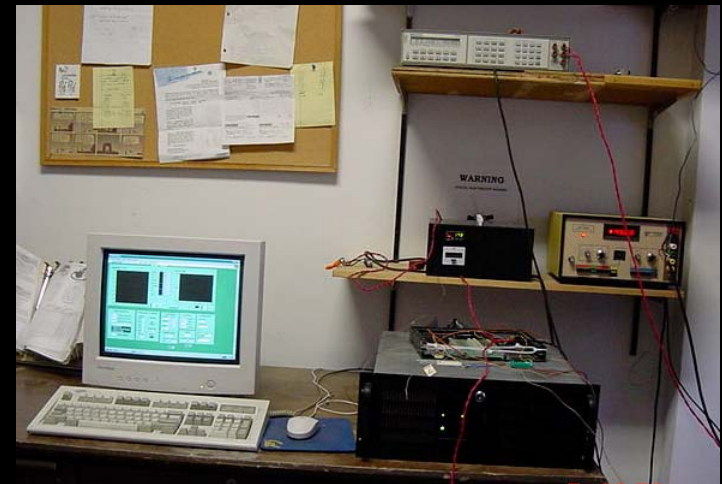


## FATIGUE



# Prototype Testing

- Functionality Test
  - Full range of motion demonstrated at 5000 lbs. tension.
- Electric Reliability
  - No significant change in resistance after 525 thermo-mechanical cycles.



# Full-Scale Field Test

---

*PG&E*  
*Aug 2002*

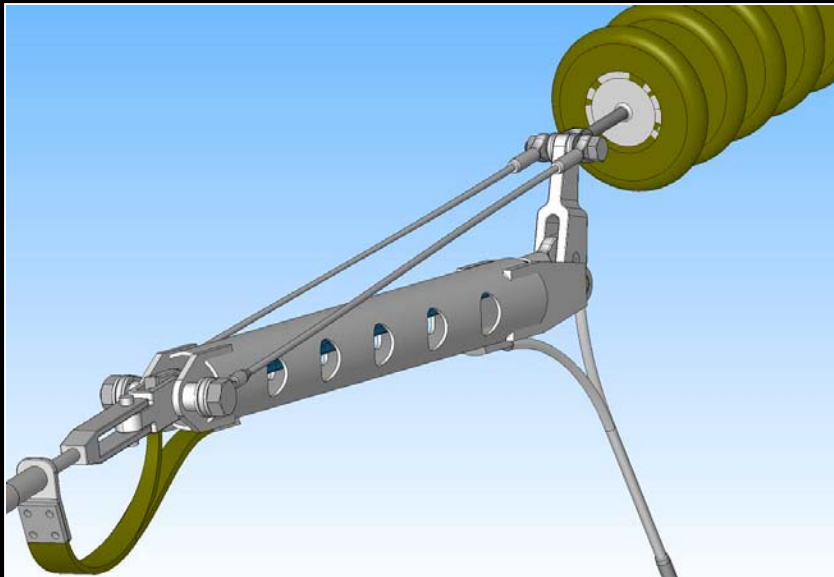


# Pre-Production Prototype Development

---

Designed/fabricated with ~40% more performance and ~30% fewer parts than R&D Prototype.

Conducted in-house functionality testing to verify performance.



# Short Circuit Test

---

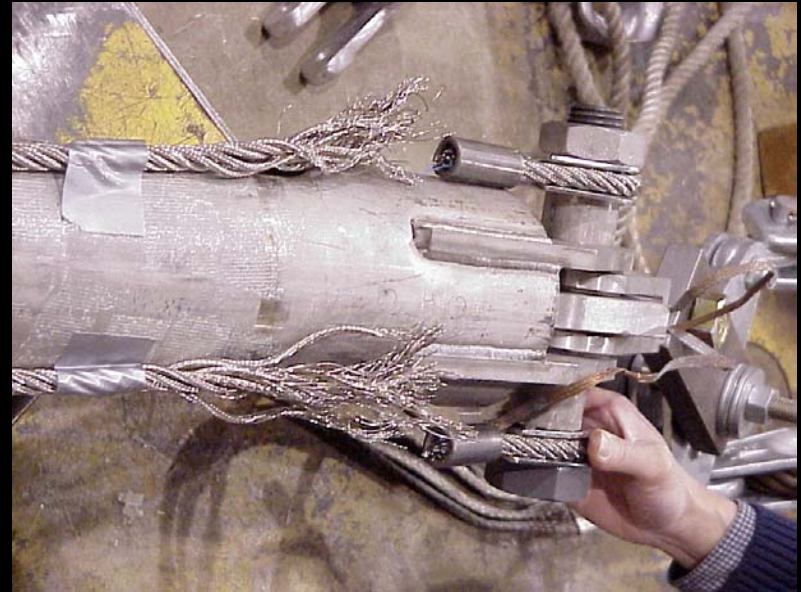
- Target: 40kA/10 cycles
- Actual: 1x20kA, 2x32kA & 3x40.2kA at 11 cycles each.
- No damage observed.
- Resistance did not change (570 to 571 m $\Omega$ ).



# Load-to-Failure

---

- Design load was **35Kips**
- Results: Failure of Safety Links at **49Kips**
- Device maintained its load carrying capacity



# SLiM Demonstration

## EPRI Tailored Collaboration

---

- Project: To install SLiM in an actual application.
- Participants:



# Project Objectives

---

- Demonstrate proper function in actual application:
  - Greater sag reduction on test phase vs. control phase
- Demonstrate reliability:
  - Consistent mechanical and electrical performance for demonstration period
- Demonstrate ease of installation:
  - Feedback from installation crew

# SLiM-Demo: Location Specifics

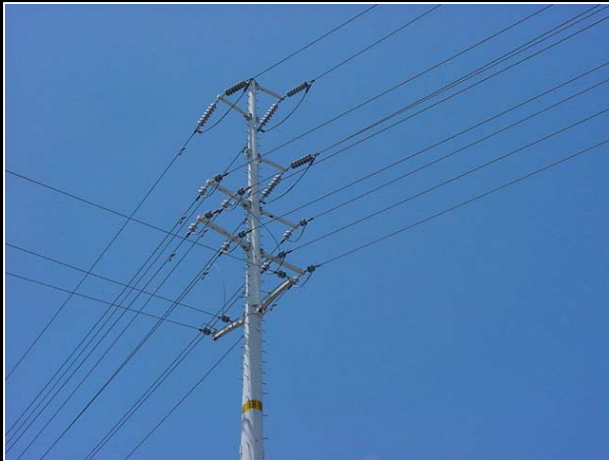
---

## SDG&E, Escondido, CA

- 69 kV Line Voltage
- 811 Amps Steady State @ 90°F (or above)
- 930 Amps 15-min Contingency @ 90°F (or above)
- 636 ACSR/AW “Rook”
- 427 ft. Span Length
- 31 ft. Elevation Difference in attachment points
- Dead-end at both ends of span
- Steel Pole Z214902 & Class 1 Wood Pole Z214903

# SLiM-Demo: Site Selection

---



***Steel Pole***



***Wood Pole***



***Distribution Pole for Monitoring Equipment***

# SLiM-Demo: Installation

---

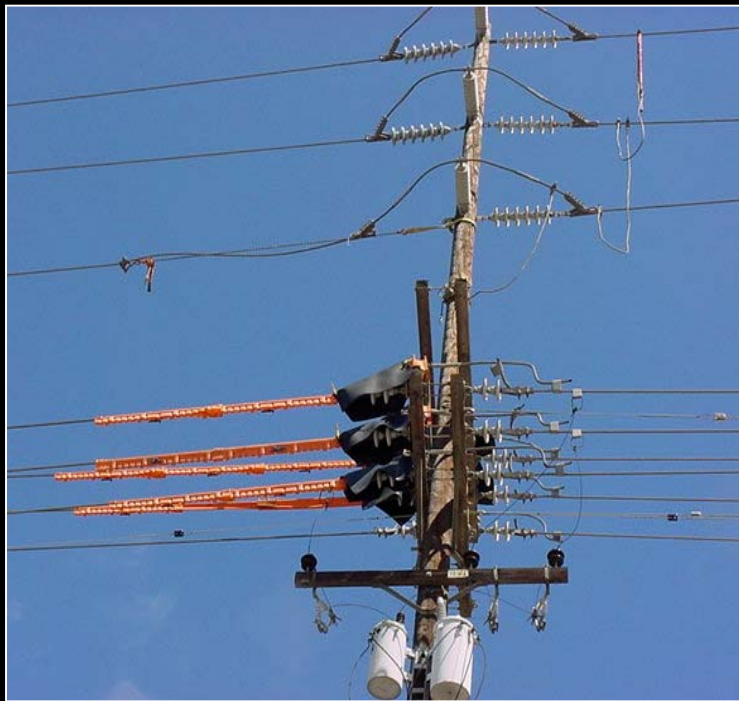
- Installed on 5/6/04.
- Cold installation via bucket truck
- SLiM mounted on bottom phase
- Tension measured w/ dynamometer.



*SLiM prepared for installation*

# SLiM Installation

---



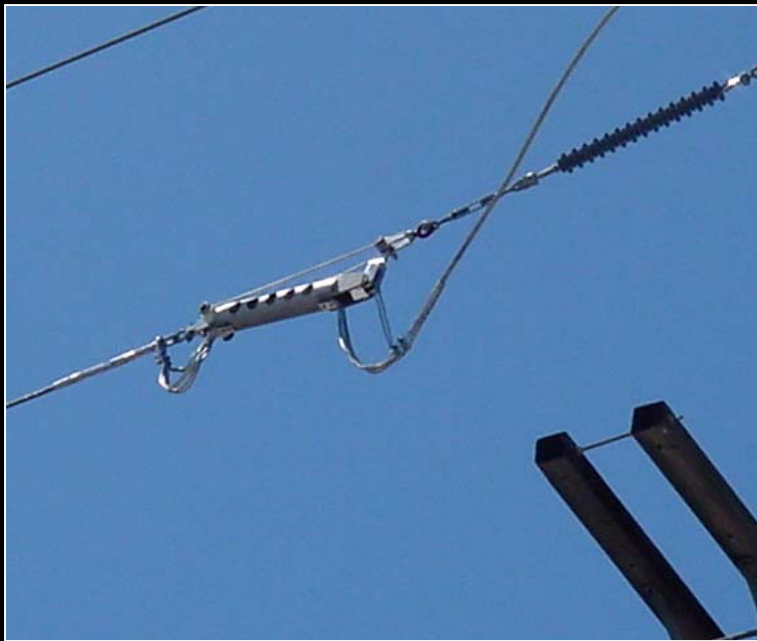
***Jumpers and covers  
placed for safety***



***Installation in progress***

# Completed SLiM Installation

---



Installation Crew:

**“Straightforward installation”**



# Monitoring Activities

---

- Monitor Equipment Operational 6/2/04
- Measured Parameters
  - Sag - distance to test and control phases
  - Ambient Temperature
  - Line Load - monitored by SDG&E
- Data recorded every 10-20 minutes



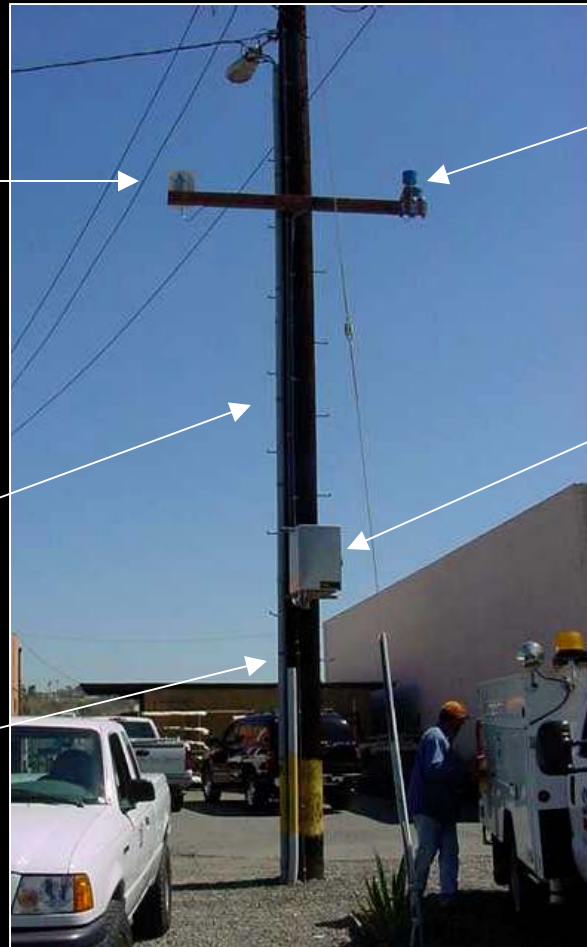
# Monitoring Equipment

---

Satellite antenna for data transfer to Levelwatch.com

Ambient Temperature Transducer

Distribution pole 100' from SLiM. Line TL696 passes directly overhead.



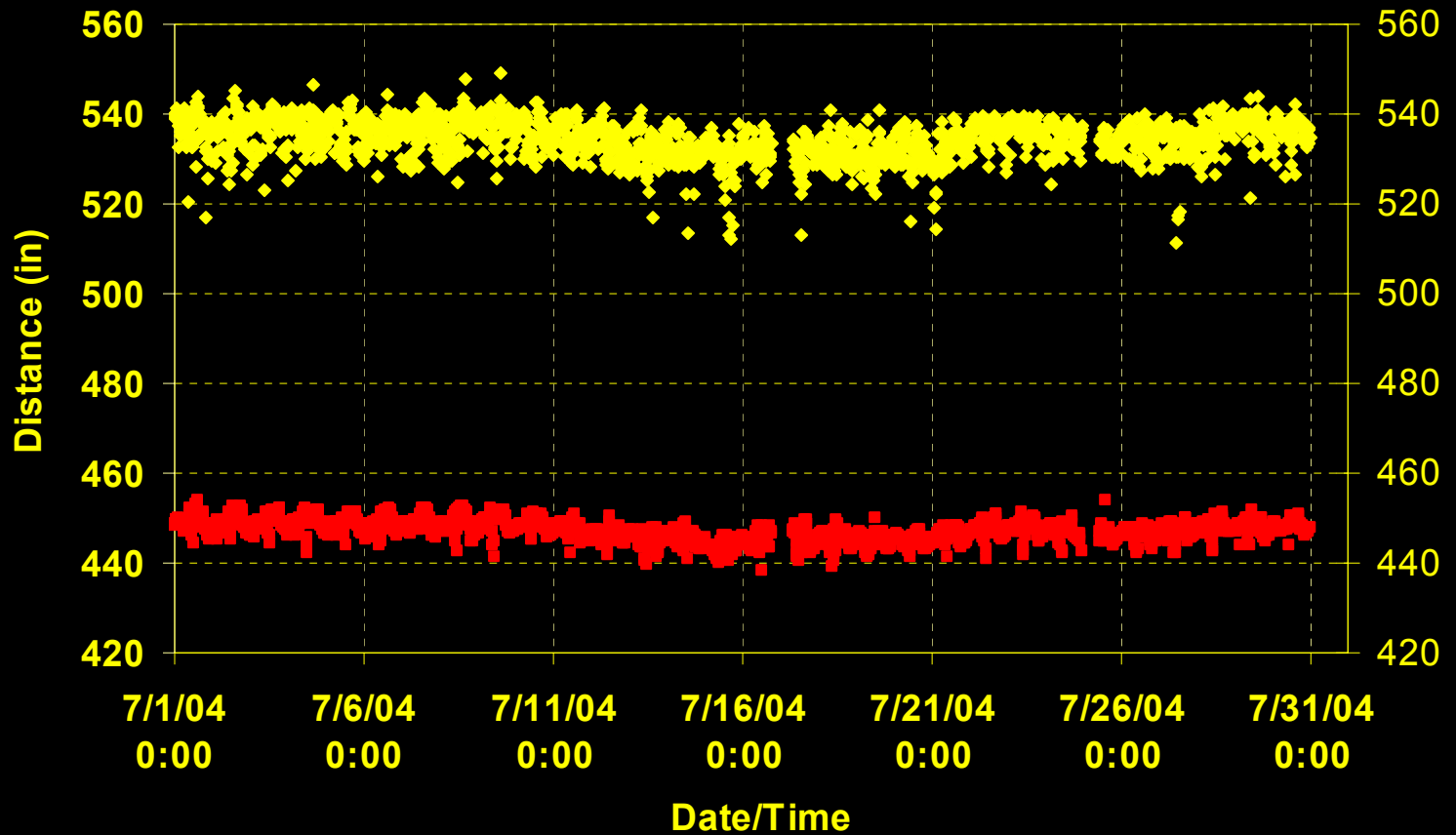
Milltronics XPS-30 Ultrasonic Transducers for measuring sag.

SCADA Box:

- \* AirRanger DPL+ Module (the brains)
- \* Levelwatch communications module
- \* HOBO Microstation for onsite data storage.

# SLiM Demo Results: July Sag Data

---



# Demonstration Results

---

- On typical day, SLiM reduced the variance in sag by 54% on the test line relative to the control line.
- Maximum sag reduction was 21”.
- Device functioned as designed; sag reduction commensurate with observed conditions.
  - Demo device designed to reduce sag 30” during a contingency (811 amps, 100°F ambient, no wind).

# SLiM-Demo: Conclusions

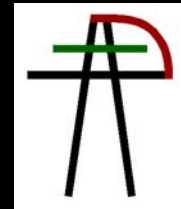
---

- SLiM installation using common connectors and tools - “*Straightforward*”.
- SLiM mechanically and electrically sound for over 6 months.
- SLiM functioning as-designed.

# Future - SLiM as a Business

---

- New company (Power Transmission Solutions, Inc.) formed.
- QC
- Manufacturing
- Sales
- Distribution
- Vendor Relations



**Power Transmission  
Solutions, Inc.**

