



# Sagging Line Mitigator (SLiM)

## Status & Future

**IEEE Winter Technical Meeting  
TPC/ESMOL Joint Meeting  
Las Vegas, NV  
January 28, 2003**



**Material  
Integrity  
Solutions, Inc.**



## Problem Statement

- **More than 50% of lines in WSCC region are 230kV ACSR lines: ~37,500 miles.**
- **These lines are typically thermally limited.**
- **Survey results:**
  - **Sag problems are of most concern on 115-230kV lines.**
  - **Most sag problems are due to high load demand on hot days.**
  - **The majority of sag problems are under 5 feet of excessive sag.**

## Alternative Solutions

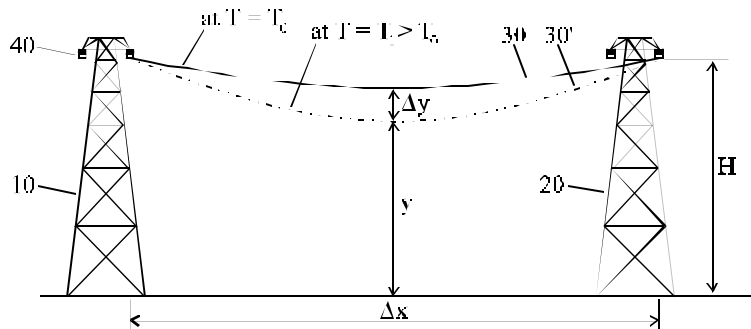
### Current Methods:

- **Limit Line Ampacity**
- **Raise Tower Height**
- **Reduce Tower Spacing**
- **Re-conductor**
- **Construct new/parallel lines**

or...

**Sagging Line Mitigator (SLiM)!**

## SLiM Philosophy



**A small decrease in conductor length equals a large decrease in sag.**



## Our Goal

**To design, construct, demonstrate, and commercialize a device which keeps the sag in power transmission lines almost constant by automatically compensating for temperature and loading changes.**



## Criteria, Targets, Standards

- **Meets Codes & Standards**
- **Uses common rules & practices**
- **Performance Criteria**
  - **Mitigate additional sag that occurs in conductors heated from 110°F to 212°F**
  - **Voltage range 230kV**
  - **Up to 6" range of motion**
  - **Up to 5000 lbs. working line tension**
  - **Mechanical failure > 35,000 lbs.**

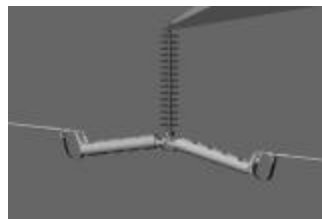
## Criteria, Targets, Standards

### ⦿ **Functionality Criteria**

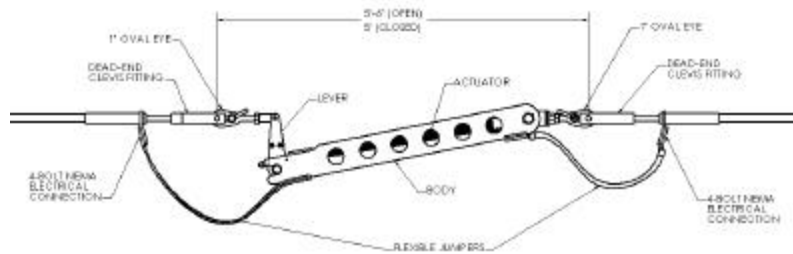
- **Corrosion resistant**
- **Low E-field for corona**
- **Negligible impact on stability**
- **Negligible impact on line vibration**
- **Emergency Constraints**

### ⦿ **Cost Targets - less expensive than other alternatives, e.g. raising towers**

## Current Designs & Prototype

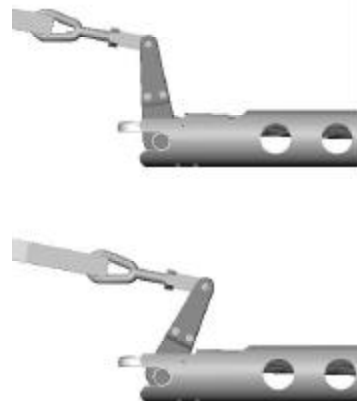


## General Specifications



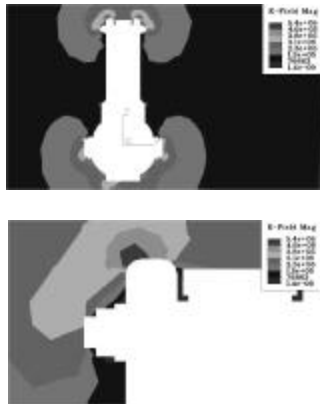
## How SLIM Works

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



# Modeling

## Corona Behavior

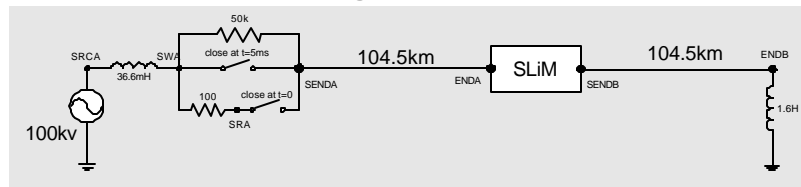


## Stress-Strain

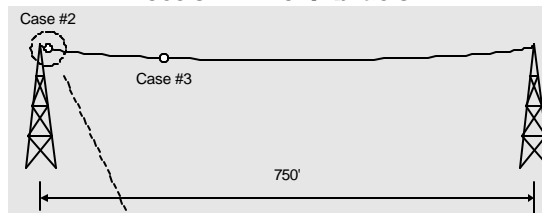


# Modeling

## Electromagnetic Transients

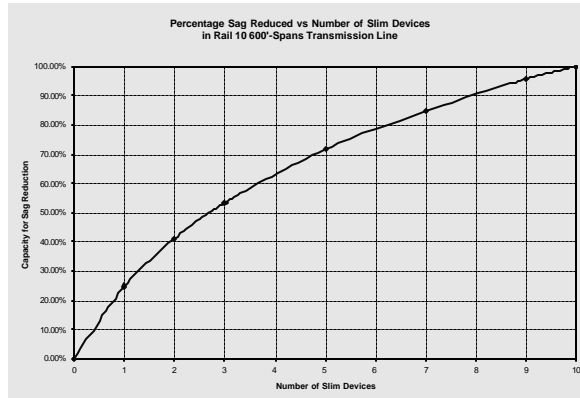


## Effect on Line Vibration



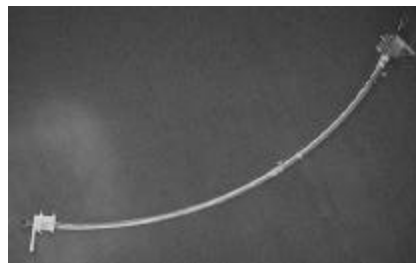
## Modeling

### Effect on SLiM on continuous lines

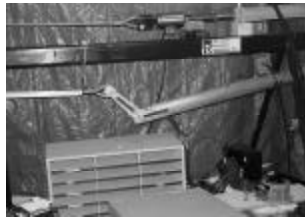
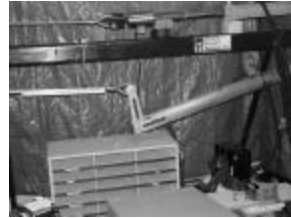
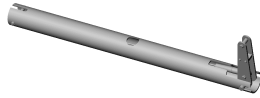


## SmartConductor - SLiM's Partner

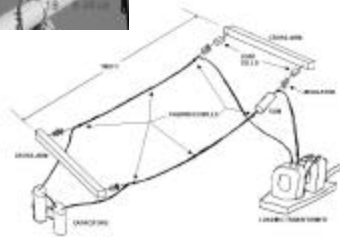
- **Length of conductor that shortens when heated due to SMA core.**
- **Lower cost alternative to SLiM.**
- **~30% of the range of motion of SLiM.**
- **Assembled rather than fabricated.**



## Small Scale Prototype Testing



## Full-Scale Functionality Testing



## Functionality Testing



## Functionality Testing

### SLiM

<b>Measured</b>	<b>Control Span</b>			<b>Test Span</b>			<b>Sag Differential</b>
	Tension (lbs.)	Height* (in)	Change in Sag (in)	Tension (lbs.)	Height* (in)	Change in Sag (in)	
Cold	4731	152	—	4808	151	—	—
Hot	2685	87.4	65.0	3747	130	21.0	44.0
<b>Predicted</b>	Tension (lbs.)	Sag (in)	Change in Sag (in)	Tension (lbs.)	Sag (in)	Change in Sag (in)	Sag Differential (in)
Cold	4731	81.5	—	4808	80.2	—	—
Hot	2980	130	48.2	4699	82	1.8	46.4

### SmartConductor

<b>Measured</b>	<b>Control Span</b>			<b>Test Span</b>			<b>Sag Differential</b>
	Tension (lbs.)	Height* (in)	Change in Sag (in)	Tension (lbs.)	Height* (in)	Change in Sag (in)	
Cold	2917	98.6	—	2925	97.5	—	—
Hot	2073	41.5	57.1	2202	50	47.5	9.6
<b>Predicted</b>	Tension (lbs.)	Sag (in)	Change in Sag (in)	Tension (lbs.)	Sag (in)	Change in Sag (in)	Sag Differential (in)
Cold	2917	135	—	2925	135	—	—
Hot	2152	184	48.9	2274	174	39.1	9.8

\* Height from ground at midspan.



## Benefits

- ⦿ **Improve line reliability and safety**
- ⦿ **Reduce cost of new line construction**
- ⦿ **Delay new line construction**
  - **Save \$\$**
  - **Realize environmental benefits**
- ⦿ **Increase line ampacity**
  - **Additional transfer capability to areas short of supply**
- ⦿ **Part of an overall solution to the current energy crisis**



## Current Status

- ⦿ **Issue final report**
- ⦿ **EPRI's Tailored Collaboration Project to Install/Demonstrate on T-Lines:**
  - **Opportunity Sheet Issued (available)**
  - **10 Utilities sought for 3 installations**
    - 5 signups already (BCH, NG-UK, CEC for PG&E, SCE & SDG&E) and three more about to sign (?).
  - **For more info. or to sign up, please contact Dr. Ram Adapa (EPRI) at:**  
**(650) 855-8988 or [radapa@epri.com](mailto:radapa@epri.com)**

## Future

- **Production Models & Standard Testing**
- **Commercialization**
  - Utilities
  - Manufacturers
  - VC's, ???
- **Sale/Support**



## Our Team / Acknowledgements

- **Research Sponsor**



- **Research/Advisory Participants**

- IREQ, SPEC, PTC, APS, AEP, BCH, EPRI, CAISO, ...

Questions?

