Distribution Line Storm Hardening

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PLS-CADD Advanced Training and User Group Meeting

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Introduction

- Due to the frequency and severity of recent storms across the country, industry attention has been centered on making the distribution system more resilient so that it will experience less damage during extreme weather events.

- EPRI is currently undertaking a multi-year research project focused on Distribution Grid Resiliency.

- The overall goal of the project is to create actionable information that utilities can apply to make their distribution systems more resilient to major weather events.

Current Participants

AEP	FirstEnergy
Alliant	Hydro One
Ameren	Indianapolis Power & Light
APS	LIPA
Arkansas Electric	National Grid
BC Hydro	Pinnacle West (APS)
Central Hudson	PPL Corp
Con Edison	Southern Co
CPS Energy	TVA
Exelon	Xcel Energy

What is Resiliency?

- Prevention
- Recovery
- Survivability

Opportunity for Improving All Three Aspects of Resiliency Through Integrating New and Existing Technologies

Damage Example

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Distribution Grid Resiliency Initiative

Task 1 – Aerial Structure Hardening

Task 2 – Vegetation Management

Task 3 – Undergrounding

Task 4 – Smart Grid

Task 5 – Practices for Storm Response

Task 6 – Prioritization of Distribution Resiliency Investments

Potential Project Benefits

- Modeling tools to prioritize distribution hardening and storm response investments
- Performance of options for overhead hardening
- Costs and benefits of overhead hardening, undergrounding, improved vegetation management, and smart grid technologies for grid resiliency
- Practices database for technologies and processes to speed restoration and improve estimated restoration times

Task 1
Aerial Structure Hardening — Goals

- Evaluate options for improved overhead resiliency:
  - Incremental improvements
  - High-performance lines
  - Retrofit options
  - Maintenance options

- Evaluate costs and benefits
  - New lines
  - Retrofit existing lines

- Performance attributes
  - Structural strength
  - Impact on fault rates
  - Impact on damage
  - Time and cost to repair

Task 1
Aerial Structure Hardening - Activities

Full-scale structure testing and component testing will be combined with analytical models and costing models to identify the most cost-effective options for hardening new and existing lines.

EPRI will work with utilities to identify common structures for full-scale testing designed to mimic major weather stresses.

Task 1
Aerial Structure Hardening — Tasks

- Surveys and interviews
- Data collection
- Past event analysis
- Structural testing
- Structural modeling
- Costs and benefits

Targeted Analysis of Major Storm Data Analysis

Data collection

- Outage data, especially damage location and damage information
- GIS data
- Pole inspection records
- Tree maintenance records

Types of questions to address

- What structures are most susceptible to damage?
- Does pole age / inspections contribute to more damage?
- Does communications equipment loading on poles contribute to damage?
- How do span length, conductor size, and pole strength relate to damage?
- Are some structures weak links (heavy angle for example)?

Aerial Structure Hardening - Full Scale Testing

Aerial Structure Hardening - Full Scale Testing

Pole Breaking Test

1100 lbs ultimate strength

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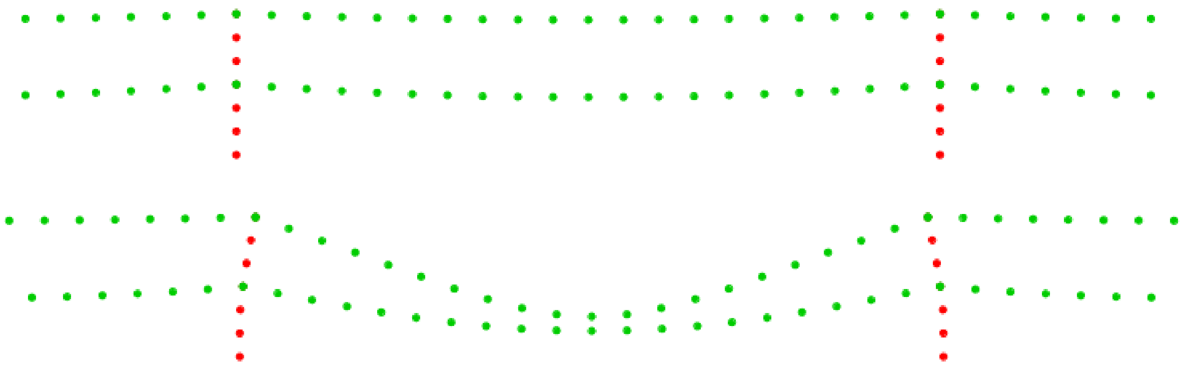
Slipping/Breaking Tests on Conductor-Insulator Interfaces

- Preformed tie
  - Limited slip; breaks off at 1000 to 1300 lbs
- Aluminum hand tie
  - Limited slip; breaks at 1000 to 1500 lbs
- Vise-top insulator
  - Allows conductor slip at about 900 lbs
- Crossarm pin
  - Bends at 600 lbs
- Ridge pin
  - Bends at 900 lbs

Structural Modeling

- Static modeling (PLS-CADD)

- Dynamic modeling



PLS-CADD Modeling To Date

- Analysis of singe and eleven span pole segments to simulate full scale tests
- Single phase wire with and without an underbuilt telecom wire
- Only considering effects on wire and pole breakage at everyday type conditions
- No overload or strength factors applied

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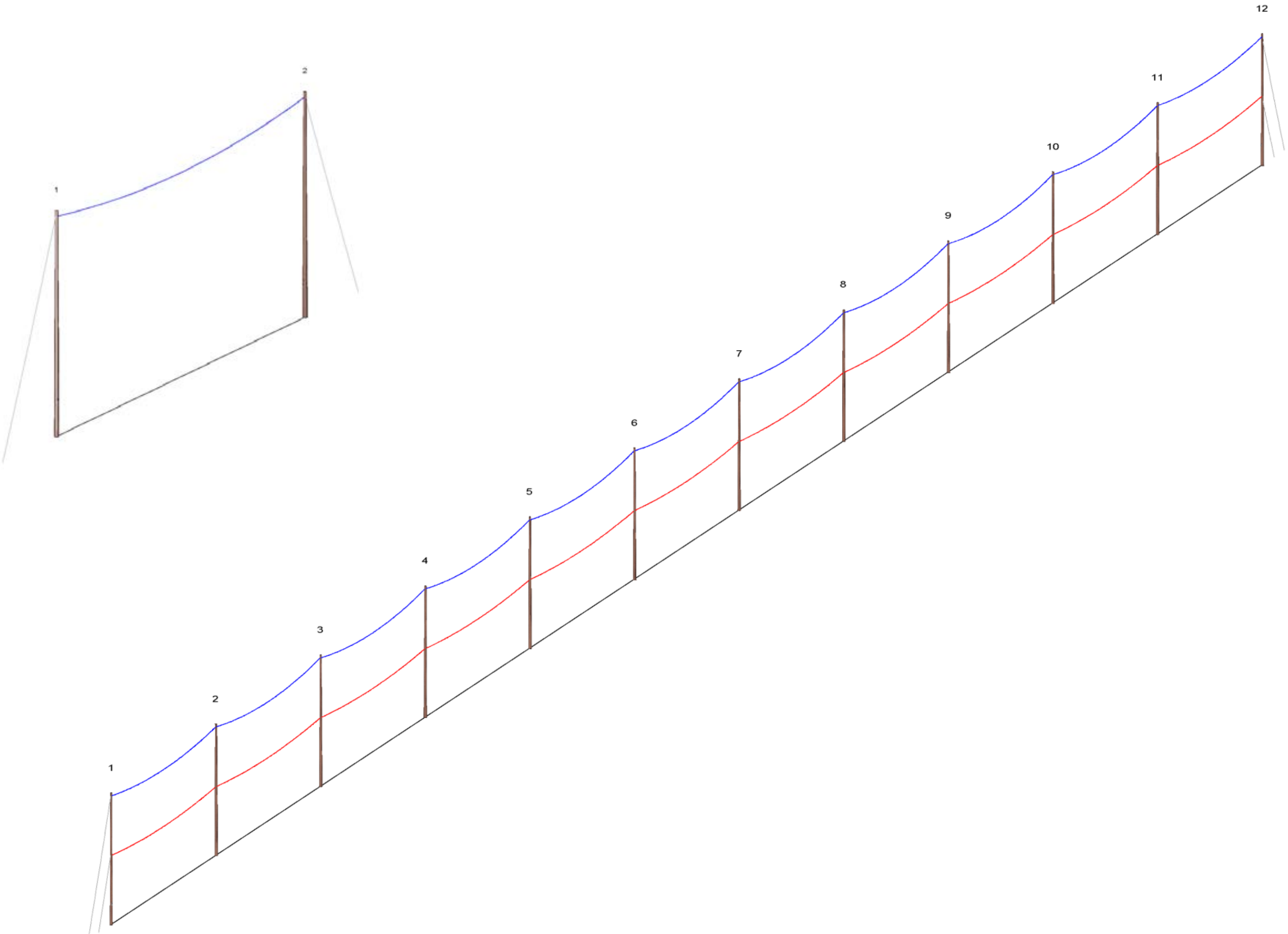
PLS-CADD Modeling To Date



Initial Results

Summary of Results with a Concentrated Load (i.e. tree) Applied at Midspan					
Case No.	Tree Weight to Break Phase Conductor (lbs)	Phase Conductor Stretch with Tree (ft)	Phase Conductor Stretch with Tree (%)	Tree Weight to Break Pole (lbs)	Pole Top Deflection with Tree (ft)
1	425	0.950	0.54	NA	NA
2	NA	NA	NA	1500	7.671
3	NA	NA	NA	1025	2.754
4	NA	NA	NA	1050	2.777
5	900	3.427	0.18	4900	7.597
6	785	2.396	0.12	3225	4.216
7	830	2.799	0.15	3660	5.174
8	850	2.113	0.11	3150	4.258

<u>Case Descriptions</u>

Case 1 – Single phase, single 175′ span, end poles guyed at top

Case 2 – Single phase, single 175′ span, end poles unguyed

Case 3 – Single phase, single 175′ span, end poles unguyed at top but guyed 20′ above ground

Case 4 – Same as case 3 but with 50% reduction in phase wire tension

Case 5 – Single phase, eleven (11) 175′ spans, end poles guyed at top, other poles unguyed

Case 6 – Single phase at top with telecom wire 20′ above ground, eleven (11) 175′ spans, end poles guyed at top and at 20′ above ground, other poles unguyed

Case 7 – Same as case 6 but with 50% reduction in telecom wire tension

Case 8 – Same as case 6 but with 50% reduction in phase wire tension

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Future PLS-CADD Modeling

- Modeling to match failure modes during testing
- Evaluation of impact of more stringent design standards
- Continued evaluation of concentrated loads on distribution lines
- Future models to include multiple phase conductors, cross arms, communication under build, etc
- Also evaluate different pole materials, configurations, guying, dead ends, etc

EPRI Contacts

Special thanks to:

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EPRI Lead on Task 1 – Aerial Structure Hardening

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