



Slide 1

*Overhead Distribution
Condition Assessment and Maintenance*

John Lauletta


Enabling the Smart Grid

January 12, 2011
Chicago Section PES Chapter
Chicago, IL



Slide 2

Agenda

- | The Problem: Overhead Performance
- | Organizational Objective
- | IEEE Failure Statistics
- | What Fails
- | Methods to Mitigate Failures
- | RF Emission Sources
- | An Arc Emission Capture and Use Methodology
- | Characteristics of Arc Emissions
- | Evaluating Emission
- | Field Experience and Case Studies





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The Problem: OVHD Performance

$$\text{SAIFI} = \frac{\text{total number of customer interruptions}}{\text{total number of customers served}}$$

$$\text{SAIDI} = \frac{\text{sum of all customer interruption durations}}{\text{total number of customers served}}$$

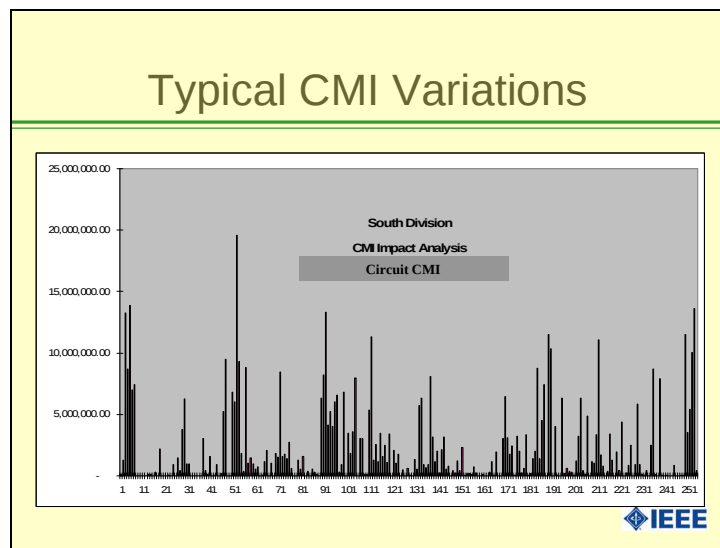
$$\text{CAIDI} = \frac{\text{sum of all customer interruption durations}}{\text{total number of customer interruptions}} = \frac{\text{SAIDI}}{\text{SAIFI}}$$

$$\text{MAIFI} = \frac{\text{total number of customer interruptions less than the defined time}}{\text{total number of customers served}}$$

CMI a Foundational Element



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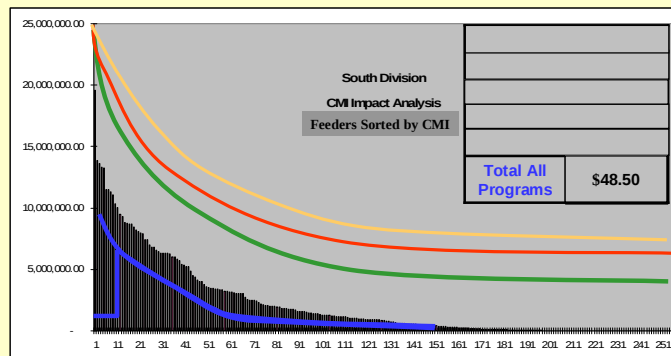
Slide 5

Methods to Mitigate Failures



Slide 6

Reliability Program Impacts





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Organizational Objectives



Slide 8

Support Multiple Business Objectives

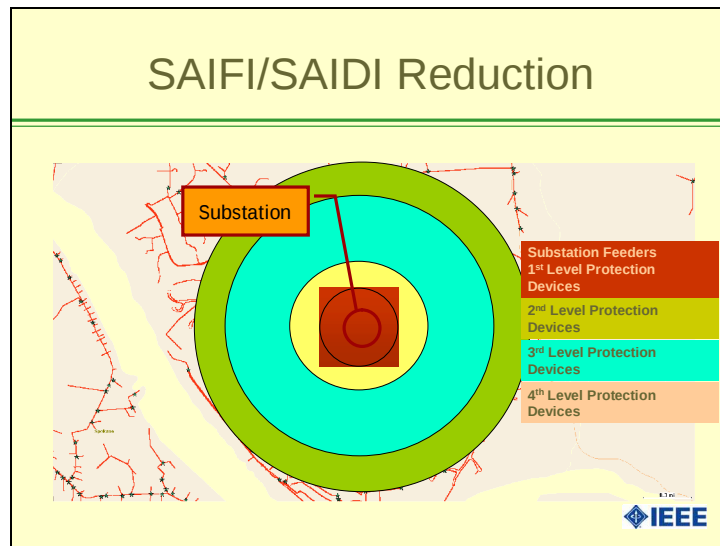
Technology &
Process
Enablement

- Empirical Data
- Leading Health Indicators
- Insight to Maximize Results

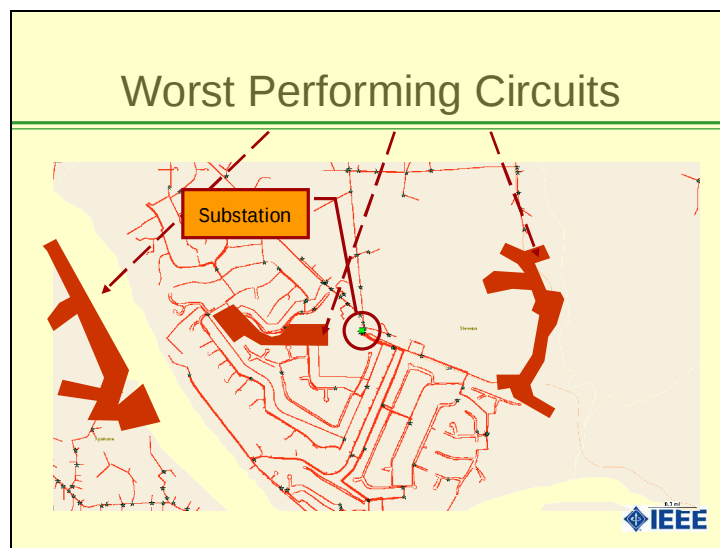


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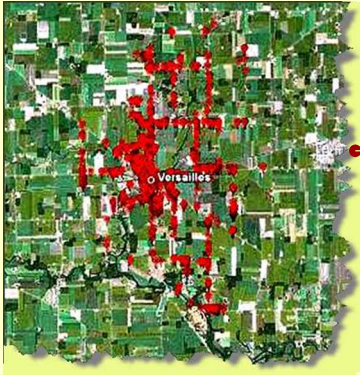




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Seasonal Damage

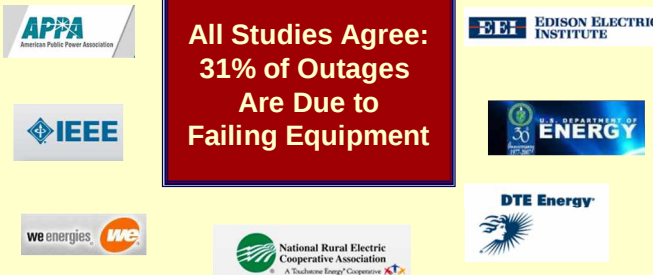


- Support for FEMA Assistance
 - Preparedness
 - Post storm recovery
 - Post restoration hardening
 - Mitigation assessment



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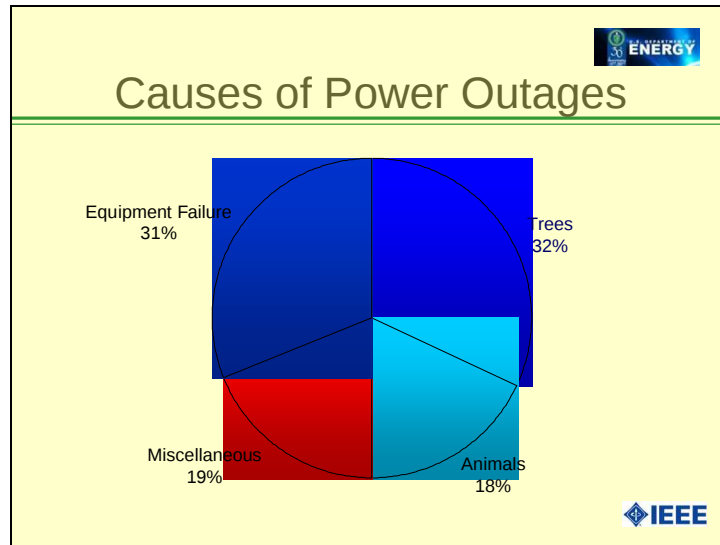
The 31% Problem



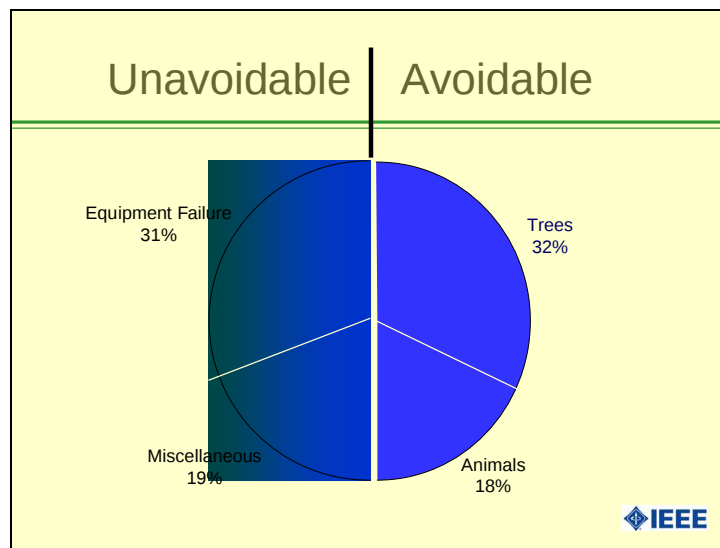


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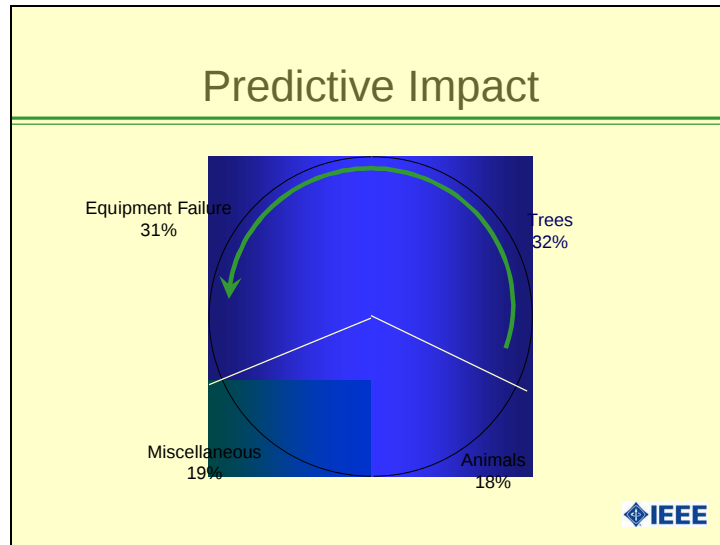
Slide 14



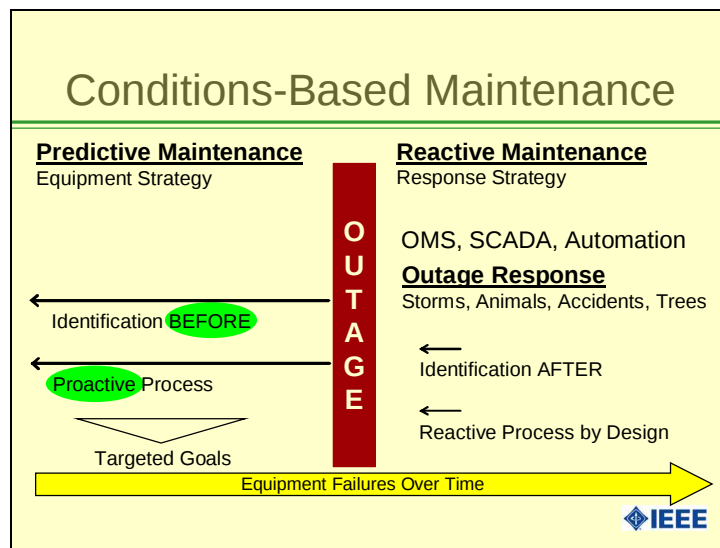


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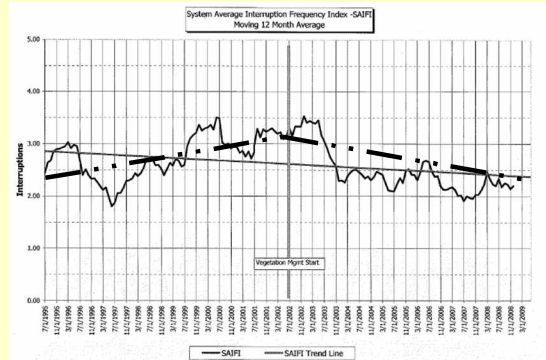




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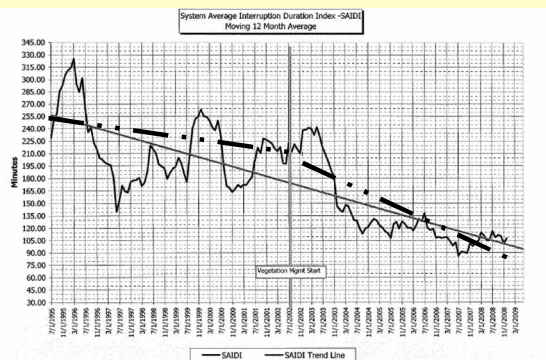
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Impact of Vegetation Mgmt: SAIFI



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Impact of Vegetation Mgmt: SAIDI



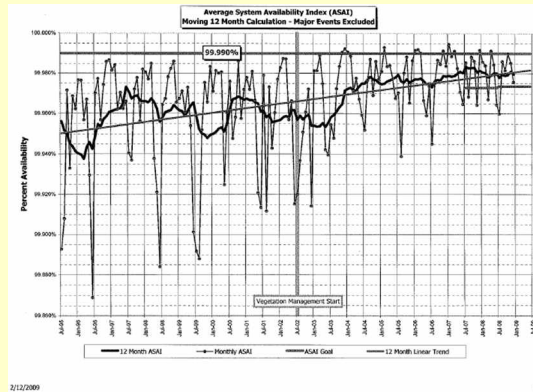
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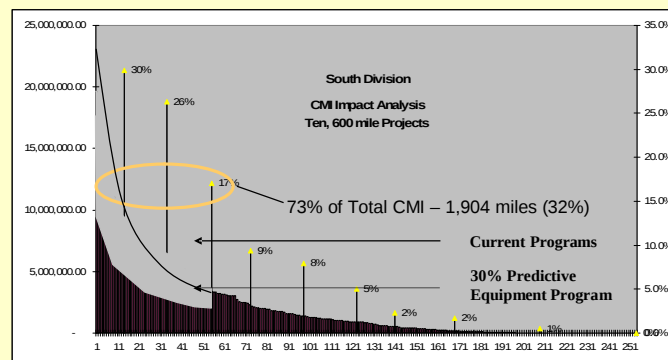
Overall System Availability



1 of 1
IEEE

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Plan for CMI Improvement



IEEE



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IEEE

Failure Statistics

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Regions Represented by the Participants

Region 0: Spans States or Unknown

Region 1: Northeast

Region 2: Mid-Atlantic

Region 3: Southeast

Region 4: Midwest

Region 5: Southwest

Region 6: South

Region 7: Northwest

Region	Color	States	Co.
0	Black	Spans states	1
1	Orange	Northeast	25
2	Yellow	Mid-Atlantic	20
3	Green	Southeast	5
4	Light Blue	Midwest	26
5	Dark Blue	Southwest	10
6	Purple	South	9
7	Red	Northwest	12
		2009 Total	107

Midwest: 26 Participants

Northeast: 12 Participants

Northwest: 12 Participants

Southwest: 10 Participants

Mid-Atlantic: 20 Participants

South: 9 Participants

Southeast: 5 Participants

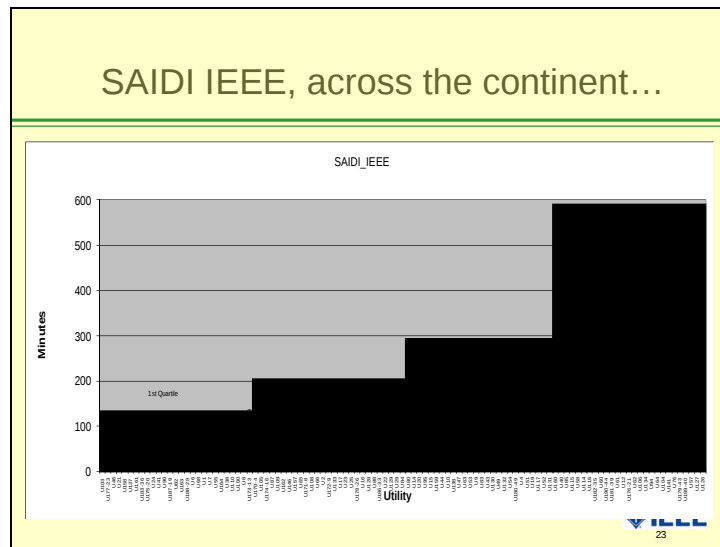
22



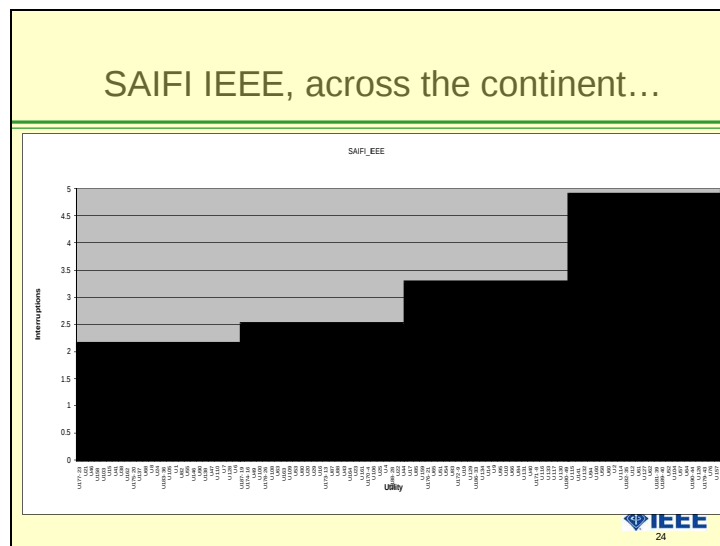


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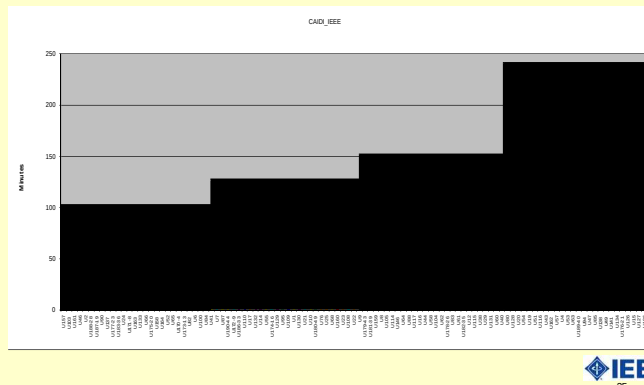
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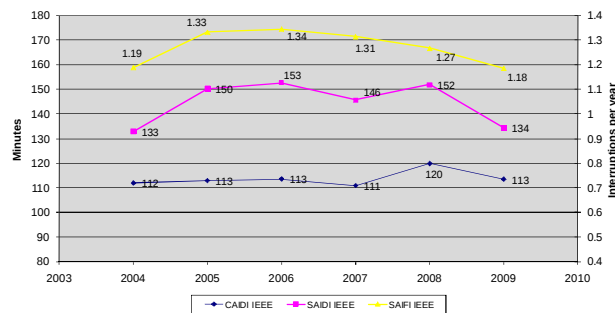
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CAIDI IEEE, across the continent...



Slide 26

Trends for Utilities providing data: through 2009

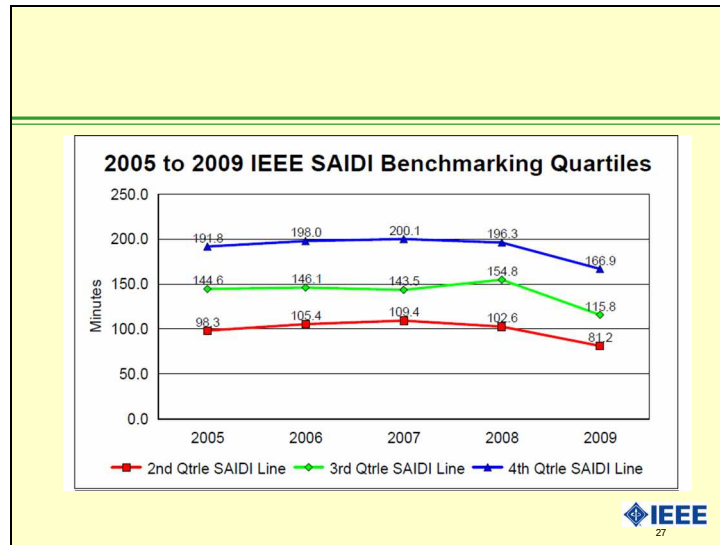


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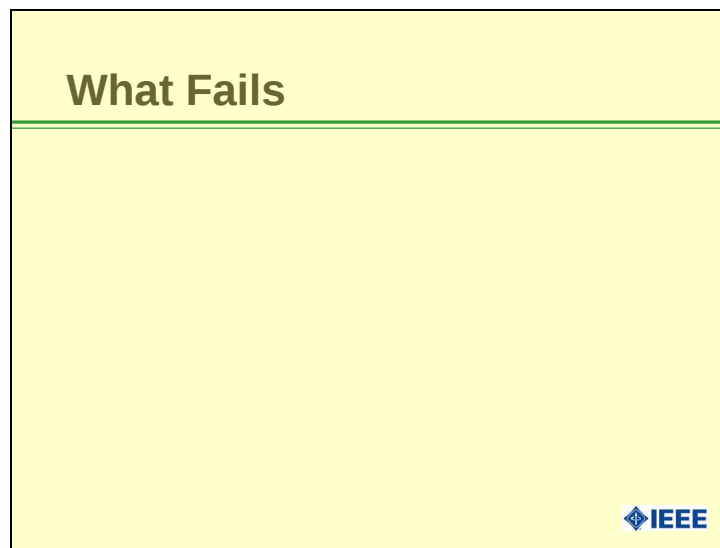


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Slide 29

Everything!



Slide 30

Symptoms of Hidden Dangers

Porcelain Cracks



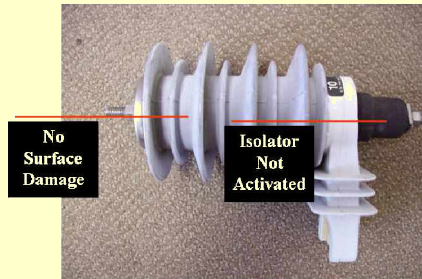
21/05/2008



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Hidden Damage – No Protection

Example of No Visual Damage



Represents about 50% of PD Active, Lab Confirmed Failed, Findings



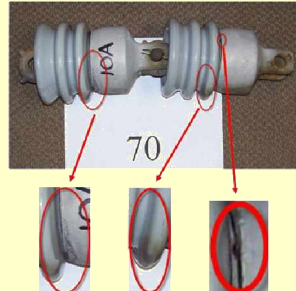
Insignificant Components Create Damage

Loose/Degraded Brackets and Clamps



Low Cost Parts Failures Lead to Expensive Pole Fires

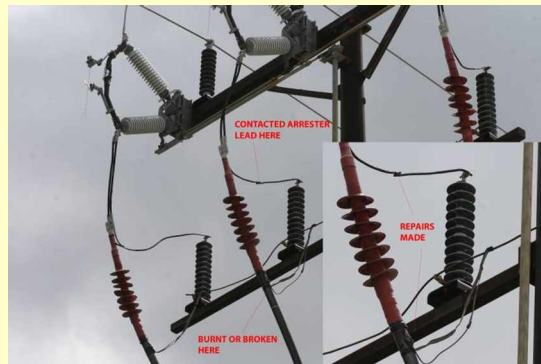
Damaged Dead-Ends



Findings: Tracking marks that are indicative of flashover ground current flow



Surge-Damaged Grounds





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Weak Porcelain Produces PD



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Insulator Fails Mechanical Test



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Cutouts Often Show No Exterior Damage



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This Utility has Other Problems



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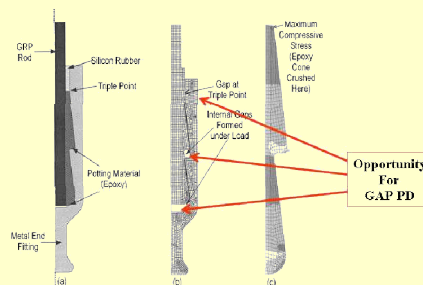
RF Emission Sources

- | Anything in the electric field
- | Arcing causes BIL reduction
- | Weakened parts flashover
- | Nuisance Fuse or Recloser operations
- | SAIFI, MAIFI, and CMI increase



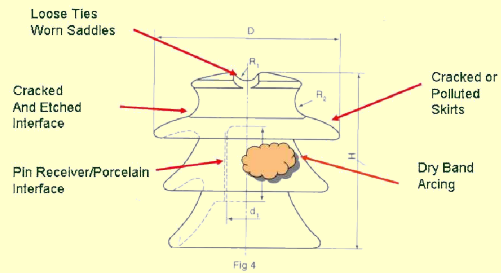
Polymer Insulators

Brittle Failure of Non Ceramic HV Insulators



Culprit in Unknown Operations

Why Pin Insulators Pose Such a Problem



Poor Workmanship Damages Conductor





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Broke When Operated



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Capacitor Located Before Explosion



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Ouch!



Slide 46

An Arc Emission Capture and Use Methodology



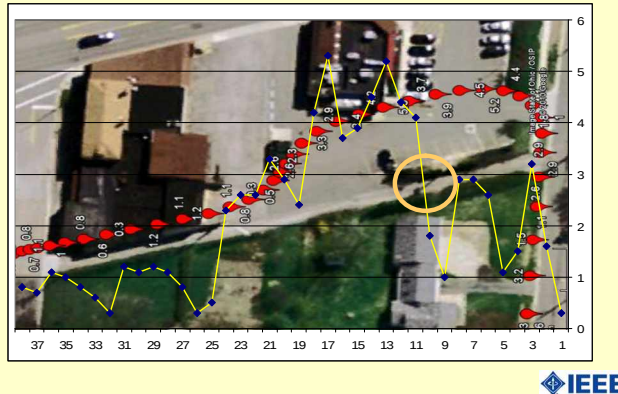
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Challenges Using RF Emissions



Slide 48

Process to Evaluate

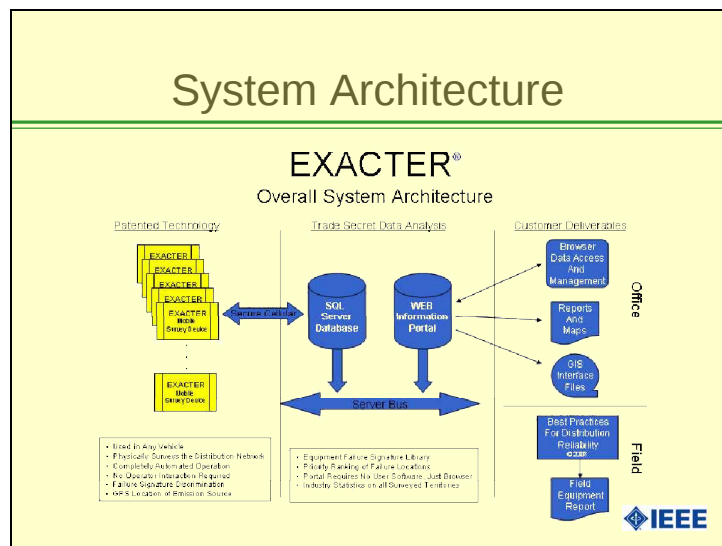
- | Survey 4 to 5 Times
 - Real-time analysis of emissions
 - Correlation to Failure Signatures and Weather influences
 - Geo-Spatial corrected references
- | Statistical evaluation of geo-spatial data
- | Conclusions on emission location



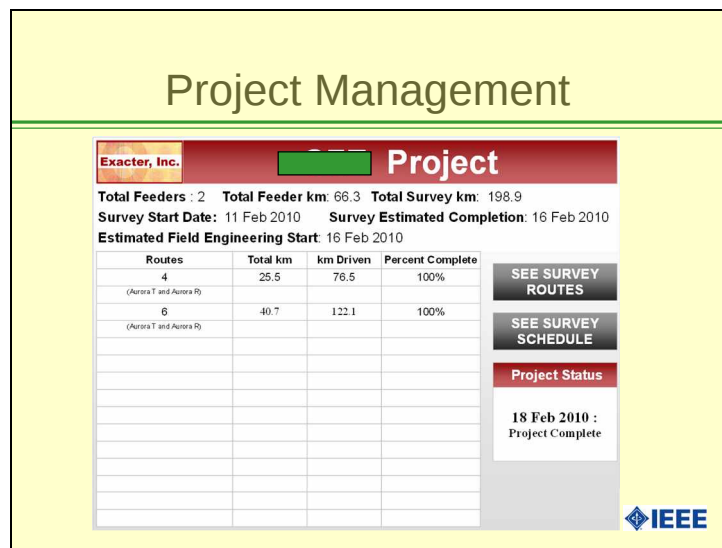


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Slide 50



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Slide 51

Survey Design



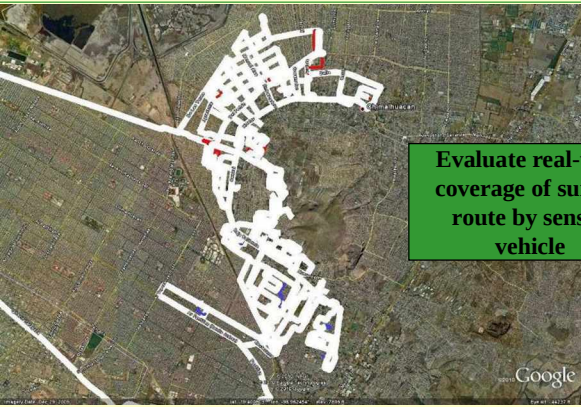
Plan Survey Routes to be within 100 meters of Overhead circuits

Google IEEE

This slide, titled 'Survey Design', displays an aerial photograph of a city street grid. Two distinct survey routes are overlaid on the map: one in red and one in blue. The red route is a complex, interconnected loop covering a significant portion of the central city area. The blue route is a more linear path, possibly following a major thoroughfare or a specific set of streets. A green text box on the right side of the map contains the instruction 'Plan Survey Routes to be within 100 meters of Overhead circuits'. The Google and IEEE logos are visible in the bottom right corner of the slide.

Slide 52

Survey Management



Evaluate real-time coverage of survey route by sensor vehicle

Google IEEE

This slide, titled 'Survey Management', shows the same aerial map as Slide 51. The survey route is now depicted as a solid white line, indicating it has been finalized or is being actively managed. A small icon of a sensor vehicle is positioned at the start of the route. A green text box on the right side of the map contains the instruction 'Evaluate real-time coverage of survey route by sensor vehicle'. The Google and IEEE logos are visible in the bottom right corner of the slide.



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Real-time Data

Collect raw Failure Signature correlation data for each survey pass

Google IEEE

Slide 54

Statistical Analysis Yields Accurate Results

Analyze corrected raw data and geo-spatial locations for conclusion

Google IEEE



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Slide 55

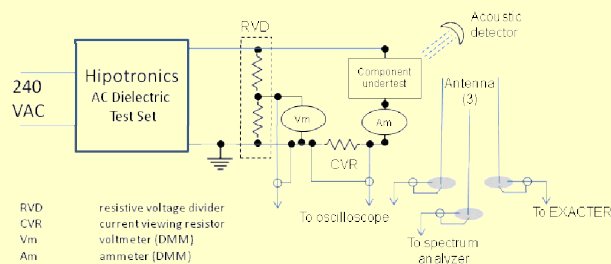
Characteristics of ARC Emissions

- | Evaluation between 1 MHz and 1 GHz
- | Coupling and reflections eliminated through multiple surveys
- | Correlation to known Failure Signatures
- | Data corrected for environmental influences



Slide 56

Typical Specimen Test Setup





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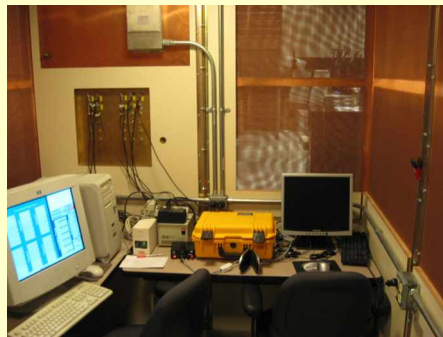
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Research Facilities



Slide 58

Faraday Cage Research Station



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Fog and Salt Spray Chamber



Evaluating Emissions

- | Collect field samples
- | Energize at field conditions
- | Match with RF Image and Field Sensor
- | Evaluate in various environmental conditions
- | Create Failure Signature or correlate to known signature

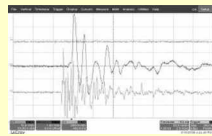
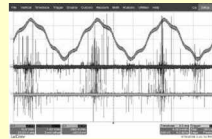




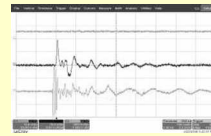
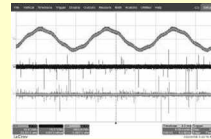
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Slide 61

Leakage and Breakdown Voltage



Surge arrester log # 30 – scope waveforms at 15 kV; top trace: applied voltage; middle trace: voltage across CVR; bottom trace: spectrum analyzer input. Horizontal scale: upper: 5 ms/div; lower: 50 ns/div

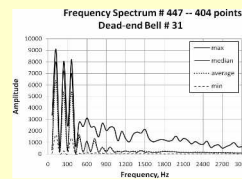
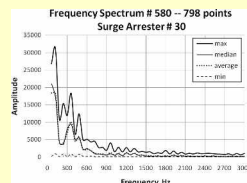


Dead-end bell insulator log # 31 – scope waveforms at 12.5 kV; top trace: applied voltage; middle trace: voltage across CVR; bottom trace: spectrum analyzer input. Horizontal scale: upper: 5 ms/div; lower: 100 ns/div



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Frequency Spectrum Analysis



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Field Experience and Case Studies

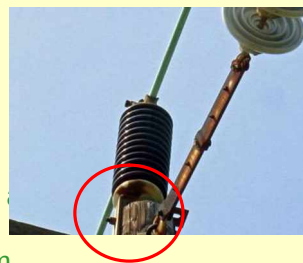


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Case Study #3

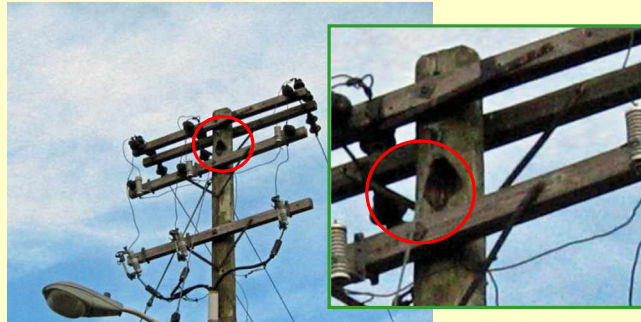
• Problem – A Northeast IOU has a recurring 69kV line outage problem that 2 years of IR scanning cannot locate.

• Solution – An Exacter demonstration survey located a 69kV post insulator that when replaced, corrects the problem.

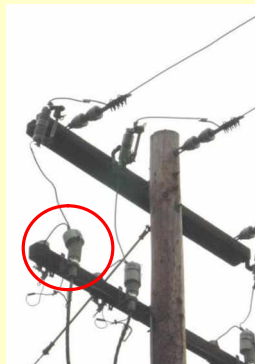


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Damaged Lightning Arresters



Failed Lightning Arrester



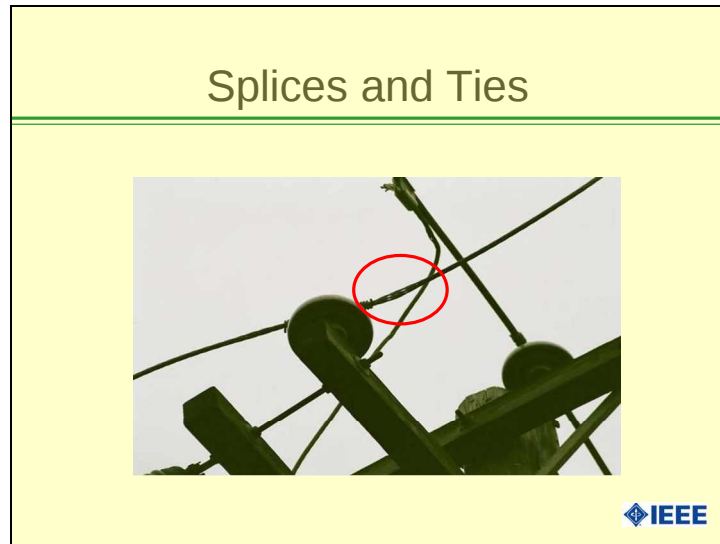
Tree Limb Emission



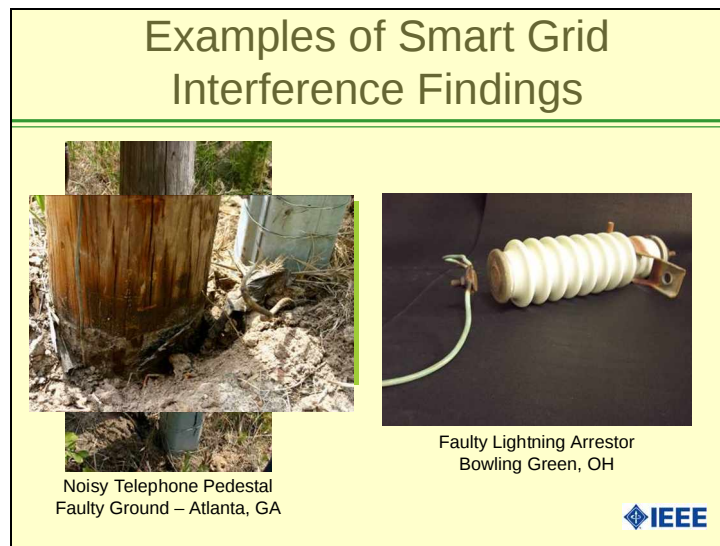
Loose/Degraded Neutrals and Clamps



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Slide 70





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Slide 71



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