Avoiding Wildfire Ignition by Early Detection of Powerline Equipment Failures

77th Annual Conference for Protective Relay Engineers
Texas A&M University, College Station, Texas
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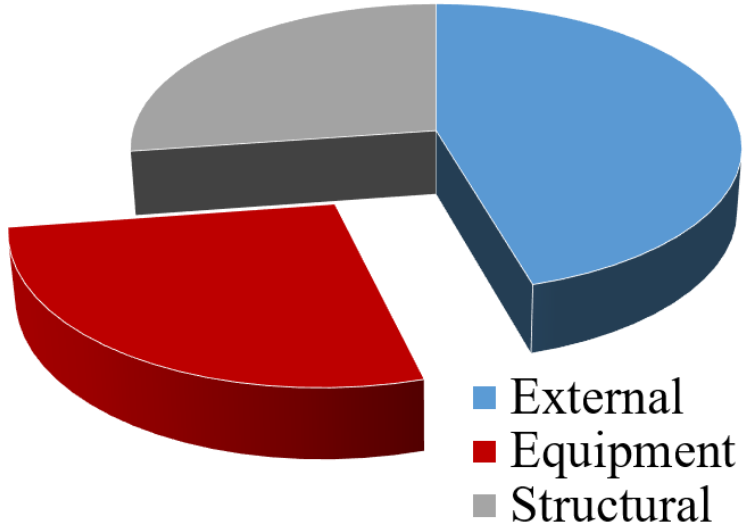
How Do Powerlines Start Fires?

Three broad categories

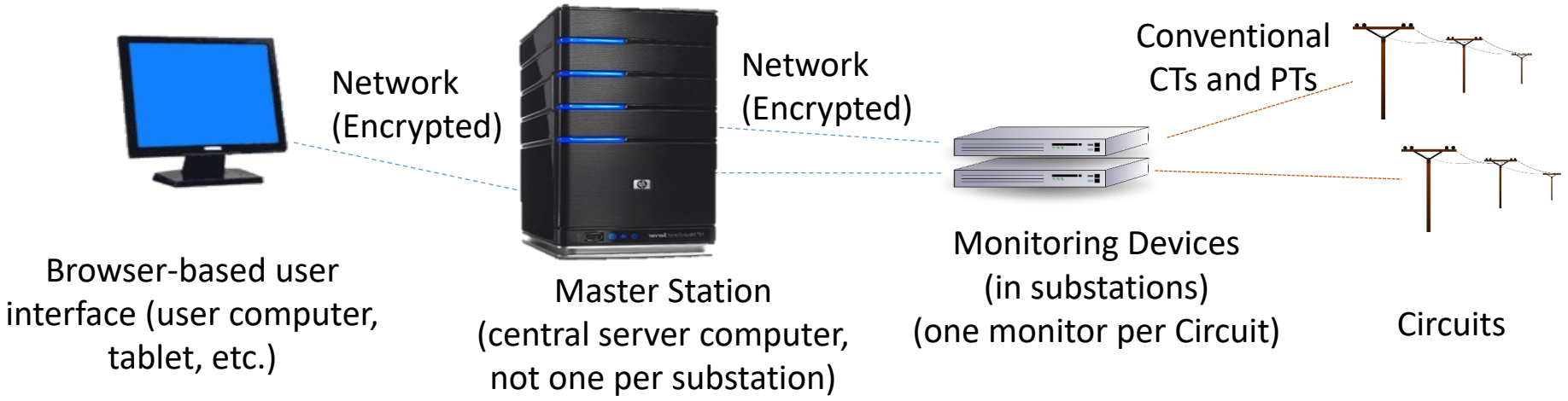
- Structural – broken poles/crossarms
- External – pole broken by auto accident; conductor broken by falling tree
- Equipment – connectors; switches; transformers; capacitor banks; …

A commonality: line failures produce arcing in the presence of combustibles.

Today's discussion focuses on the Equipment slice.



Background: Data for Case Study

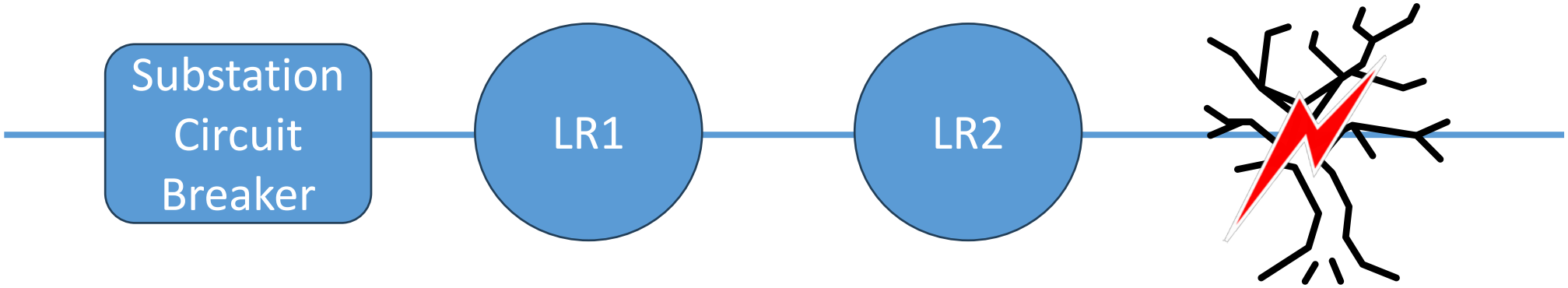


This monitoring system provides high resolution, sensitive triggering, and long records. It is installed on more than 600 circuits and detected the field case discussed in this presentation.

Sample Case Study

Case Study

Protection Miscoordination???

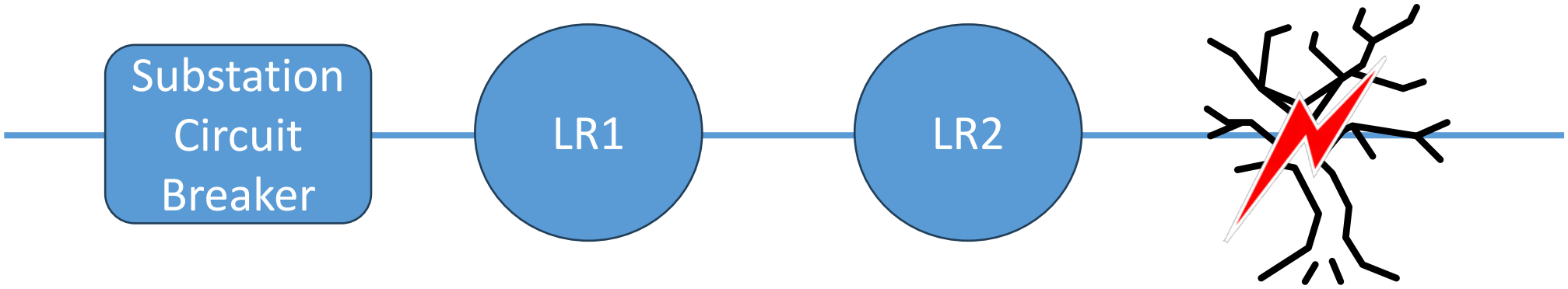


Sequence of events

- A tree caused a phase-to-phase fault that tripped line recloser LR2.
- But LR1 also tripped. Why?
- A patrol identified the tree-caused fault but no problem upstream of LR2.
- Apparent protection miscoordination between LR1 and LR2?

Case Study

Protection Miscoordination???

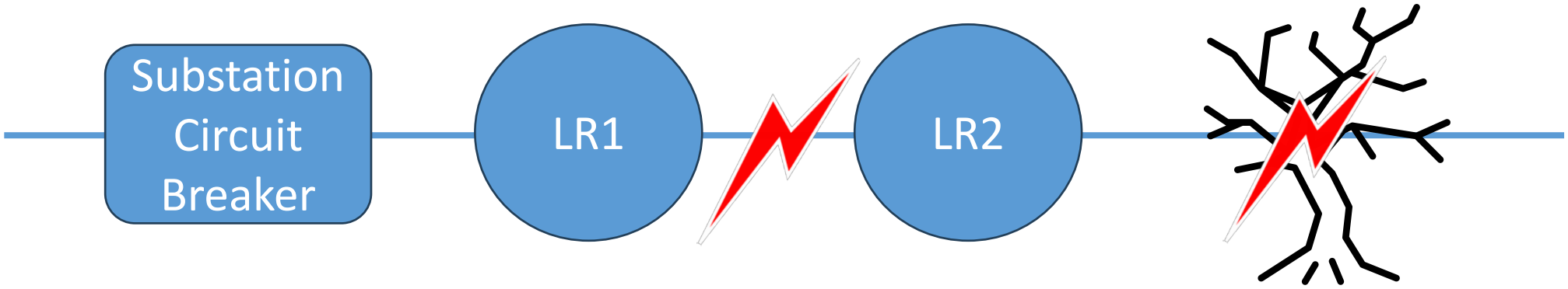


<u>Again and again</u>

- The sequence occurred 12/2/2022.
- And again 1/16/2023, 2/23/2023, and 2/4/2024.
- In each case, only LR2 should have tripped … but LR1 also tripped.
- The cases spanned 14 months, and personnel did not recognize that the <u>same</u> “miscoordination” was occurring repeatedly.

Case Study

~~Protection Miscoordination???~~ No, FICS



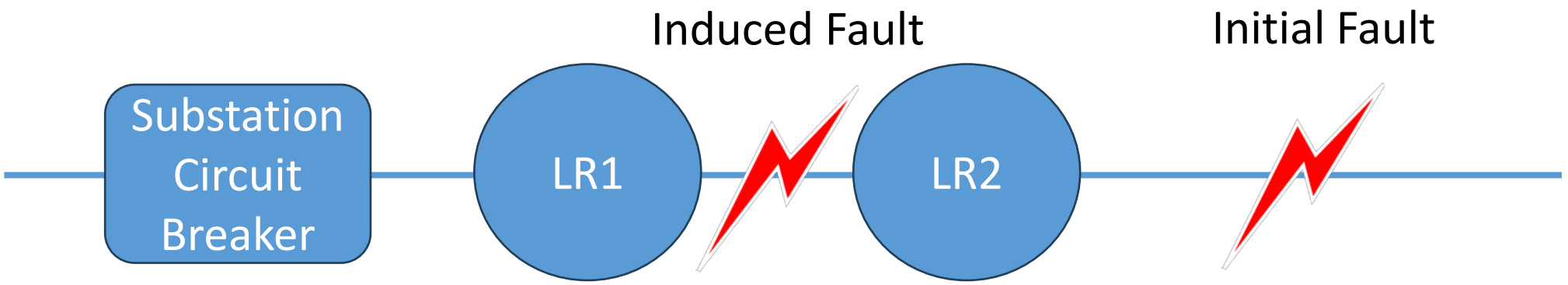
The answer

- Fault-induced conductor slap (FICS) was occurring each time.

Possible fault-induced conductor slap (FICS)	ABC	Three-Phase trip F-(18.0c,2273A,BC)-T-(8,9,14)%-1.5s-C-F-(40.0c,3566A,ABC)-T-(60,52,60)%	2 ops	2022-12-02 16:55:22

Case Study

Fault-Induced Conductor Slap (FICS)

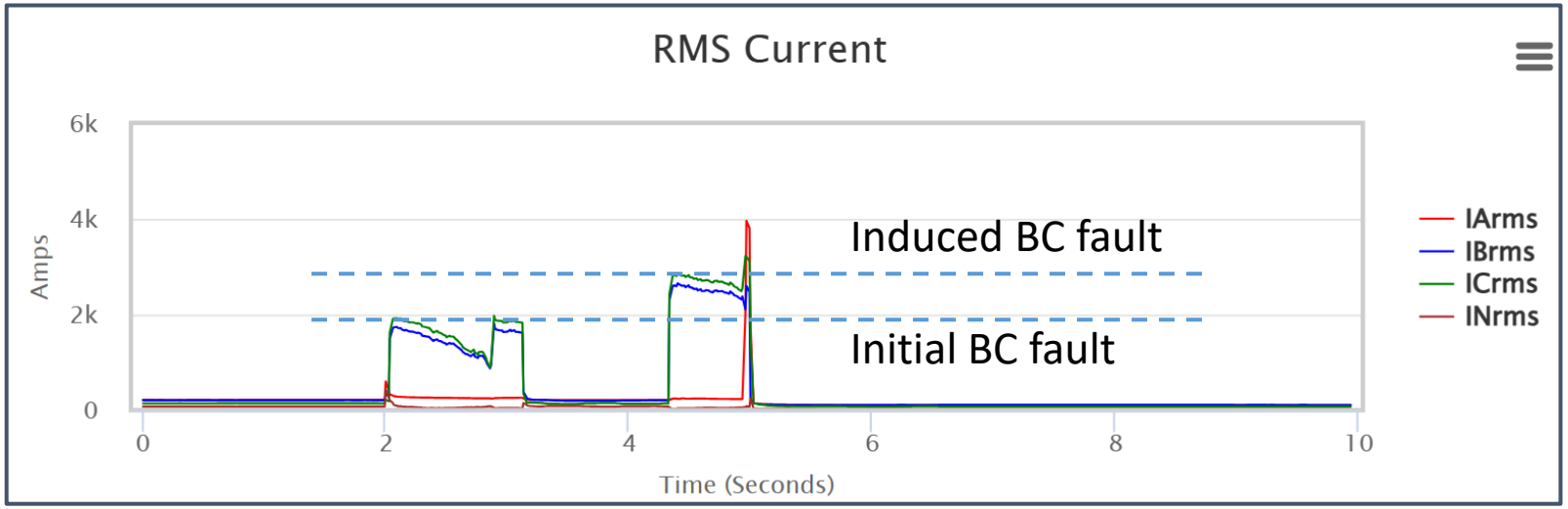


Fault-induced conductor slap? What's that?

- Current of the initial fault, beyond LR2, induces magnetic forces that push conductors apart, all the way back to the substation.
- When LR2 trips, the magnetic forces suddenly cease, allowing upstream conductors to "pendulum."
- Conductors upstream of LR2 may touch, "inducing" a second fault.

Case Study

Fault-Induced Conductor Slap (FICS)



Software in the substation-based monitor automatically analyzes electrical data (above), detects the unique FICS electrical pattern, and reports it (below).

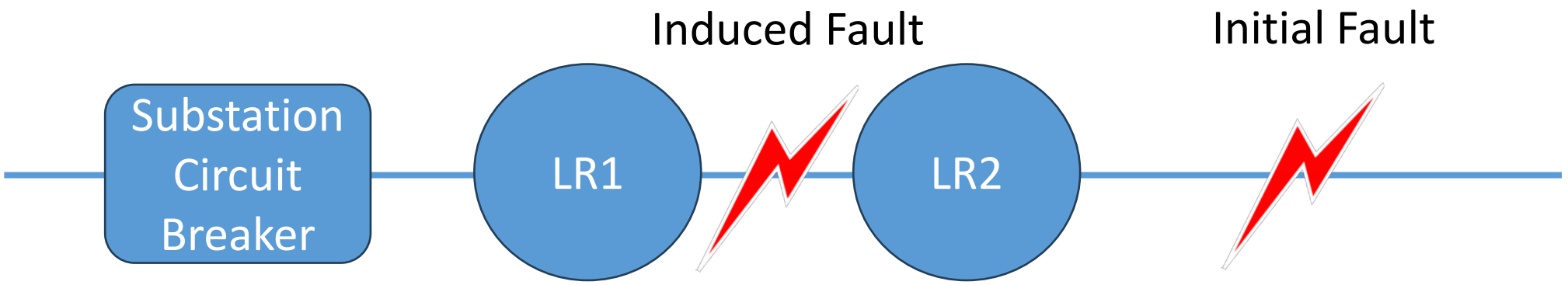
Possible fault-induced conductor slap (FICS)	ABC	Three-Phase trip F-(65.5c,1809A,BCN)-T-(0,5,0)%-1.2s-C-F-(40.0c,3662A,ABC)-T-(54,47,44)%	2 ops	2024-02-04 09:02:09

Case Study

Fault-Induced Conductor Slap (FICS)

- Model-based prediction of location then guided a successful patrol.
- The single span had <u>seven</u> documented FICS incidents in <u>16 months</u>.
  - (Repairs were not immediate, so the FICS recurred after discovery.)
  - Some witness marks were dull (old), others shiny (new).
  - Correcting that span prevents future recurrence.
- <u>*Important*</u>: The without-which-nothing was knowing FICS was happening.

Case Study
Fault-Induced Conductor Slap (FICS)

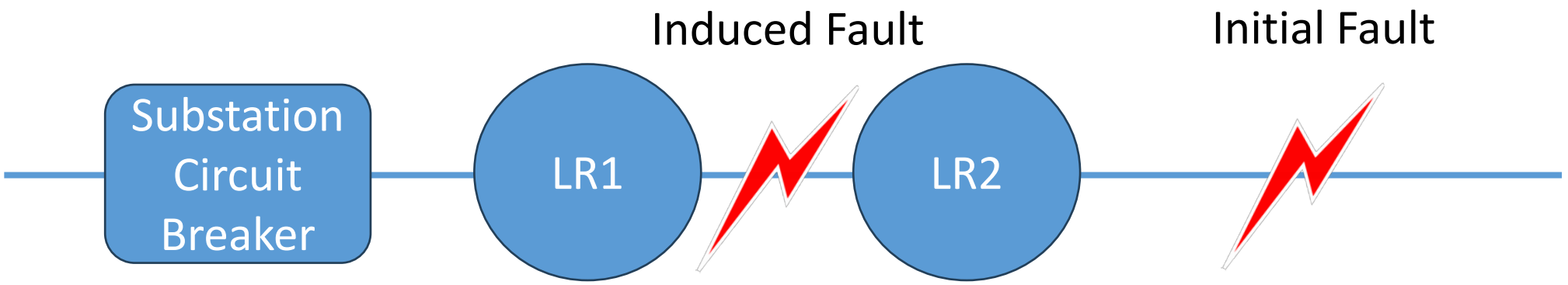


<u>Question: How does FICS cause fires</u>?

1. When aluminum conductors slap, expelled particles are <u>in combustion</u>.
   - The episodes described here happened in wet months. Dry months would have higher ignition probability. Fixing in wet months prevents slaps in dry months.
2. Each slap also damages the conductors and eventually could break them.

Case Study

Fault-Induced Conductor Slap (FICS)



<u>Question: FICS has a unique pattern. Can I recognize it in relay records</u>?

- <u>Answer</u>: Maybe, if you have 1) a person with knowledge of the FICS phenomenon 2) who has lots of time and 3) fingertip access to all relay data.
- But it seldom occurs in practice. Continuous circuit health monitoring, with real-time analysis software, analyzes every fault record and reports FICS (and other conditions) within minutes of occurrence.

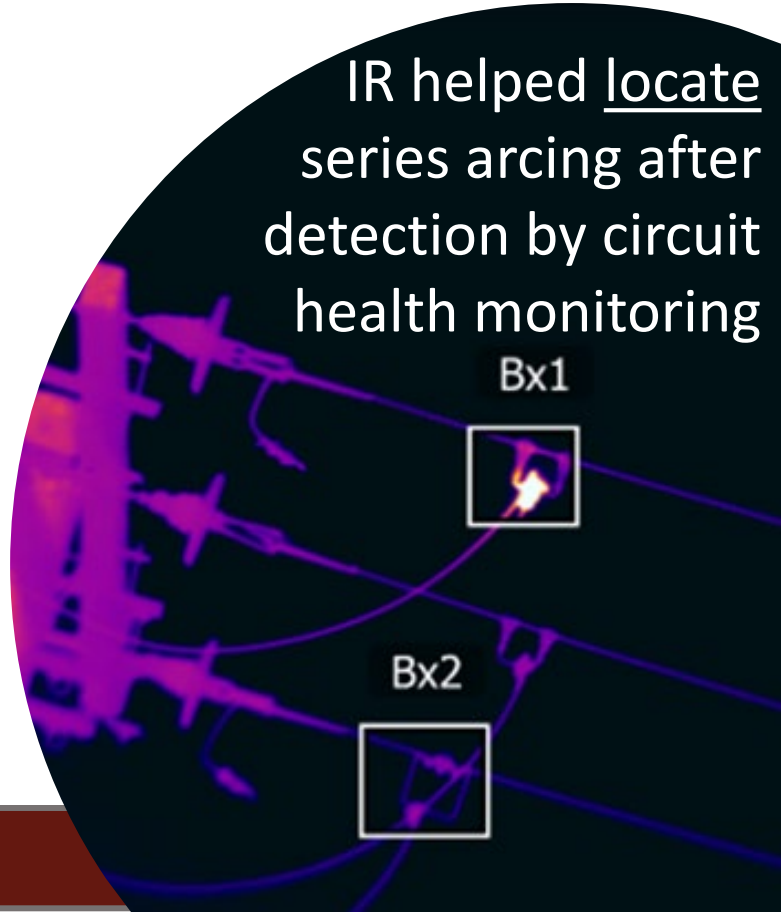
Other Electrically Detectable Incipient Equipment Failures That Can Start Fires

Many equipment failures can start fires (and affect reliability).

- FICS (Emission of burning particles; broken conductors)
- Repetitive, self-healing faults (e.g., broken bushings, intermittent vegetation push-together contacts)
- Compromised-vacuum capacitor switches (bottle explosion)
- Failing, arcing connections (e.g., hotline clamps, switch contact surfaces, bushing connections)

The monitoring system has provided early warning for multiple cases of each, enabling proactive repairs that reduce fire risk and improve reliability.

Continuous circuit health monitoring can provide early warning for a variety of incipient conditions and enable detection, location, and timely repair, to reduce outages, collateral damage, safety hazards, and ignition risks.



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