# Wildfire Ignition from Latent, Undiscovered Distribution Faults: Early Detection Using Signature Recognition

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# The Problem

Wildfires are increasing in number and scale.

1.5 million wildfires have occurred since 2000.

Increasing drought conditions means any ignition cause can result in a fire with large losses in lives and property.

# Wildfire Causes

| |
|---|
| Unintended human activity (trash burning, campfires, BBQ, etc.): 19% |
| Equipment use (vehicles, dragging chains, lawn mowers): 15% |
| Powerline related: 8% |
| Dry lightning: 6% |
| Arson: 6% |
| All other known causes: 18% |
| Unknown causes: 28% |

# Powerline Ignition Mechanisms

- Failure of a part or device (switch, clamp, connector, fuse)
- Downed conductor
- Explosion of apparatus (transformers, capacitors)
- Clashing conductor-emitted ignition particles
- Arcing across conductors (e.g. mylar balloons)
- Vegetation interference

# Powerline Caused Fires

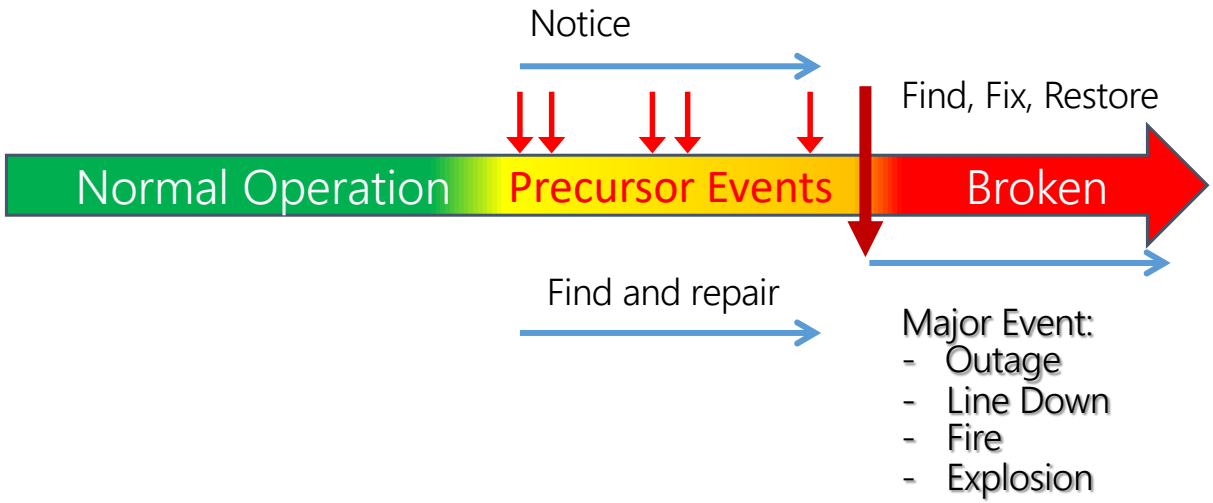
- Downed conductors will likely arc and represent a potential ignition mechanism
- BUT!...

  Why did the conductor fall?

  a. Off right-of-way tree falls and tears down line (not electrically detectable prior to contact)
  b. Clamp arcs for three weeks, erodes conductor (electrically detectable, sometimes preventable)

Current Operating Paradigm

# Incipient Failure Detection – The Concept




Incipient failures and their precursor signatures have always existed. Sensitive 24x7 monitoring enables their capture. Automated software, applied to high-fidelity data recordings, enables practical use.

# Characteristics of certain latent circuit defects and failing devices

Low current magnitude (a few amps to a few tens of amps)

Can persist over considerable time (e.g. weeks)

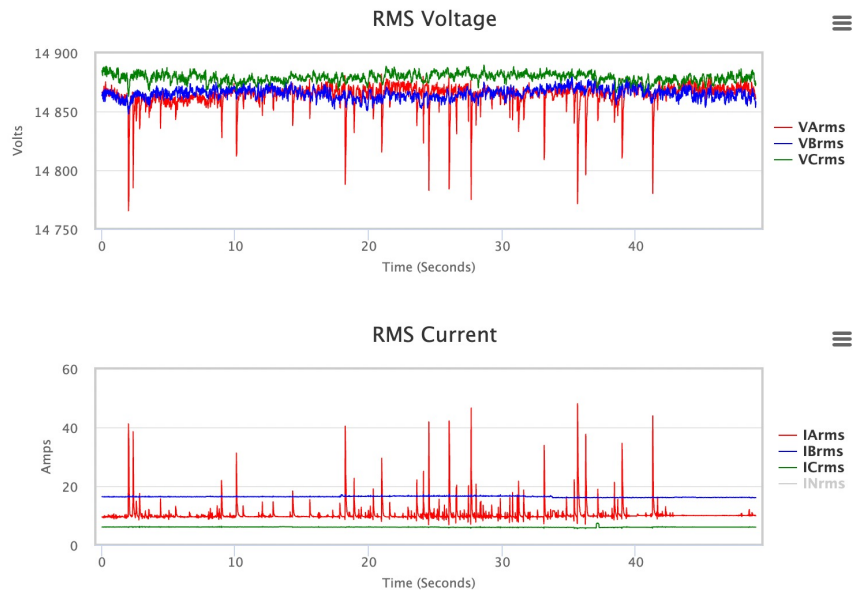
Intermittent behavior

Undetected by conventional means

Known to ignite fires

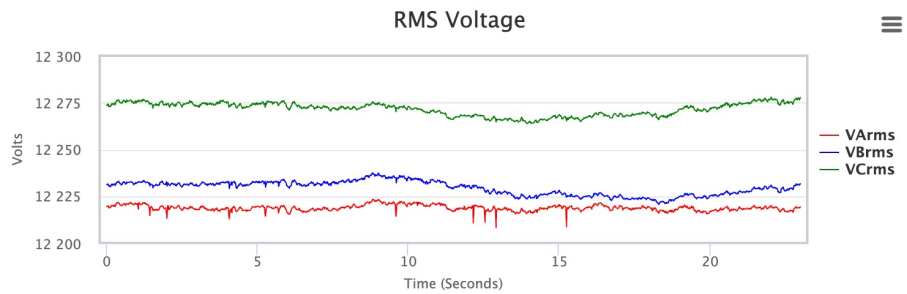
# Example 1: Arcing substation switch

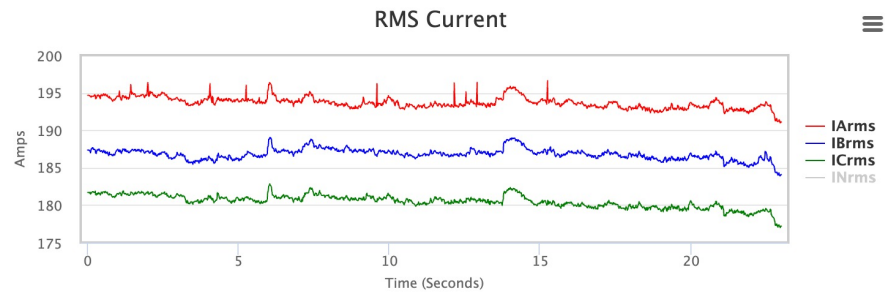
- Series arcing from a substation switch produced sustained current transients over multiple hours.
- Even though transients are visible to the naked eye, they fall well below the detection threshold of conventional systems.



# Example 2: Failure of a connector

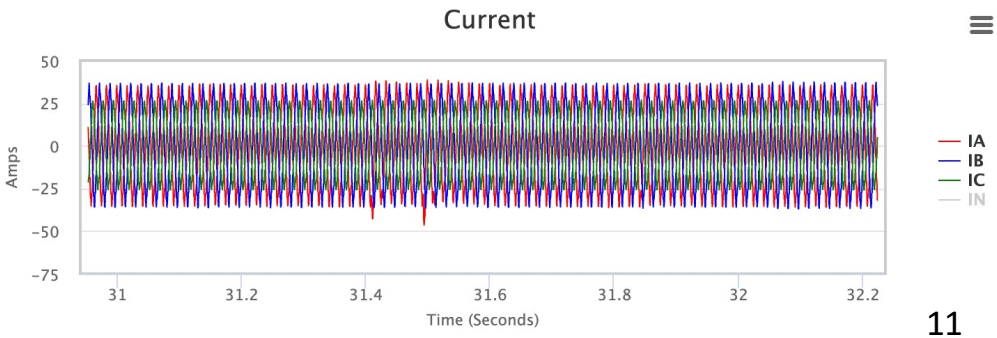
- A downstream fault (likely) weakened a current-carrying connector because of passage of high current through the connector.
- Ten days of persistent, low-level arcing in the connector eventually broke the conductor.
  - This would not be captured by conventional means.
- Downed conductors and persistent arcing both are competent ignition mechanisms.



# Example 3: Failing hotline clamp

- The failure of hotline clamps results in distinctive signatures, though some modulate only a few amperes of current.
- Clamp failures can persist for months, with each arcing episode a potential ignition mechanism.
- Failures eventually can break conductors.

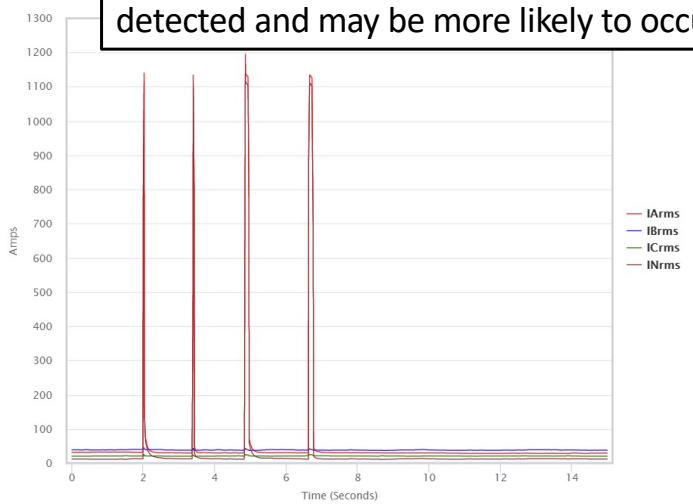


# Which is more likely to start a fire?

Single-phase reclose sequence (2A2B)

Low-magnitude persistent arcing

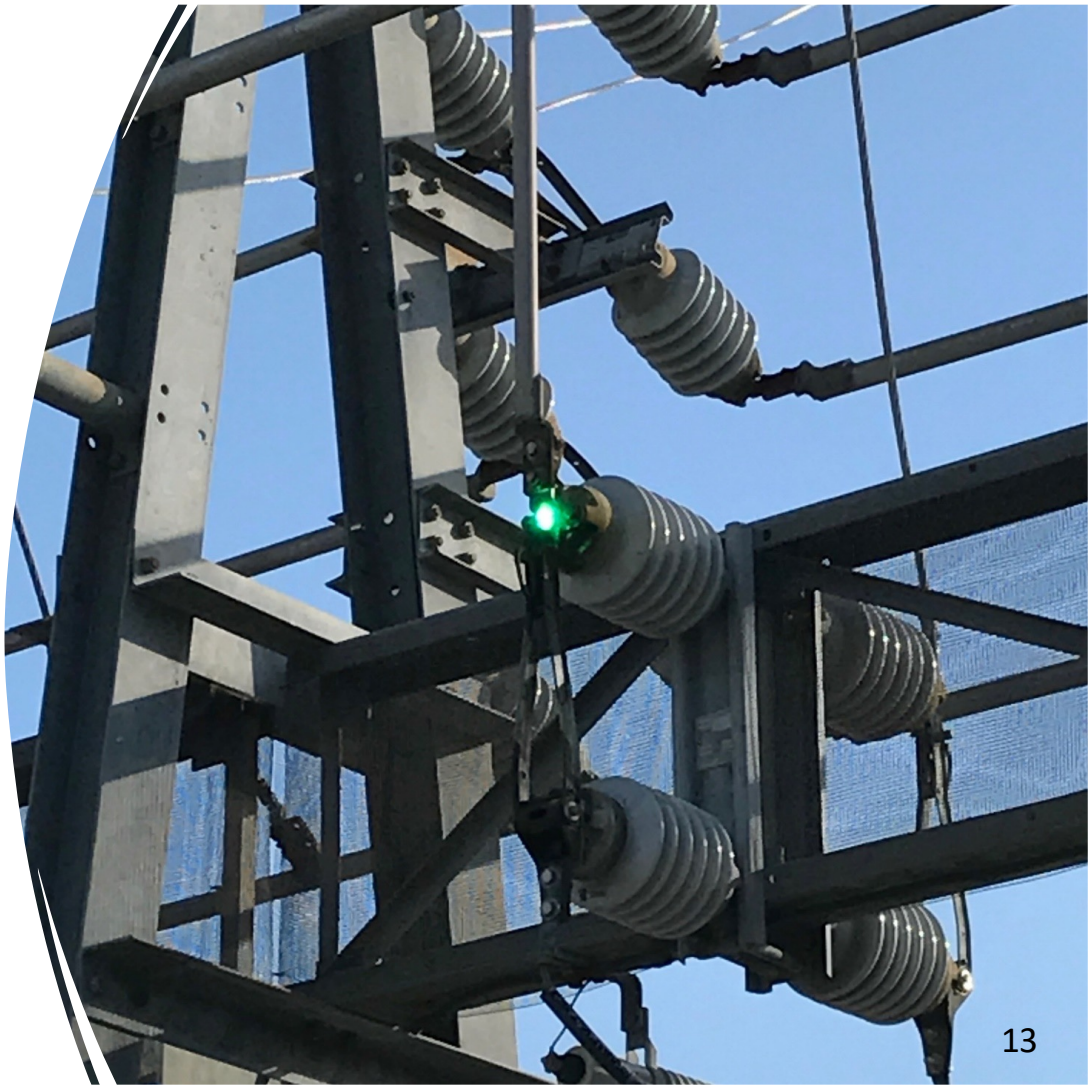
Both are competent ignition mechanisms, but low-magnitude events are less likely to be detected and may be more likely to occur when conditions are conducive to a fire!




# Finding impending failures – low magnitude

How do we detect low magnitude failures?

- Need to detect small signatures in lots of load (e.g. a few amps buried in hundreds of amps)
  - This cannot be done with conventional recordings.
- Recognize which signatures are important (”normal” events often produce similar or larger transients than “abnormal” ones)
- Combine electrical information synergistically with utility to enable location (AMI, line sensors, customer calls, etc.)



# Finding impending failures – high magnitude

- High magnitude faults can also represent repetitive latent conditions (a/k/a incipient failures)
  - For example, conductor slap occurs multiple times in the same location over years without awareness of operations.
  - Locating high-magnitude faults is often straightforward – but requires that you know about it first! Not all faults are equally important!

# Conclusions

- Many fires are ignited by latent or incipient circuit defects that do not operate protection devices.
- Circuits may be unhealthy for weeks, unbeknownst to the utility, while conditions deteriorate and lead to fire ignition or other unsafe conditions.
- The same conditions that cause outages and circuit unreliability can also cause fires.
- Many persistent, failing devices can be found and fixed before fire ignition using advance waveform analytics.