

Distribution Fault Anticipation Technology

Reducing Wildfire Ignition Risk through Advanced Electrical Monitoring

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Proposed Improvements to Reduce Wildfire Ignition Risk

- Harden systems, including better poles, covered wires, non-expulsion fuses, and increased conductor spacing.
- Increase vegetation inspection and pruning.
- Further explore and exploit smart meter capabilities.
- Expand deployments of weather stations and high-definition cameras.
- Use monitored reclosers, sensitive protection settings, and fallen wire detection.
- Preemptively deenergize selected circuits.

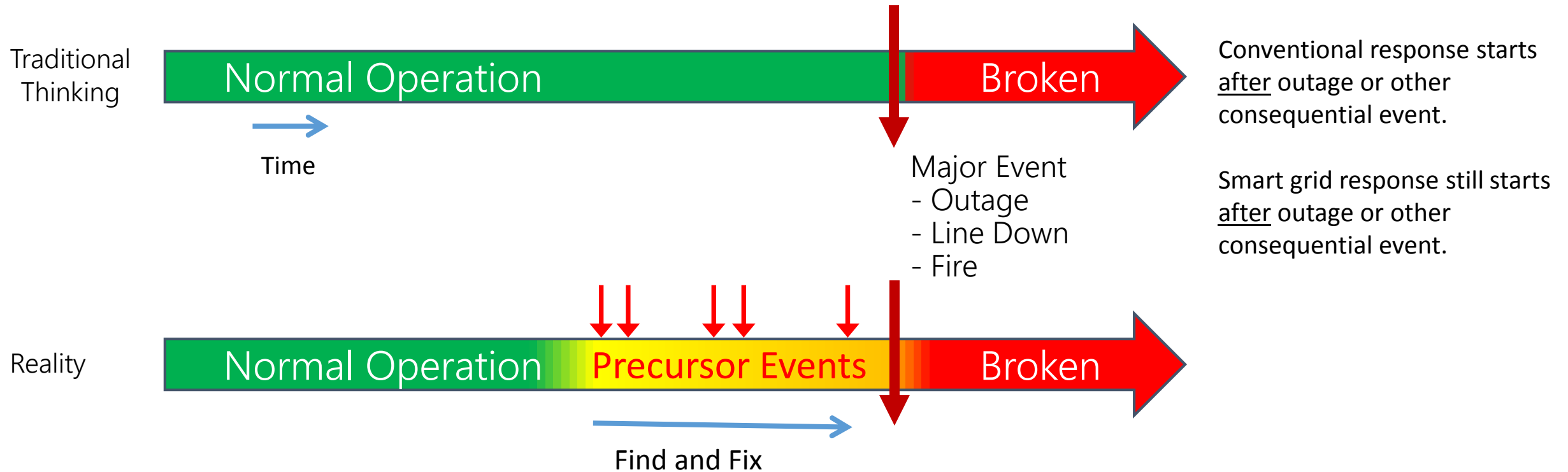
What is missing?

What is Missing?

- Continuous health monitoring of circuits (24/7/365).
- Automated diagnostics – what is breaking or broken?
- Actionable information to operators in real-time.

The Solution: DFA Technology

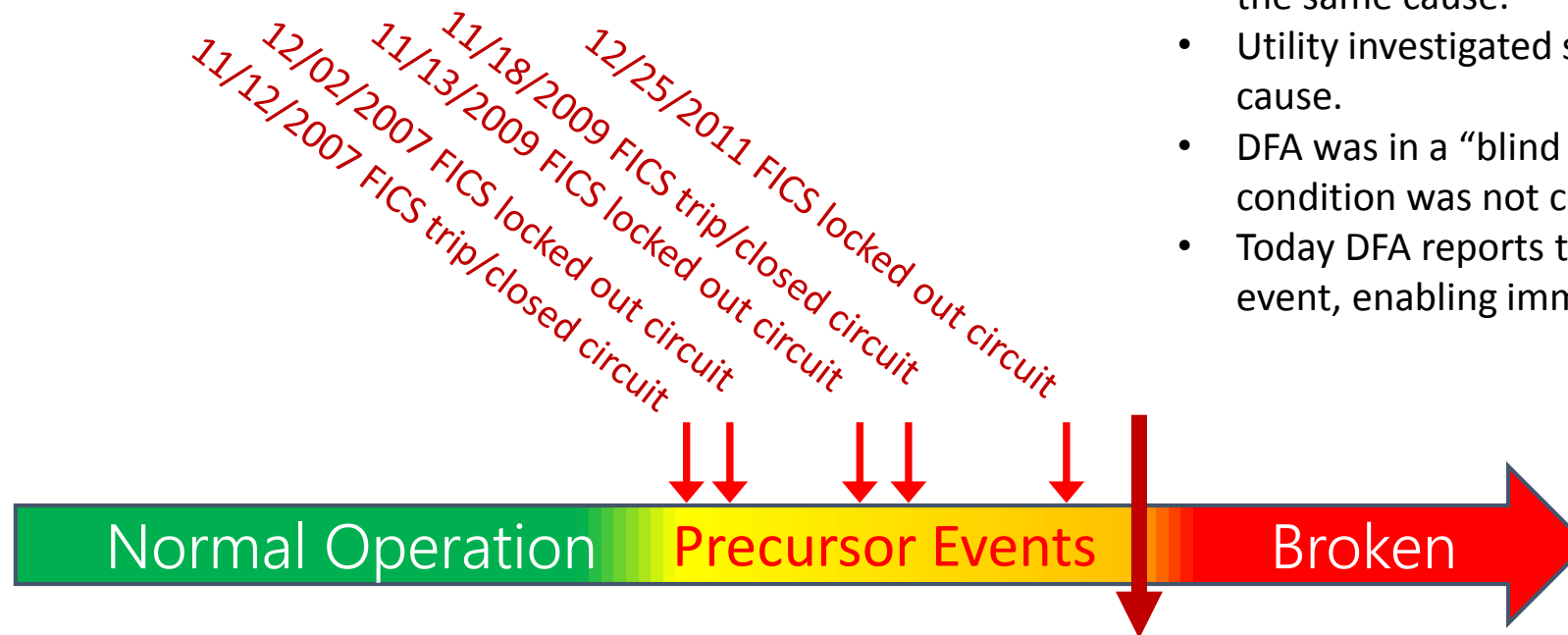
Distribution Circuit Operating Paradigms



Key to better circuit management is early awareness of actual circuit activity.

Distribution Circuit Operating Paradigms

Actual Example



- Five FICS events occurred at the same location and had the same cause.
- Utility investigated some events but failed to diagnose cause.
- DFA was in a “blind study” mode during first events, so condition was not corrected.
- Today DFA reports this specific condition, after first event, enabling immediate location and repair.

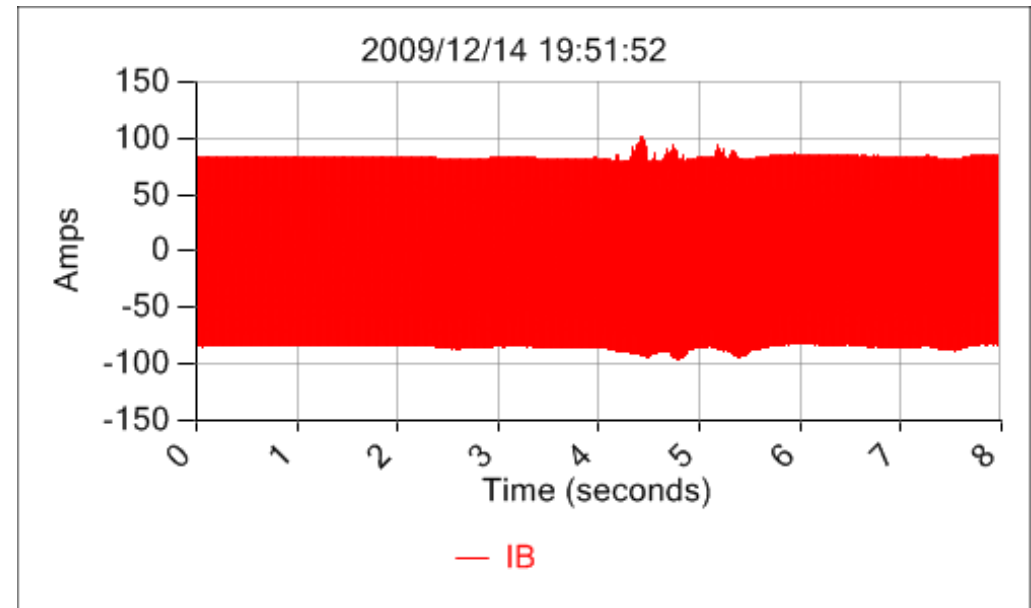
Repetitive FICS at the same location causes cumulative damage, fire hazards, and downed conductors.



Undetectable/Unknown Wildfire Ignition Mechanisms

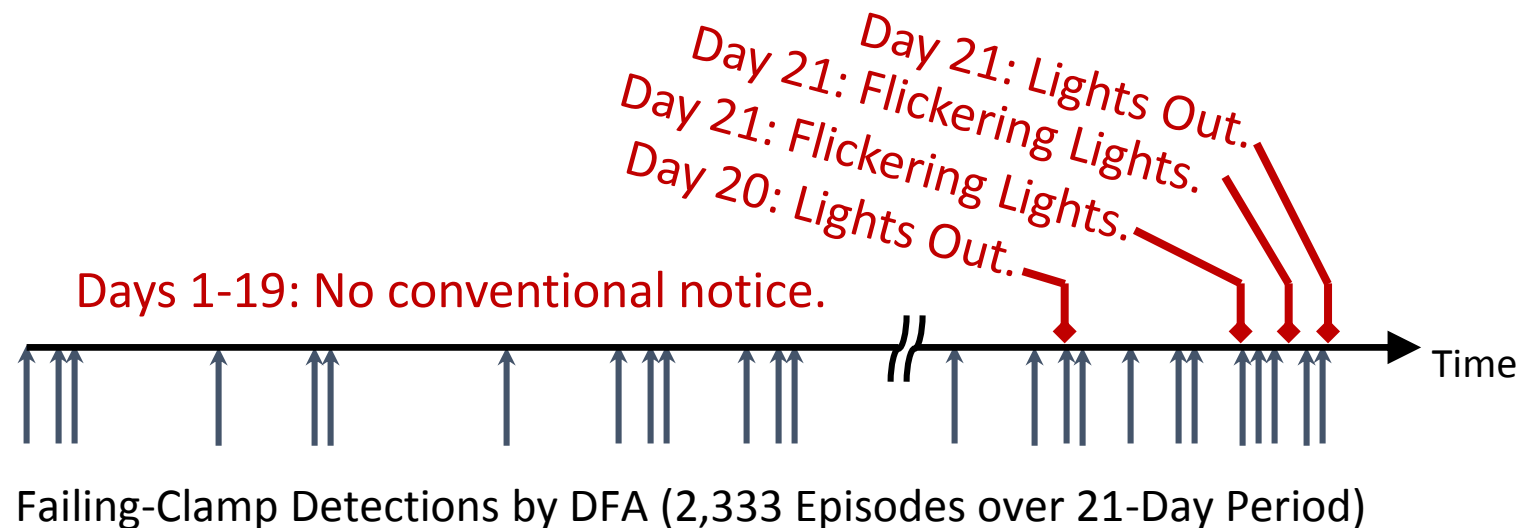


- No existing system used today can detect, diagnose, or identify this incipient clamp failure.



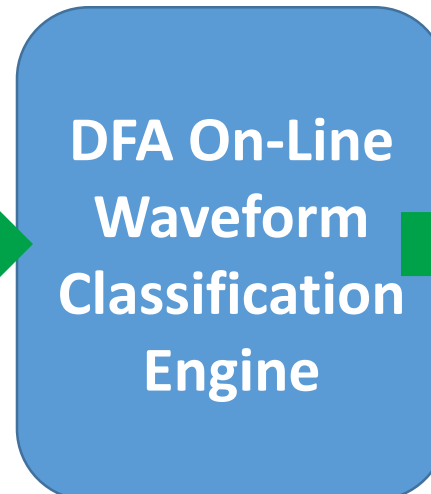
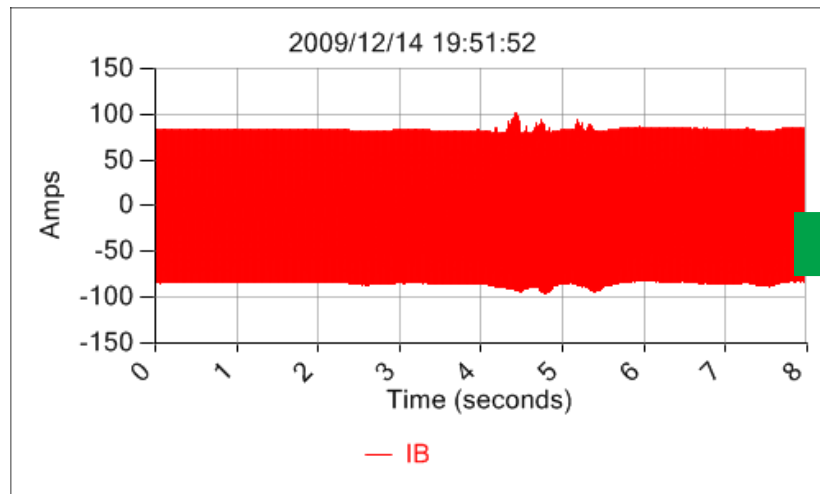
DFA Detects Wildfire Ignition Mechanisms

- DFA detected incipient failure of a single clamp repeatedly for three weeks.
- DFA was operating in “blind study” mode. Utility crews responded four times but had difficulty identifying the root cause.
- A single failing clamp unnecessarily “cost” four trouble tickets, four truck rolls, and replacement of two pole-top transformers (that actually were not faulty).
- Without DFA, a potential wildfire ignition source existed for three weeks.

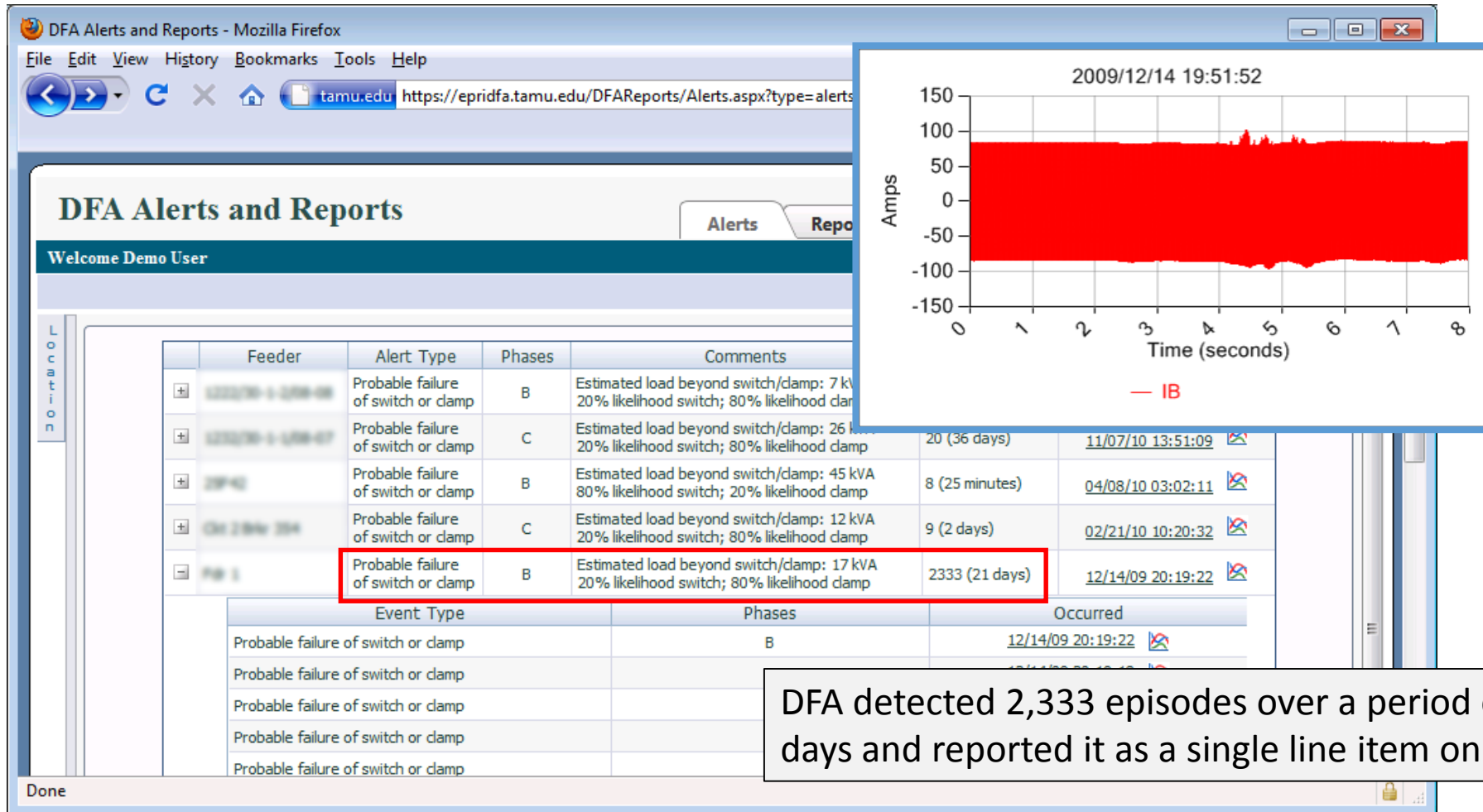


DFA Principle: Waveforms Contain Useful Information

DFA advanced waveform analytics automatically convert recorded waveforms into a specific diagnosis of “failing clamp,” without human intervention.

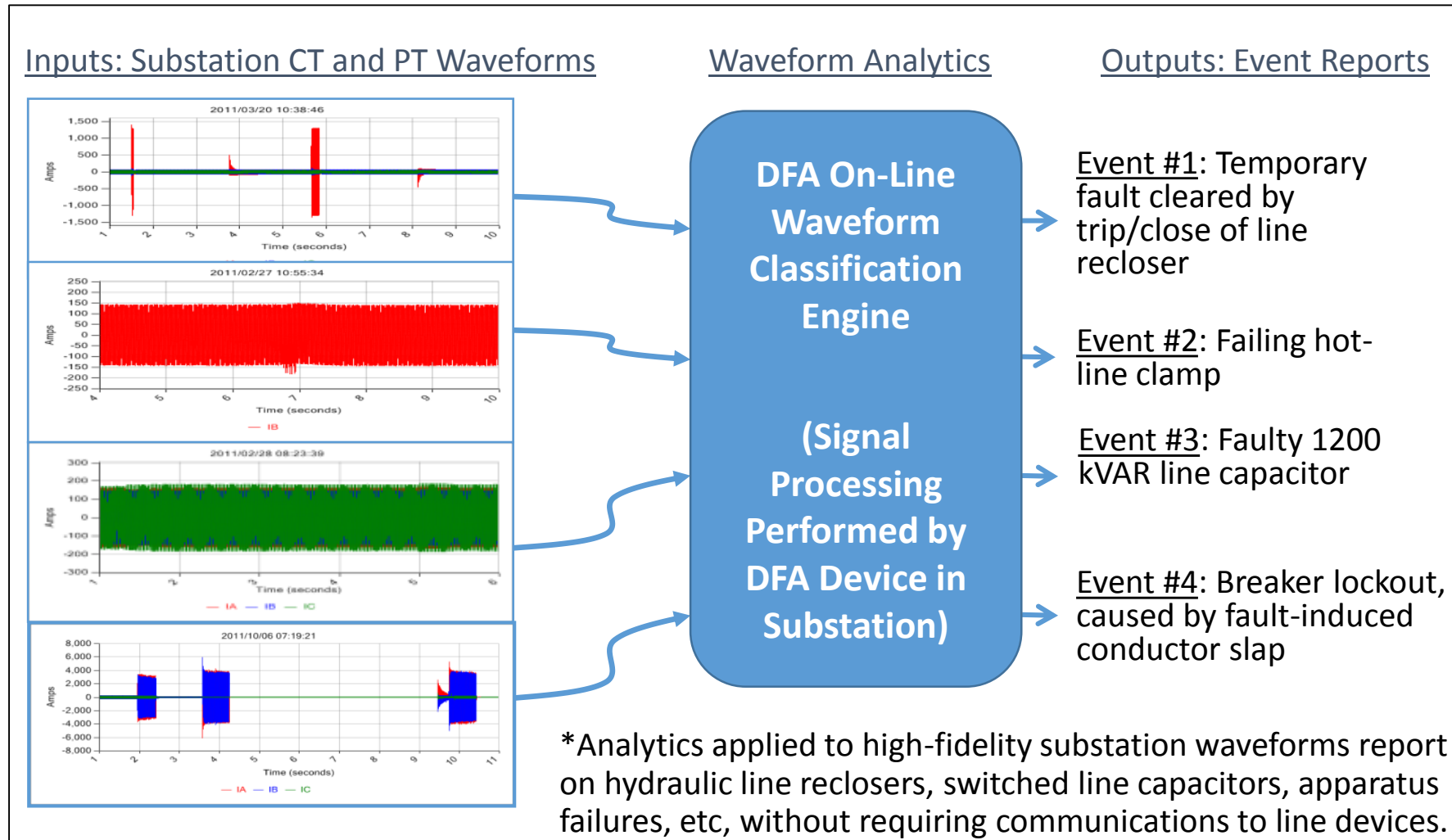


Automatic Reporting by DFA



DFA detected 2,333 episodes over a period of 21 days and reported it as a single line item on a report.

Waveform-Based Analytics – Behind the Scenes



DFA Technology – Behind the Scenes

**DFA On-Line
Waveform
Classification
Engine**

**(Signal
Processing
Performed by
DFA Device in
Substation)**

DFA Device software technologies

- Multi-rate polyphase filter banks for phase drift compensation
- Fuzzy expert system for classification
- Fuzzy dynamic time warping for shape recognition
- Hierarchical agglomerative clustering for recurrent faults
- Finite state machine for fault SOE identification
- Shape-based and event-specific feature extraction
- Hierarchical classification architecture for feature space dimensionality reduction

The DFA on-line waveform classification engine uses sophisticated software to analyze waveforms and thereby characterize circuit events.

Failing Substation Switch

- Rural 25 kV distribution substation
- Three circuits, hundreds of customers
- Incipient failure
 - No outage, no customer calls
 - No indication from SCADA
 - No indication from smart meters, even when pinged after being alerted to the switch problem by DFA



Failing Substation Switch (cont'd)

- DFA notification allowed utility to avoid an outage, catastrophic switch failure, or substation fire.
- Crews made repairs without time pressure inherent to large outage (crew safety).

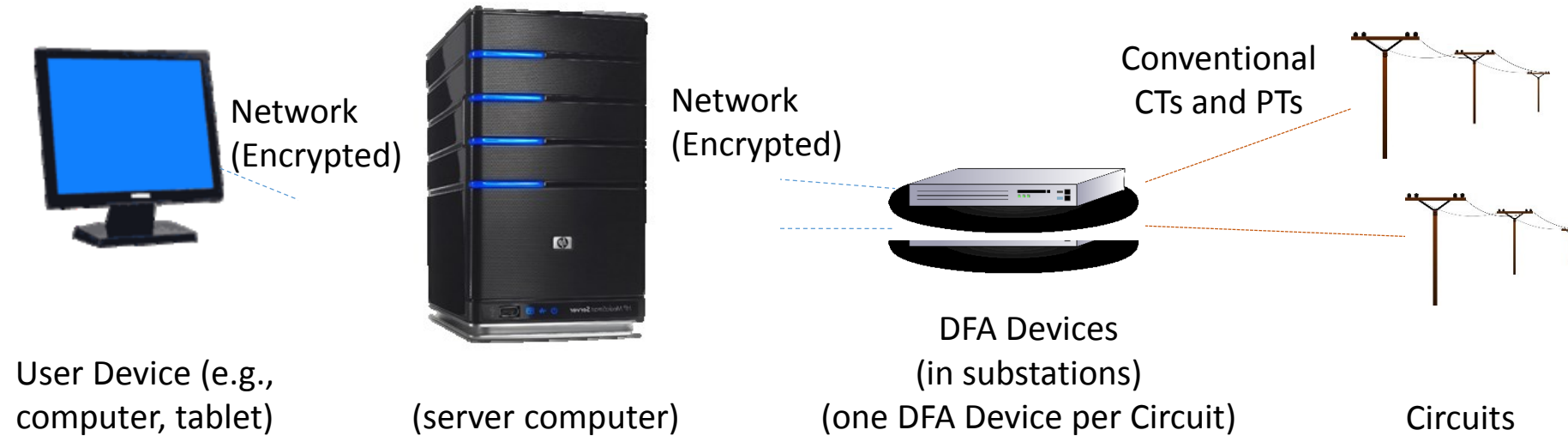


Arcing Line Clamp

- DFA reported an arcing line clamp.
- The utility found the burning clamp in a national forest.
- Continued arcing could have dropped hot particles or even burned down the line, both ignition sources.
- DFA provided the only notice (no outage, no SCADA information, no customer calls).
- Visual inspection likely would not find this.



DFA Monitoring Topology



Each substation-installed DFA Device runs waveform analysis and classification software and then sends results to a central DFA Master Station. Personnel access DFA results via DFA Web, a browser-based website provided by the DFA Master Station.

Texas Powerline-Caused Wildfire Mitigation Project

DFA installed on 50+ circuits allowed six participating utilities to correct many issues.

A partial list:

- Detect and repair a substantial number of routine outages, without customer calls.
- Detect and locate tree branch hanging on line and causing intermittent faults.
- Detect and locate intact tree intermittently pushing conductors together.
- Detect and locate broken insulator that resulted in conductor lying on and heavily charring a wooden crossarm.
- Detect and locate catastrophically failed lightning arrester.
- Detect and locate arc-tracked capacitor fuse barrel.
- Detect and locate multiple problems involving capacitor banks.



Vegetation-Caused Faults



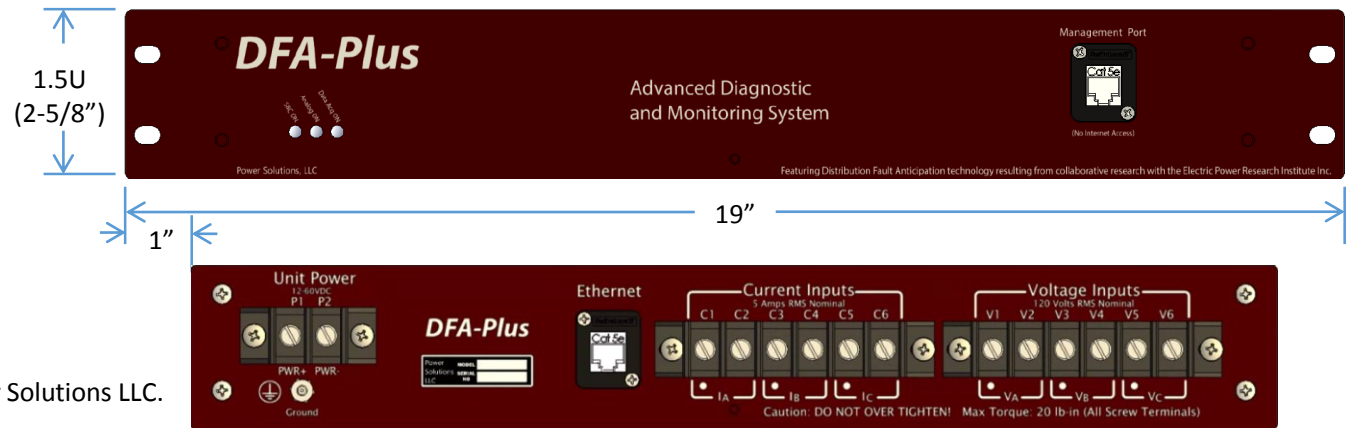
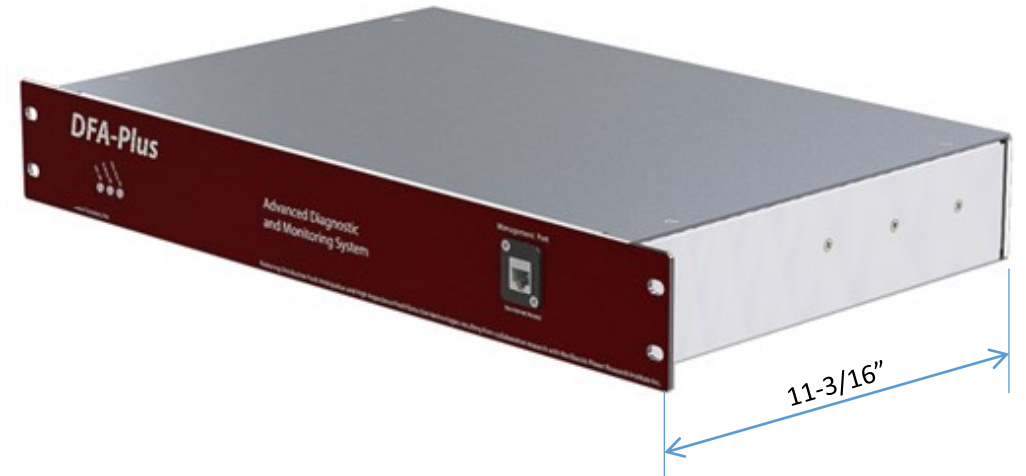
Vegetation fault
Multiple flashovers in a 24-hour period
Burned down line



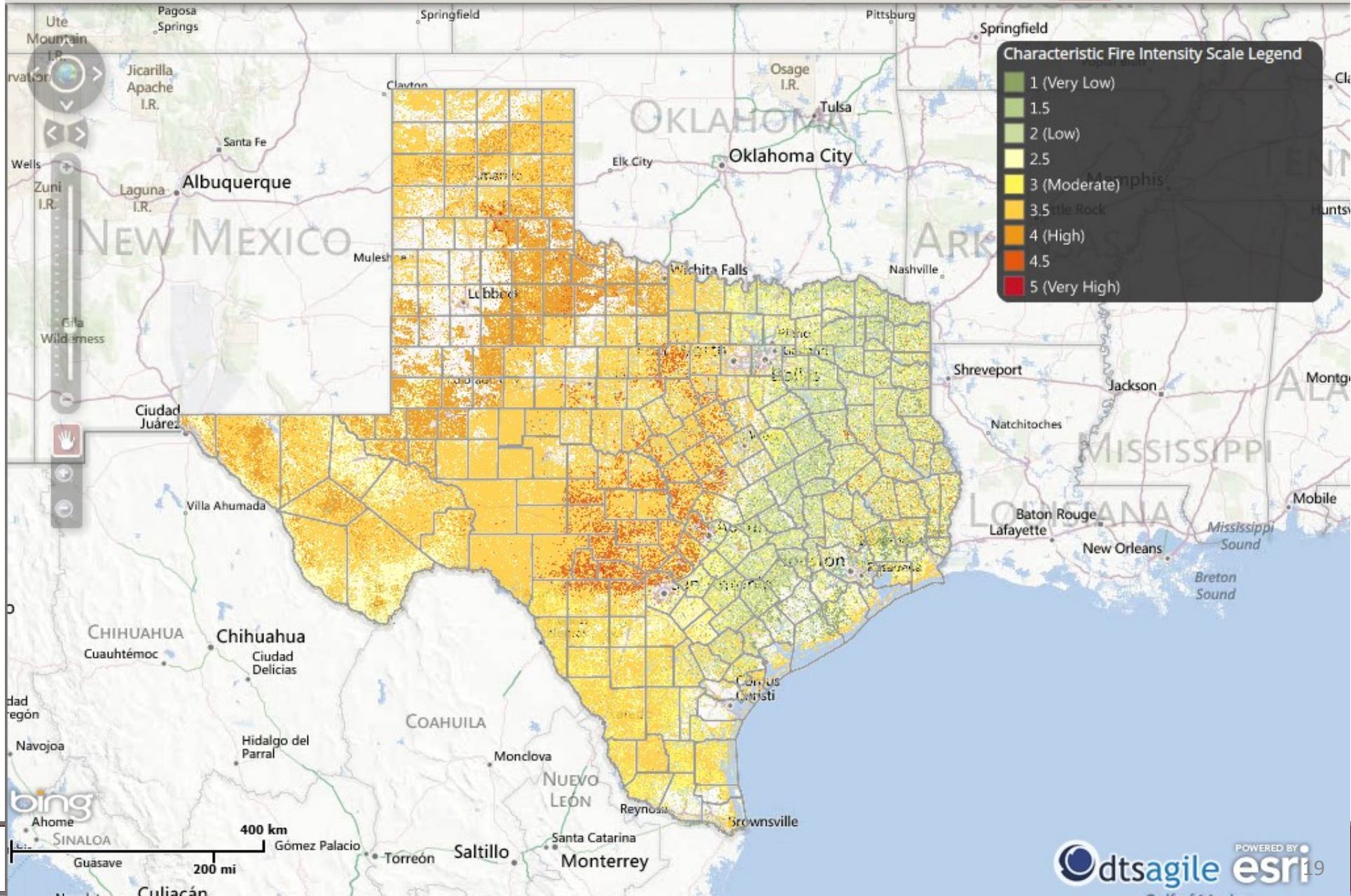
Vegetation fault
Multiple flashovers in a 24-hour period
Detected and corrected with DFA

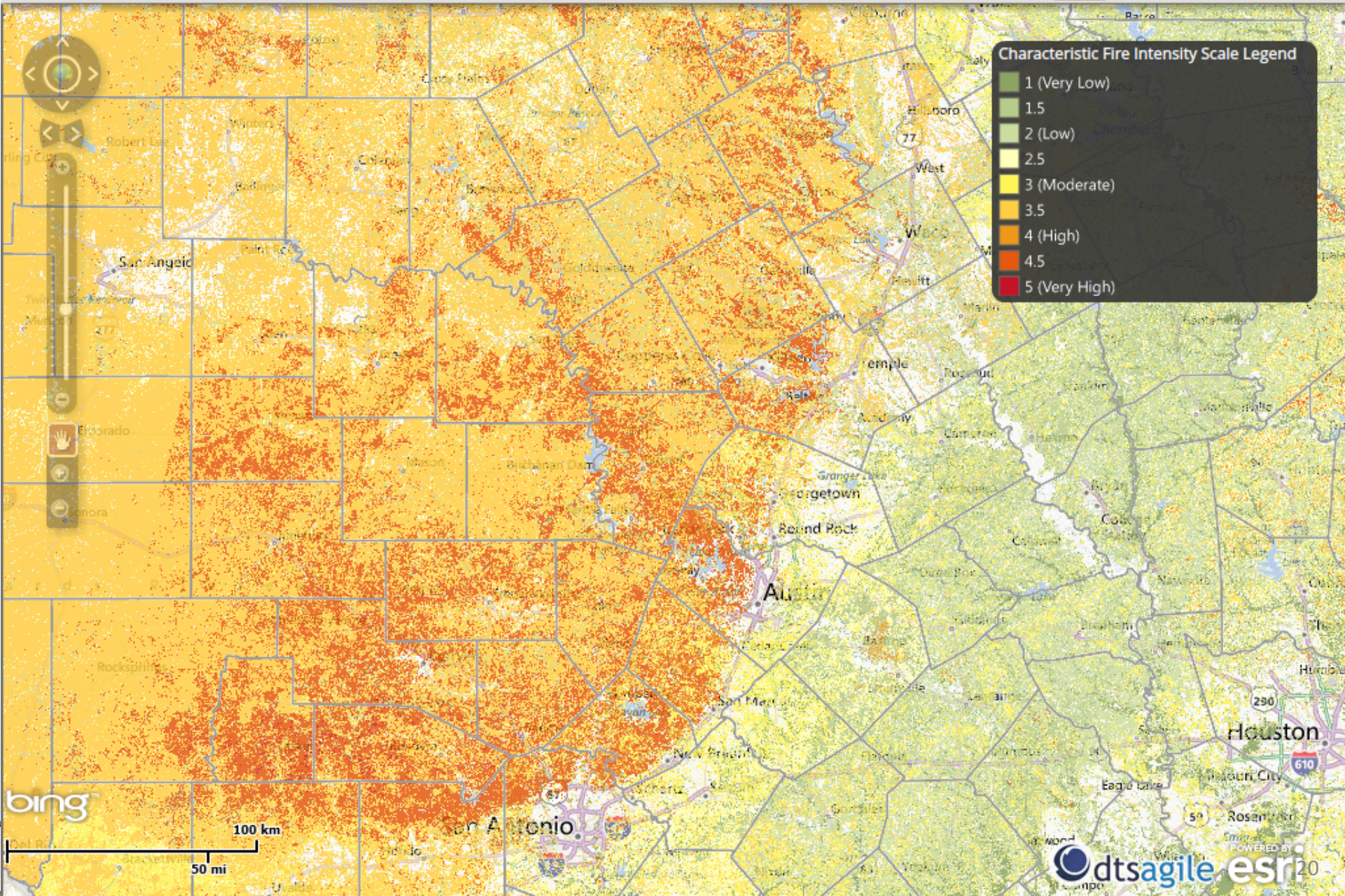
DFA technology is available from Power Solutions LLC under license from the Electric Power Research Institute (EPRI) and Texas A&M University.

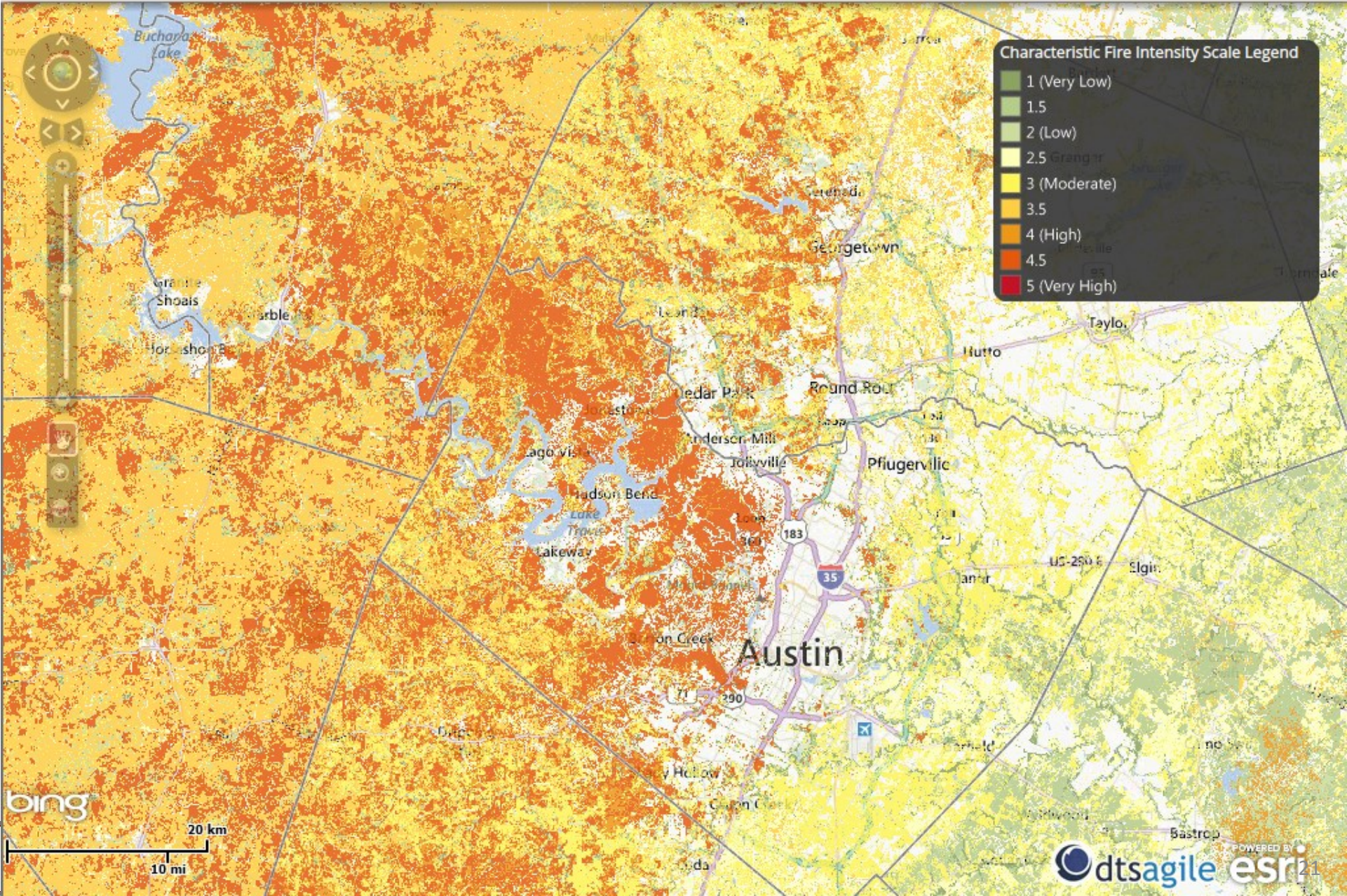
info@powersolutionsllc.us



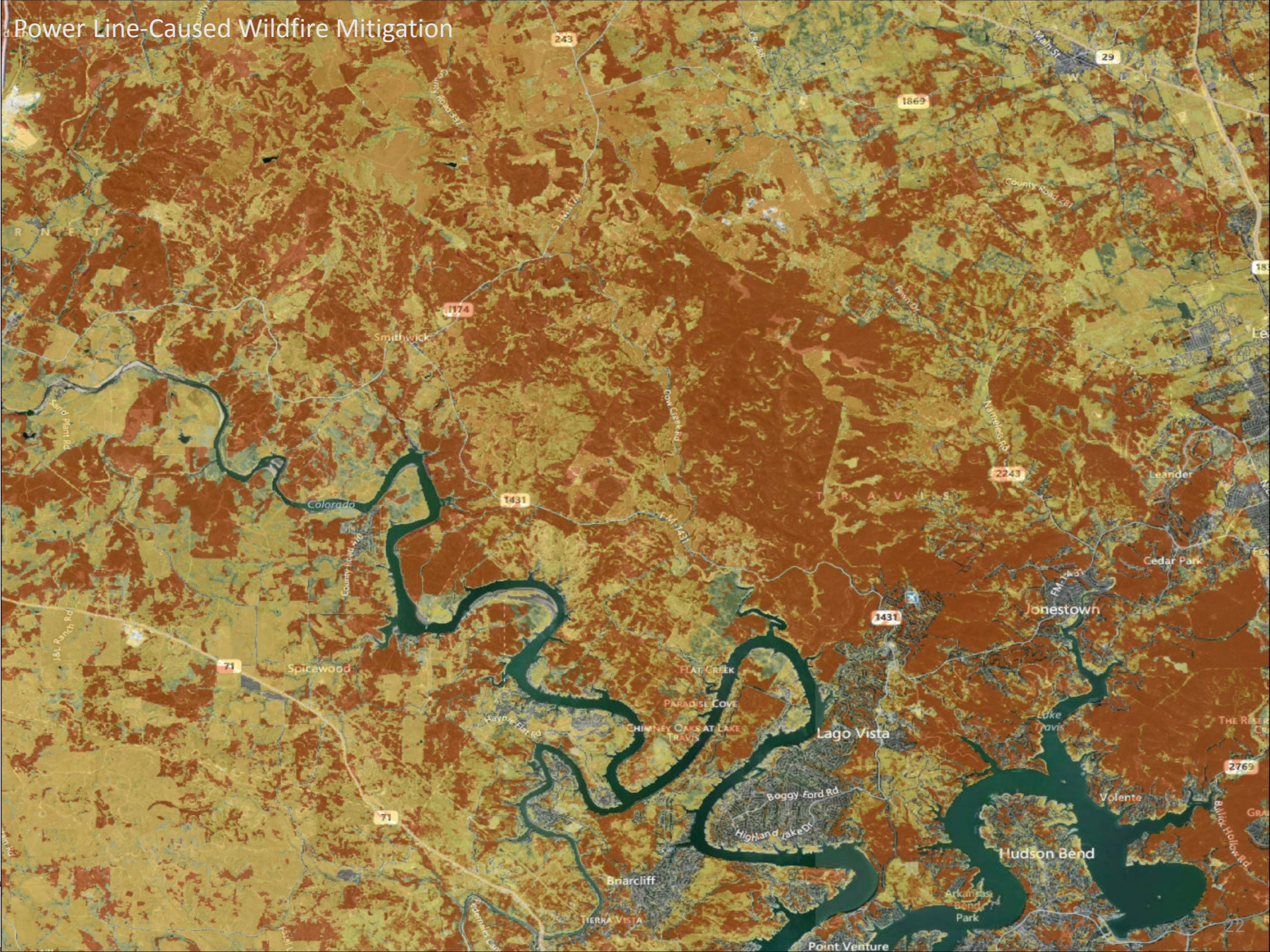
Hardware platform by Power Solutions LLC.



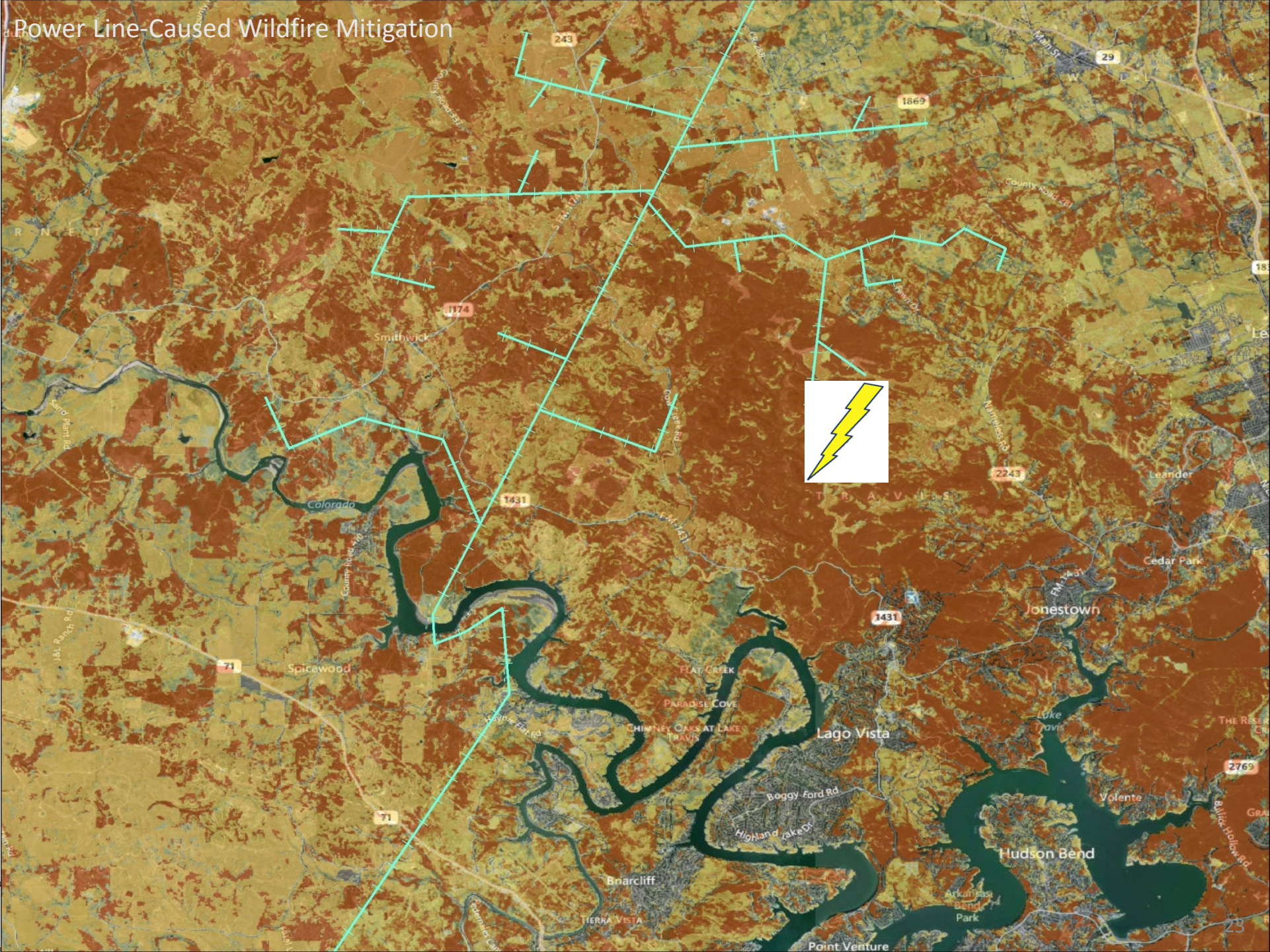


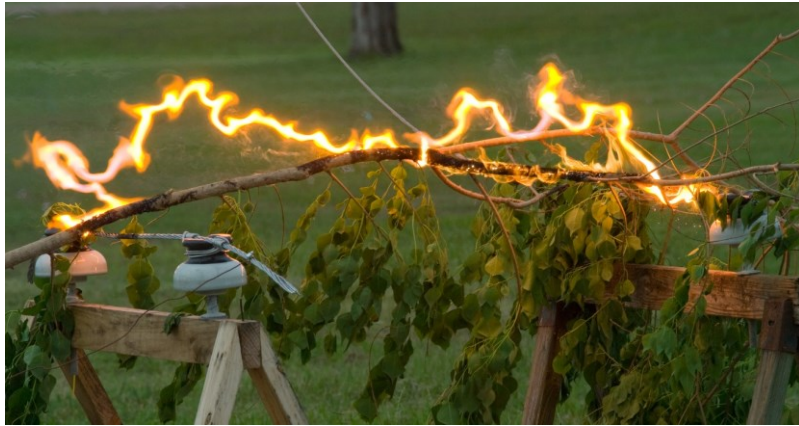


Power Line-Caused Wildfire Mitigation



Power Line-Caused Wildfire Mitigation





No technology detects all events, but DFA reduces risk by enabling utilities to find and fix many hazards.

