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.

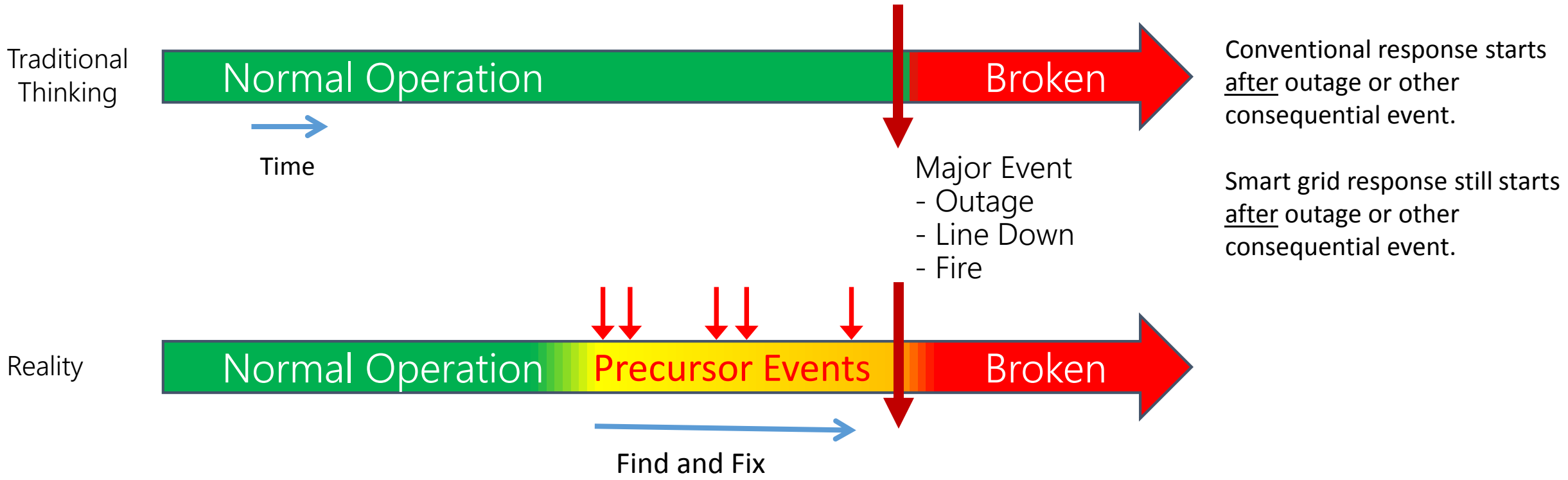
What is missing?

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



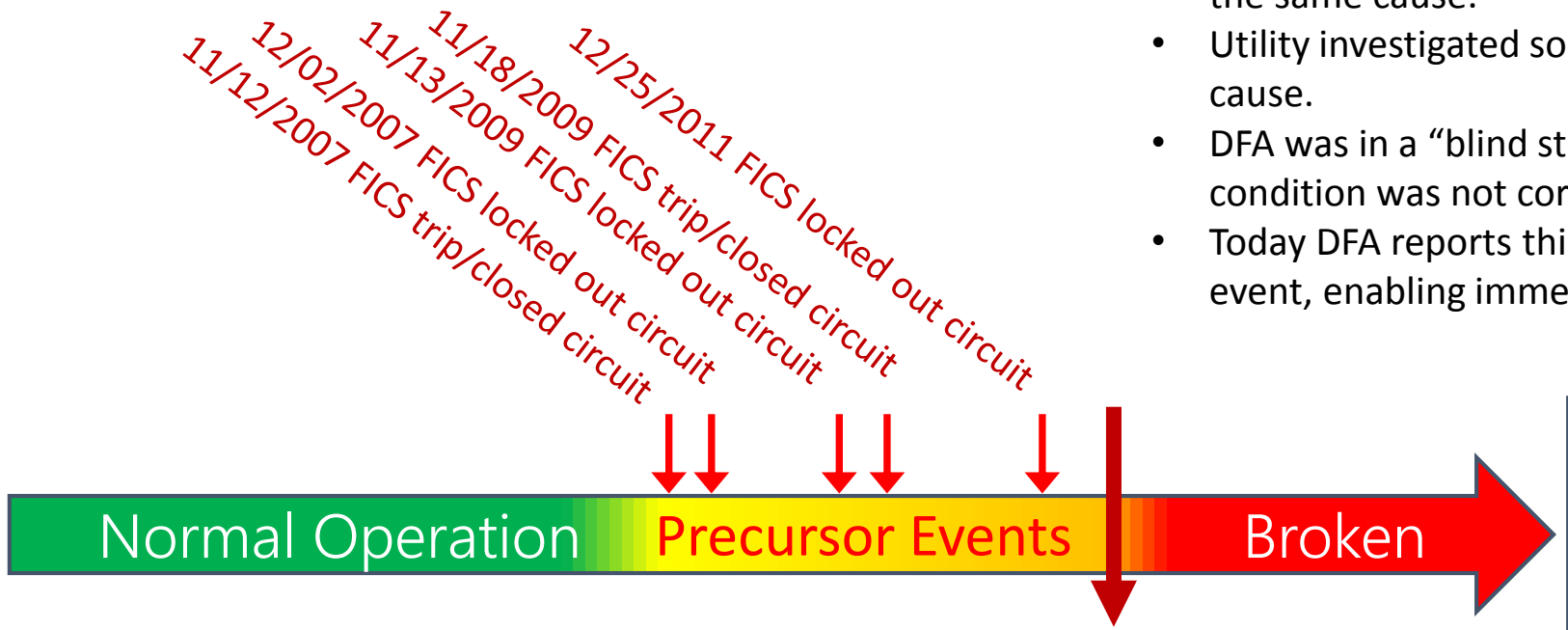
Conventional response starts after outage or other consequential event.

Smart grid response still starts after outage or other consequential event.

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

Distribution Circuit Operating Paradigms

Actual Example

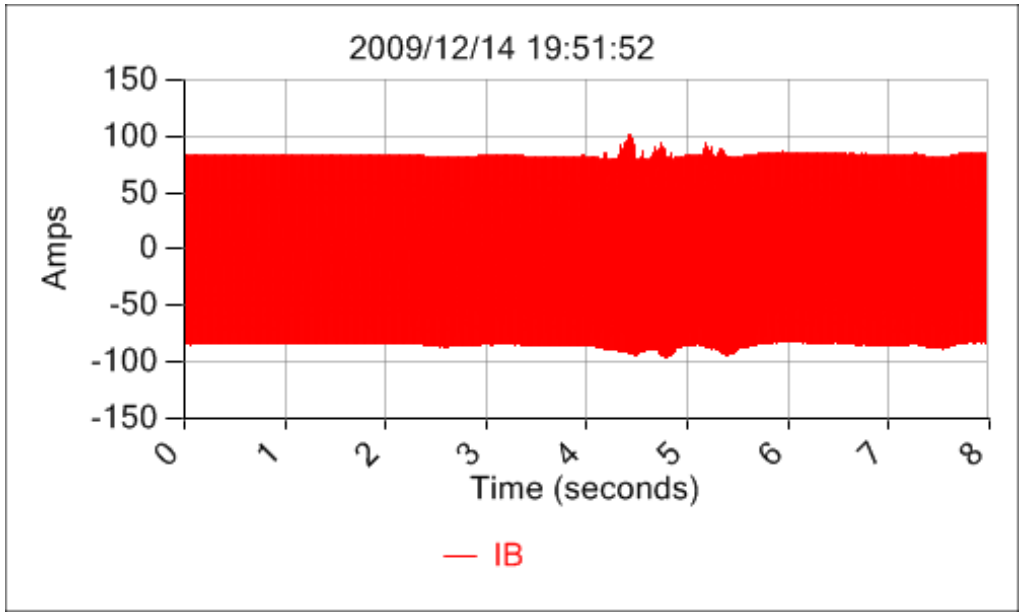


- Five FICS events occurred at the same location and had the same cause.
- Utility investigated some events but failed to diagnose cause.
- DFA was in a “blind study” mode during first events, so condition was not corrected.
- Today DFA reports this specific condition, after first event, enabling immediate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

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

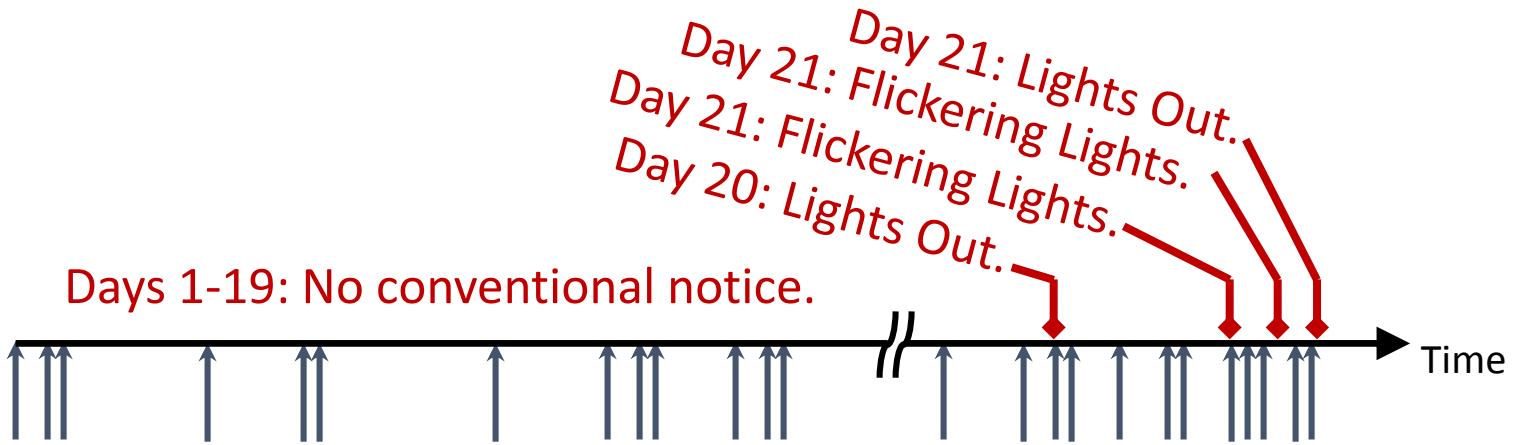
Undetectable/Unknown Wildfire Ignition Mechanisms

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



DFA Detects Wildfire Ignition Mechanisms

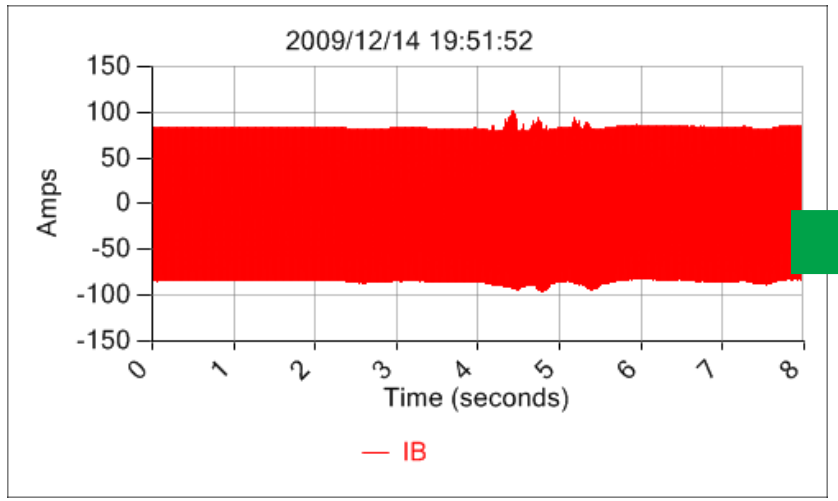
- DFA detected incipient failure of a single clamp repeatedly for three weeks.
- DFA was operating in “blind study” mode. Utility crews responded four times but had difficulty identifying the root cause.
- A single failing clamp unnecessarily “cost” four trouble tickets, four truck rolls, and replacement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



Failing-Clamp Detections by DFA (2,333 Episodes over 21-Day Period)

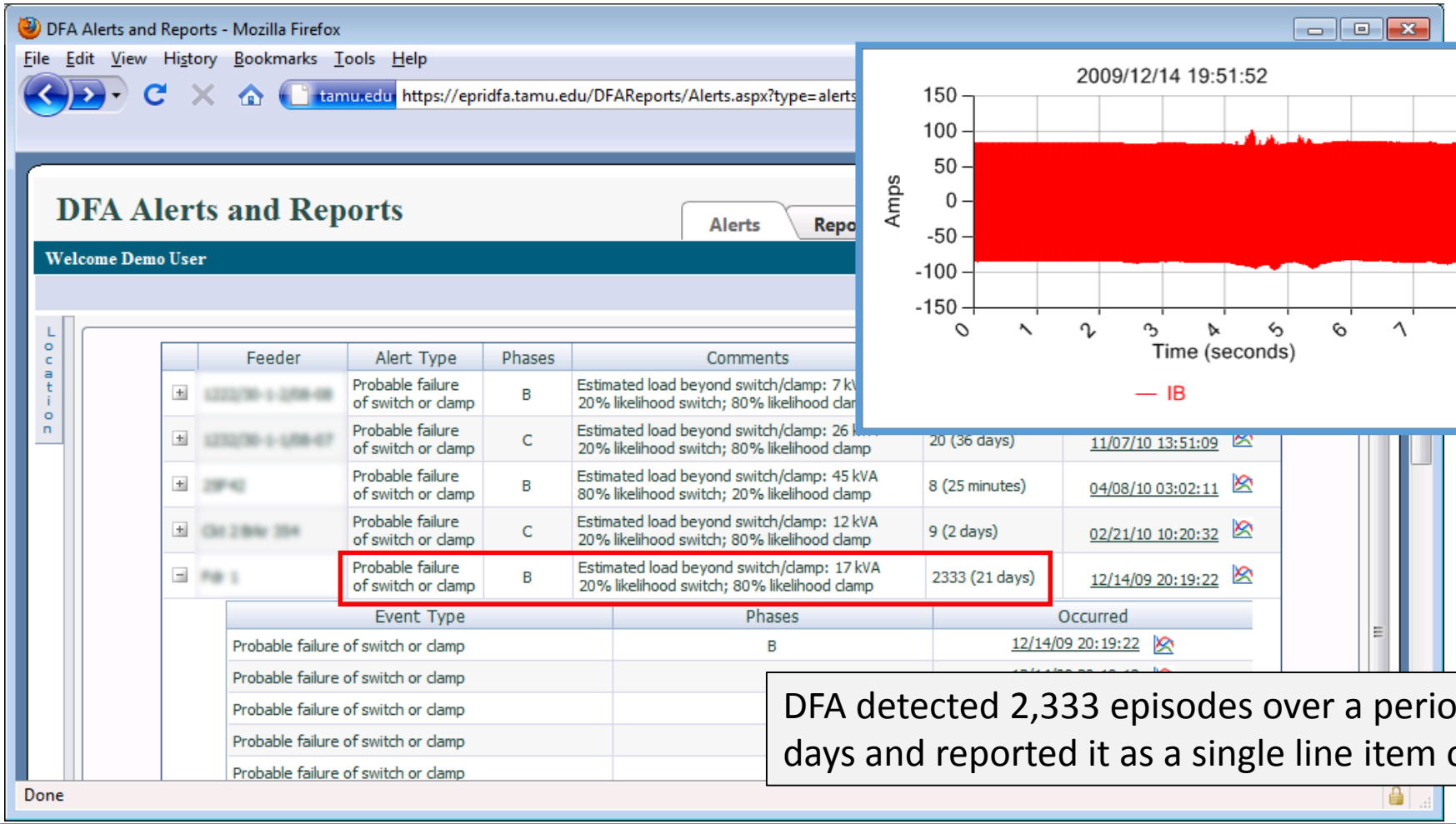
DFA Principle: Waveforms Contain Useful Information

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



DFA On-Line Waveform Classification Engine

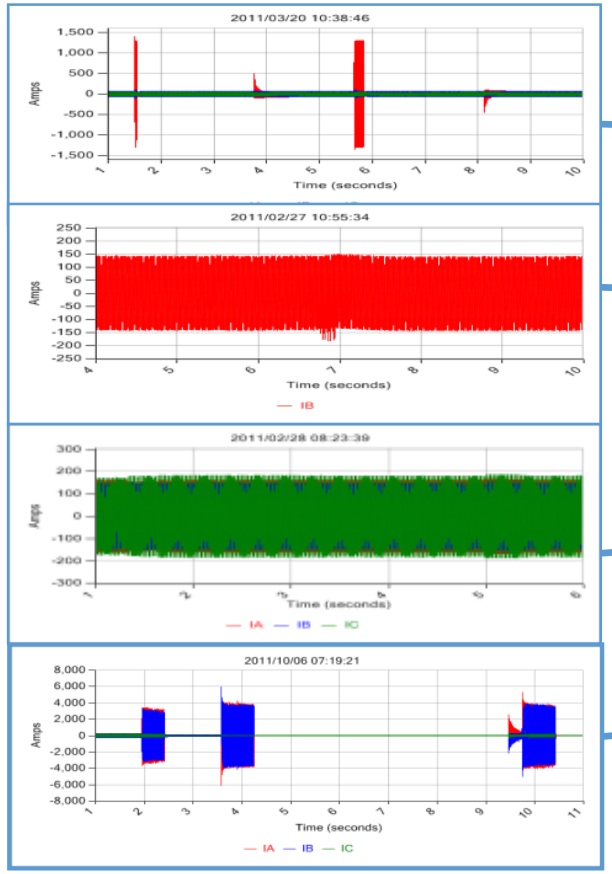
Automatic Reporting by DFA



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

Inputs: Substation CT and PT Waveforms



Waveform Analytics

DFA On-Line Waveform Classification Engine

(Signal Processing Performed by DFA Device in Substation)

Outputs: Event Reports

Event #1: Temporary fault cleared by trip/close of line recloser

Event #2: Failing hot-line clamp

Event #3: Faulty 1200 kVAR line capacitor

Event #4: Breaker lockout, caused by fault-induced conductor slap

*Analytics applied to high-fidelity substation waveforms report on hydraulic line reclosers, switched line capacitors, apparatus failures, etc, without requiring communications to line devices.

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

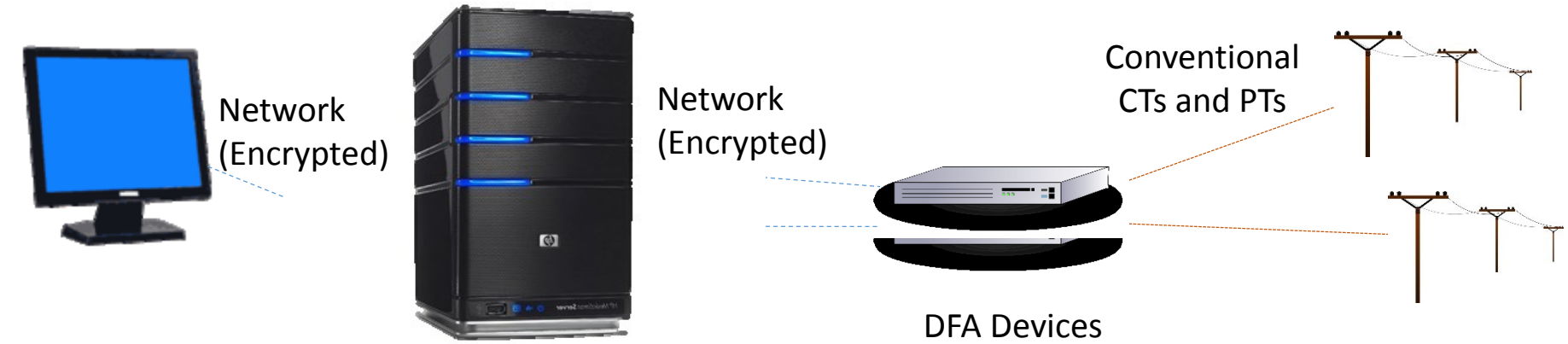
Failing Substation Switch (cont'd)

- 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.

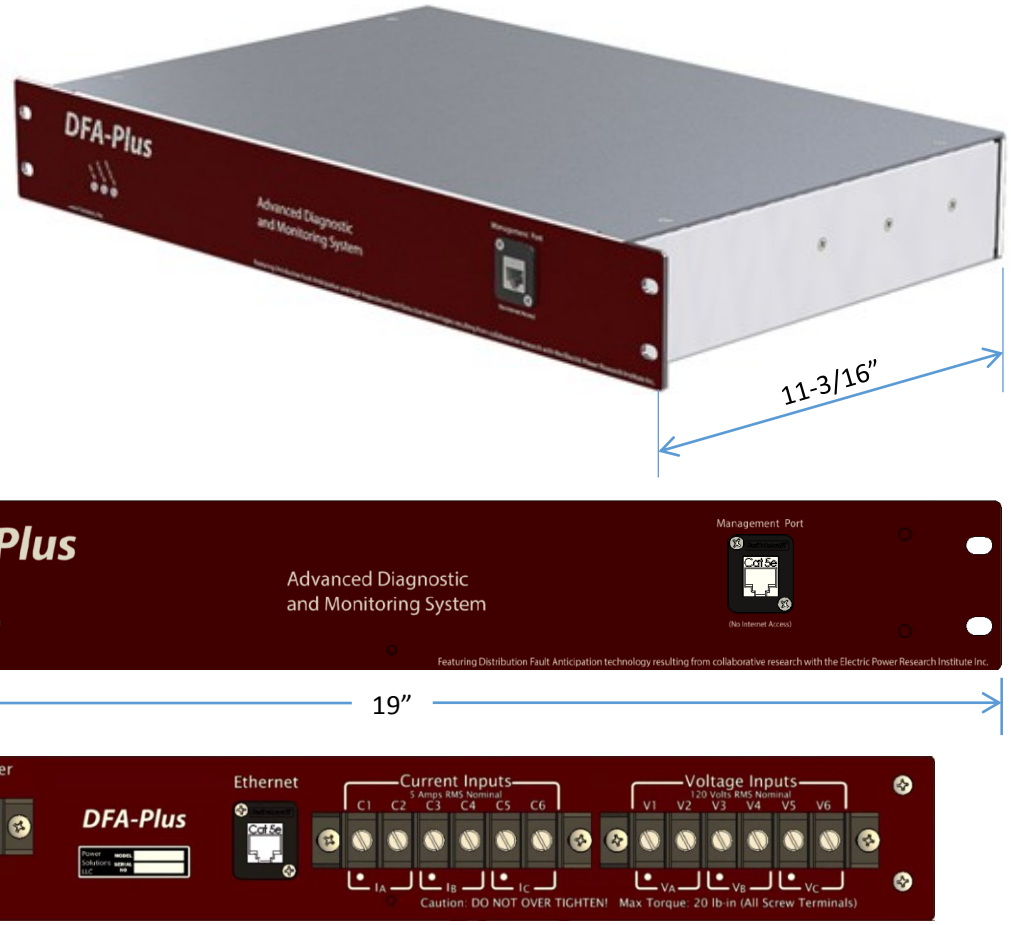
Vegetation-Caused Faults

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

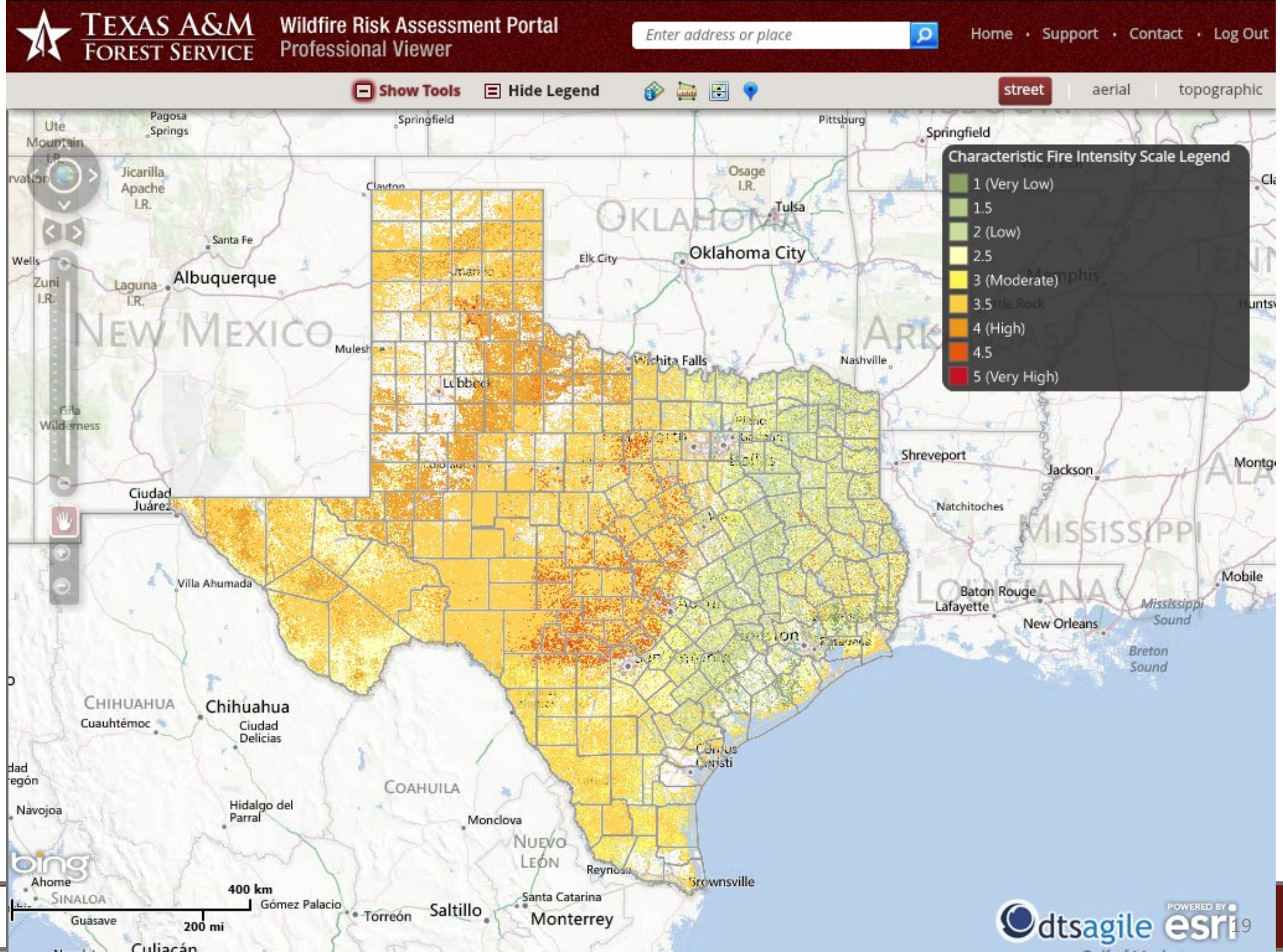
Vegetation fault
Multiple flashovers in a 24-hour period
Detected and corrected with DFA

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.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Wildfire Risk Assessment Portal
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Hide Legend
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Characteristic Fire Intensity Scale Legend
1 (Very Low)
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2 (Low)
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3 (Moderate)
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Springfield
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Jicarilla Apache I.R.
Clayton
Osage I.R.
Tulsa
OKLAHOMA
Santa Fe
Wells
Zuni I.R.
Laguna I.R.
Albuquerque
Elk City
Oklahoma City
NEW MEXICO
Muleshoe
Wichita Falls
Nashville
Lubbock
Gila Wilderness
Shreveport
Jackson
Ciudad Juárez
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MISSISSIPPI
Villa Ahumada
Mobile
Baton Rouge
Lafayette
New Orleans
Mississippi Sound
Breton Sound
CHIHUAHUA
Chihuahua
Cuauhtémoc
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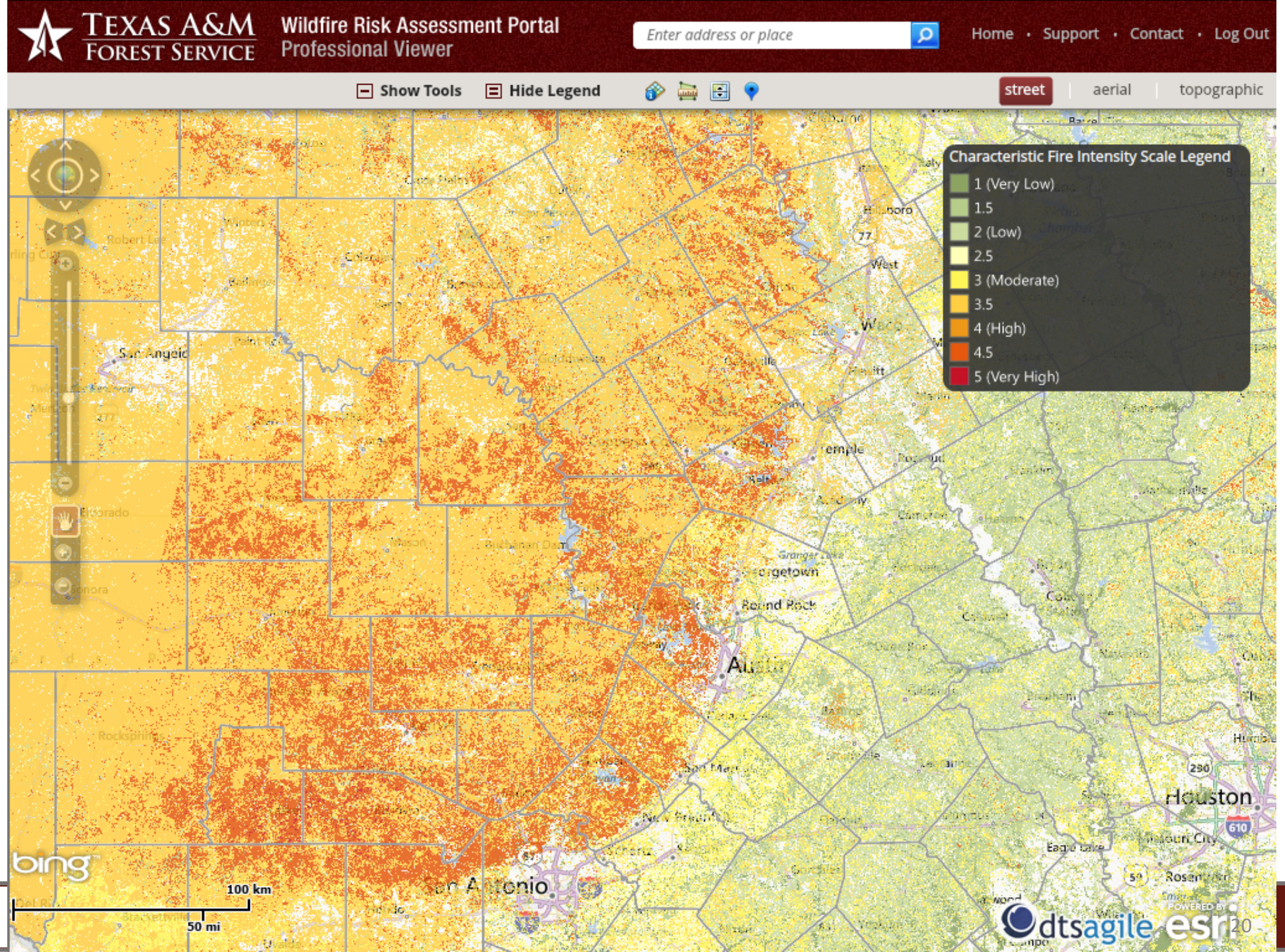
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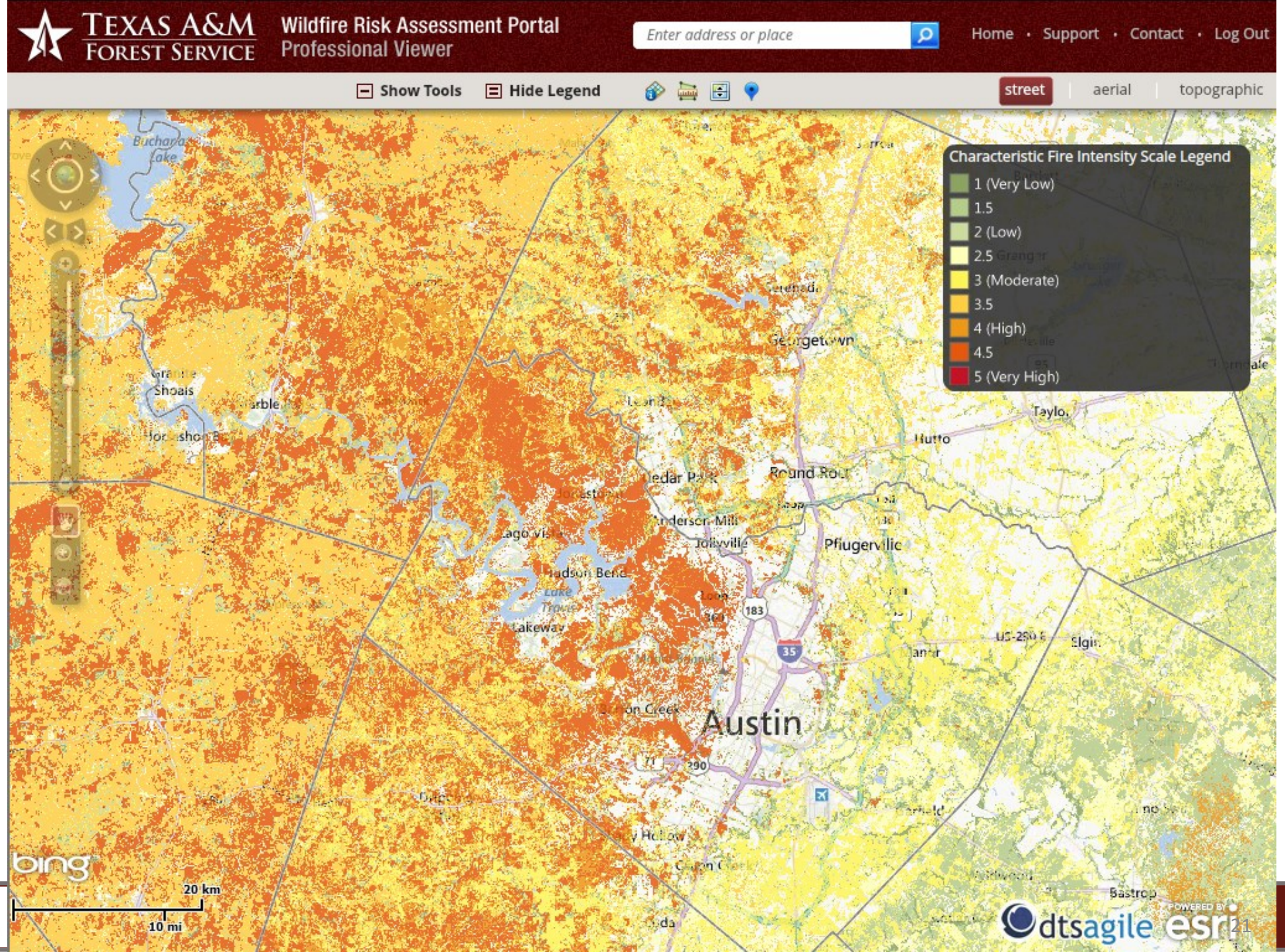
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Austin
Pflugerville
Round Rock
Georgetown
Hutto
Taylor
Elgin
Bastrop
Lakeway
Hudson Bend
Anderson Mill
Jollyville
Shoals
Buchanan Lake
20 km
10 mi
dtsagile
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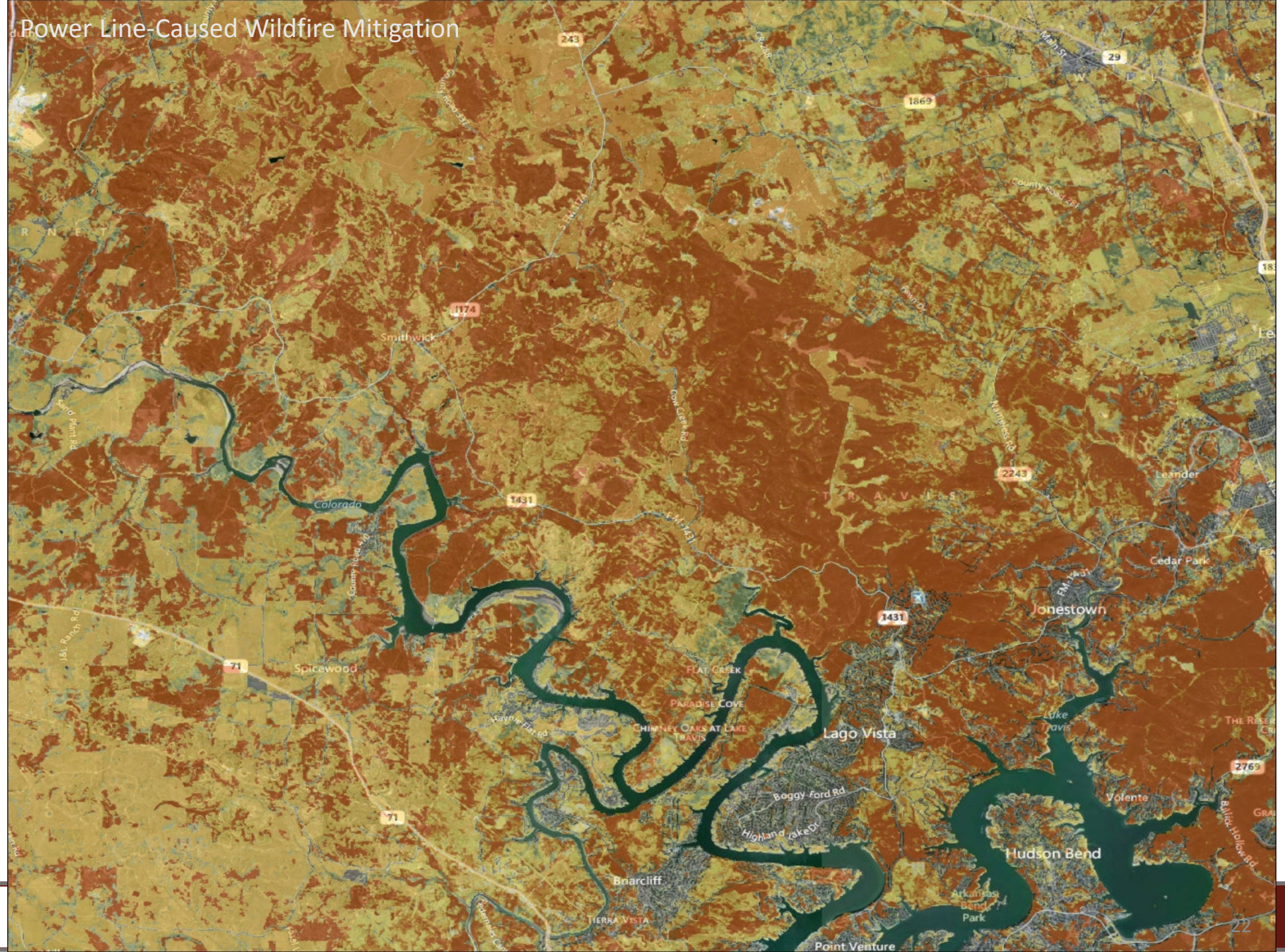
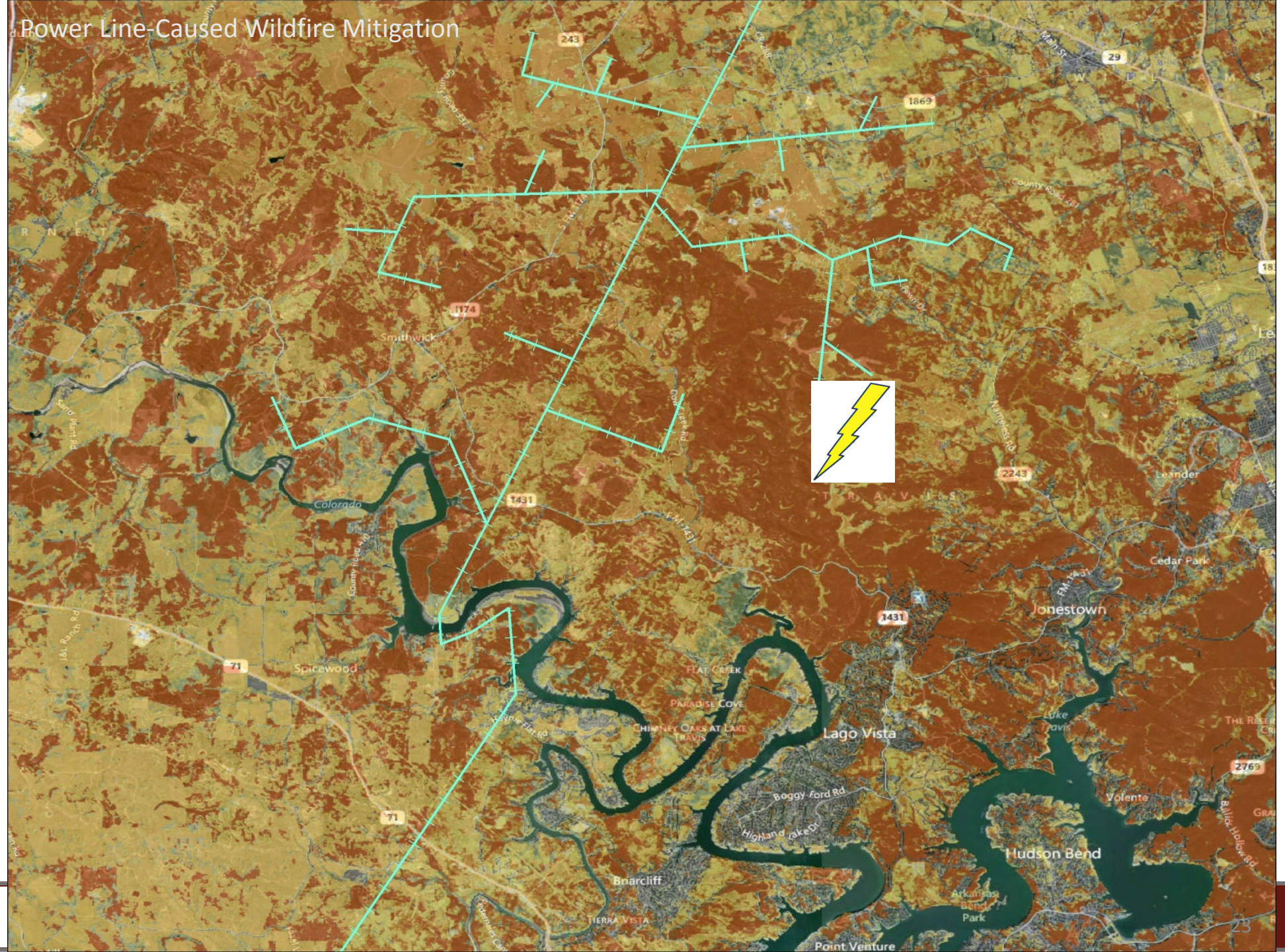
Power Line-Caused Wildfire Mitigation



Power Line-Caused Wildfire Mitigation



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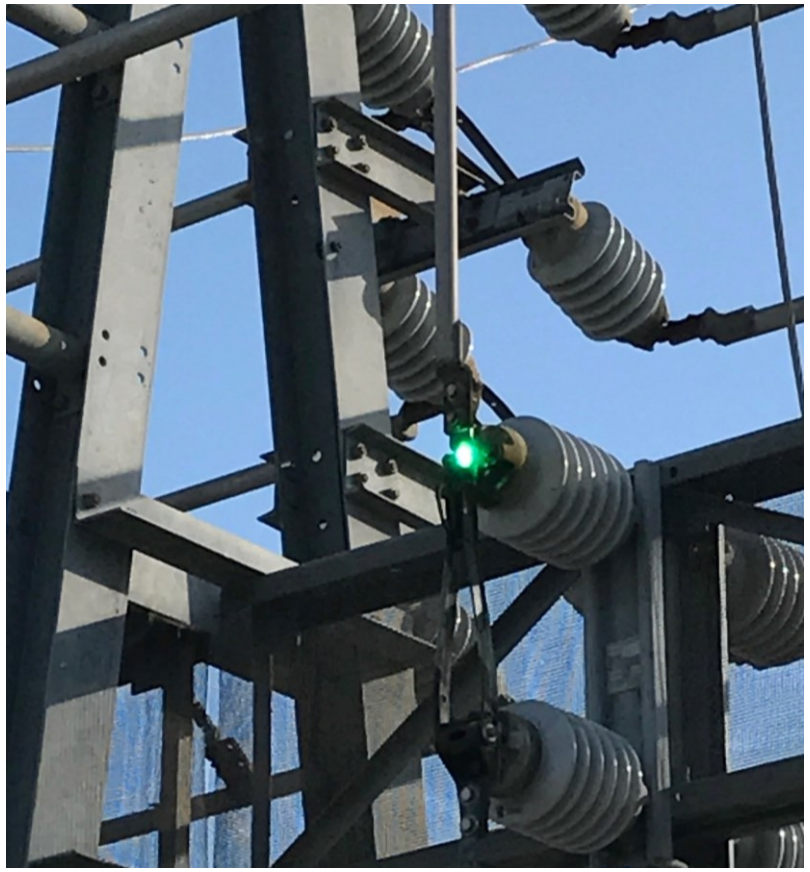

No technology detects all events, but DFA reduces risk by enabling utilities to find and fix many hazards.