Improved Outage Response Through Advanced Monitoring: Detecting and Repairing Minor Faults Before the Customer Calls

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CIGRE Grid of the Future

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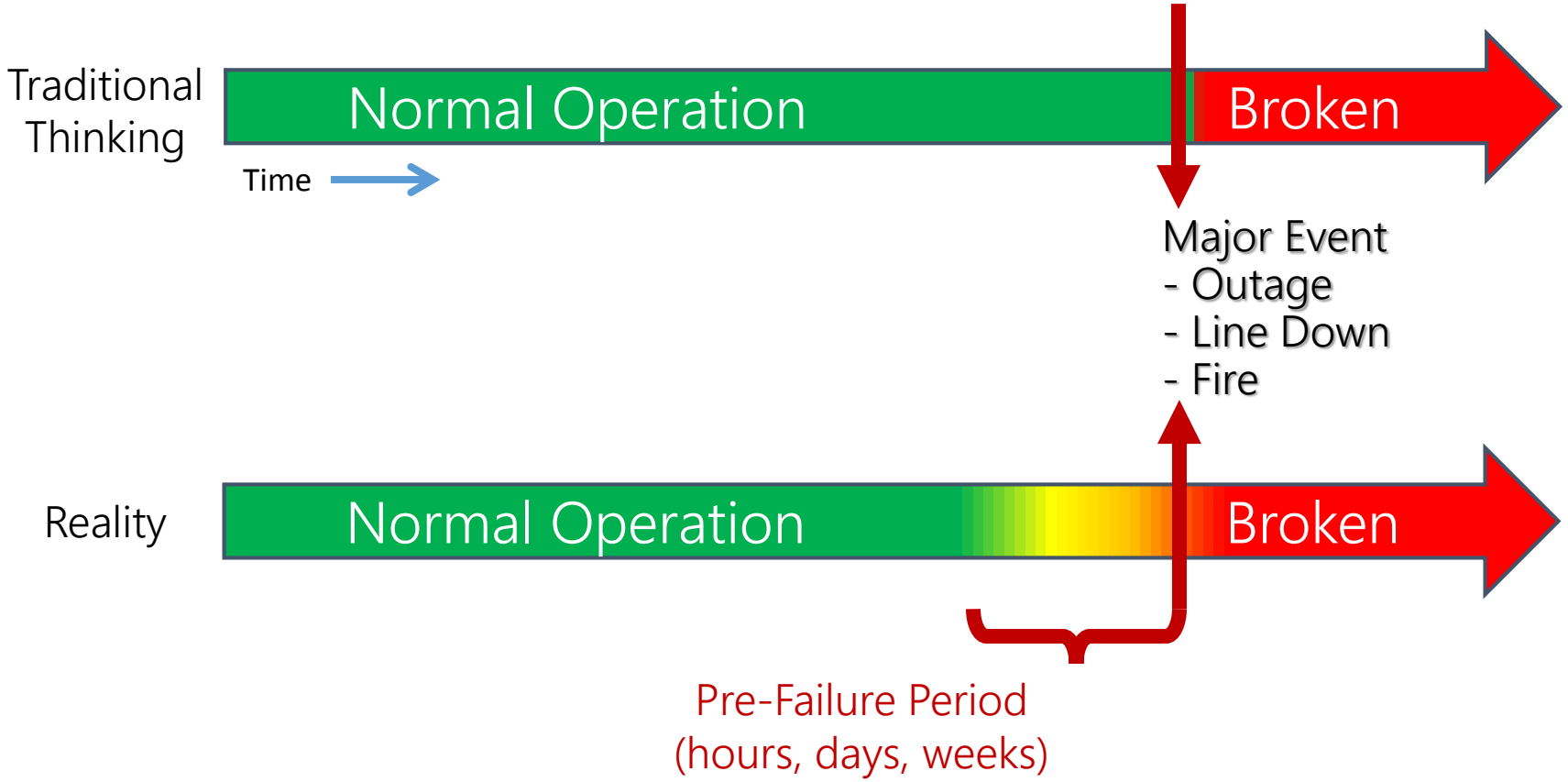
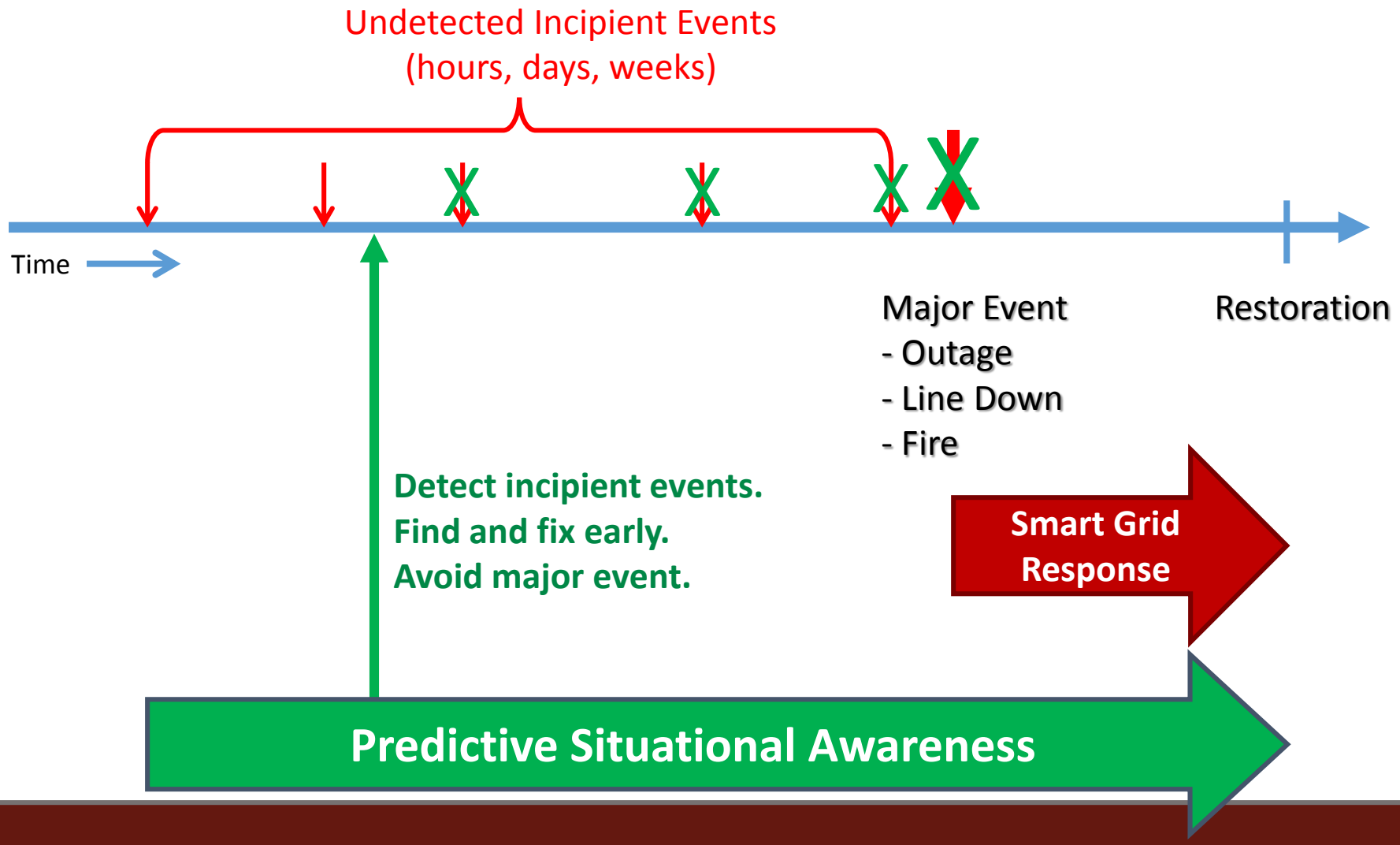
Distribution Circuit Operating Paradigms



If we could detect failures in the incipient period, we could make proactive repairs and avoid major events.

Situational Awareness or "Visibility"

(Conventional vs. Smart Grid vs. Predictive)



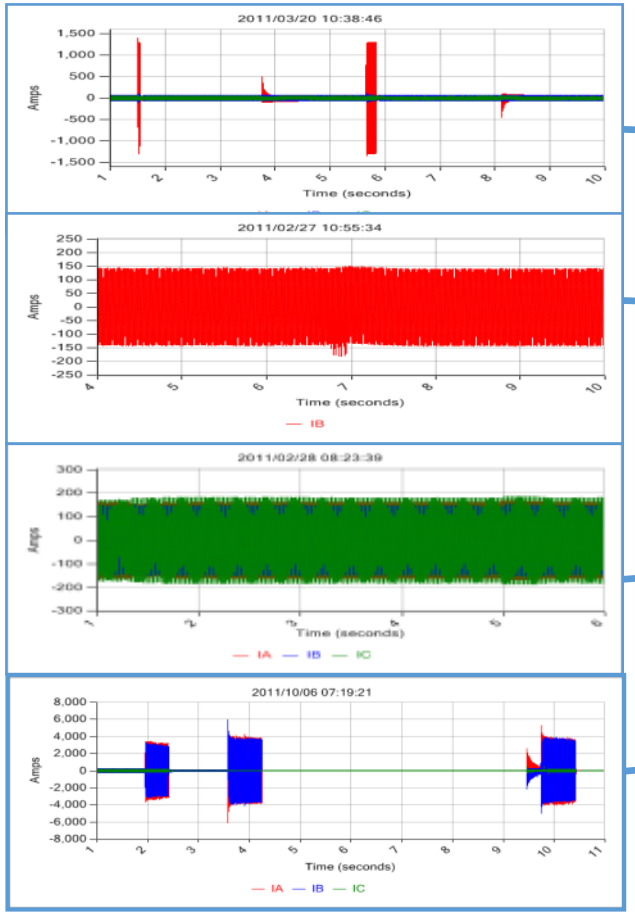
Fundamental Principles of Waveform Analytics

- Circuit-level electrical waveforms represent circuit activity.
- Sophisticated waveform analytics, applied to waveforms of sufficient fidelity, can detect failures, pre-failures, and other circuit events.
  - PQ meters and relays have the same inputs (i.e., CTs and PTs) but do not record data of sufficient fidelity to support DFA functions.
- Waveform analytics also report operations of line devices (reclosers, capacitors, etc.), enabling oversight of those devices, without requiring communications to them.

With support from EPRI and others, Texas A&M has developed an on-line system of waveform analytics. This system, known as DFA Technology, provides situational intelligence that enables improvements in reliability, operational efficiency, and safety.

Waveform-Based Analytics – Behind the Scenes

Inputs: Substation CT and PT Waveforms



Waveform Analytics

On-Line Signal Processing and Pattern Recognition Analytics

(Performed by DFA Device in Substation)

Outputs

- Line recloser* tripped 8% of phase-A load twice, but reclosed and did not cause outage
- Failing hot-line clamp on phase B*
- Failed 1200 kVAR line capacitor* (phase B inoperable)
- 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.

Documented Failures

- Voltage regulator failure
- LTC controller maloperation
- Repetitive overcurrent faults
- Lightning arrestor failures
- Switch and clamp failures
- Cable failures
  - Main substation cable
  - URD primary cables
  - URD secondary cables
  - Overhead secondary cables
- Tree/vegetation contacts
  - Contacts with primary
  - Contacts with secondary services
- Pole-top xfmr bushing failure
- Pole-top xfmr winding failure
- URD padmount xfmr failure
- Bus capacitor bushing failure
- Capacitor problems
  - Controller maloperation
  - Failed capacitor cans
  - Blown fuses
  - Switch restrike
  - Switch sticking
  - Switch burn-ups
  - Switch bounce
  - Pack failure

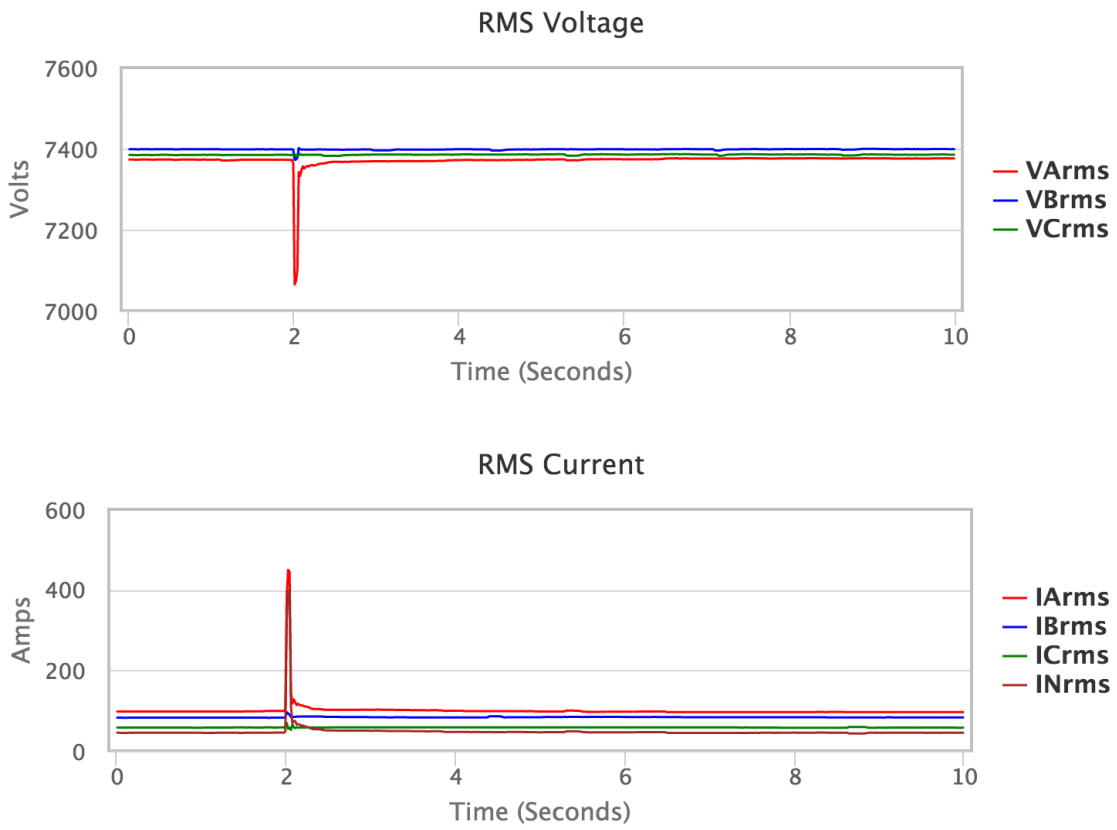
Certain failure types have been seen many times and are well understood. Others have been seen fewer times. DFA system architecture anticipates and accommodates updates to analytics as new events are encountered, analyzed, and documented.

Minor Problems, Major Impact

- Utilities want to be notified promptly of “major” problems, such as a recloser lockout that causes an outage for dozens of customers.
- “Minor” problems, such as a blown fuse at a single customer location, generally aren’t considered “important” until the customer calls – a process which can be hours or even days after the initial fault occurred.
- Utilities who know of and correct these “minor” problems as soon as they occur realize multiple benefits:
  - Improved customer satisfaction, repairing some outages before customer is aware
  - Distribute outage response throughout the day, “leveling” workflow
  - Improved work crew efficiency and time to repair (work crews not stuck in traffic)
  - Prompt restoration of unmonitored “customers,” preventing extended outages.

Case Study: Utility repairs outage before customer call

- On 30 July 2016, a DFA monitored feeder experienced a fault, shown at right.
- The fault was relatively brief, lasting only three cycles.
- The utility received no customer calls, but did receive a SCADA notification of a “MinTrip” from one protective device on the circuit.

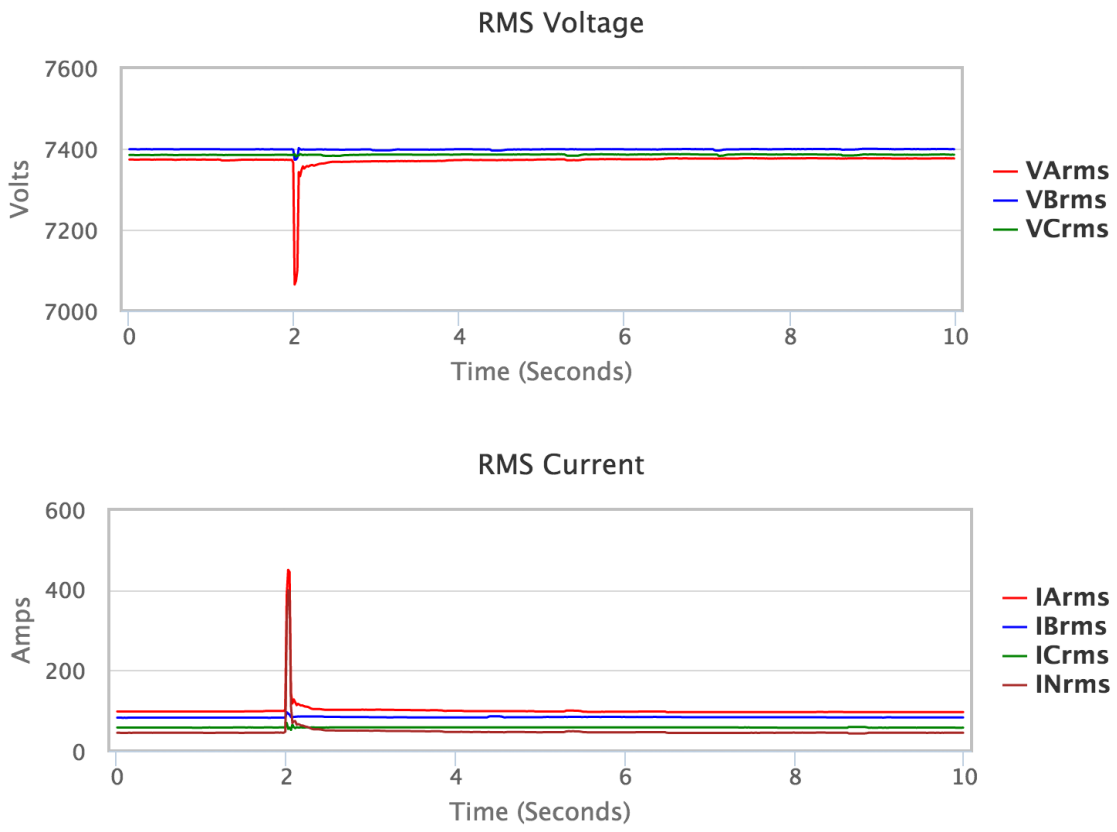


Case Study: Utility repairs outage before customer call

- A “MinTrip” occurs when a protective device observes a fault current above its minimum pickup level.
- The “MinTrip” warning indicates that the device began a cycle-to-trip, but the cycle did not complete before the observed current dropped below the pickup level.
- MinTrips can occur because a downstream protective device operated, or because of incipient, self-healing problems.
- When a MinTrip occurs, the fault current level is usually *not* reported by the protective device.

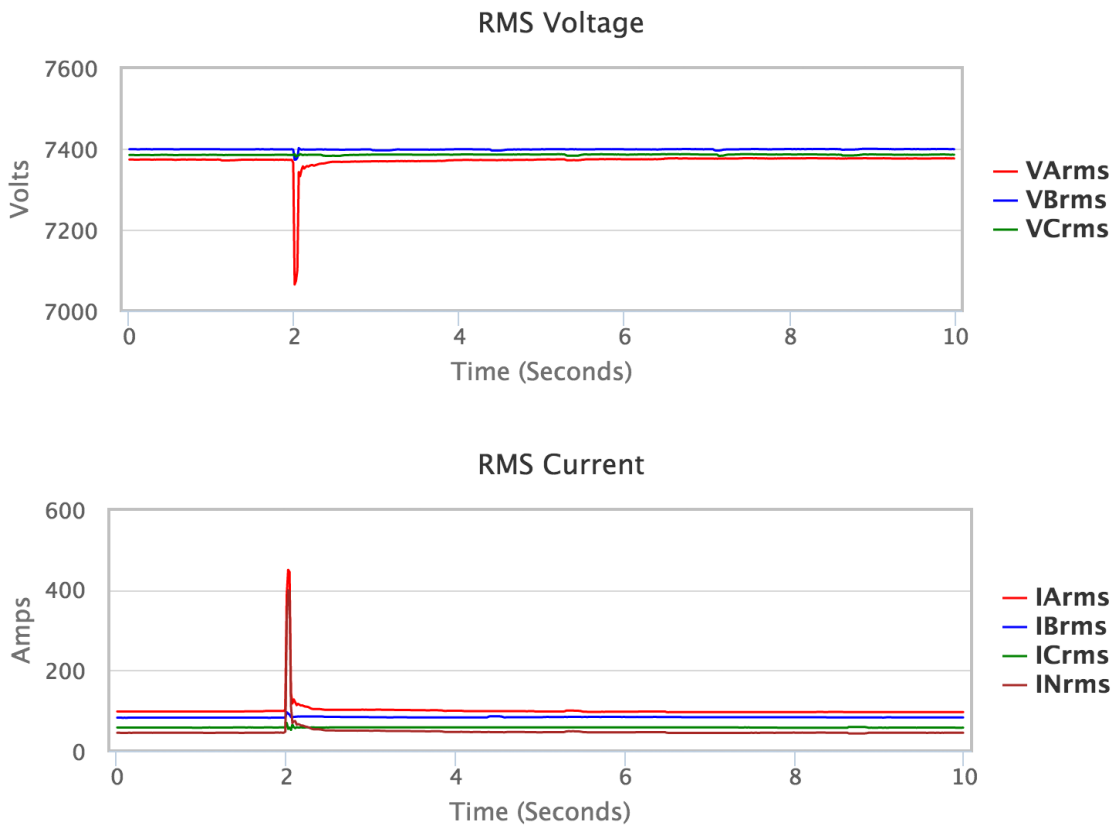
Case Study: Utility repairs outage before customer call

- Some utilities, including this one, use their AMI system to “ping” meters following a MinTrip alert.
- This process can locate out-of-service meters, but can be very time consuming, particularly if a large number of meters are beyond the protective device.
- Reducing the number of meters you need to query is critical for operational success.



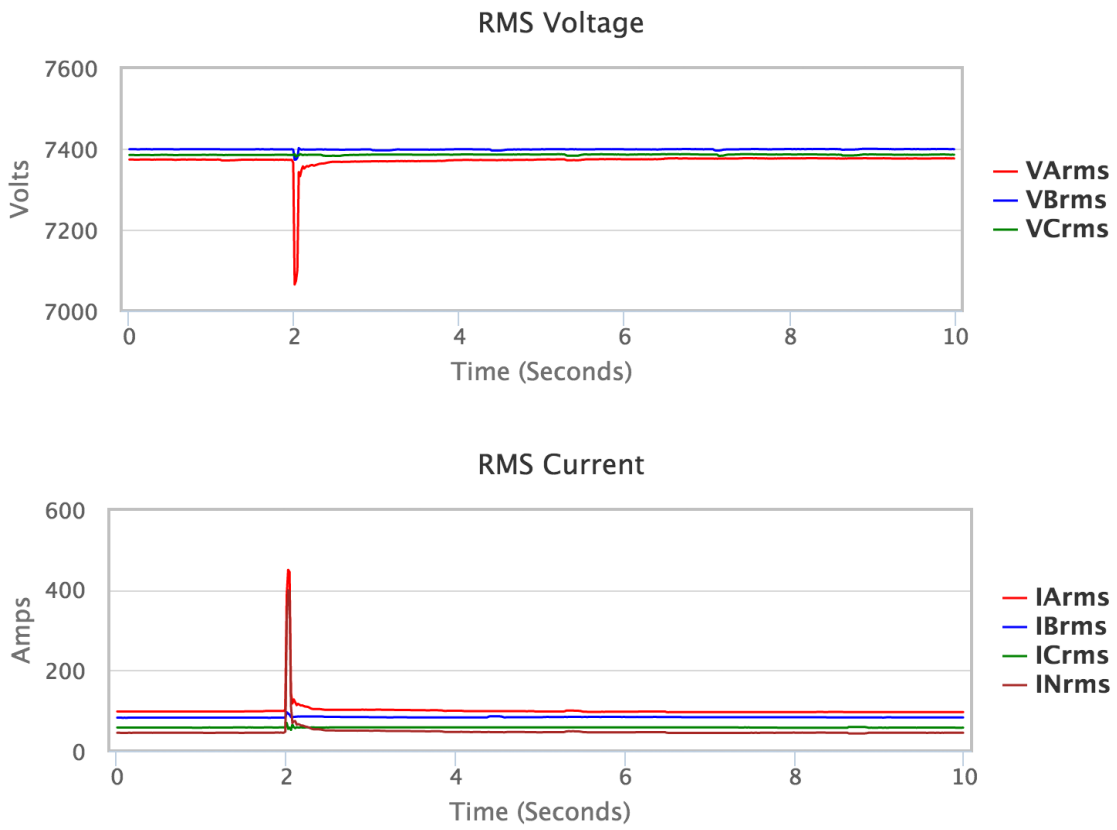
Case Study: Utility repairs outage before customer call

- In this case, the control center operator used information from the DFA waveform analytics system to narrow the search.
  1. Recordings from the DFA device indicated that the fault was on Phase A.
  2. The DFA device calculated a fault current of 372 amperes.
- Using DFA-supplied information, the operator significantly reduced the number of AMI meters to query.



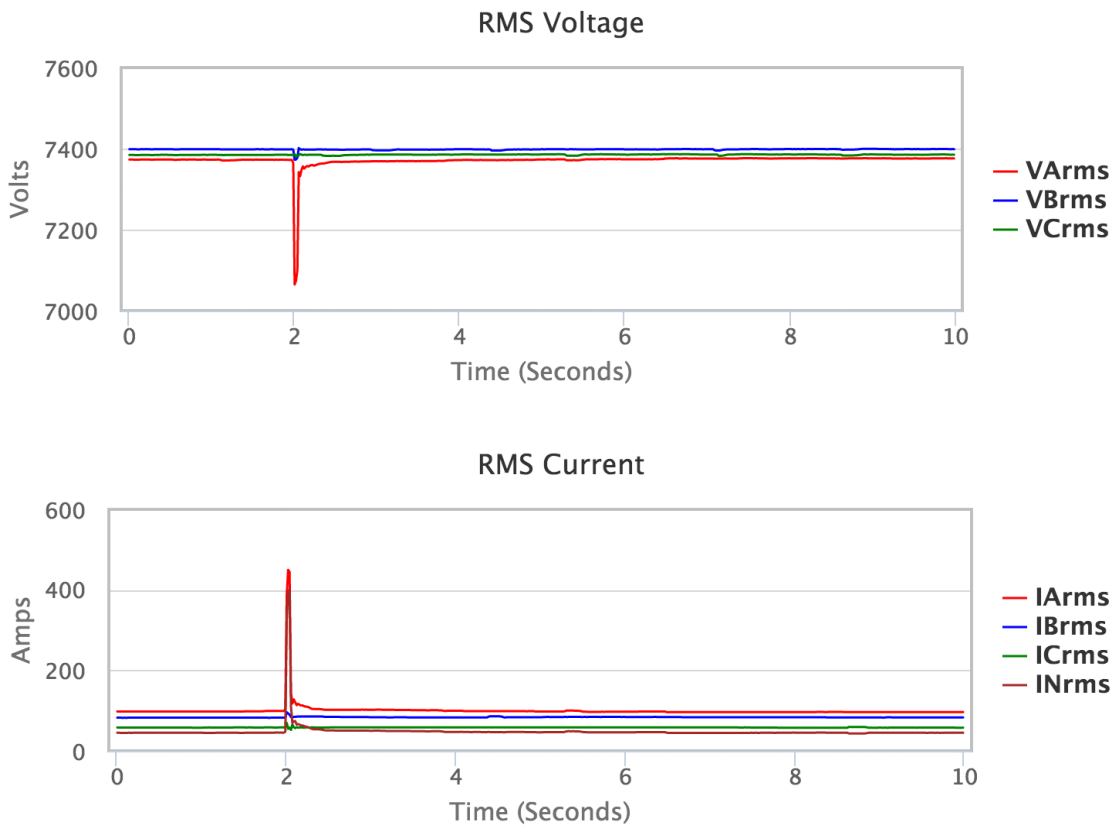
Case Study: Utility repairs outage before customer call

- After pinging only meters on Phase A on sections of the circuit with approximately 370 amperes of available fault current, one meter reported no power.
- A crew dispatched to the location found a dead bird at the base of a transformer, and replaced the fuse.



Case Study: Utility repairs outage before customer call

- The customer was not home when the outage occurred, and therefore did not report it.
- By combining DFA supplied information, delivered automatically in the control room, with existing SCADA and AMI tools, the utility was able to detect, diagnose, and repair the outage before the customer knew there was a problem.



Summary

- Cases like this one are not an isolated incident! In a span of one month, DFA-supplied information found two additional unreported outages of a single meter at the same utility (14 circuits at the utility are DFA-monitored).
- Knowing about minor outages has multiple benefits:
  - Improved SAIDI, SAIFI.
  - Better utilization of work crews.
  - Improved customer satisfaction.
- Waveform analytic systems like DFA, in conjunction with existing utility tools, have the potential to transform the way utilities think about and respond to “minor” events.