Georgia Transmission Corporation's Application and Development of a Digital Fault Recorder Dashboard (EPRI – PQ Dashboard) for Improving System Reliability

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1. **Who is Georgia Transmission Corporation?**
   Georgia Transmission Corporation (GTC) is a transmission only, not-for-profit cooperative formed in March of 1997. It is one of three companies that were formed from the restructuring of Oglethorpe Power Corporation (OPC). GTC provides network transmission services which provide point-to-point services to 38 member EMCs in Georgia. GTC owns more than 3,100 miles of transmission lines. GTC has access to more than 17,000 miles of transmission lines in Georgia through the Georgia Integrated Transmission System (ITS) which are assets owned by GTC, Georgia Power Company (GPC), MEAG Power (MEAG) and Dalton Utilities.

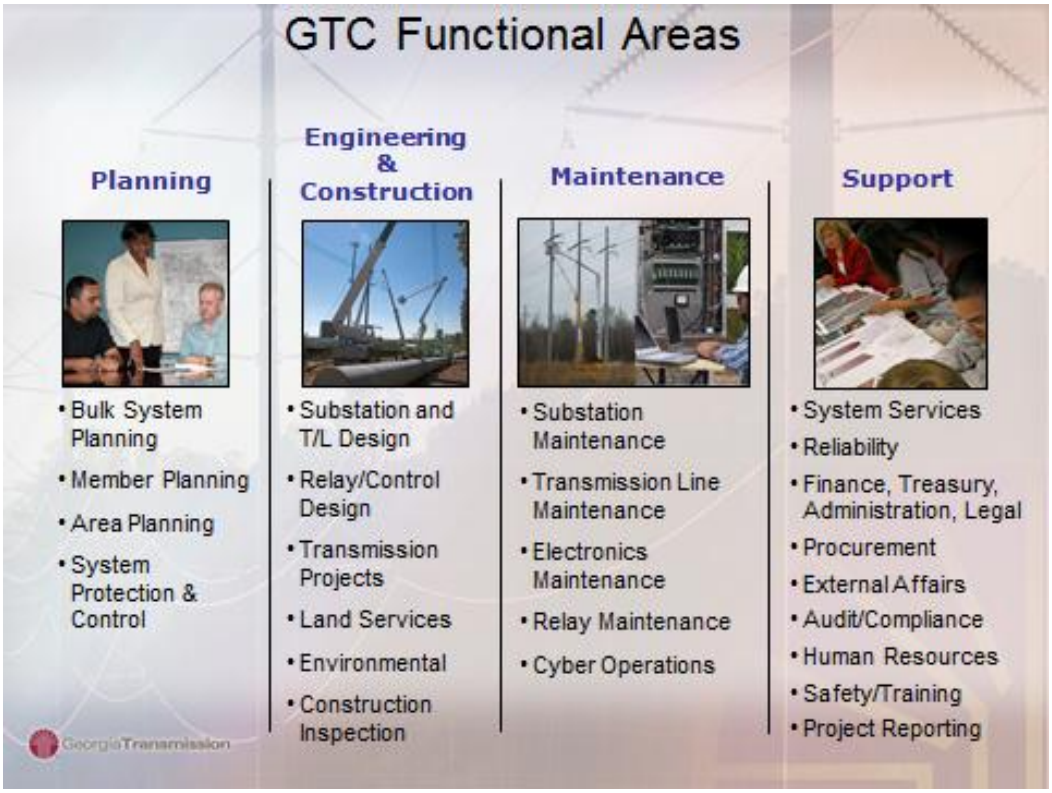
   <u>GTC Owned Transmission Lines</u>

   46 kV lines – 275 miles
   69 kV lines – 14 miles
   115 kV lines – 1132 miles
   230 kV lines – 1274 miles
   500 kV lines – 477 miles
   Total lines – 3172 miles

   <u>GTC Owned Substations</u>

   Transmission substations - 91
   Distribution substations - 569
   Total substations – 660

Below is a list of GTC functional areas of which Reliability has the responsibility for the PQ Dashboard.



2. **What lead up to GTC choosing to use the EPRI PQ Dashboard and open software?**
   Over the past several years GTC had been looking for additional ways to use data from the 75 plus DFR/SERs that it has. GTC has DFR/SERs in all of its transmission stations and some sub-transmission stations. Before the PQ Dashboard, GTC only used DFR/SER data for fault analysis, distance to fault location and lightning correlation. GTC did not review triggered non fault events unless requested by a customer or EMC for electrical system disturbances (sags, swells, etc.). It was the desire of GTC to find a way to quickly review all system disturbances in hopes of finding problems and fixing them. GTC wanted to look at stations where the DFR/SER has recurring triggering and review and investigate the problem as needed.

   From the previous Georgia Tech Fault Analysis conferences, GTC had heard about the benefits of using open source software, where development of software by one company can be used by other companies. Presentations by Fred Elmendorf, Grid Protection Alliance (GPA), at the 2014 Georgia Tech Fault Analysis conferences led GTC to talk to GPA as well as going to Dominion Virginia Power to look at the work they had done with single and double-ended

faults in the EPRI openXDA software. We also traveled to TVA to look at the work they had done with the PQ Dashboard and power quality meters. After meeting with GPA, Dominion Virginia Power and TVA, GTC decided to establish a contract with GPA for the EPRI PQ Dashboard product to use it with GTC's Digital Fault Recorder data. GTC uses both USI and APP brands of DFR/SERs. The openXDA program would use Comtrade data files from both brands of DFR/SERs and display the results in the PQ Dashboard.

3. **GTC 2015 goals for the PQ Dashboard and openXDA program:**

I. The PQ Dashboard would provide a visualization tool for non-trip events that take place on the transmission system and a method to identify and classify these events (Voltage and current sags and swells and other disturbances).

II. Improving fault location accuracy by focusing on automated double-ended fault calculations where possible and multiple methods of single-ended calculations all taking place in near real-time.

III. Automatically calculate and analyze breaker timing each time a transmission breaker operates and classify the results in order to identify slow or slowing breakers before they cause problems.

GTC believes the above goals will lead to improved system reliability by:

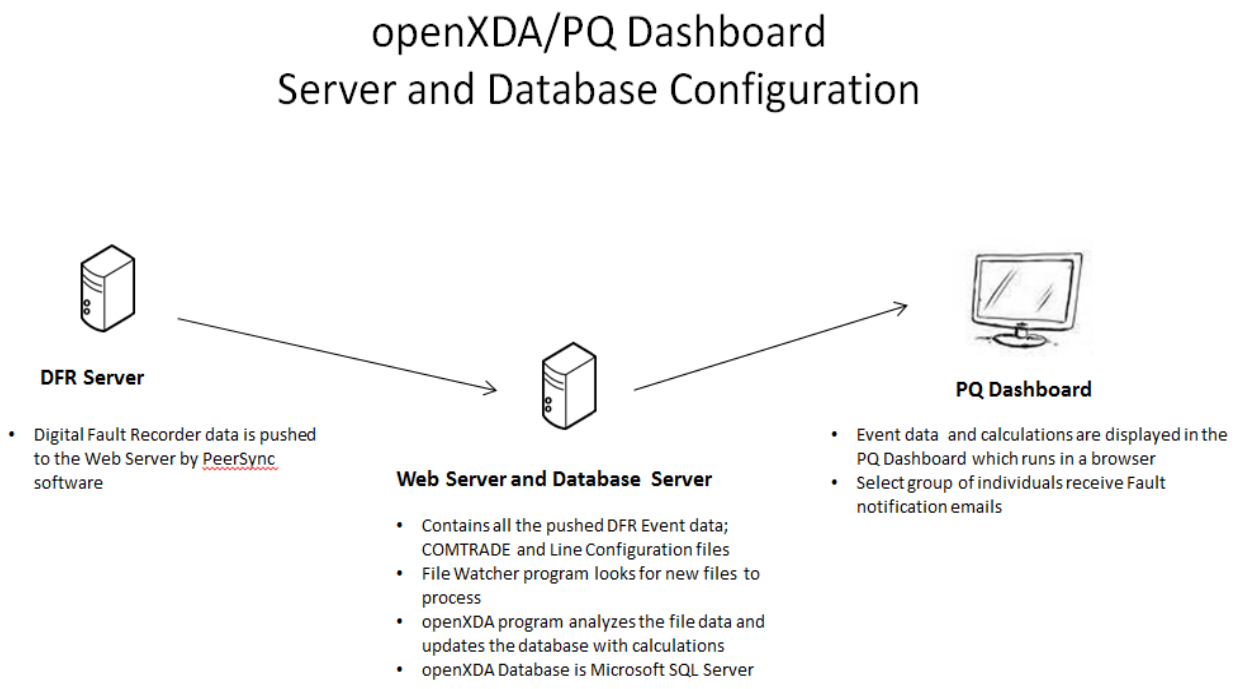
I. Reviewing the PQ Dashboard and GTC being proactive in looking at non-trip events to determine if a corrective action is needed.

II. Having a more accurate distance to fault location which should improve switching time during restoration.

III. Identifying slowing breakers before they cause a problem such as breaker failure.

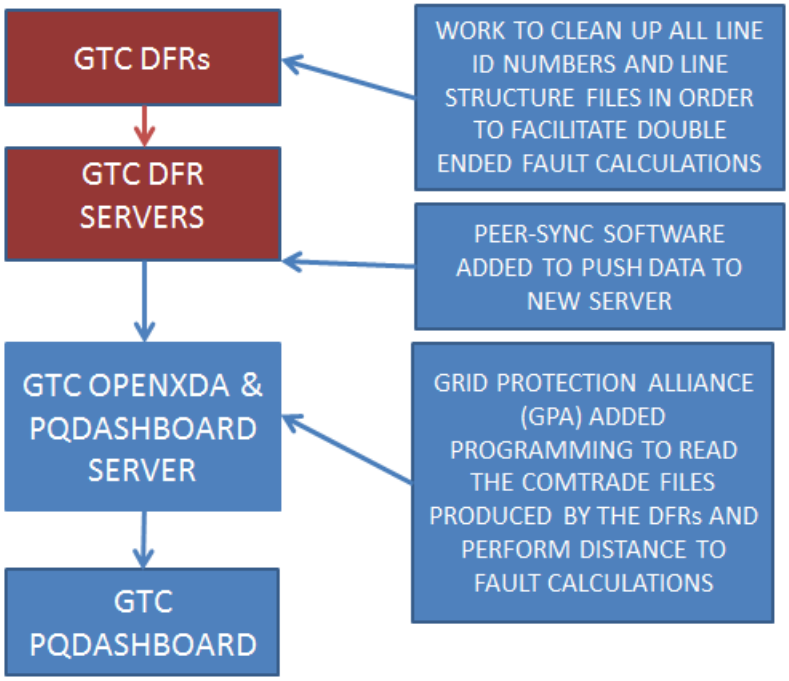
4. **How the PQ Dashboard functions:**
   The openXDA program analyzes the data from the DFR/SER Comtrade files and then displays the data on the PQ Dashboard which is running on a browser.

   Below is a diagram of the server and database configuration.

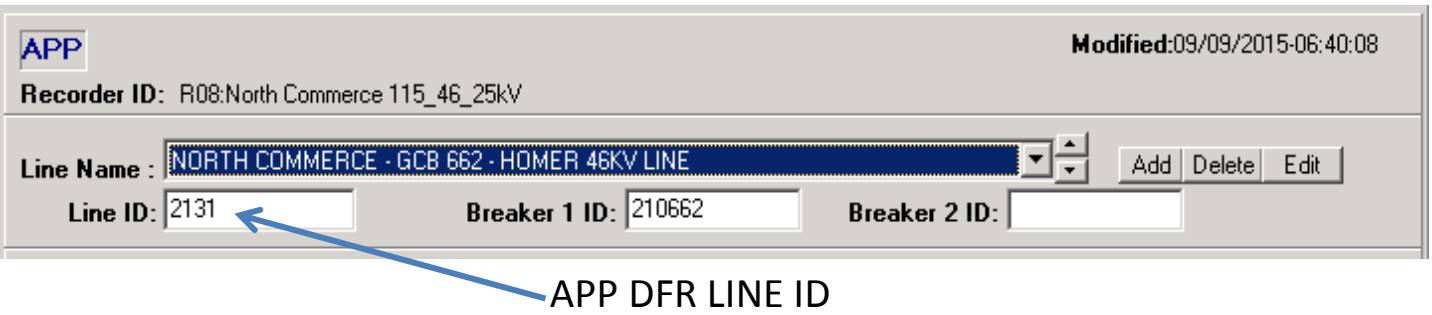


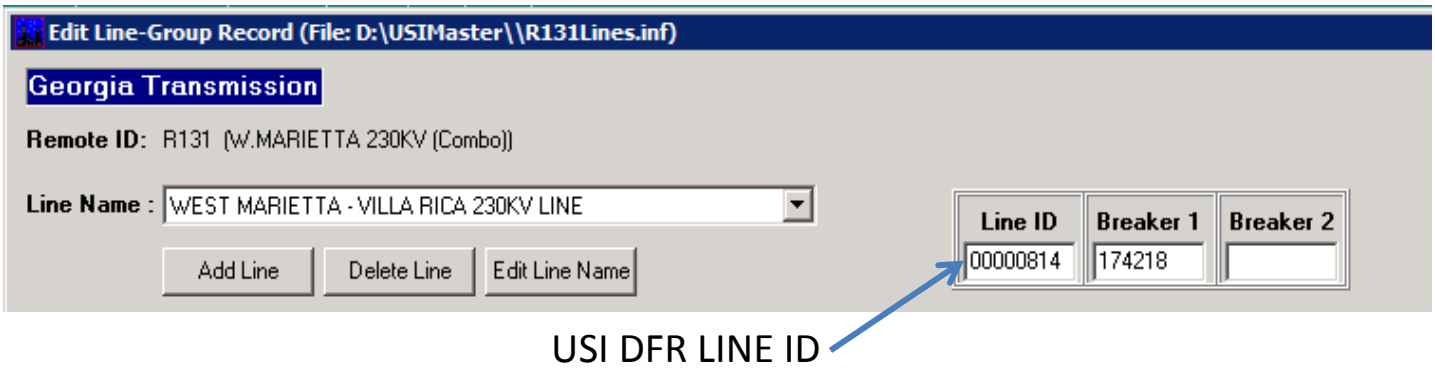
5. **What GTC needed to do to apply the PQ Dashboard to Digital Fault Recorders:**
    a) Events and Faults – openXDA uses five methods to calculate single-ended distance to fault, and one double-ended method. For openXDA to calculate distance to faults by all single-ended methods and the double-ended method each transmission line needs a unique identifier. The DFR/SERs identify the line by a line ID number. In the case of a double-ended fault calculation, each end of the line would have the same Line ID even though the DFR/SER ID and Station name is different. The openXDA program identifies a GTC DFR/SER is located on both ends of the line and does a double-ended calculation as well as all single-ended methods from each end of the line.

Below is a description of the data cleanup and equipment and software additions that had to be made to incorporate openXDA and the PQ Dashboard display. The data cleanup was needed to support the openXDA software single and double-ended distance to fault calulations.



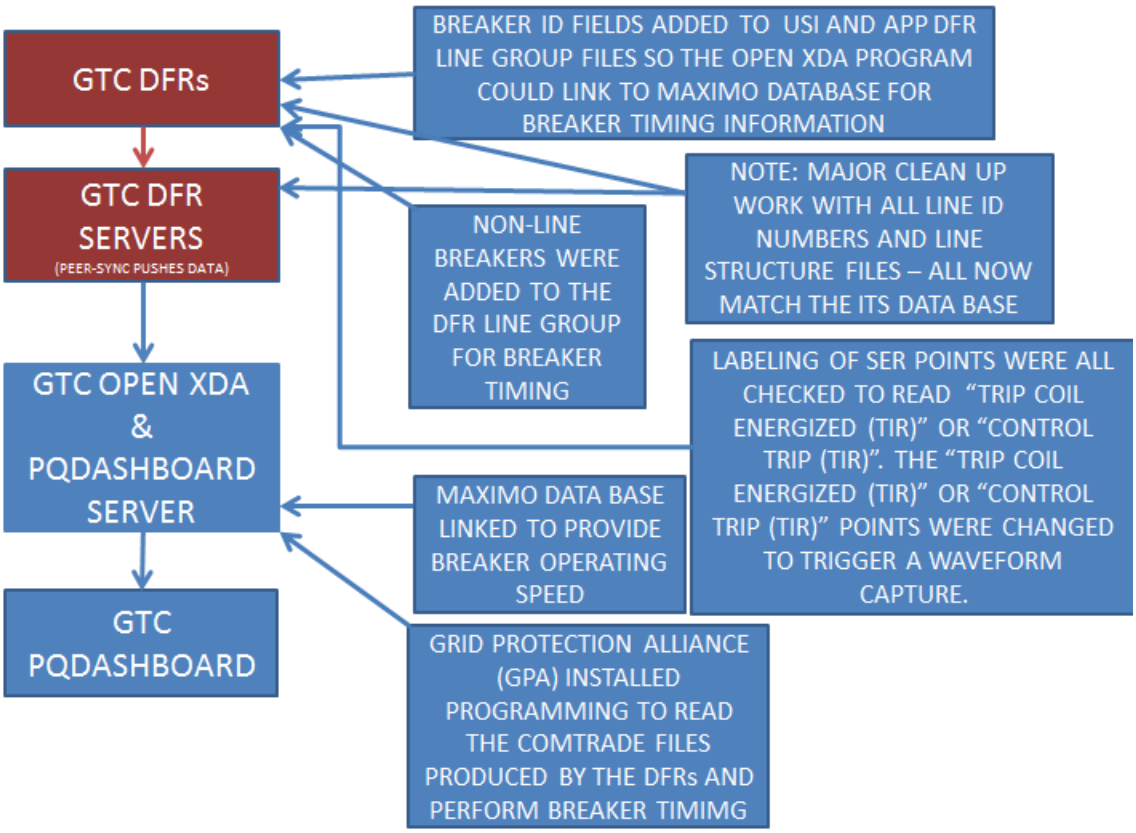
Below are screen shots from the USI and APP DFR/SERs Line Files showing the Line ID location. The line ID's were audited and corrected to match the ITS numbering of the lines.



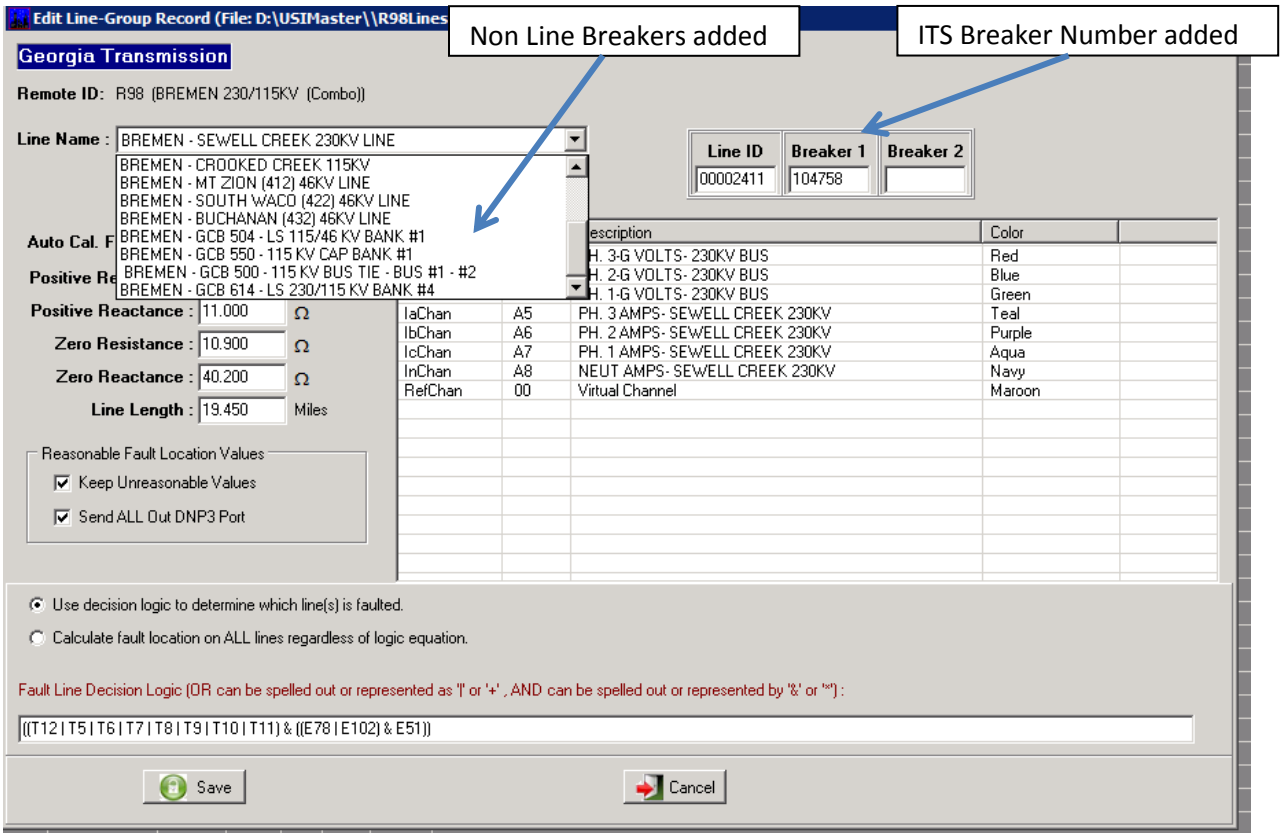


b) Breaker Timing

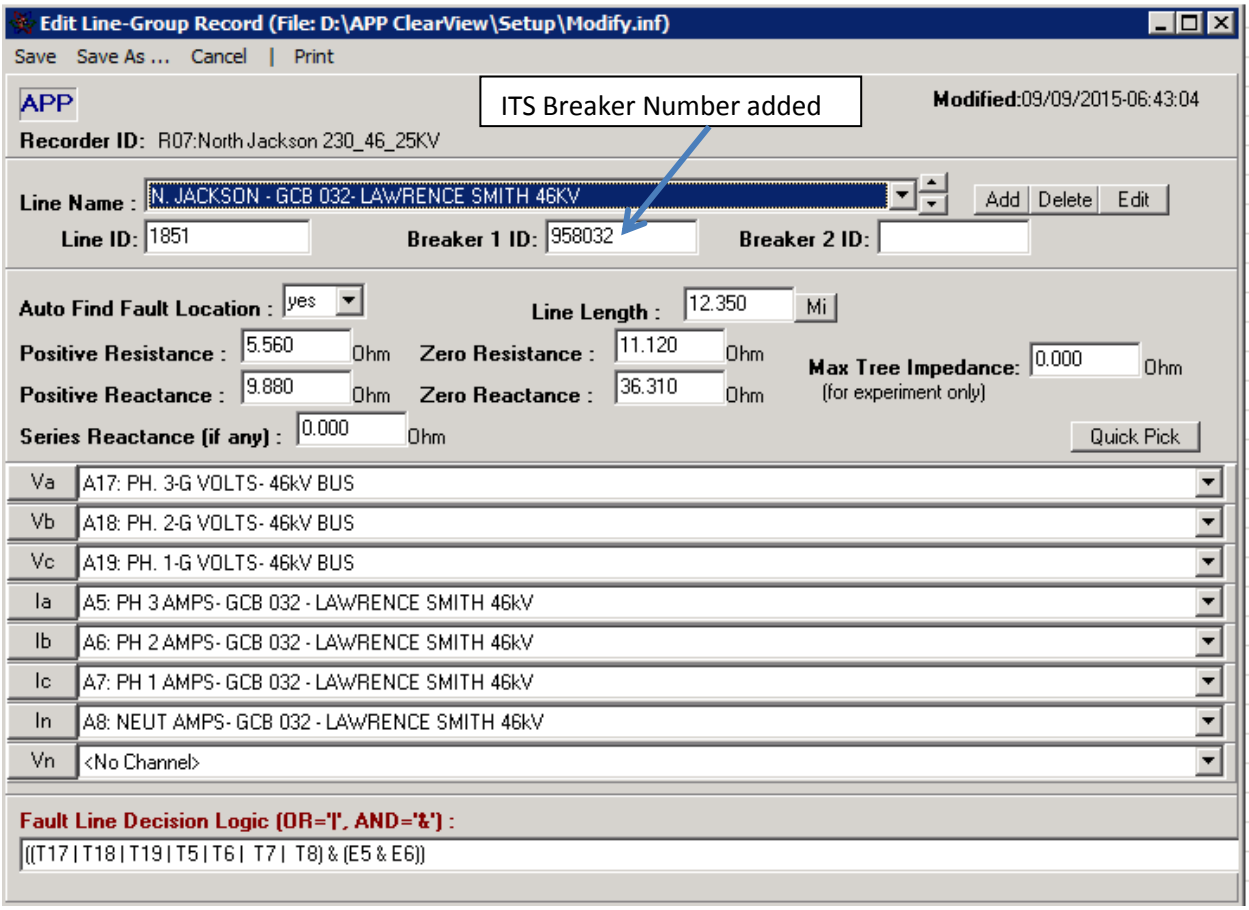
Below is a description of the modifications that had to be made in the DFR line files to support the OpenXDA waveform timing calculations for breaker operating/opening speed.



Below is a snapshot showing a USI DFR/SER Line File where we added non-line breakers and their associated breaker ITS operating numbers. The breaker operating number is used to link to GTC's MAXIMO system for breaker timing information.

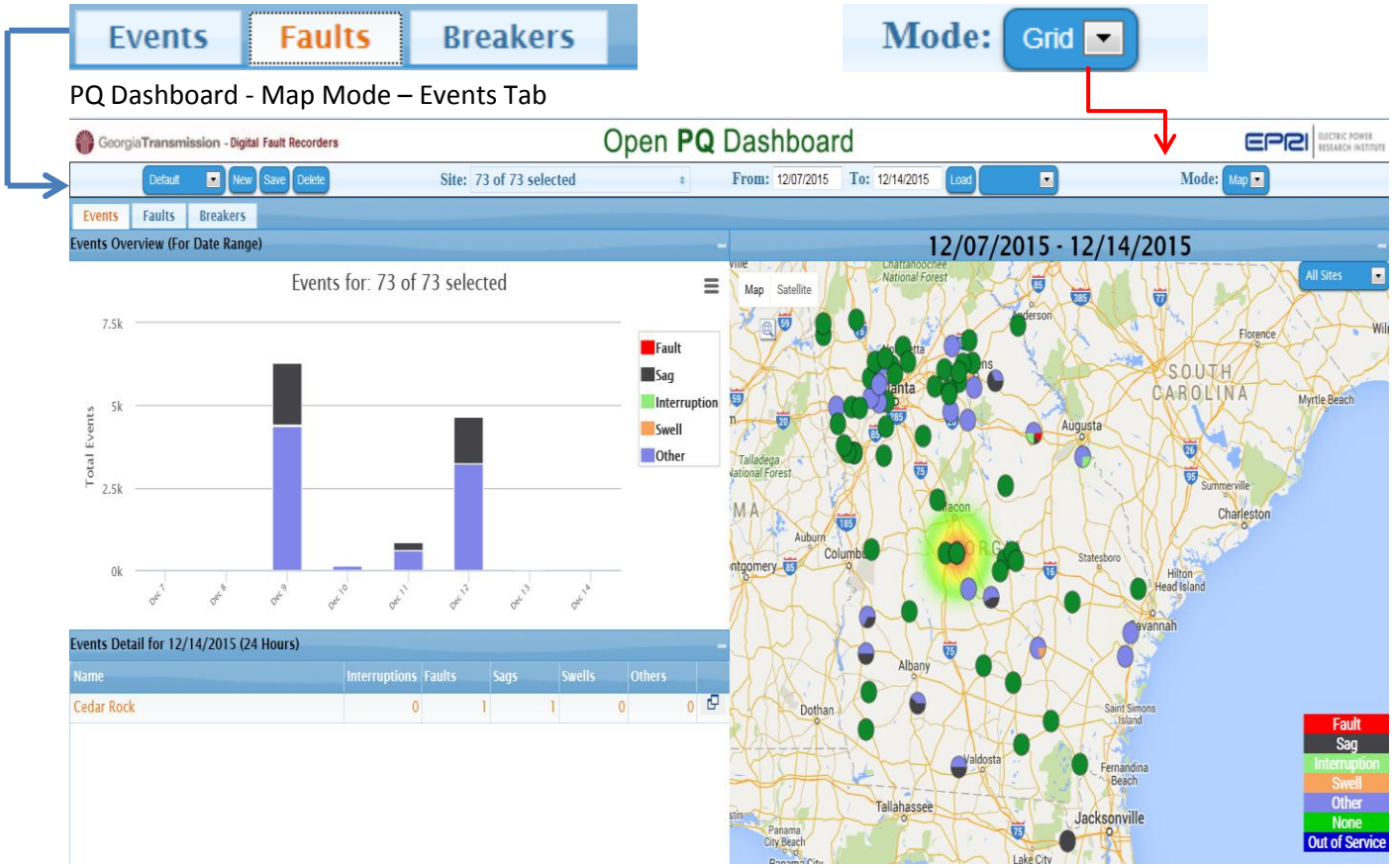


Below is a snapshot showing an APP DFR/SER Line File with its assigned ITS breaker number. Non-line breakers and their associated ITS breaker operating numbers can also be added if needed. The ITS breaker operating number is used to link to GTC's MAXIMO system for breaker timing information.

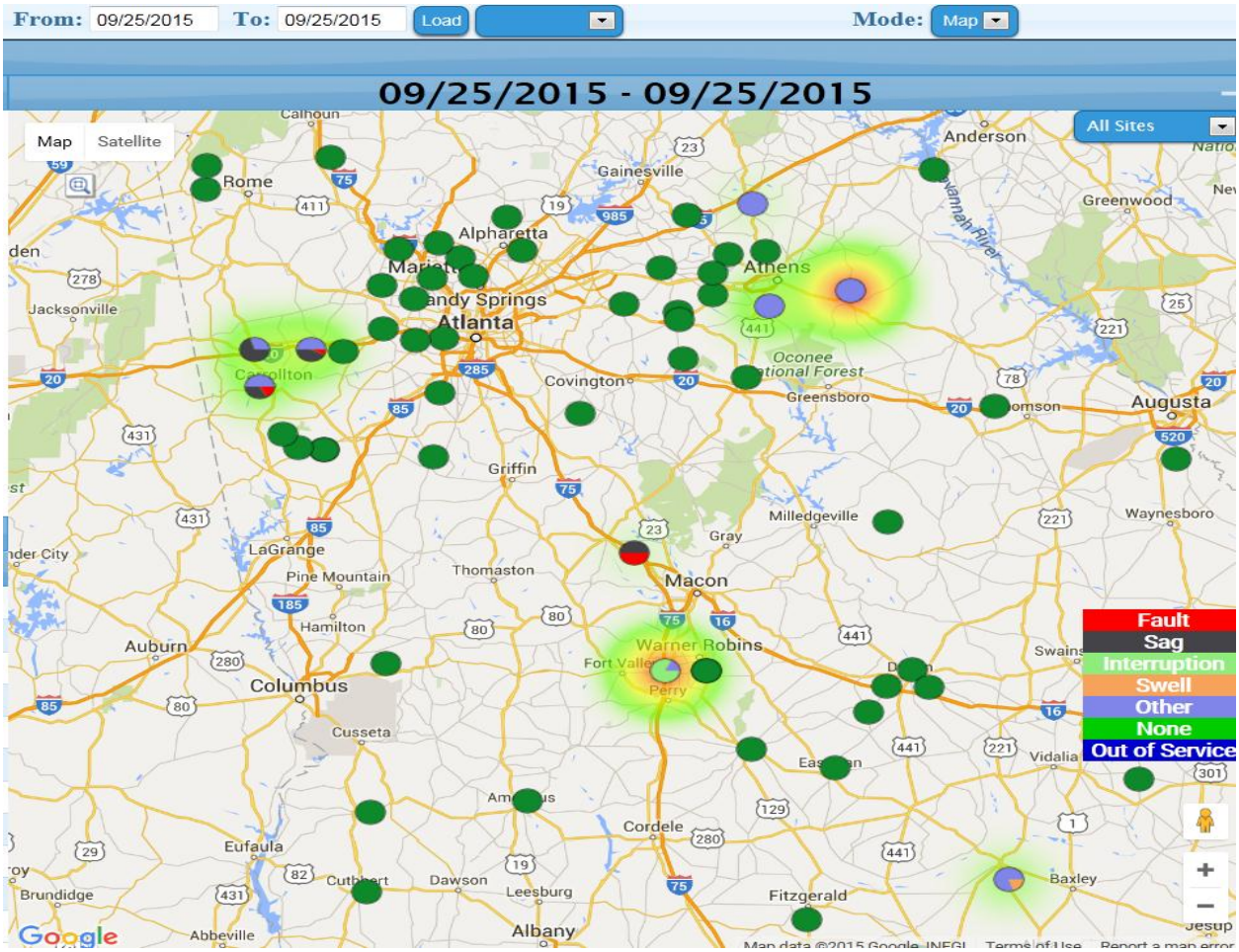


6. **How GTC is currently using the PQ Dashboard.**
GTC currently uses the PQ Dashboard for daily review of events, faults and breaker timing.

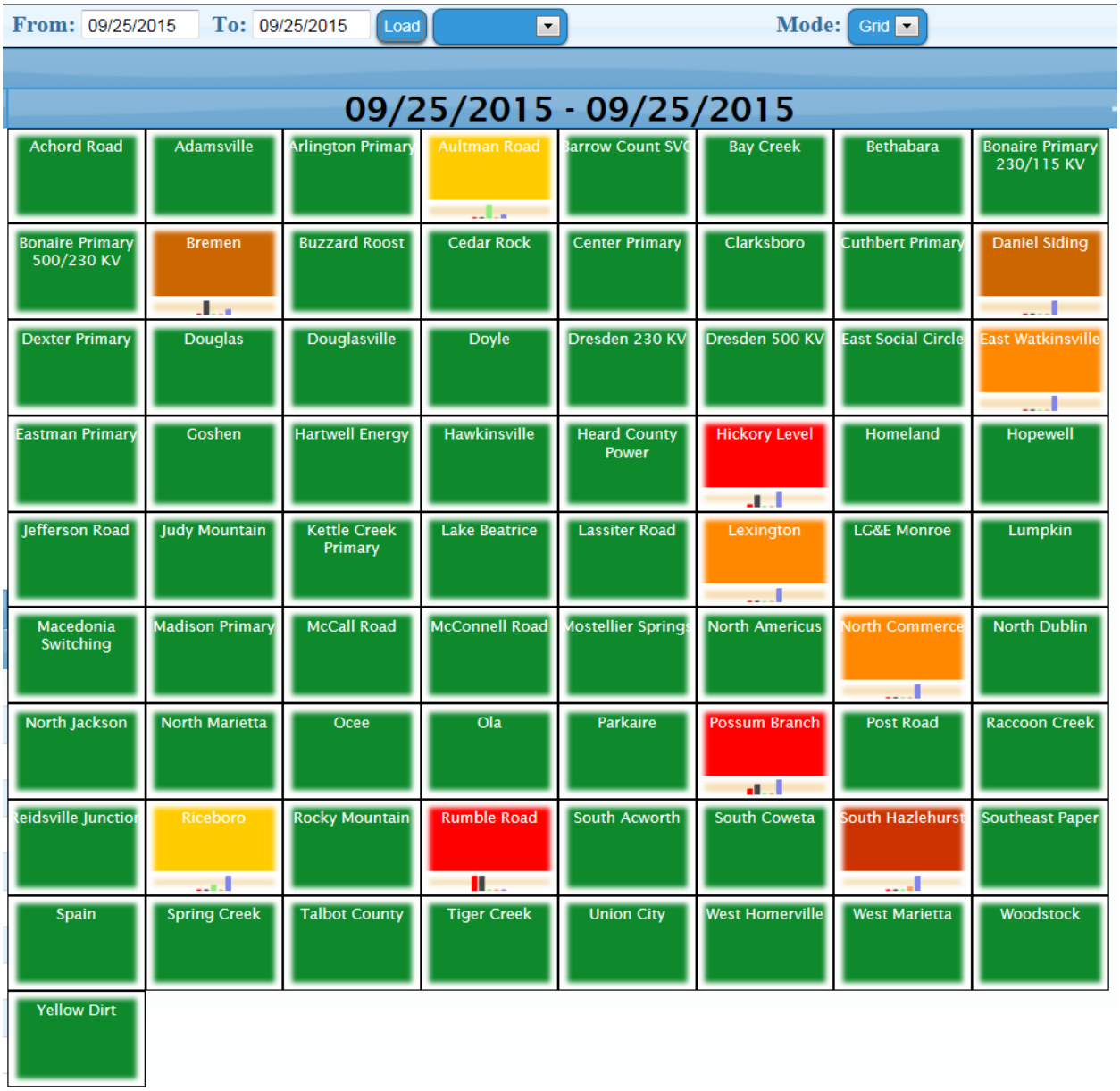
Below are screen shots from the PQ Dashboard showing what one would typically see when you first connect.



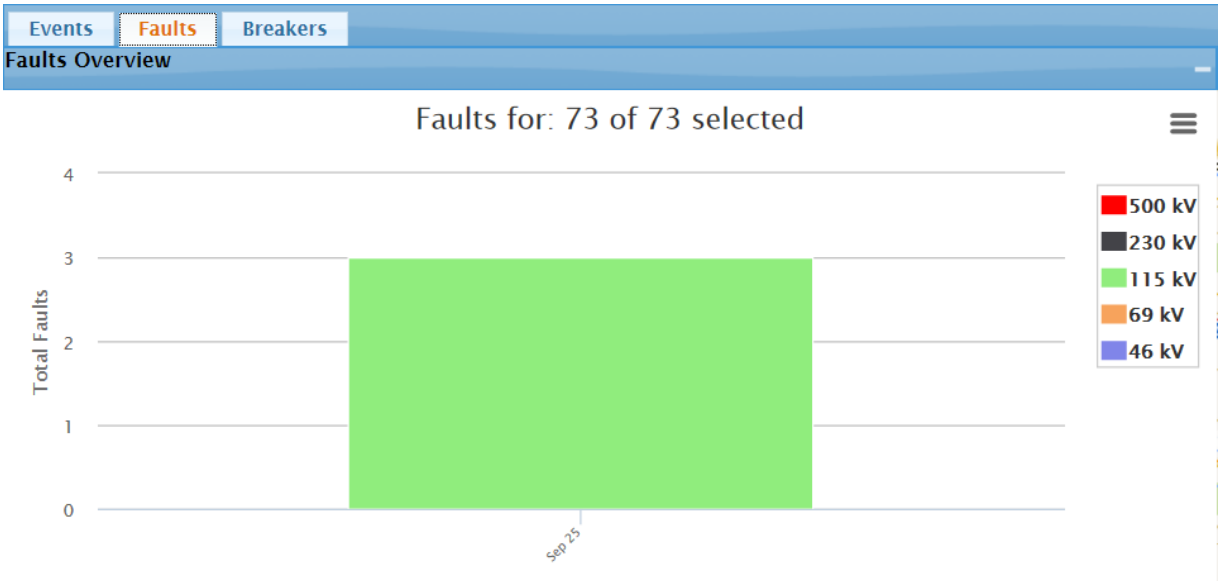
PQ Dashboard Map View – Shows geographical location of all of GTCs DFR/SERs



An alternate way to look at the DFR/SERs on the PQ Dashboard is a Grid View which shows an alphabetical listing of GTC DFR/SER.



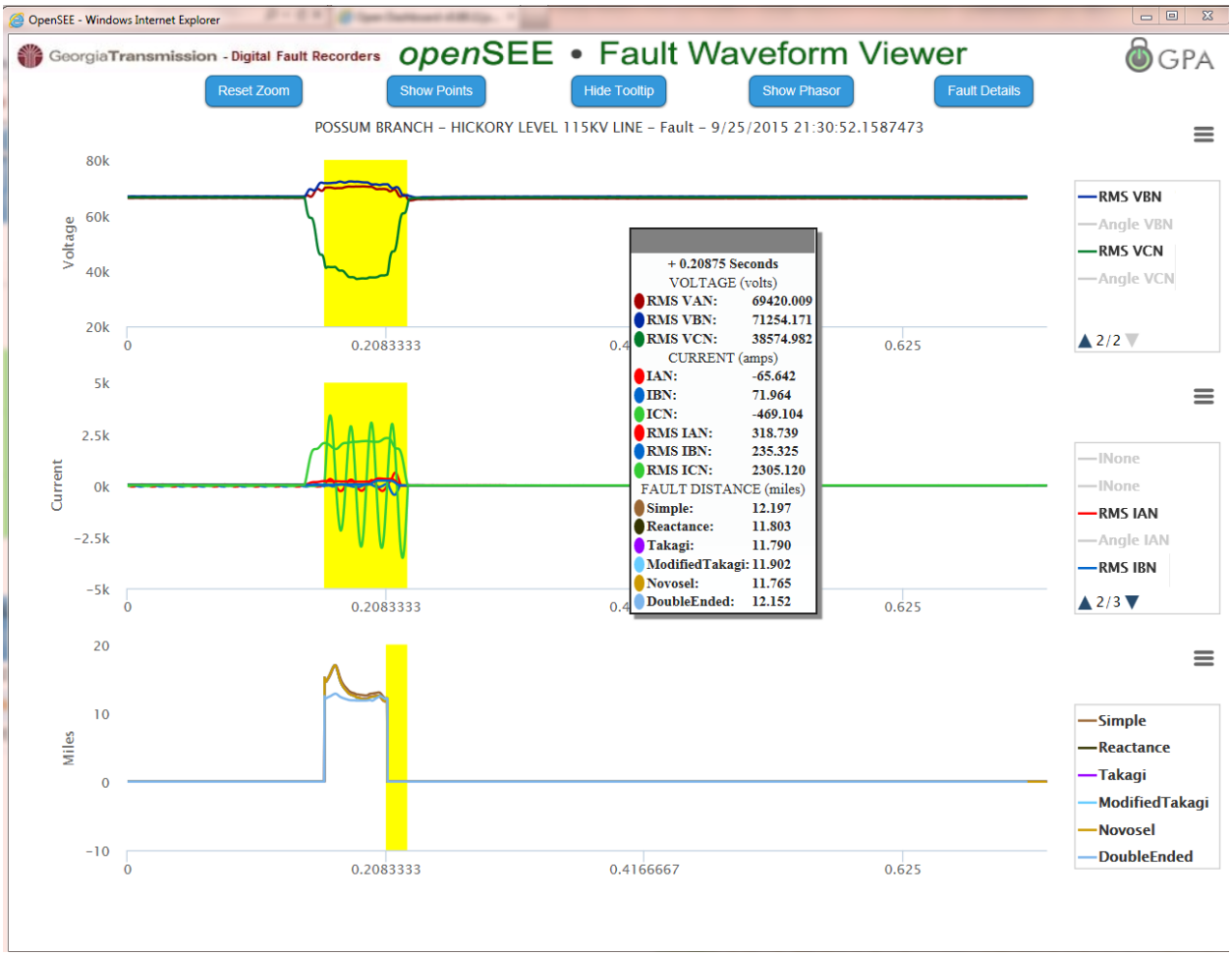
You can also drill down for Events, Faults and Breaker timing. Below is a view from the Fault tab being selected and showing all faults for September 25, 2015.



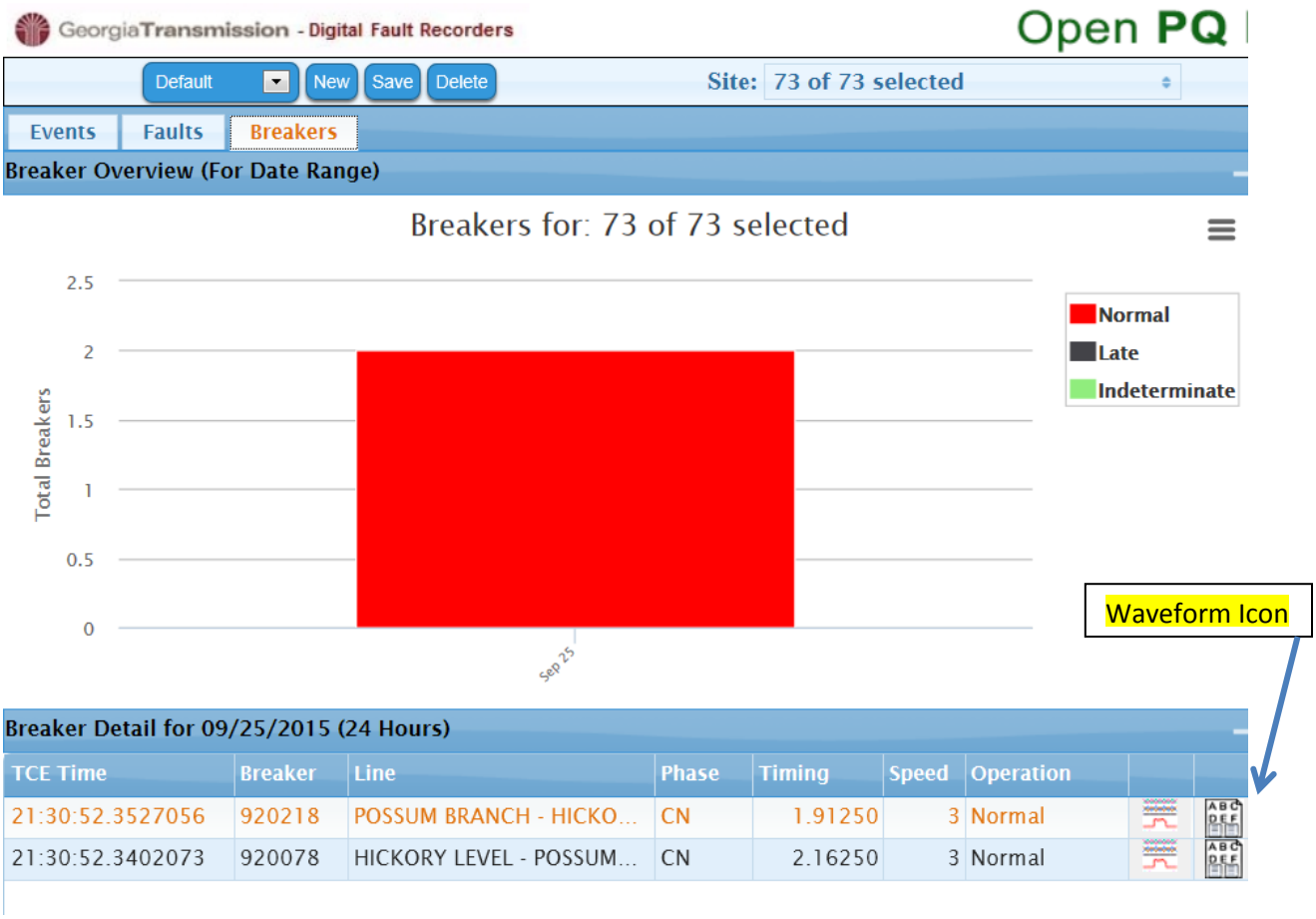
Faults Summary for 09/25/2015 (24 Hours)

Start Time	Line	kV	Type	Miles	Location
07:09:11.7410413	RUMBLE ROAD - LAMAR COUNTY INDU...	115	BN	10.76	Rumble Road
21:30:52.1587473	POSSUM BRANCH - HICKORY LEVEL 115...	115	CN	11.81	Possum Branch
21:30:52.1583323	HICKORY LEVEL - POSSUM BRANCH 115...	115	CN	8.51	Hickory Level

Below is an example of drilling down to look at the fault information. You can turn items on or off as needed to customize your view.

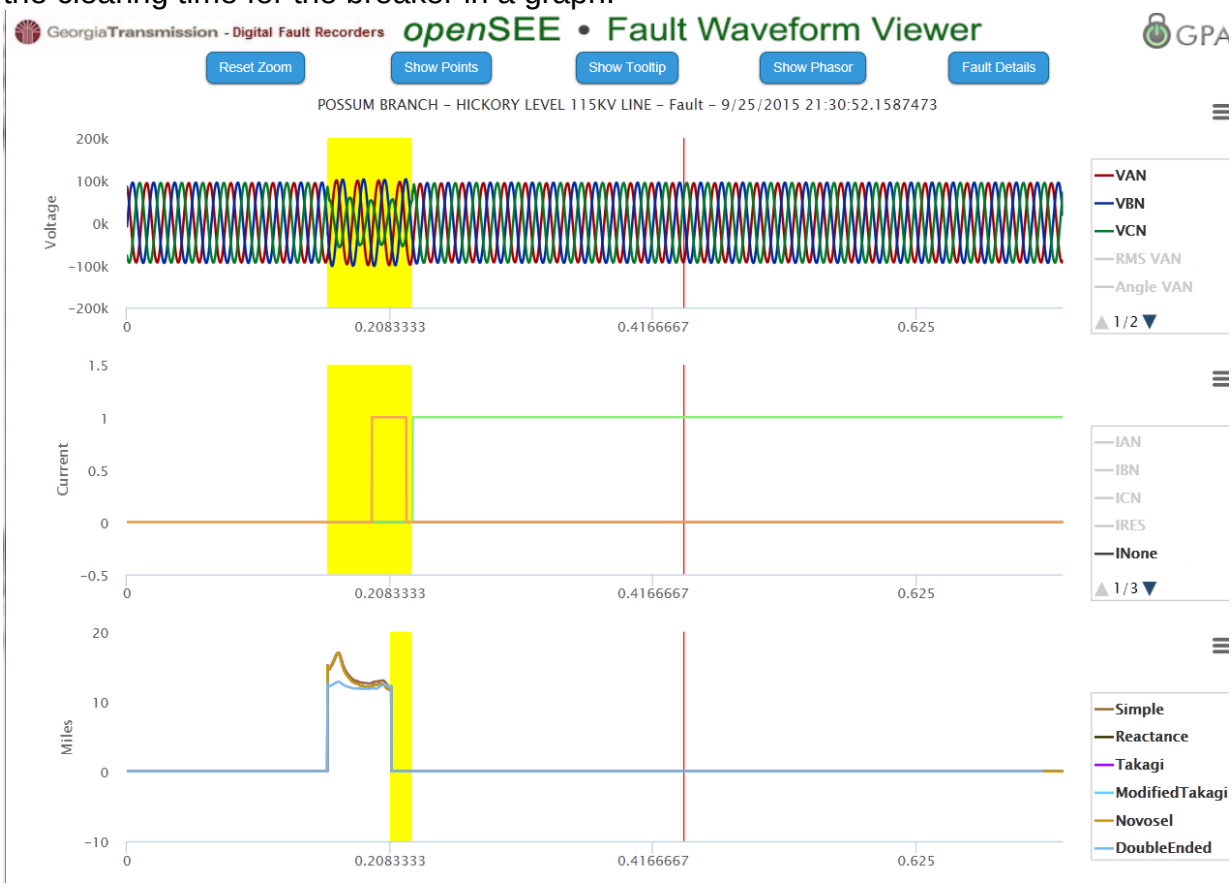


By clicking on the Breaker tab you can check the breaker timing for the Possum Branch – Hickory Level 115 kV fault.



TCE Time	Breaker	Line	Phase	Timing	Speed	Operation
21:30:52.3527056	920218	POSSUM BRANCH - HICKO...	CN	1.91250	3	Normal
21:30:52.3402073	920078	HICKORY LEVEL - POSSUM...	CN	2.16250	3	Normal

Clicking on the waveform icon above allows you to see the Trip Coil Energize point and the clearing time for the breaker in a graph.



A select group of individuals receive Fault notification emails for faults. Below is a sample of what is shown in the e-mail. This one shows a double-ended fault distances.

Subject - Fault detected on HICKORY LEVEL - POSSUM BRANCH 115KV LINE (00003440)

Link to PQDashboard

Fault 1 - 2015-09-25 21:30:52.3174990

DFRs: R224 at Hickory Level triggered at 21:30:52.1583323 (click for waveform)
R226 at Possum Branch triggered at 21:30:52.1587473 (click for waveform)

Files: 150925,213052318,-3td,HICKORY LEVEL 230_115 (Combo)GTC,USI_2002,Georgia Transmission Corporation,R224F2093.dat
150925,213052319,-3td,POSSUM BRANCH 115KV (Combo) GTC,USI_2002,Georgia Transmission Corporation,R226F0812.dat

Line: HICKORY LEVEL - POSSUM BRANCH 115KV LINE (19.04 miles)

	Hickory Level – R224	Possum Branch – R226
Fault Type:	CN	CN
Inception Time:	21:30:52.3174990	21:30:52.3174973
Fault Duration:	58.750 msec (3.53 cycles)	67.083 msec (4.02 cycles)
Fault Current:	4321.3 Amps (RMS)	2305.5 Amps (RMS)
Prefault Current:	170.7 Amps (RMS)	20.6 Amps (RMS)
Postfault Current:	11.9 Amps (RMS)	3.2 Amps (RMS)
Distance Method:	Reactance	Reactance
Single-ended Distance:	8.508 miles	11.813 miles
Double-ended Distance:	6.942 miles	12.156 miles
Double-ended Angle:	0.103°	-0.059°
Short file name:	R224F2093.dat	R226F0812.dat
openXDA Event ID:	304900	304897

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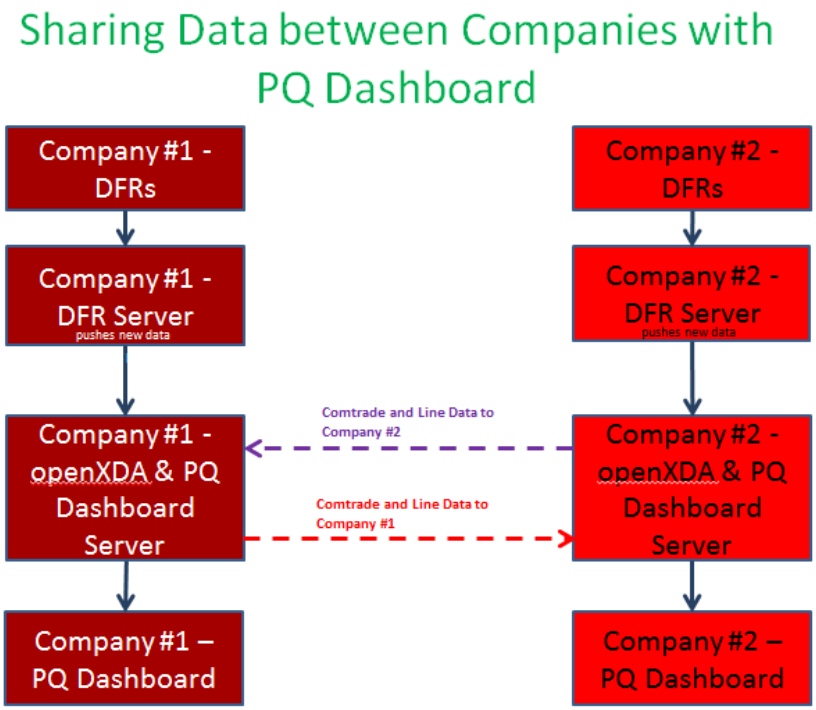
7. **GTC has shared the PQ Dashboard with Georgia Power in hopes of improving system reliability for the state of Georgia and the ITS.**

   GTC, GPC, MEAG, and Dalton Utilities all own parts and share in the use of the ITS in Georgia. As such, GTC may own a transmission station at one end of the line and GPC or MEAG may own the transmission station at the other end of the line and both would contain a DFR/SER. For the betterment of the ITS and system reliability (reduced switching times) GTC has proposed to GPC, the system operator, that data be shared from DFR/SERs such that double-ended fault distances can be calculated where possible for each fault. This will benefit all by having a more accurate fault location for the control centers. It has not been decided whether GTC or GPC will be the site for the calculation, but the results will be shared with all parties.



8. GTC 2016 goals for the PQ Dashboard

A. Modify the current PQ Dashboard to use the logic equations used in the DFR/SER to determine the specific line in an event record that was faulted. This logic includes the use of breaker status point, relay outputs and current or voltage triggers as defined in the DFR/SER logic equation.
B. A GIS layer will be added to the PQ Dashboard that will display the location of structures near the fault location as well as all possible fault location.
C. Event correlation with lightning will also be added to the PQ Dashboard. This is currently being done in the DFR program which uses comma delimited files for the line location. The openXDA program will link directly to the GIS data in GTC's TIGER GIS system.
D. Event reclassification and tagging in the PQ Dashboard.
E. Addition of a tab for GTC's low-side power quality meters.
F. Addition of a layer for fault indicator data and using that data to help with the location of faults where the line has branch circuits.
G. Extend the breaker analytics to include reports and graphs, and add additional breaker analytics such as pole not closing and breaker restrikes.

9. Future uses for the PQ Dashboard at GTC

A. Capacitor bank monitoring for over voltage or under voltage conditions. Control Center closing the capacitor bank multiple times stressing the capacitors. NOV monitoring to reduce cap bank nuisance alarms.
B. CCVT monitoring.
C. Breaker duty cycles; capture operations due to faults and current magnitudes. Develop algorithm to calculate each breaker's life time breaker duty based on manufacturers guidelines.
D. Transformer through faults.
E. Collaborate with other utilities for uses of the dashboard.