Analysis of the Plant Gorgas Breaker Failure

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Introduction:

On June 16th 2008, Plant Gorgas was bringing Unit #6 online when suddenly the Unit Breaker failed catastrophically. This initial failure caused Bus #2, and two 115KV lines to trip. When the Unit Breaker failed it sprayed oil onto the Bus Tie Breaker causing it to be engulfed in flames. The Bus Tie Breaker fault started a chain reaction of buses, lines, generating units, and transformers tripping in and around Plant Gorgas. Under normal circumstances the Bus Tie Breaker fault should have taken out Bus #3, Unit #7, and two 115KV lines. We had to utilize Digital Fault Recorder (DFR) event records and field personnel observations to recreate what actually happened that night and to investigate why the Bus Tie Breaker fault did not clear as designed. In all we had twenty seven transmission lines trip (2 - 46KV, 15 - 115KV, 4 - 161KV, and 2 - 230KV), twenty two distribution substations out, and seven generating units offline (1315 MW's). This paper will show the events that took place on Jun 16th, 2008 and how we ended up recreating the event using DFR event records and field personnel observations.

Background:

Plant Gorgas is located in Alabama Power's Western Division near Parrish, AL. It is the oldest operating fossil plant in Alabama Power's generating fleet and houses five coal units with a total nameplate capacity of 1,221 MW's. It has three substation switchyards with voltages ranging from 46KV to 230KV. The #1 Switchyard contains one 161KV, two 115KV and one 46KV buses as well as Units #8 and #9. The #2 Switchyard contains two 115KV buses and Units #6 and #7. The 230KV Switchyard contains the two 230KV buses and Plant Gorgas's largest generating unit – Unit #10.

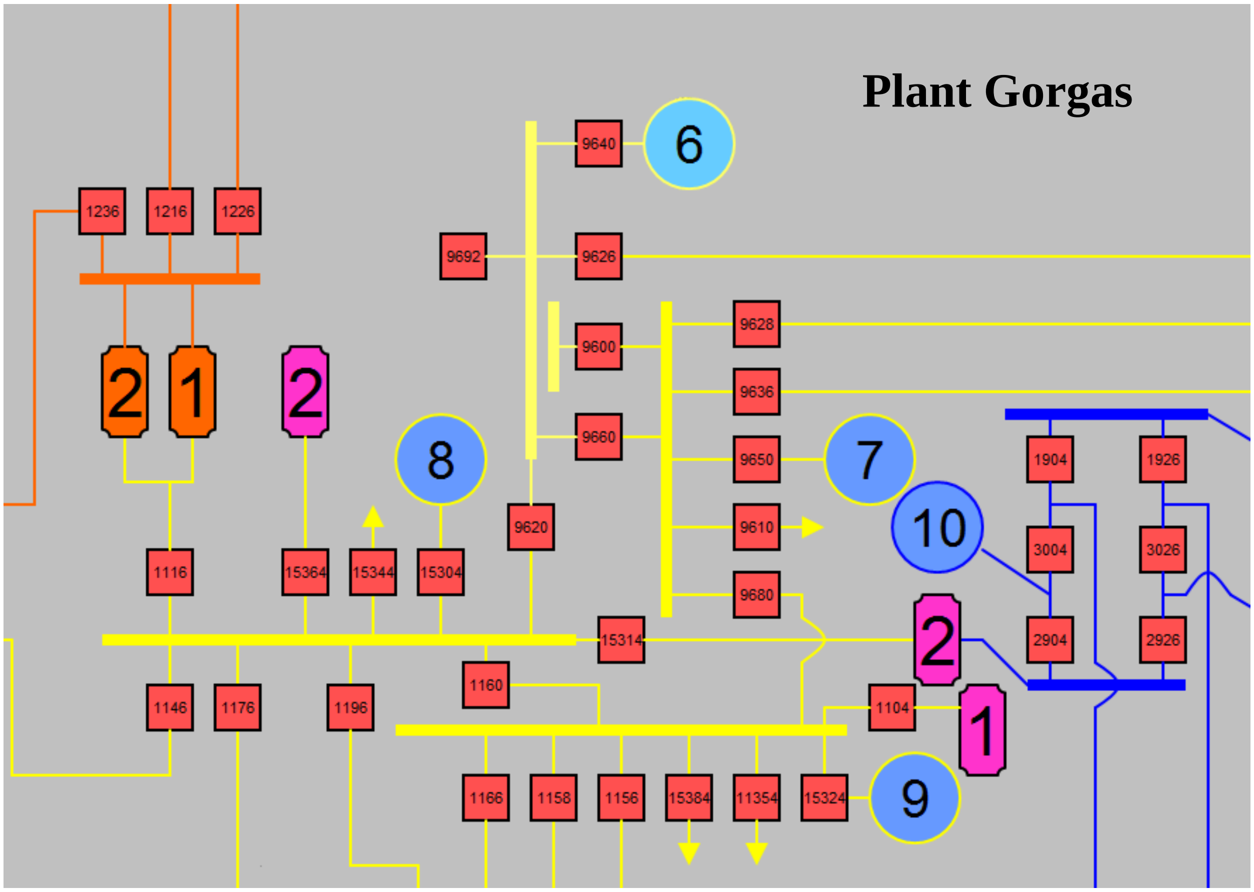

Figure 1: Plant Gorgas Single Line Diagram

Event:

On June 18th, 2008, Plant Gorgas was operating normally except for Unit #6 which was coming back online from a maintenance outage. Breaker 9640 was closed to bring Unit #6 online at approximately 12:50 AM. When Breaker 9640 is closed it fails catastrophically and trips the #2 115KV Bus differential which will isolate the faulted breaker. The fault is *not* isolated and it now includes the #3 115KV Bus. The #3 115KV Bus differential operated but it does not open the breakers. This starts the operation of several lines feeding Plant Gorgas. Units #7, #8 and #9 also trip offline as well. After three seconds there is a pause in operations and then one second after the pause it starts up again. This time Unit #10 trips offline and starts the operation of numerous lines feeding and around Plant Gorgas. The whole event lasts for thirty six seconds from the closing of Breaker 9640 until the #2 and #3 115KV Buses are isolated. Within another 49 seconds all the breakers are reclosed and operational, except for one at USX

#8 (breaker problem), Tuscaloosa (breaker was operated to a lockout) and the breakers at Plant Gorgas.

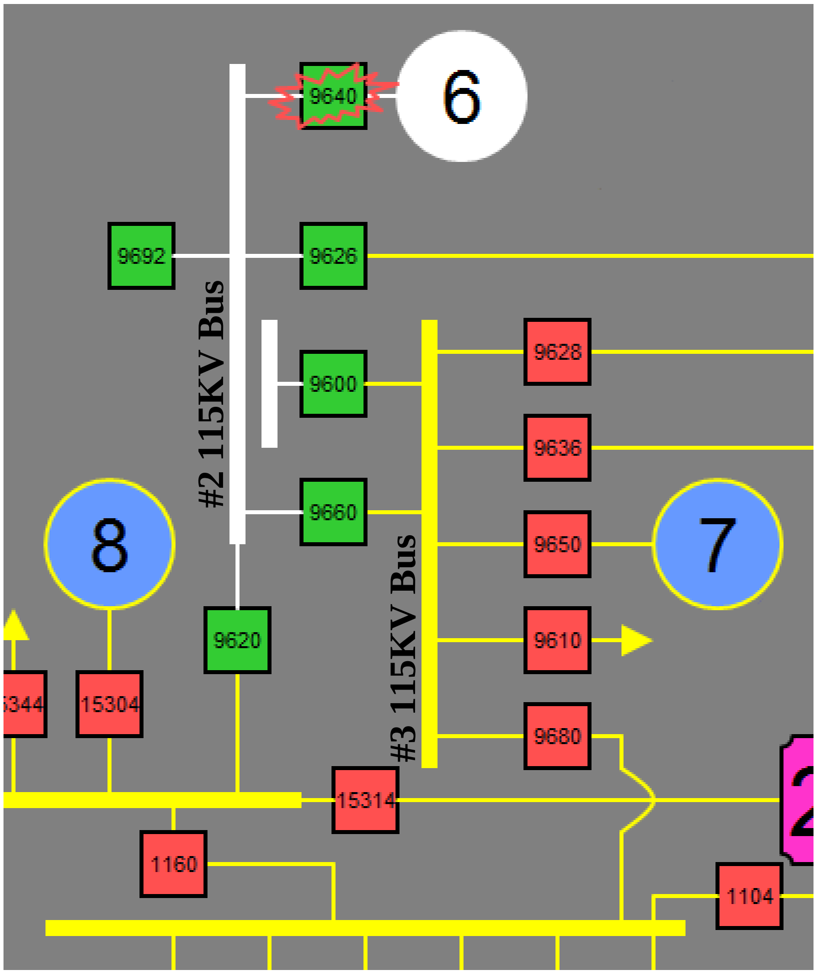

Figure 2: Plant Gorgas #2 and #3 115KV Buses - Shortly after Breaker 9640 fails

In the operational world, unlike the fault analysis world, thirty six seconds is a short amount of time for all of this to happen let alone understand why and what happened. The first questions that were asked were:

- Why didn't the #2 115KV Bus differential operating isolate the fault?
- Why didn't the #3 115KV Bus differential operate to isolate the fault?
- Why was there a pause in the breaker operations three seconds after Breaker 9640 failed?

It would take analyzing the DFR event records and investigation by field personnel to answer these questions and to try to recreate what actually happened that June night.

Analysis:

To begin the analysis of this event it was determined that we had to gather all the DFR event records to create a sequence of events of what happened because the EMS times of all the operations were proven to not be accurate. Our EMS system scans every six seconds so the time reported could be off by as much as 12 seconds. Also due to the magnitude of the fault the RTU's at Plant Gorgas failed or lost communication. Each DFR location is equipped with a network connection to transfer data from the substation to the centralized data storage at Alabama Power's corporate headquarters. Once a DFR creates an event record it is automatically transferred within fifteen minutes. Unfortunately the DFR's at Plant Gorgas lost communication during the event and only transferred two sets of records and deleted the remaining records when it thought it had transferred the event records successfully. There were five other DFR's that captured event records for the event and they were spaced out across the transmission system which provided a different "look" at the event.

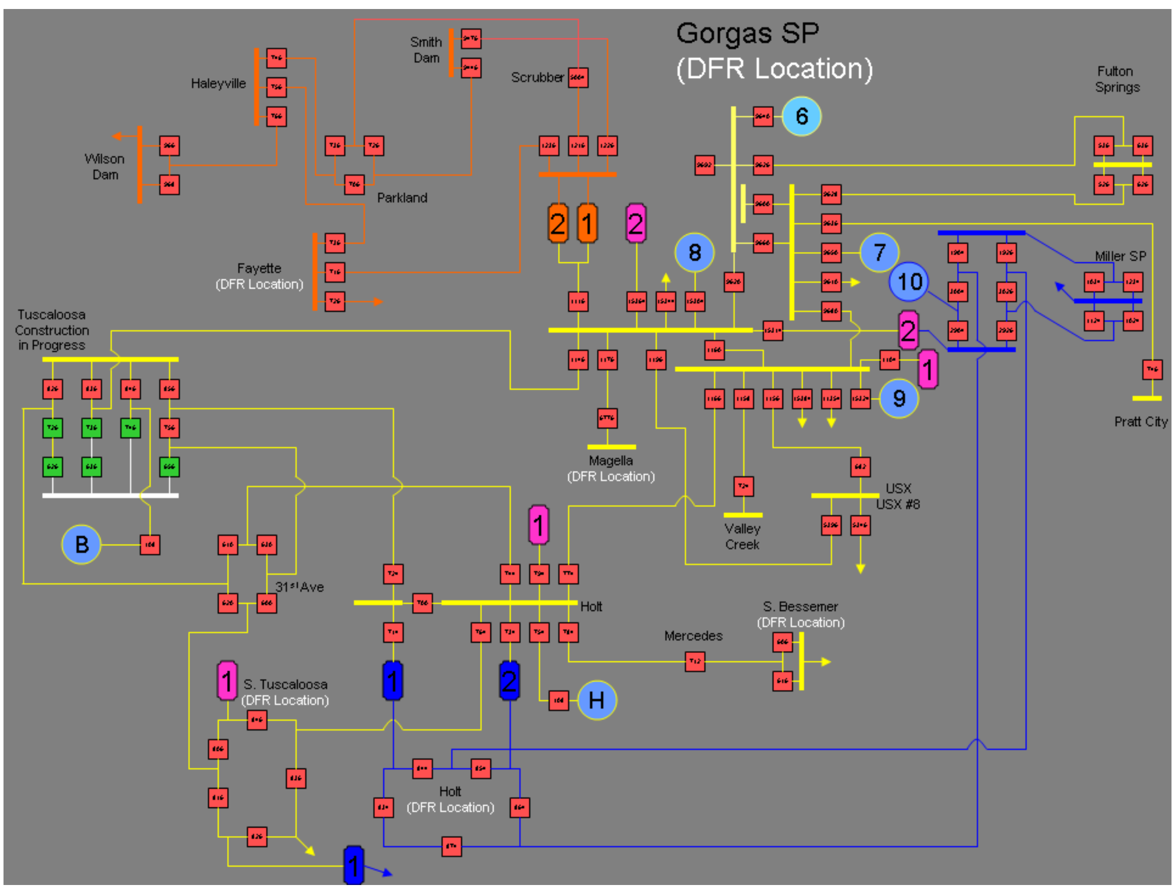

Figure 3: Event Area Single Line Diagram w/ DFR Locations

All the DFR's were connected to a GPS Clock, which gave them all the same reference point, so they could be combined and examined to discover the true sequence of events.

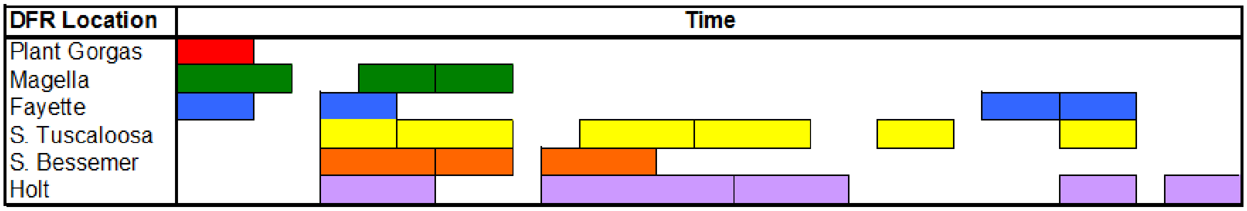

Figure 4: DFR Event Record Timing Diagram

It was also discovered that the event actually contained two faults. The first one was a three phase fault, which was the failing of Breaker 9640. The second fault started as a phase 2-3 but soon turned into a three phase fault like the first one. The magnitude for a three phase fault on Plant Gorgas's #2 115KV Bus was approximately 48,000 amps.

It was confirmed that the #2 115KV Bus differential operated for the failure of Breaker 9640, but why didn't that isolate the fault? After field personnel examined the switchyard it was discovered that when Breaker 9640 failed it sprayed oil onto a neighboring breaker. That breaker was Breaker 9660, the #2 and #3 115KV Bus Tie Breaker. The oil then caught fire and the fault that started out on the #2 115KV Bus now included the #3 115KV Bus.

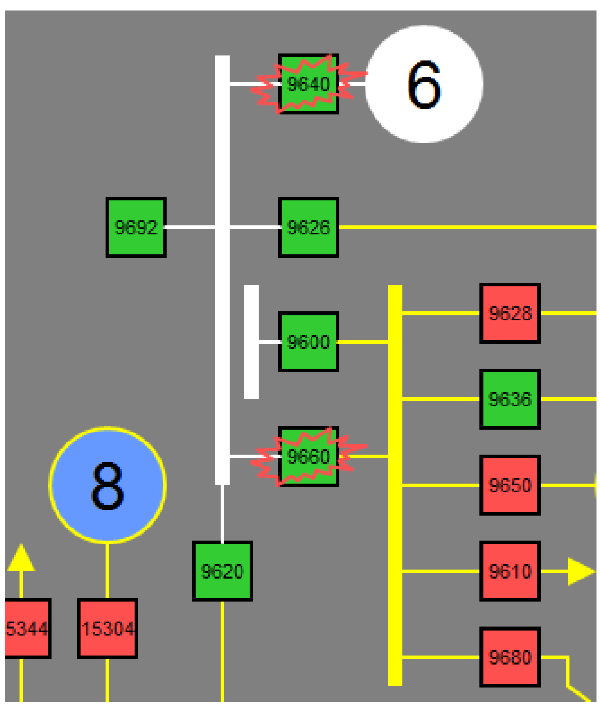

Figure 5: Plant Gorgas #2 and #3 115KV Buses - Shortly After the Fault Included Both Buses

The #3 115KV Bus differential operated but the LOR did not trip any of the breakers on the #3 115KV Bus. Breaker 9636 tripped when the fault included the #3 115KV Bus because the fault magnitude was so high and it had old electromechanical relays. It was later discovered that the Lockout Relay (LOR) for the #3 115KV Bus had failed before the event took place but we had no way of monitoring these coils. Since the differential couldn't trip the bus breakers lines feeding Plant Gorgas began to trip out for Zone 2 and reclose. Unit's #7, #8, and #9 trip off as well for Out of Step, this was a loss of 421 MW's. We now had the answer to why the fault was not isolated to the #2 115KV Bus and when is spread to the #3 115KV Bus. We also learned why the lines around Plant Gorgas began tripping.

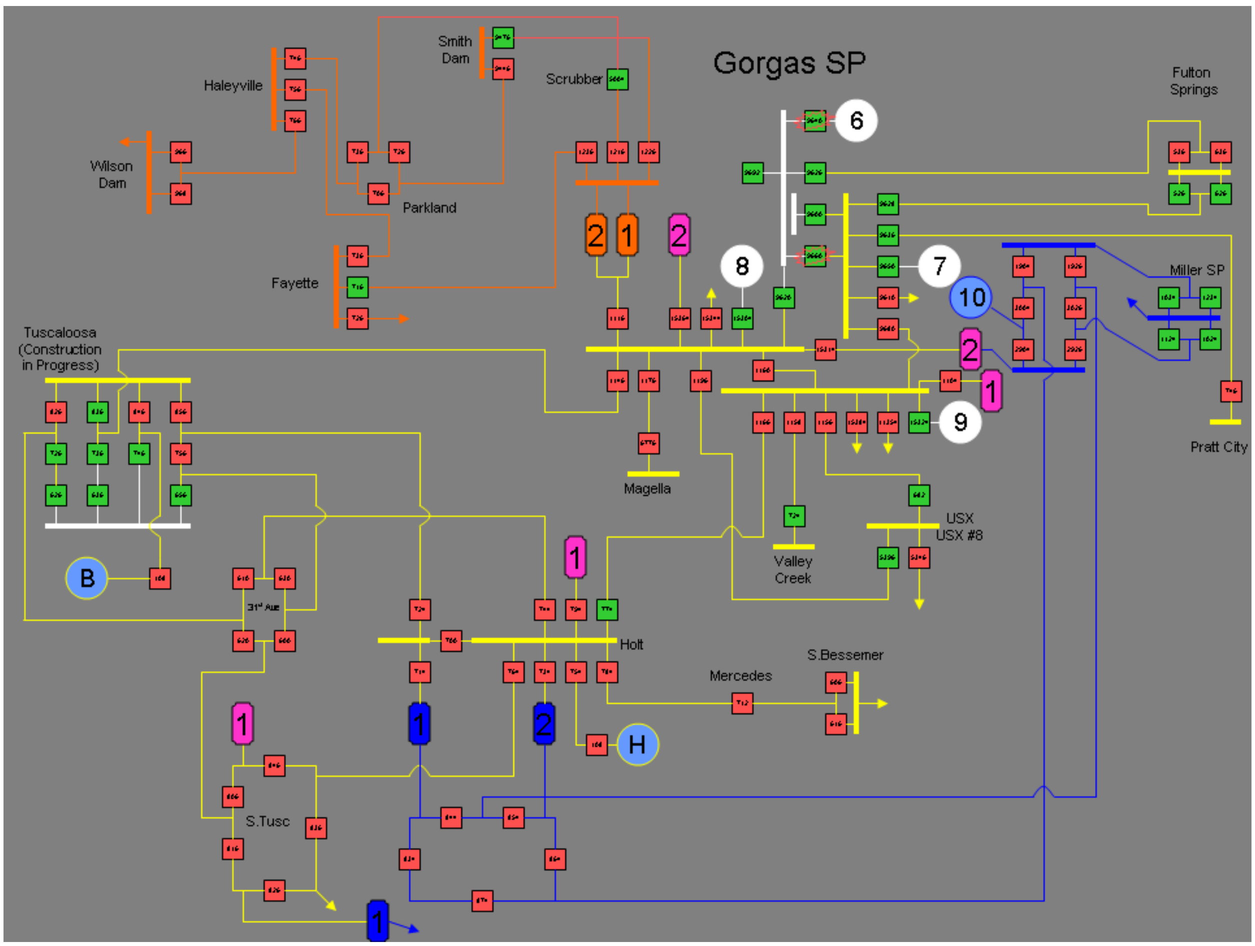

Figure 6: Event Area Single Line Diagram - Shortly After the 1st Fault Disappears

The second fault appears and Unit #10 soon tripped offline which accounted for 700 MW's. This significant loss in generation causes more lines to trip out for Zone 3 and reclose. One hydro facility is also tripped offline during the second fault, which accounts for another 45

MW's. Eventually all lines feeding the #2 and #3 115KV Buses trip out and the fault is isolated. The second fault is was discovered, on site, to have been a huge fireball of burning oil that engulfed most of the #3 115KV Bus from the failing of Breaker 9640.

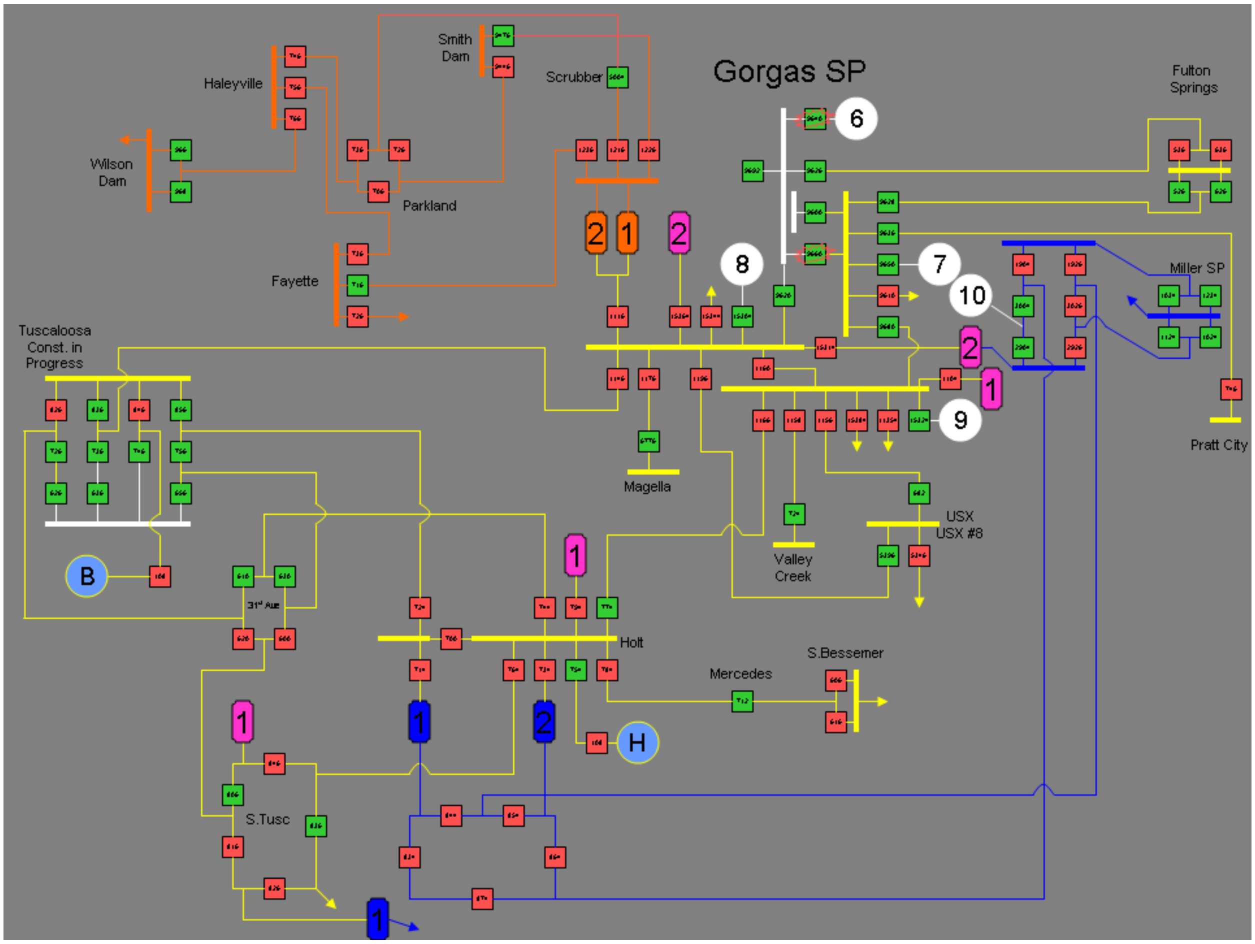

Figure 7: Event Area Single Line Diagram - Shortly After the 2nd Fault is Isolated

After reviewing all event records it was determined that everything that operated, operated as it was designed and installed to do.

Conclusion:

This event turned out to be one of the biggest, if not the biggest, event ever recorded on Alabama Power's transmission system. It took days to fully investigate and recreate what happened on paper. Luckily this event took place early in the morning while our load was relatively light. It is still unknown today what would/could have happened if this would have happened during the day. Alabama Power's EMS system currently does not have a simulation function but we are in the process of swapping over to a new system that does. This should help us to further analyze the impact of an event like this on our transmission system with different loading levels. After reviewing all event records it was also determined that everything that operated, operated as it was designed and installed to do.

We took away quite a few action items from the event to help prevent similar types of events in the future. Alabama Power has started to install monitoring devices on all LOR coils at all critical locations which included Plant Gorgas. Inspect a random sampling of similar breakers for any signs of problems to help determine if this was an isolated case or if new measures need to be taken for breaker inspections.

Author Bio:

Jerrod Moll is the Outage Planning Coordinator for Alabama Power, a subsidiary of Southern Company. Since 2007 he has worked in Operations Support department for the Alabama Transmission Control Center where he coordinates all construction and maintenance projects that pertain to Alabama Power's transmission system. In addition to his coordination work Jerrod also performs all fault analysis for Alabama Power and performs all electronic map board updates. From 2002-2007 he worked in the Automation & Fault Analysis department, also for Alabama Power. Some of his responsibilities included fault data collection & storage, and DFR/SER specification & placement. He graduated from Auburn University in 2002 with a Bachelor's Degree in Electrical Engineering – Computer Engineering Option. In 2005, he graduated from the University of Alabama – Birmingham with a Master's Degree in Electrical Engineering, specializing in Information Engineering and Management