Contract No:

This document was prepared in conjunction with work accomplished under Contract No. 89303321CEM000080 with the U.S. Department of Energy (DOE) Office of Environmental Management (EM).

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Fork Union EPC Installation Observation Report

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June 29, 2021

E-RPT-A-00003, Revision 0

1.0 Summary

On June 22nd and 23rd, a representative from Savannah River National Lab (SRNL) traveled to the Fork Union substation in Fork Union, Virginia (owned and operated by Dominion Energy) to observe the installation, calibration, and commissioning of three Electric Phenomena Cluster (EPC) sensors. The installation in its entirety included the physical securing of the EPC sensors by Dominion Energy, fiber optic cable (furnished by SmartSenseComm) being run in conduits and cable trays from the EPC sensor to the Optical Processing Unit (OPU) located in the substation switch house. The location of the EPC sensors, OPU, and cable routing can be seen in the figure below.

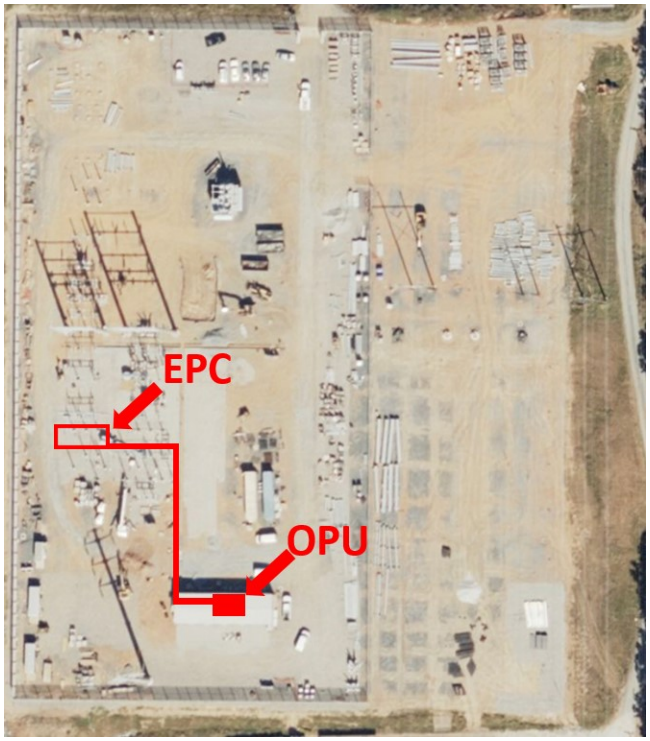

Figure 1-1. Location of EPC and OPU in Substation

After the EPC and fiber optic cables were installed, SmartSenseComm attached connectors and terminated both ends of the fiber optic cable to both the EPC and the OPU. At this point, the SRNL representative left the site due to travel requirements, however, the remaining steps that occurred were documented and are as follows: after cable connections were verified, SmartSenseComm calibrated the OPU by injecting 100A and 2000V into the EPC sensor and adjusting values on the OPU. After calibration, remote access was established via ethernet radio. A description of the entire process is detailed below.

2.0 Observation Synopsis

2.1 June 22nd, 2021

We determined that both Dominion Energy (DE) and SmartSenseComm (SSC) did not know how to interface between the ribbon cable interface (from low-voltage inputs in the SEL-351 relay) and the coaxial interface from the Optical Processing Unit (OPU). Klaehn Burkes designed a solution and used SRNL's E&I shop to fabricate a panel that was mountable on a 19 inch rack to place above the OPU unit, as well as a ribbon cable to connect the SEL-351 to the OPU, shown in the figures below. Other than that, no work was performed due to rain.

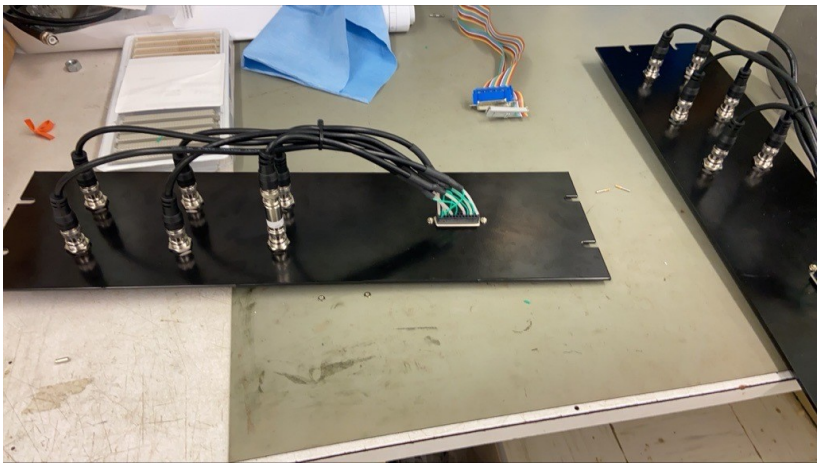

Figure 2-1. Ribbon Cable-Coaxial Interface Panel Back View

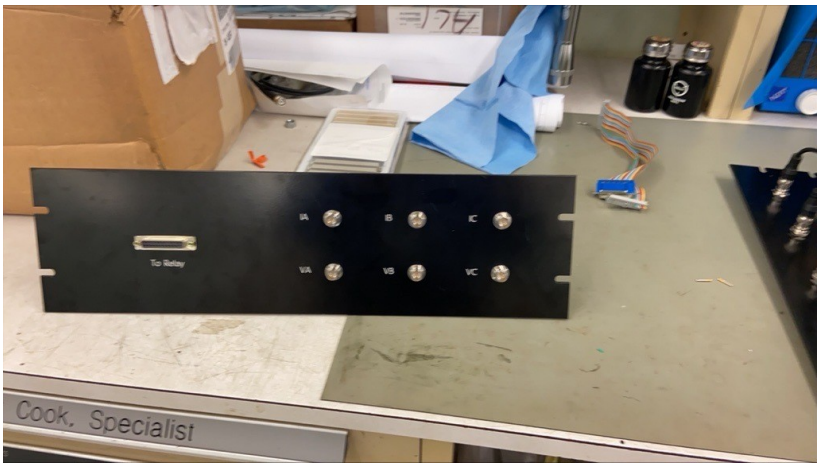

Figure 2-2. Ribbon Cable-Coaxial Interface Panel Front View

2.2 June 23rd, 2021

Met with Ariel and Stefan from SmartSenseComm (EPC and OPU technicians) and Nathan Morris from Dominion Energy (facility escort) at the Fork Union Substation. When I arrived, Dominion Energy contractors were installing the EPC units between two bus bars, shown in Figure 2-3 below. While we waited for the installation of the EPCs to conclude, Nathan, Ariel, Stefan and I went into the substation and identified the cable routing path for the ribbon cable from the SEL-351 to the OPU, which required the cable to route from the front-facing pin headers on the SEL-351 to go out an available hole in the back of the unit, shown in Figure 2-4. This then routes to the OPU via the cable path shown in Figure 2-5.

Figure 2-3. EPC Sensor Installation in Progress

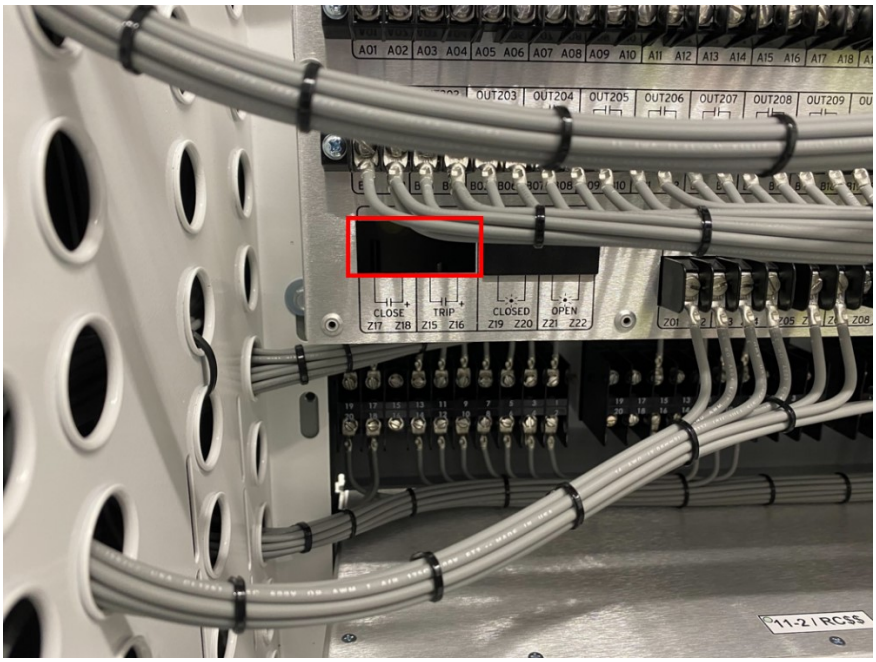

Figure 2-4. Location of Cable Exit on SEL-351

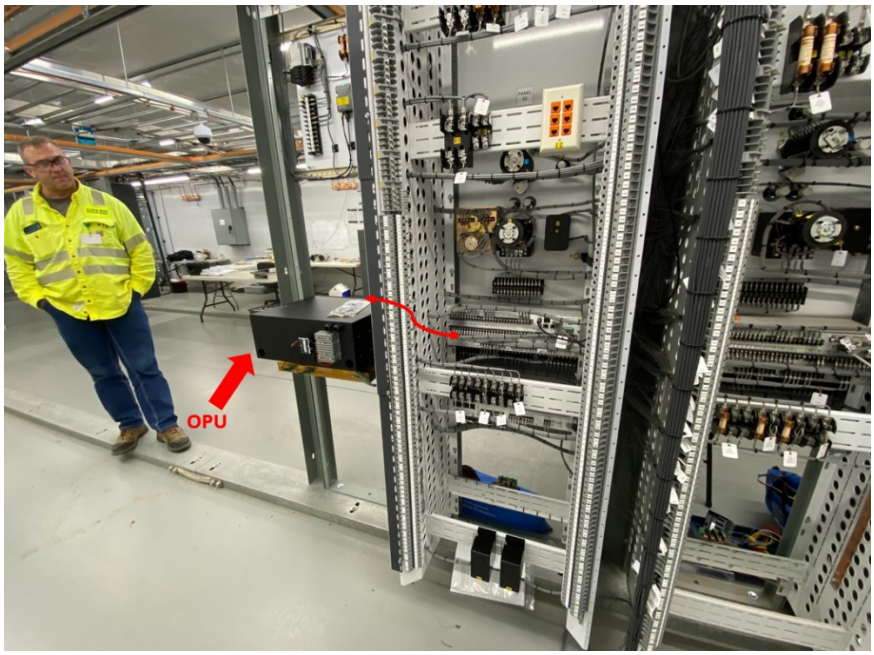

Figure 2-5. Cable Routing Between SEL-351 and OPU

After the physical EPC installation was complete, fiber optic cables were run by Dominion Energy from the switch house to the EPC sensors in the yard. Dominion Energy made sure when they were pulling the cable through the cable trays and conduit to leave enough fiber optic cable such that the cable could drop down from the base of the EPC sensor all the way down to the ground so that the cable ends could be accessed on the ground for SmartSenseComm to perform their cable work (the cable dropping down to the ground can be shown in Figure 2-3). From that point on, SmartSenseComm started their work. Their process for EPC/OPU calibration requires 2 trained individuals from SmartSenseComm, and is as follows:

1. Have person 1 in the yard where the fiber optic cables are run for the EPC and shine a laser down each cable to test for reflectivity (the integrity of the cables, making sure no damage was done) and coordinate with person 2 (via phone) in the switch house to observe the laser coming down the cable. This is also done to determine which cable is connected to each device.
2. After cables have been evaluated to be in good condition, person 2 in the switch house begins the process of installing the fiber optic cable connectors, which requires stripping and attaching the connectors to the fiber, which is then epoxied and baked using an oven. This is a very precise and time consuming process, the baking process takes an hour for each connector, however, multiple cables can be placed in the oven at the same time. This also requires a space for SmartSenseComm to set up a small table and chair (which they will furnish) and also requires a 120V outlet for the oven.
3. While the cables in the switch house are being prepared, person 1 in the yard is lifted via a boom-lift (furnished by Dominion Energy) and tests the installed EPC sensors for their respective reflectivity, ensuring that the transport and installation of the sensors did not harm the device.
4. After the cables in the switch house are done baking, person 2 goes to the switch yard and starts the process detailed in step 2, but for the cables in the yard. It should be noted that this requires either a generator or an available outlet to supply 120V for the cable baking process in the yard.
5. While person 2 works on installing the connectors for the cables in the yard, person 1 begins polishing the recently finished cables in the switch house. At this point, the cables in the switch house are inspected and re-makes are done as necessary, which is a very time consuming process. (in the case of this installation, 5 remakes in the switch house alone had to be done due to micro-fractures)

At this point in the installation, we ran out of time during the day, and I could not observe the remainder of the process because I was leaving the next morning. I did however get as much information as I could on the remainder of the process.

6. Once the cables in the switch house are polished and are verified to be in good condition, and after the cables in the yard are done baking and are polished, the cables in the yard are installed by person 1. This process requires person one to be lifted via boom-lift to the EPC and connect the cables.
7. Person 2 connects the cables in the switch house into the OPU unit.

At this point, the installation is complete. The calibration of the sensors is now initiated.

8. If the power cables connecting the EPC sensor to the rest of the substation are connected, the utility (DE) needs to remove these power cables. The power cables for the Virginia installation were disconnected and tied away from the EPC sensor, which can be seen in image Figure 2-6.

Figure 2-6. Power Cable Securing

9. The utility (Dominion Energy) installs cables leads for the Omicron CPC-100 (shown in Figure 2-7 below) onto the EPC sensor in the yard (which is a high current and high voltage source used by SSC to inject high currents and high voltages into the EPC for calibration) and lowers the cable leads to the ground, where the CPC-100 is located. In some instances, SmartSenseComm remarks that they have elevated the CPC-100 on a platform to make the cables reach. It should be noted that the CPC-100 also requires a 120V source, which requires either a generator or an outlet in the yard in close proximity to the EPC.

Figure 2-7. CPC-100 Calibration Device

10. Person 2 connects a monitor and keyboard to the OPU in preparation for calibration, both of which are supplied by SmartSenseComm
11. After the CPC-100 is plugged into both power and the EPC, person 1 coordinates with person 2 (who is located in the switch house and connected to the OPU) to inject upwards of 100 Amps to calibrate the current and 2000 Volts (separate tests) to calibrate the voltage. The process detailed in steps 8-11 is repeated for each EPC sensor.
12. After the calibration process is completed, the utility reconnects the power cables to the EPC

At this point, remote access was configured. Dominion Energy provided a Sierra RV50X Industrial LTE Gateway as well as a SIM card for remote transmission of data from the substation to both SRNL and SmartSenseComm facilities. The LTE gateway can be seen in Figure 2-8 below.

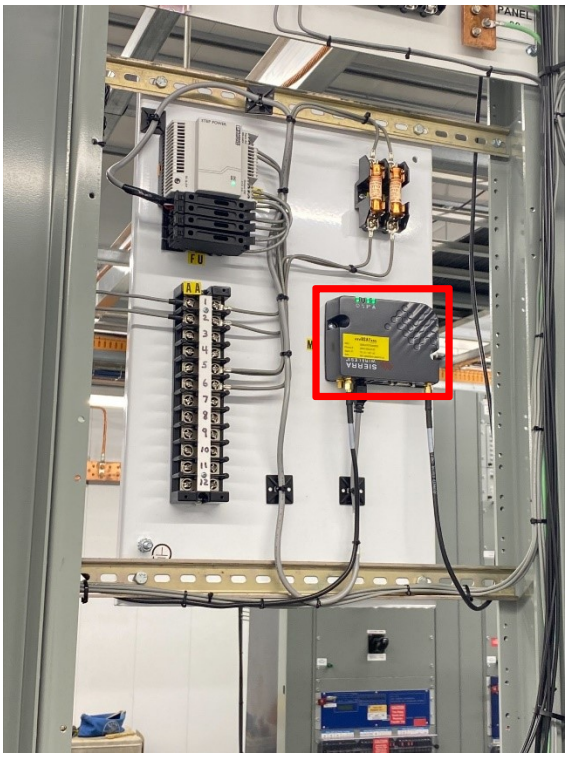

Figure 2-8. Cellular Gateway Installation

3.0 Important Notes and Lessons Learned

- The SSC team needs 120V in both the switch house and in close proximity to the EPC in the yard, possibly need extension cables
- Have the EPC installation completed, and the fiber optic cables already ran between the EPC and the OPU the day before SSC arrives. SSC cannot perform any work until the EPC is installed and cables are run.
- Cable manufacturing is a very time consuming process, best case scenario the entire SSC process takes a half day, worst case a day or more
- On the day of, the only utility crews (on the operations side) required would be a crew to operate the boom-lift and disconnect/connect power cables to and from the EPC and a crew for switch house wiring.
- Have all of the SSC equipment mailed to the site long beforehand. They need 2 hard-body boxes for the cable connector manufacturing, a foldable table (possibly 2), a foldable stool (possibly 2), 2 hard-body boxes for the CPC-100 (image (3)), and misc. extension cables/tools.
- The cables for the CPC-100 are only 16 ft long and **cannot** be extended for instrument precision reasons.
- For the SRNL installation, the EPC is 50 ft in the air (rough estimate). I spoke with both Ariel and Stefan and they informed me that they could train a Dominion Energy personnel to operate the EPC. That way we would not have SmartSenseComm personnel 50 ft in the air injecting hazardous energy levels into the sensor.
- Dominion Energy can connect and operate the CPC-100, but **anything** involving fiber optic cables has to be performed by SmartSenseComm. This includes the inspection of the EPC after Dominion Energy installs (step 3) and the installation of the cables into the EPC (step 6).
    - This means that a SmartSenseComm personnel will have to go up the boom-lift for both of those activities
- Dominion Energy should not ever (unless instructed by SSC personnel) open the box at the base of the EPC sensor. Any tampering with the device other than the necessary installation tasks is off-limits.