NAME: Rafael Fernandes (Second Contribution to Q2.03)
COUNTRY : Brazil
REGISTRATION NUMBER : DLG7268

GROUP REF. : B5
PREF. SUBJECT : PS2
QUESTION N° : 2.03

1. Question

Q2.03: What are the experiences to fault identification and location and how to design the scheme to meet the practical application requirement?

2. Keywords

Fault Location, Metereeological Data, Root-Cause, Disturbance, Transmission Line

3. Main Contribution

The use of resources for fault location, including lightning and fire estimation, for example, has been very useful for the first identification of faults in high voltage transmission lines. This contribution will present the state-of-the-art of a meteorological system used in the high voltage networks of a Transmission System Operator (TSO) in Brazil and also a real case of disturbance in a 500 kV TL. In Brazil, the ONS (Brazilian National Grid Operator) requires that a description of the disturbance need to be classified, including identification of the root cause. Depending on the day of the week the disturbance occurs, there may be a very short period of time for the TSO TL maintenance teams to identify the root cause, which may be less than 3 days, for example. The use of meteorological resources helps a lot in the identification of Atmospheric Discharges (AD), winds and/or fires.

4. Metereological System

Brazil has more than 150,000 kilometers of transmission lines. On the other hand, Brazil is a country with a continental extension, where AD and fires are part of the TSOs daily routine operations. With so many assets spread throughout Brazil, many companies find problems justifying the interruption of a certain section of line after a lightning storm occurs, or even after a fire has occurred nearby, since in many places physical access becomes very difficult. A viable alternative is the remote monitoring, in real time, of the meteorological and environmental variables around the TL. In Brazil there are two tools, Climatempo and Netclima, both developed nationally. With these tools it is possible to:

- Consult the historical database of lightning and others for the TL (1 - 10 km around the TL);
- Send weather risk alerts for a given stretch of TL a few minutes in advance through a mobile application;
- Weather report with specific document to prove damage and outages in the TLs;
- Real-time monitoring of rain, wind, lightning and fires around the TL;
- Development of custom APIs, such as automatic notification/email sending;

In addition, state-of-the-art systems allow you to load specific layers of information, such as:

- Substations;
- TL towers of all voltage levels;
- TL with different colors of identification, according to the voltage level;
- Visualization of regions in Brazil, being able to visualize the displacement of storms with lightning, etc.

5. Incidence Monitoring of Atmospheric Discharges

The visualization of AD is done through maps with georeferenced data (allowing zooming in the region of interest), using data from the ENTLN (Earth Network) detection network reference. The systems have cloud-to-cloud and Cloud-to-ground data that can be followed in a predictive way to follow the storms' displacement, showing for each discharge its precise location as well as the intensity of the AD current, in kA. The discharge resolution reaches up to 200 meters, allowing the updating of the images minute by minute, indicating point by point the discharges that are occurring. There are possibilities of discretization of the discharge visualization period, for example, 5 min, 10 min, 20 min, 30 min and even 60 min, for example. The robustness of these systems also allows the crossing of satellite images and meteorological radar simultaneously with the transmission assets, with animation of the images, including also the maps of rain forecast, air temperature, relative humidity, atmospheric pressure, wind direction and speed, as well as atmospheric precipitation with up to 24 hours in advance, including also the fires in real time. In Figures 1 and 2, it is possible to verify the crossing of rainfall information with the incidence of AD, as well as the amount of meteorological radar used for monitoring the amount of rainfall, particularly in southeastern Brazil.

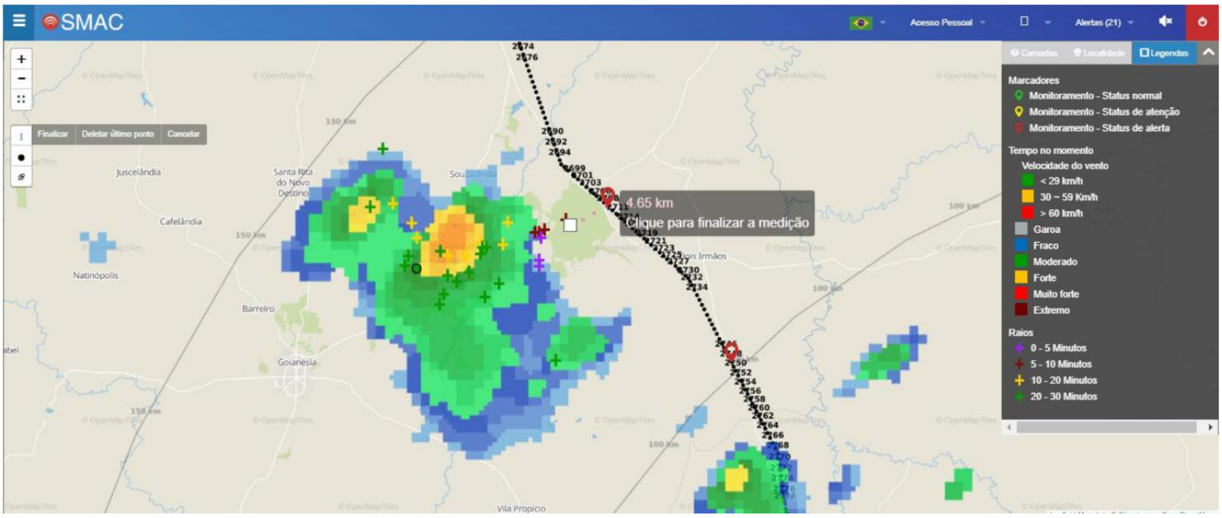

Figure 1 – Rainfall Monitoring x Lightning Incidence

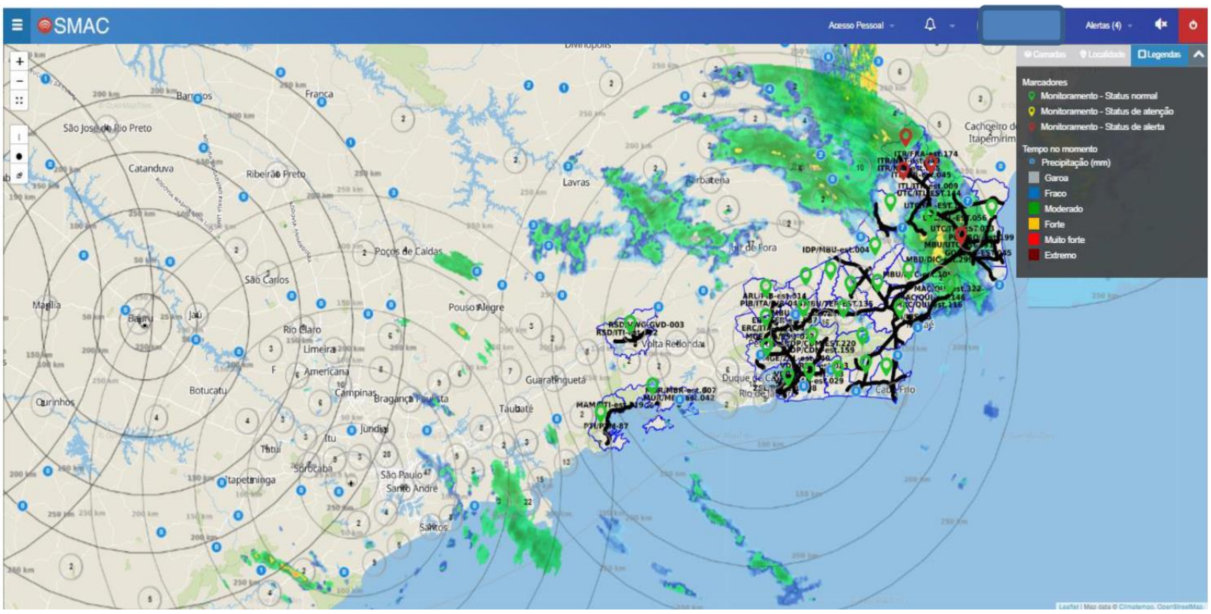

Figure 2 – Metereological Radars for Rainfall Monitoring in Southeastern Brazil

6. Real Case Disturbance in the BIPS

A real case will be presented considering a 500 kV TL, in the Northeast region of Brazil, where there was a TL shutdown by AD, using the Climatempo tool. This identification was possible a few minutes after the shutdown, where there was field confirmation by the TL maintenance teams, with an error of only one span of the tower (500 meters). Figure 3 shows the monitoring of the 500 kV TLs of one TSO in Brazil, with the identification of the tower numbers directly on the operator's screen.

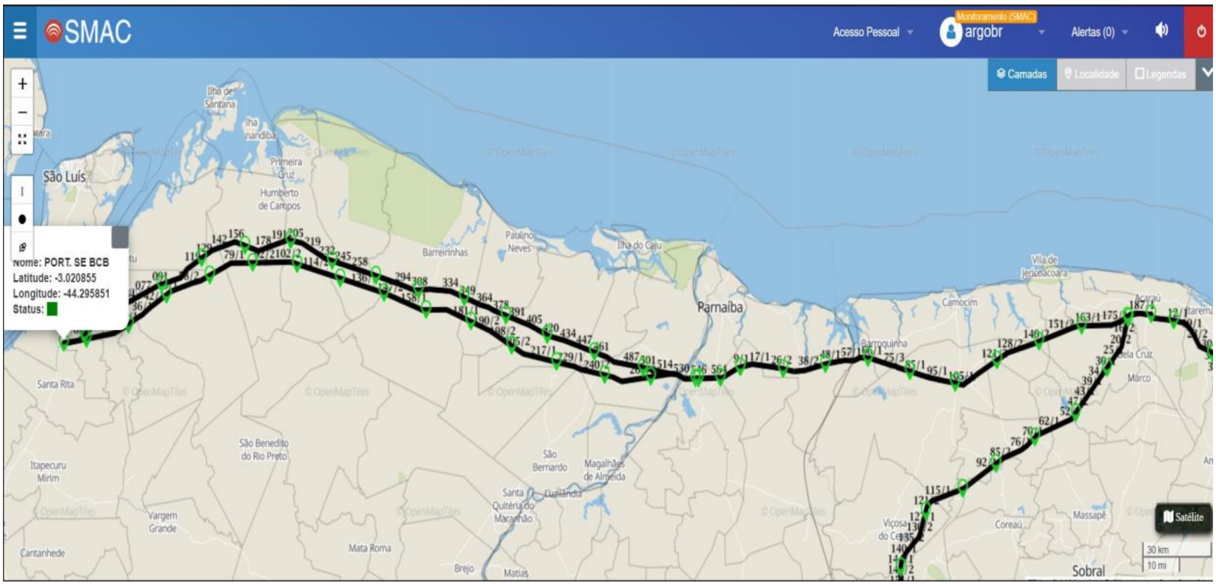

Figure 3 – Climatempo System – Identification of the 500 kV System´s Transmision Towers

On 07/29/2022, at 15:04h (GMT-03h) there was an automatic disconnection of a 500 kV TL in the BIPS. The protection teams department identified it as a single-phase short circuit involving phase A, with correct performance of the protection systems and satisfactory performance of the automatic reclosing scheme. The TL has a length of 286 km, and the protection system identified the location of the fault at 29,9 km from one reference terminal, and the negative sequence algorithm located the fault at 43,0 km. However, using the Climatempo system, the fault was located at 35 km from this reference terminal. In Figure 4, there is the location of the fault, and the identification of the Transmission Tower (between towers 69 and 71). In Figure 5, there is the calculation (estimation) of the fault location. It can be seen that the meteorological system identification of the AD, was able to locate the fault with a better precision, helping and supporting the field engineers.

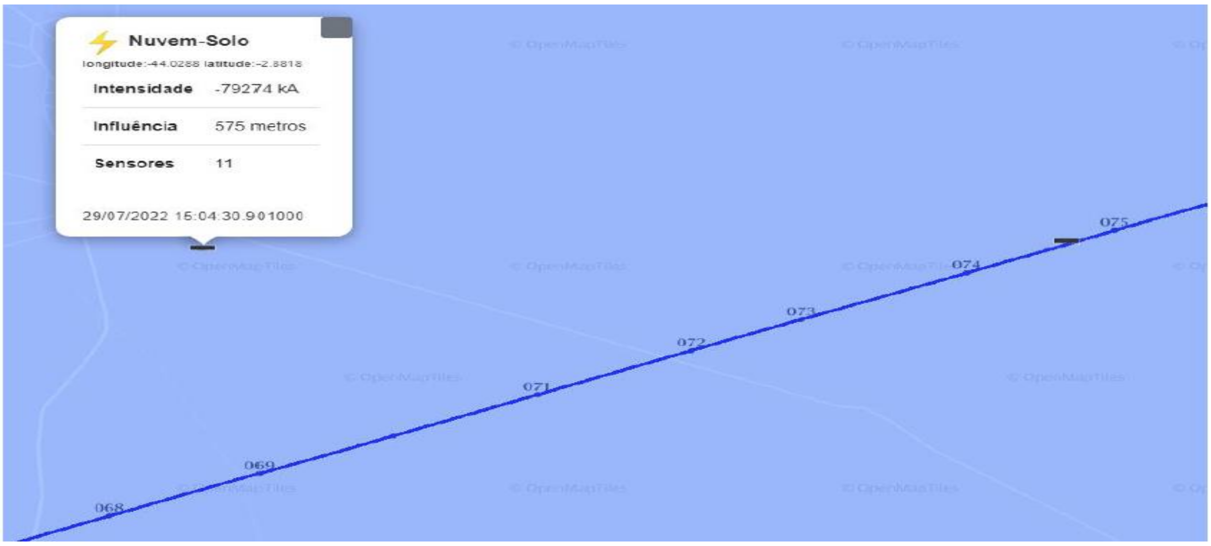

Figure 4 – Fault Location Estimation (Trasmission Towers)

Figure 5 – Fault Distance Calculation and Transmission Tower Identification

Finally, after visual identification, carried out by the maintenance teams, traces of AD were found on the insulators, in transmission tower number 69, as can be seen in Figure 6.


Figure 6 – Atmospheric Discharge Identification – Tower nº 69

7. Conclusion

The use of support tools to locate and identify faults on high voltage transmission lines is extremely important for root-cause analysis by the maintenance and disturbance analysis teams by TSOs. Without such tools, all that remains is the fault location calculations by the protection relays and DFRs, and such equipment is not always able to calculate the fault with good precision, depending on several factors, such as fault impedance, non-homogeneity of the sources, intermediate infeed, etc., as well as not always being able to estimate the fault impedance, and differentiate from one atmosferic discharge or wind, for example. This contribution showed a real case, where the benefit was very significant for the company when using the tool for monitoring meteorological quantities, which, therefore, besides classifying the root-cause of the disturbance, helped a lot in the identification and localization of the fault. Moreover, having weather variables monitoring tools available, in real time scenario, enables the predictive operational monitoring of the assets of one TSO, such as transmission lines, for example, being able to evaluate the rainy and burning periods and, if necessary, to reevaluate the maintenance intervention dates already planned. Thus, a series of benefits can be observed when using such a resource, being a handle tool, which can be used directly by the operation teams of the control centers, for example.

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