BX12 - Cutting-edge Technology Supporting Hydro Paragominas Transmission Line Management System

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Abstract

Hydro Paragominas bauxite mine is a Norsk Hydro enterprise with a fully integrated system for the production of processed bauxite, which includes mining activities and ore processing on the Miltônia Plateau 3 in Paragominas, as well as a pipeline pumping system to transport the bauxite from Hydro Paragominas to Hydro Alunorte. Electricity is supplied through a 230 kV Transmission Line (TL) made up of 560 transmission towers and 236 km long, and there is no redundancy in the energy supply to the plant In this way, guaranteeing the reliability of this transmission line is extremely important for the business continuity. In this way several monitoring strategies were adopted to strengthen the reliability of the Transmission Line and to increase the safety for employees, the environment and the population around the LT right-of-way. Among these strategies can be mentioned the annual aerial inspection with laser mapping, continuous imaging and thermography; pilot project for online monitoring of the towers; wheather monitoring, among others. The aim of this work is present these strategies and how they helped Hydro Paragominas to guarantee the continuity of the business, avoiding transmission line incidents and shutdowns.

Keywords: Operational management, Transmission line, Reliability, Operational guarantee, Energy supply.

1. Introduction

Hydro Paragominas bauxite mine (MPSA) is a Norsk Hydro enterprise and contemplates the implementation of an integrated system for the production of processed bauxite, which includes mining activities and ore processing at Plateau Miltônia 3, in Paragominas-Pará (PA).

The electricity supply for the enterprise is made through a Transmission Line (TL) of 230 kV composed of 560 transmission towers and 236 km long, starting at the substation of Vila do Conde in Barcarena-PA, to the substation in the MPSA in Paragominas-PA, crossing seven municipalities: Barcarena, Abaetetuba, Mojú, Acará, Tomé-Açú, Ipixuna do Pará and Paragominas, as shown in Figures 1 and 2. The Pump Station 2 (PS 2) pump station is located in the municipality of Tomé- açu and is also served by the said Transmission Line, through a bypass existing at km 120.

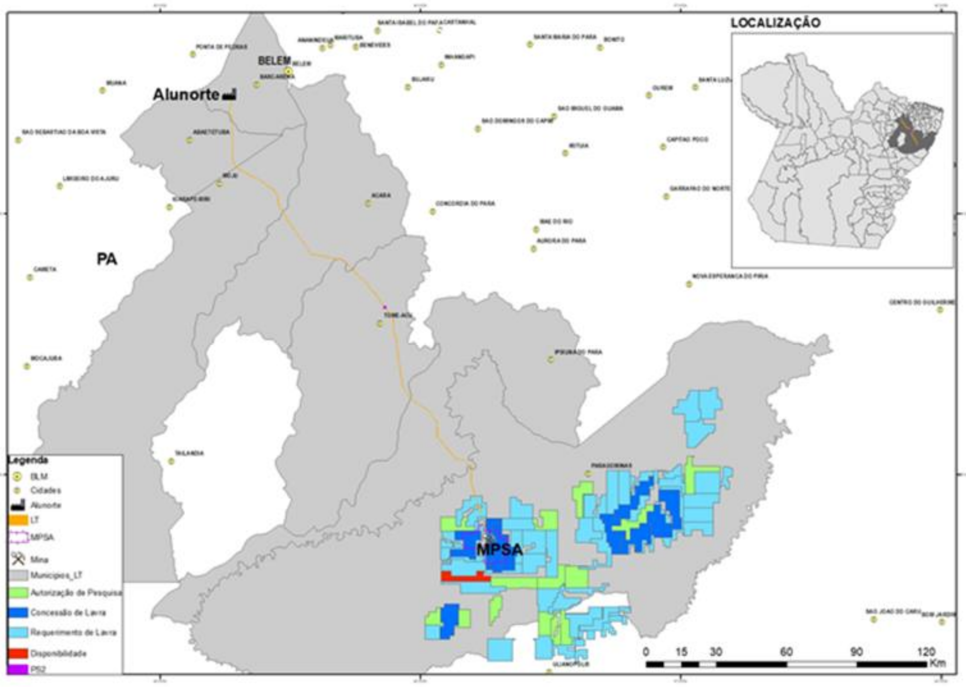


Figure 1. Vila do Conde - Miltônia 3 transmission line [1].

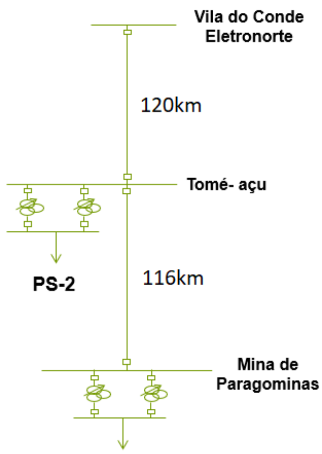


Figure 2. Vila do Conde - Miltônia 3 transmission line and pump station 2.

The transmission towers are divided by municipality according to Table 1.

Table 1. Towers by municipality.

City	Towers	Quantity of towers
Barcarena	1 to 29	29
Abaetetuba	30 to 78	49
Moju	79 to 140	62
Acará	141 to 228	88
Tomé-Açu	229 to 406	178
Ipixuna do Pará	407 to 489	83
Paragominas	490 to 560	71

2. Objective

The objective of this work is to present how the operational and maintenance strategies of TL Vila do Conde – Miltônia 3 helped Mineração Paragominas to strengthen the reliability of the Transmission Line and increase safety for employees, the environment and the population around the transmission line.

3. Transmission Line General Characteristics

Among the main characteristics of the Transmission Line the following can be mentioned:

- Name of LT: Vila do Conde – Miltônia 3
- Approximate length of LT: 236 km
- Operating voltage: 230 kV
- Structures: Metal lattices, self-supporting and cable-stayed, with a single circuit
- Conductor cable: CAA 795 MCM – 45/7 wires - “TERN”
- Lightning cables: CAA - EF 51.56 mm^2 – 12/7 – PETREL and galvanized steel 3/8” – EHS – 7 wires
- Insulators: suspended, tempered glass, CB 254 ×146 mm, class 12 000 kgf
- Grounding: copper-plated steel wire (Copperweld) - No. 4 AWG - radial arrangement
- Medium span: 421 meters and Maximum span: 648 meters
- Service range: 60 meters

4. Types of Structures

The transmission line is composed of guyed and self-supporting lattice metallic structures, the typical silhouettes of these towers are shown in Tables 2 and 3.

Table 2. E3, S3, SE, S7 and ST Structures [1].

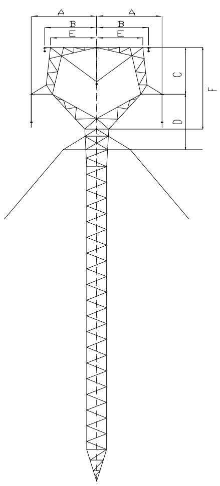
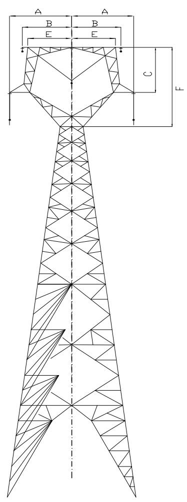
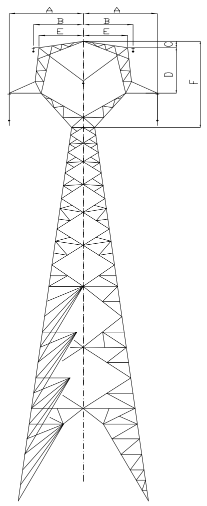
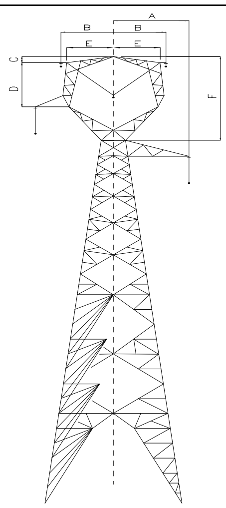
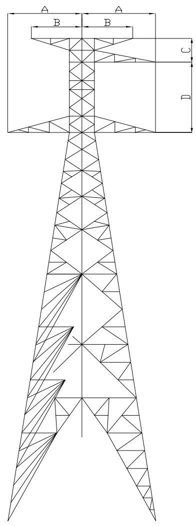
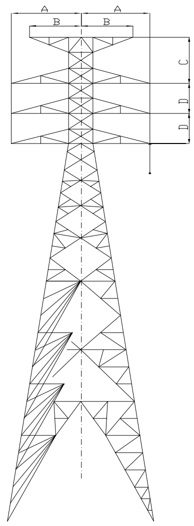
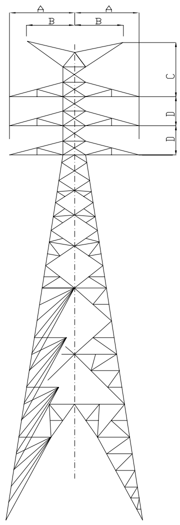
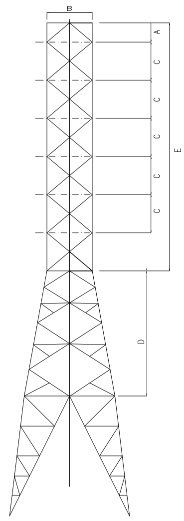
			
E3 Structure	S3 Structure	SE and S7 Structures	ST Structure

Table 3. A30, A60F, DS3, D60F e DG Structures [1].

			
A30 and A60F Structures	DS3 Structure	DA60F Structure	DG Structure

The E3 tower is a guyed-type structure, this structure is formed by the union of overlapping modules, forming a tower that must be tied to the ground or guyed; the other types of towers in this TL are self-supporting, that is, they are towers that support themselves independently, dispensing with the aid of other structures, such as stays.

The E3 structure corresponds to approximately 63 % of the Transmission Line towers. In the Transmission Line project there was a preference for the use of this type of tower because they are low consumption steel towers, compared to self-supporting towers, which guarantees lower cost and easier installation.

5. Technology Supporting Hydro Paragominas Transmission Line Management System

In order to guarantee the integrity of the transmission line, operational continuity of the business and ensure the safety of the community and employees, some monitoring technologies were deployed in the transmission line and its towers. These technologies are detailed below.

5.1 Annual aerial inspection

Since 2020, an annual aerial inspection of the Vila do Conde – Miltônia 3 Transmission Line has been carried out along the entire length of the TL, from the municipalities of Barcarena to Paragominas, in the state of Pará.

In the aerial inspection, the following are checked: the general condition of the transmission line, the integrity of the insulator chains, the verification of hot spots, the integrity of the lightning rod cables, the stability of the structures, the approximation of vegetation to the cables and the possibility of burnings.

5.1.1 Laser profiling

Remote sensing has proven its usefulness in collecting information and its products are easy to integrate with other tools used in transmission line inspection. The Laser Profiling system is an active remote sensor used to measure the distance between the imaging system and the surface of objects, effectively, the system obtains digital data from the surface of the land with accuracy equivalent to that of the GPS system.

The operating principle of the LiDAR system is based on the use of a laser pulse that is fired in the direction of the surface and when it reaches it, part of this emitted signal is reflected in the direction of the sensor. Figures 5 and 6 show data acquired using LiDAR technology.

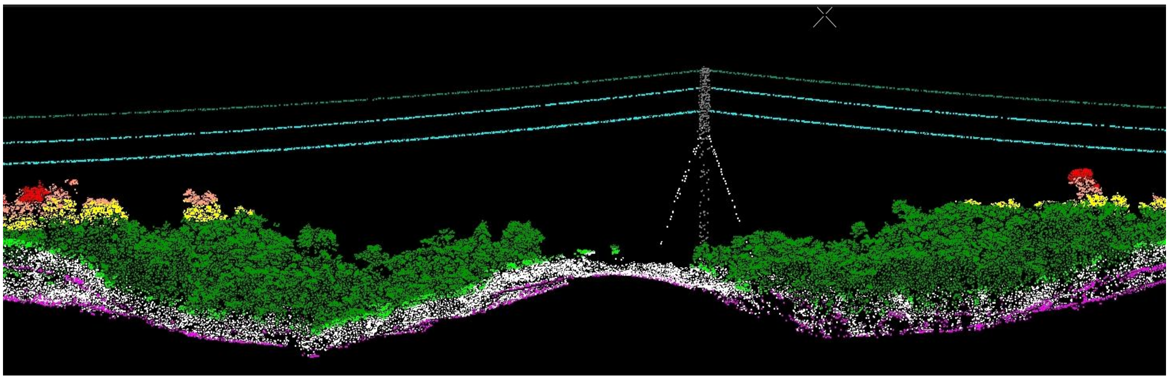


Figure 3. Vegetation of the Transmission Line Right of way [2].

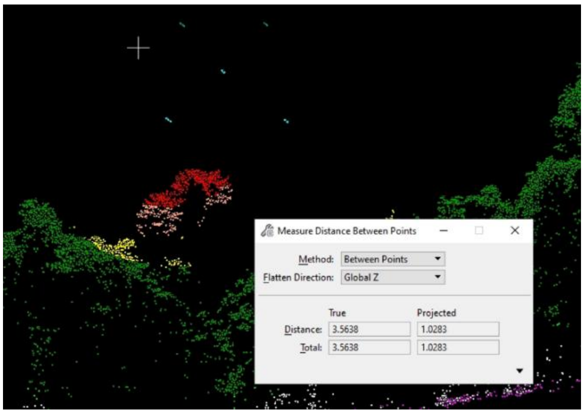


Figure 4. Proximity between the tree and the conductor [2].

The great advantage offered by the system is the possibility of obtaining a large amount of data of the surface of interest, which can be processed, thus obtaining digital models of the terrain. The greatest potential for applying laser profiling technology for topographic mapping is obtaining altimetric information for a given surface using a different methodology than traditional ones with shorter working time.

LiDAR analysis occurs after the manual process of classifying the point cloud, using automatic macros, which can, through a pre-defined distance, identify and categorize anomalies/interferences according to their level of danger in relation to the transmission line.

5.1.2. Digital Photographs

Besides to be very promising, the use of digital photographic images provides an easy acquisition of important information about the integrity of the TL. The use of digital images improves the process phases and makes it less expensive in terms of time and cost. Figures 5 and 6 show images acquired using digital photography technology.

Figure 5. Digital photography of aerial inspection [2].

Figure 6. Inspection of splices in conductor cables [2].

The analysis is carried out using digital photographs and the anomalies identified involve everything from oxidation of equipment, broken/defective parts, transformers with oil leaks, deteriorated structures, cracked/burned/broken insulators, among others.

5.1.3 Thermography

One of the main objectives of thermograms in the area of mapping electric power transmission lines is the identification of objects that were previously not interpreted due to lack of data and can now be studied properly.

Thermal analysis is carried out using thermograms and the identified anomaly points have temperatures that can pose a risk to the functioning of the transmission line. Thermograms are capable of showing temperature differences through color changes, as shown in Figure 7.

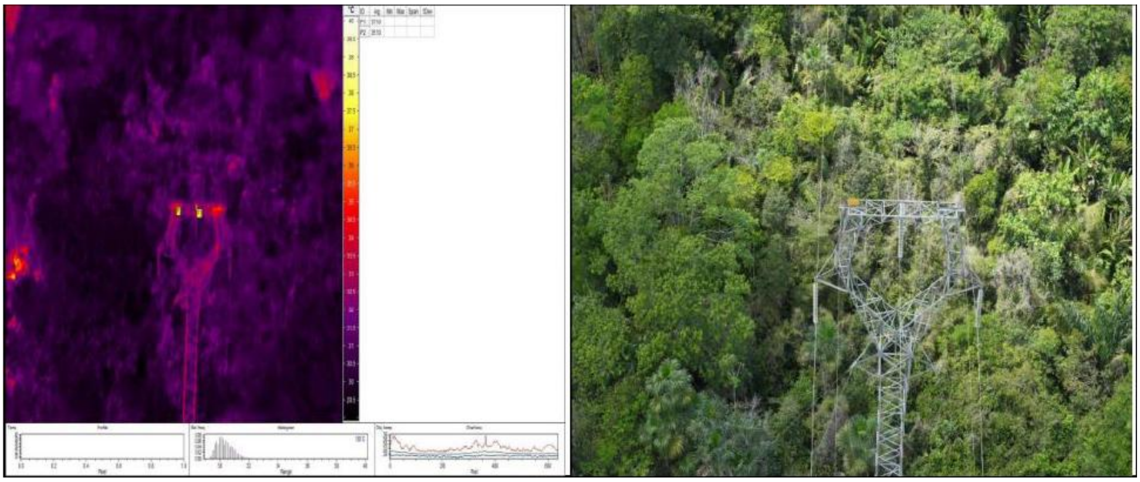


Figure 7. Termography [2].

The combination of thermographic data, digital photographs and laser profiling allows us to better analyze the integrity of the transmission line, making the integration of these data provide more satisfactory results. In this way, the maintenance strategy is always directed to the most critical points.

5.2 Transmission towers online monitoring

A pilot project for online monitoring of transmission towers is being tested, this system consists of sensors capable of detecting vibration and temperature of towers and a communication solution that allows sending this information to the cloud, thus generating an alarm for the maintenance and asset surveillance teams. Initially, this system was installed in two towers as a test and will be installed in another 20 transmission towers in critical areas. Furthermore, the installation of a sensor fiber to monitor the towers as well as the MPSA pipeline is under feasibility analysis.

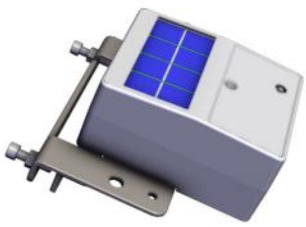


Figure 8. Sensor.

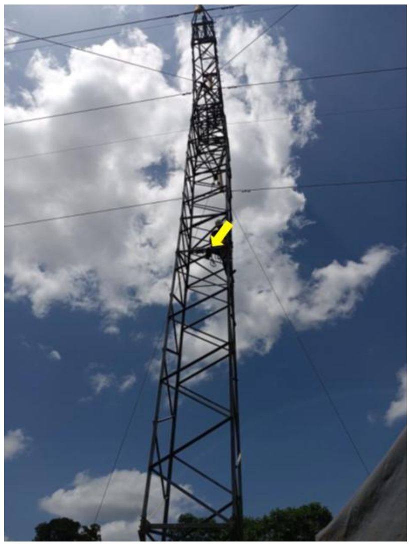


Figure 9. Device installed.

The specific panel of each monitored tower is accessed both through the alarm panel and the tower monitoring panel. It displays a map with the location of the tower in evidence, a graph with temperature and humidity variation over time, alarms triggered by current conditions, the most recent data from the tower's sensors, including main battery levels and backup and tower status (Normal or Impact Detected) as showed in Figure 10.

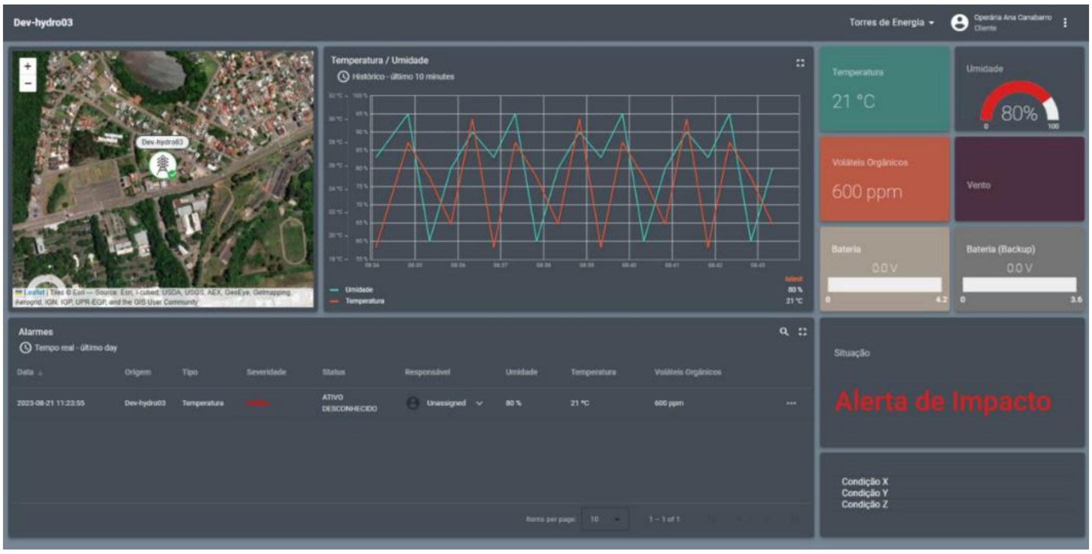


Figure 10. Tower monitoring panel.

5.3 Weather monitoring

Hydro Paragominas Bauxite Mine has a contract for remote weather monitoring and alert service for the entire Transmission Line right-of-way. The monitoring, alerting and consulting services referred to in this agreement consist of:

- Monitoring of Incidence and history of Atmospheric Discharges
- Monitoring and history of fires
- Real-time monitoring, sending and historical alerts for lightning, rain and strong winds
- View weather stations and radars
- Hourly weather forecast for 72 hours
- Weather Forecast for 15 days
- Access to monitoring application
- Sending a daily bulletin to monitor forecasts
- 24h technical support and issuance of weather reports

This monitoring allows us to identify the exact location of shutdowns caused by lightning, as well as the risk of fires, rain and strong winds, ensuring the scheduling of maintenance and inspection activities more effectively. Figure 11 shows the online monitoring of the transmission line.

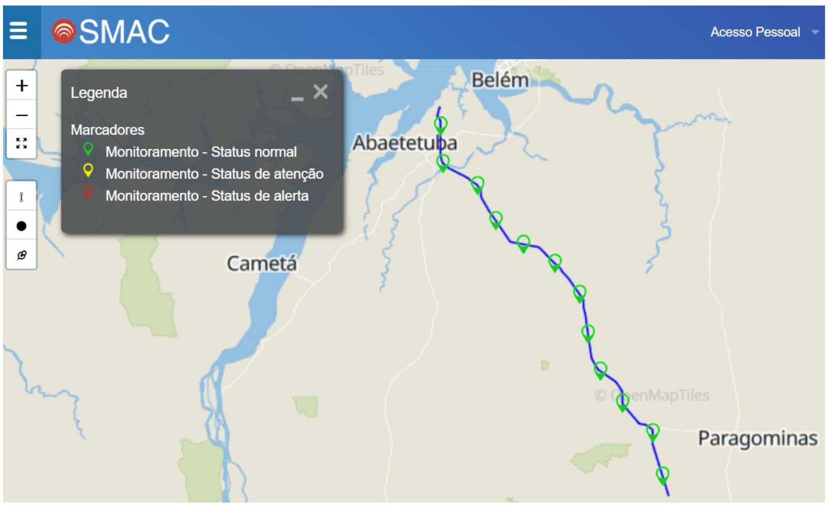


Figure 11. Transmission Line Meteorological monitoring [4].

5.3.1 Atmospheric discharge monitoring and history

The monitoring system has cloud-to-cloud and cloud-to-ground lightning data that can be monitored in a predictive way to track the location of storms, showing for each discharge its exact location as well as the intensity of the lightning. The system allows images to be updated minute by minute, decreasing point by point according to the discharges that are occurring. There is also the possibility of choosing the viewing period for downloads in 5min, 10min, 20min, 30min and 60min.

All discharges detected in this system are stored in a database that allows for subsequent evaluation, widely used to prove damage caused by these incidents, interruptions and possible delays. This history can be accessed in tables or maps, in the latter, by clicking on a radius it is possible to obtain its information. Furthermore, the system shows the lightning count for the selected period and location, where it is possible for the user to define a right-of-way, ranging from 0−10 km, around a transmission line (including substations and other assets) and obtain information for any period within the last 10 years; this basis for consulting the download history is available with the interval defined by the user, providing at least the following information:

- Date/time of discharge occurrence;
- Discharge Intensity (kA) and polarity;
- Geographic coordinates of the discharge occurrence and precision in meters;
- Indication of the presence of direct current;
- Type of discharge (Cloud-Cloud or Cloud-Ground);
- Influence area.

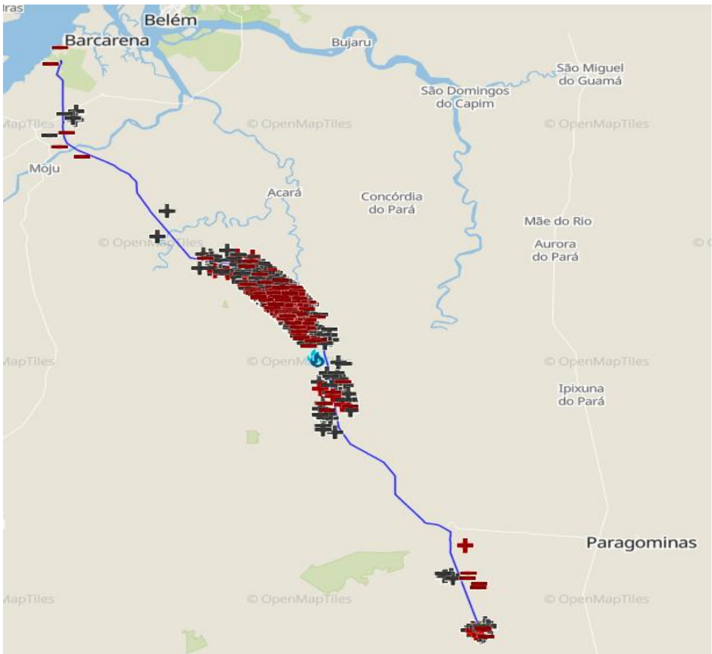


Figure 12. Atmospheric Discharges monitoring [4].

5.3.2 Fire monitoring and history

Monitoring fires/burnings is of great operational relevance for the transmission line. The monitoring system offers, through its platform, monitoring using satellite data, capable of identifying fire outbreaks (average location of 1 km), the information can be updated every 15 minutes. The images are stored and can be available for retrospective consultation.

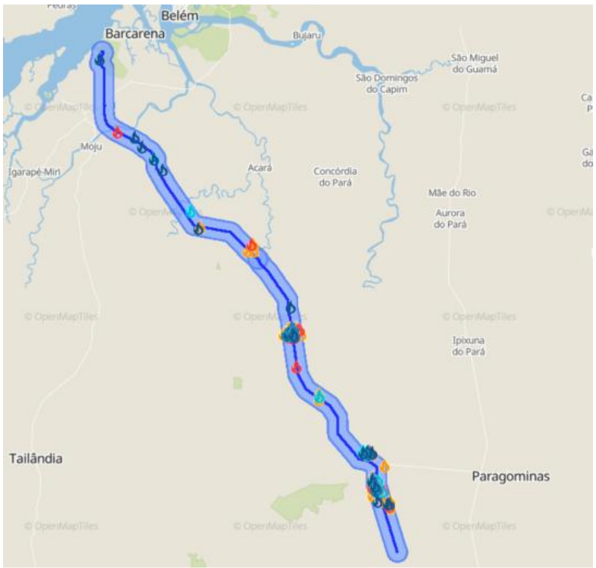


Figure 13. Burnings [4].

5.3.3 Hourly weather forecast

Over a period of 72 hours, it is possible to monitor, with hour-by-hour resolution, the forecast of temperature, relative humidity, atmospheric pressure, direction and average wind speed, precipitation and sunshine. To highlight the most relevant information, it is possible to define in the system itself which threshold values should be considered as a risk for the operation.

Within a 15-day scenario, it is possible to monitor daily forecast variations in meteorological parameters such as probability of occurrence and total volume of rain, maximum temperature, minimum temperature, wind, air humidity, visibility, pressure. The information is available in the form of a table, graph and map. It is also possible to define risk thresholds directly in the system to be highlighted in forecasts.

6 Conclusion

The Vila do Conde – Miltônia 3 Transmission Line is an extremely important asset for Hydro Paragominas bauxite mine as it guarantees the energy supply for the entire enterprise (bauxite extraction, production and pumping).

In this way, guaranteeing the reliability of this asset allows not only the operational guarantee of the Hydro Paragominas Bauxite Mine but also the safety for employees, the environment and the population around the TL right-of-way, which is the heart of Hydro's operations.

Among the monitoring adopted can be mentioned the annual aerial inspection with laser mapping, continuous imaging and thermography; pilot project for online monitoring of the towers and weather monitoring. In this work we present these strategies and how they helped us to guarantee the continuity of the business avoiding transmission line incidents and shutdowns.

7 References

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