

INNOVATIVE SOLUTION OF SAFETY CORRIDOR DESIGN FOR OVERHEAD LINES: INCREASING RESILIENCE TO EXTREME WEATHER EVENTS WHILE PROVIDING ENVIRONMENTAL BENEFITS – CONCEPT IMPLEMENTATION

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ABSTRACT

The present paper describes the initiatives that are being developed, involving the characterization of the Risk Management Buffer (RMB) criteria and implementing risk mitigation measures with the involvement of various stakeholders. Portuguese DSO have developed an effort aimed at increasing the reliability of overhead lines established through forests, while managing safety corridors with solutions that yield positive environmental impacts.

INTRODUCTION

A large proportion of Portugal's territory is populated by forests that extend to 3.2 million hectares some 36% of the geographical area. EDP – Distribuição (EDPD), the Portuguese distribution system operator (DSO) is responsible for the operation of the HV and MV networks. These HV and MV networks include 23,200 km (14,416 miles) of overhead lines erected in forest regions and 8,300 km (5,158 miles) overhead lines are routed through forests and areas designated for nature conservation. These overhead lines are exposed to hazards that include wild fires and damage caused by falling trees – particularly when subjected to extreme weather events.

The legislative and regulatory framework requires the Portuguese DSO to perform the management of safety corridors of overhead lines, including for solid fuel management. In addition, quality of service requirements are increasing, including the ones associated with the short interruptions indicator, MAIFI, mainly associated with the contact of trees/branches in the conductors of the overhead lines. Therefore, the network must become more resilient not only to Extreme Weather Events (EWE), but also to contacts on conductors leading to short interruptions.

One EWE, occurred in 2013, originated interruptions with an Equivalent Interruption Time (proportional to interrupted installed capacity) of 30 minutes and direct total cost of € 6 million.

EDP Distribuição has invested in network automation, which must be complemented with an increase on the resilience of overhead lines – which account for about 80% of total line length.

The fall of trees outside the safety corridors was identified as the main cause / factor in reducing the resilience of overhead lines.

EDPD have developed an effort aimed at increasing the reliability of overhead lines established through forests, while managing safety corridors with solutions that yield positive environmental impacts.

The concept of a Risk Management Buffer (RMB) was developed by EDPD, in cooperation with FloraSul, an environmental NGO that aims for the conservation of forest areas throughout the entire country. This concept was introduced in [1]. It was implemented on an area identified in [2] as being exposed to EWE with impact on the electrical infrastructure. It also considered other potentially aggravating conditions impacting on overhead lines, including the ones described in the Forest Fire Risk Chart and the Natural and Technological Hazard Map [3].

An EWE might cause trees falling and/or contacts with branches, resulting in damage to the overhead line conductors. These events are more likely to occur in areas prone to strong wind turbulence, with tall trees, particularly isolated pine or eucalyptus trees, pine trees weakened by parasite (nematode), or isolated trees growing in unstable soils.

In response, the RBM was created, now being tested through a pilot implemented on Lourical, a Portuguese region vulnerable to EWE.

The research pilot project required the production of land use cartography (LUC) using aerial platform equipped with LiDAR and HD camera (RGB/NIR) to record large areas and to identify those large trees within the falling distance to damage the overhead line. The LUC also records the forest species in close proximity to the overhead lines and the pine trees potentially affected by pests and diseases.

CASE STUDY

Lourical is one of the vulnerable regions regarding EWE, combining high exposure with the existence of extensive forest cover and unstable soil conditions. In 2013 Lourical suffered a large storm (Gong) which did plenty of damage to the overhead line networks. Therefore, the Portuguese DSO is using this area as a pilot for the RMB concept as presented in [1].

The pilot project involves interactions with various stakeholders, including local authorities, land owners and environmental associations, in order to maximize the opportunities associated with safety corridor management. This intervention area includes 614 km (382 miles) of HV and MV overhead lines.

The pilot was implemented based on the process presented in Fig. 1.

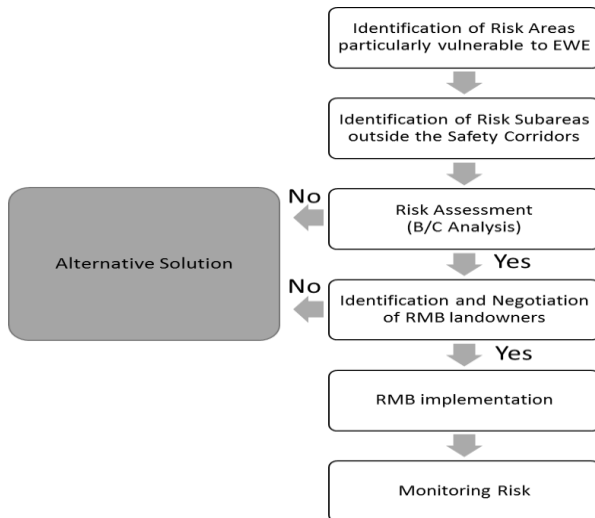


Fig. 1 RMB process

An innovative advanced methodology of LiDAR and HD image data processing was developed for this project, with an average cost of 375€ per km. The LiDAR flight and HD camera (RGB/NIR) was performed by the highly experienced EDP Group Consortium – EDP Labellec who monitor the overhead lines for EDP Distribution.

The critical areas are identified through advanced analysis performed with the data from LiDAR and HD camera (RGB/NIR) to record the forest features in terms of location, type and size of trees that may present a potential risk. These technologies allow to quickly characterize RMB, even for significant lengths of corridors. Examples are shown in Fig. 2.

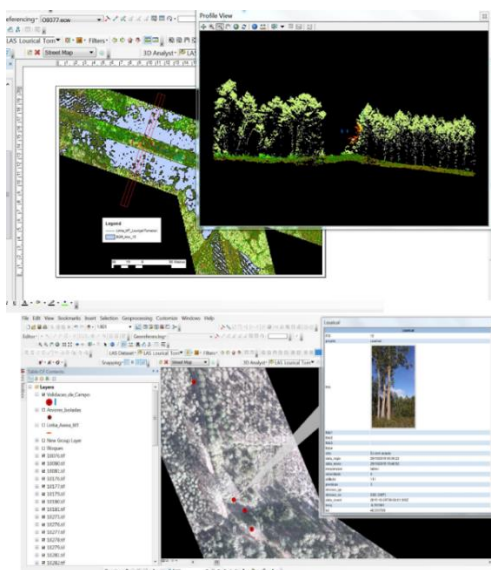


Fig. 2 a) Transversal buffer analysis b) 3D buffer view with maximum tree high c) Field control points.

The use of HD aerial images (4X4 cm pixel) allows the production of high quality land use cartography, including the identification of tree species in the RMB.

As shown in Fig. 3, the integration of the LiDAR data with this cartography supports the 3D advanced automatic analysis performed, making it possible to predict the potential risk during the life cycle of the overhead line, since annual growth of the different tree species is also considered for a period of 15 years. The mitigation interventions planning is done in this context where major risk factors are evaluated, measured and simulated.

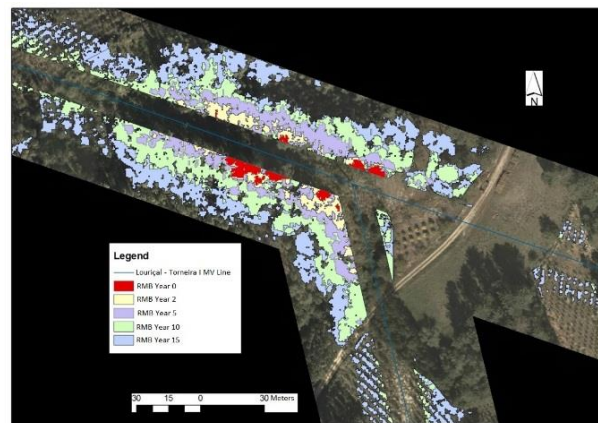


Fig. 3 RMB example for 15th years on a MV overhead line in Lourical.

The subsequently RMB Cost-Benefit Analysis (CBA), performed according with the rules that EDP – Distribuição accepts for distribution network investments [4], we were able to conclude that about 60% of the intervention areas in Lourical have only isolated forest stands or trees. On this situation, the risk can be mitigated through cost-effective interventions based on the CBA. For the remaining 40%, the decision will be taken after negotiating with the landowners and CBA reassessment. Further solutions can be implemented if the RMB does not have a positive CBA and these include:

- Installing underground cables as an alternative to overhead lines.
- The use of insulated overhead line conductors
- The use of aerial bundled conductors (ABC) on overhead lines.
- Change tracings.
- Strapping the trees.
- Others.

One project risk factor is associated with the need to negotiate RMB interventions with landowners. This risk is mitigated with the involvement of stakeholders: Civil protection, the community councils, the Institute of Nature and Forest Conservation, environmental associations, NGO, among others.

An example of property survey done in area close to the overhead lines is shown in Fig. 4. With this survey we can combine interventions in RMB with the parcel management and we are able to make easier the negotiation and the intervention itself.

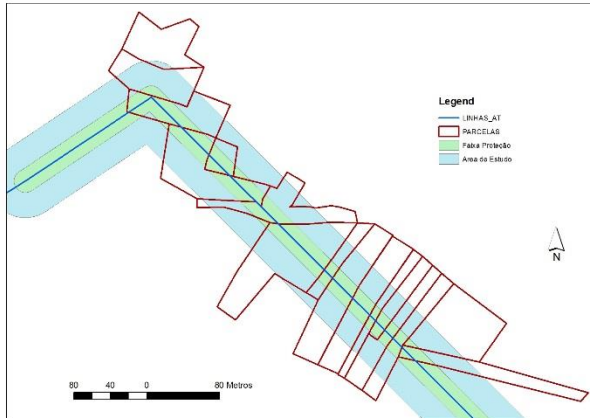


Fig. 4 Owners Parcel identification.

It should be noted that all interventions in Lourical are made in the base of promoting the replacement of fast grow tree species by other biodiversity valuable tree and shrub species and mitigating CO₂ emissions through reforestation. In a region where eucalyptus and pines are dominant forest species, these RMB include the implementation of a strategy of controlling invasive plant species such as *Acacia sp.*

Acacia sp. was identified as being present in safety corridors. Due to its fast growth, it increases maintenance costs by up to 4 times the average cost. Furthermore, this species is considered a problem by environmental authorities. A control strategy for this species, associated with the RMB, was developed in order to maximise the environmental benefits associated with the RMB concept [5], [6].

CONCLUSION

Risk Management Buffer concept is expected to increase resilience of overhead lines subject to extreme meteorological events, while achieving economic benefits and also providing environmental benefits. The expenditure on the pilot project will be 2 million euros (\$US 2.19 million) and the benefits are estimated to be 3 million euros (\$US 3.28 million) resulting in a net saving of 1 million euros (\$US 1.09 million).

The use of RMB concept to increase network resilience to extreme weather events is being used innovatively, protecting the biodiversity and guarantying that interventions are CO₂ neutral, leading to ecological sustainable corridors.

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