

OCENSA'S RIGHT-OF-WAY STRATEGY. AN OVERVIEW OF THE PIPELINE INTEGRITY AND ITS ENVIRONMENT.

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ABSTRACT

The maintenance of the Right of Way (ROW) in pipelines that run in mountainous environments such as Colombia's is a challenge for engineering. Topography, geology, hydrology and triggering agents such as rain and earthquakes require a detailed work of identification, prioritization and correction of natural hazards.

However, in recent years other types of occurrences have arisen, such as interference with third parties and the relationship with demanding communities that make the engineering challenge only a part of the work to be developed.

The Strategy considers issues like detection of threats and occurrences through helicopter-borne routes, the use of manned and unmanned aircraft and the capture of geo-referenced images, instrumented tools and regular ground surveys that provide knowledge of the pipeline, the right-of-way and its surroundings.

Currently, it is not only significant to prioritize and execute works that guarantee operational continuity, but also business sustainability over time must consider environmental issues that must be approached and led by the Operation.

Keywords: Geohazards, third parties, Management system, pipelines, hydrocarbons, right of way

1. OCENSA SYSTEM

The OCENSA pipeline is one of the most extensive linear infrastructures in Colombia, running 836 km underground and 12 km of underwater line connecting the Orinoco region with the Caribbean Sea, crossing the Andes mountain range. It is considered the backbone of hydrocarbon transportation in the country.

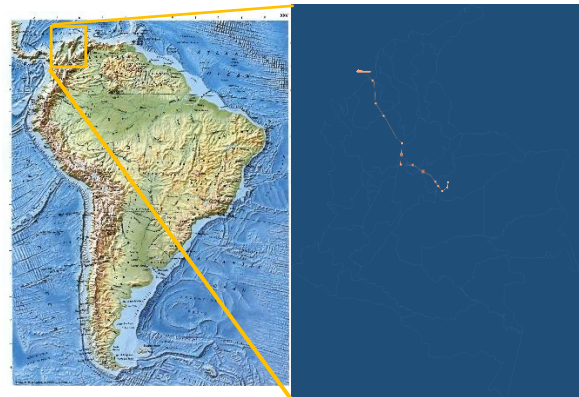


FIGURE 1: GENERAL LOCATION OF THE OCENSA PIPELINE IN SOUTH AMERICA

2. CURRENT SITUATION

Colombia's strategic location is privileged, but it reports overlapping of threats since it entirely crosses the arm of the Andes called the Eastern Cordillera and the lower areas of the Central Cordillera, with countless rivers and tributaries in the tropical zone and significant seismicity given its proximity to the Nazca plate.

Despite of the above, the selection of the construction layout and the adequate maintenance have allowed OCENSA to remain unharmed against ruptures due to natural causes.

Interferences with third parties, including other pipeline operators (OCENSA's ROW runs in a corridor of pipeline transportation of several products), roads, farmers channeling their land, miners and urban expansion into previously unpopulated areas, have made the so-called Third Party Interference Threat increase in intensity in recent years.

2.1 Geohazards

Geohazards are a major factor to be considered due to the particular combination of factors that converge in Colombia.

The OCENSA pipeline crosses an entire branch of the Andes Mountains in Colombia, which has complex topographical and geological conditions.

The convergence of the Nazca plate with South America causes the area of influence of the pipeline has significant seismicity Figure 2.

Colombia is a tropical country, so the pipeline crosses countless rivers, streams and seasonal streams. Rainfall in some areas can reach 5,000 mm/year. Instantaneous and accumulated precipitation can trigger landslides and torrential floods in the two rainy seasons that are reported during the year (Figure 3).

The global phenomena like climatic change, climatic variability led to the detection mechanism are more frequent and accurate. For this purpose, the new detection techniques playing an important role in the risk reduction.

Consequently, the identified findings and the necessary control and mitigation works require a robust maintenance plan.

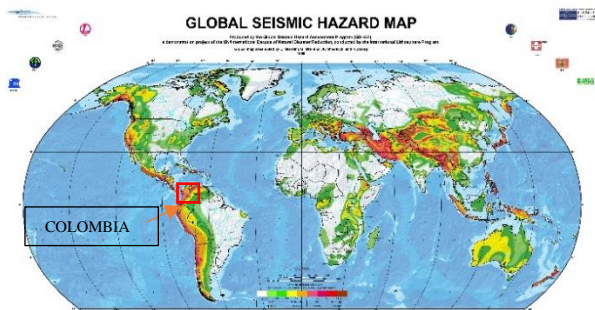


FIGURE 2: GLOBAL DISTRIBUTION OF SEISMIC HAZARD. Source: Princeton University.

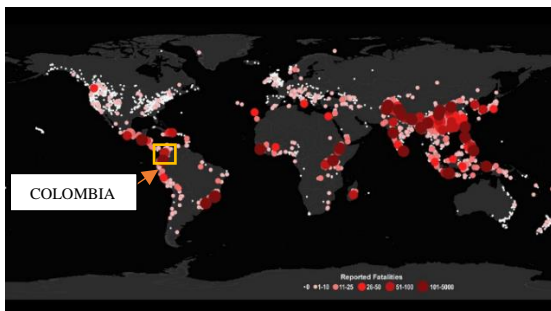


FIGURE 3: GLOBAL DISTRIBUTION OF FATALITIES DUE TO RAINFALL-TRIGGERED LANDSLIDES.

Source: NASA landslide catalog.

2.2 Third Party Actions

Colombia is a developing country. During the last two decades, economic growth, high commodity prices, road construction programs and successful implementation of peace processes with illegal armed groups have led to significant economic growth, occupying areas that were previously unpopulated. This expansion has impacted sectors of the Right of Way that have acquired economic interest for country housing, warehouses and agriculture.

The so-called northeastern Antioquia (northwestern Colombian area), is rich in lode and alluvial gold mining. This has made legal and illegal open-pit mining very common. Routine patrols and inspections should be weekly and notification visits should be immediate (Figure 4).



FIGURE 4: OPEN PIT MINING NEAR THE OCENSA PIPELINE. Source: Ocesa.

Farmers, particularly in valley or savannah areas, often use machinery to deepen the canals of cattle ranches or build new access roads. These actions by landowners constitute a threat to be detected.

High value country houses are built in new areas like Villa de Leyva, a tourist, antique and colonial town. The land-owners change rapidly, and the division of the land in little parcels led to the interaction with new land owners are very dynamic.

The so-called third party threat is the main threat to the integrity of the OCENSA pipeline according to the frequency of identification of findings.

2.3 Current Management System

In order to successfully manage the control of Integrity threats affecting the Right of Way, there is a system of

identification - assessment - execution, which has been effective, but which is now reinforced and expanded with the Right of Way Strategy reported in this article.

- **Activities to identify findings**

Planned Activities

- Patrols to the ROW. Weekly helicopter routes.
- Step-by-step patrol with specialists. One annual tour with emphasis on geohazard identification and assessment.
- Topographic monitoring. In areas of interest and in particular with soil creep that demands a follow up.
- Geotechnical monitoring. Piezometers and inclinometers
- Pipeline monitoring. Deformation gauges placed in movement zone pipe joints.
- In-line inspection. The Geopig tool, which measures pipeline displacements, provides very accurate data on the locations of buried pipeline movements and pipe deformation.
- Rainfall information. Through own rain gauges and national network, allowing to apply rainfall and landslide relation algorithms. [2].
- Earthquake information. Received from the national geological network, and treated by the rock transport and soil damping algorithms developed in a specific seismic study to assess hazard [5].

External information

All reports received through PCC and the toll free line 018000 are classified, verified and answered. Many of them correspond to requests for verification of owners to findings related to geohazards, or requests for verification of pipeline location that avoid the generation of interference or constructions in the ROW.

- **Assessment and prioritization activities**

Using simplified prioritization matrices and risk analysis and detailed studies for the most complex cases, the selection of maintenance plans with works on the ROW are carried out. The organizational structure divides the planning in the Risk and Process Safety area and the execution in the Pipelines area.

- **Execution of works**

OCENSA has framework contractors for civil and mechanical interventions that allow it to develop annual maintenance plans and attend to emergencies and contingencies.

The main works being developed on the pipeline and ROW are:

- ROW maintenance works. These are erosion control, surface channels management, maintenance and repair of existing works and protection of the ROW. They are normally covered by the operational budget.
- Stabilization and Control Works. These are robust works that include retaining structures, sheet piling, filters, anchors that stabilize and control landslides and protect crossing structures.
- Stress relieving. Performed at sites of ground movements such as creep movements, scheduled according to the deformations and measured displacement rates. Usually combined with associated stabilization and mitigation works. (Figure 5).
- Works of replacement of pipeline sections, circumvention and variants. Developed in movement sites that cannot be stabilized and require strategies to coexist with the problem. They are reported in a smaller proportion.



FIGURE 5: EXCAVATION FOR STRESS RELIEF.

Source: Ocesa.

3. RIGHT-OF-WAY STRATEGY (ROW)

This is a comprehensive strategy that seeks to improve and complement the actions that have been developed to preserve the integrity of the pipeline and the ROW.

The Right of Way for OCENSA has 25 m wide, 12,5 m on each side of the pipeline, over which it has a transit pipeline easement established by public deed since its construction. In asset management it is considered a linear asset, derived from the pipeline itself, and which requires preventive and corrective maintenance works.

The strategy has origin in the evolution of the law and changes in the philosophy of the risk management. Since 2012 (Colombian Law 1523), the disasters are conceived as a non-treated risk and the result of social process. This change, is a new vision in the risk management, and push modifications in the form of the relationship with communities, government and land-owners.

The strategy, which began in 2023, includes five components that cover technical and environmental issues to improve the capacity to detect threats through the use of technology, maintenance and clearance of the ROW, relationships and actions to ensure the sustainability of the pipeline over time.

3.1 Technical component

- **Complement to air patrol**

Each year, there are four manned and unmanned aircraft trips using photogrammetric-quality remote sensors, that allow to obtain geo-referenced orthophotomosaics in which are identified four types of occurrences:

Intruders: these are vehicles, people, equipment, works, temporary facilities that are over the pipeline, right-of-way or surrounding area that should be monitored because they could represent an intentional or unintentional threat to the integrity of the pipeline. They can be identified from the first overflight, by differences in height, geometry, colors or textures of the land.

Encroachments and interferences: permanent structures such as houses, shacks, corrals, kiosks, roads, excavations, ditches that constitute a disturbance to the Company's right-of-way, a challenge to perform maintenance or attend to emergencies, and a threat to integrity. They can be identified from the first overflight, by differences in height, geometry, colors or textures of the terrain. In the first overflight they must

be identified and recorded (vector or area format in a shape plane). In subsequent overflights there should be multi-temporal analysis to identify the evolution in a measurable way. This category includes industrial plantings of long growing cycle trees.

It should identify threats that are close to DDV in a larger area of influence (Figure 6).



FIGURE 6: IDENTIFICATION OF ROW ENCROACHMENT DETECTED WITH UAV. Source: OcenSA.

Geohazards: landslides, gullies, settlements, erosions, floods, torrential floods, damage to construction sites, burns, etc. These can be identified by differences in height, geometry, colors or textures of the terrain. In the first overflight they should be identified and recorded (vector or area format on a shape plane). Subsequent overflights should include multi-temporal analysis to identify the evolution in a measurable way.

That is the case of the KP 105, in the mountainous zone. There, a flow of soils over a ravine accumulated the material against a bridge due a large rock obstructing the passage of the soil mass. This situation threatening to create an avalanche affecting the ROW 200 m downstream. The rock was demolished, and the gradual decreasing of the dammed mass soil was monitoring via UAV technique. The height of the dammed mass was reduced from 0,9 m under the plate of the bridge to 2,7 m a month later (Figures 7, 8, 9 and 10).

This type of alternative using RGB photogrammetric, thermographic and infrared cameras allows precise detection and control of features that are not identifiable with a simple view.

- **Ground patrol to ROW**

Traditionally, OCENSA has performed a step-by-step ground survey of the ROW with specialists. The ROW strategy defines the realization of four tours per year, being able to have a better control and dimensioning of the findings. The scope of the findings refers to technical issues such as geotechnical and hydro-technical data sheets, but also to interferences with third

parties and regular ROW issues such as overgrown vegetation, ROW signaling, works needing reinforcement, etc.

The periodicity of the tours allows the crew's professionals to be familiar with the environment. In the case of intruders, it allows them to identify them and take the corresponding legal actions within the timeframe of the Colombian national police code.

- **Preventive signposts**

Campaigns are carried out to place signage at sites identified as potential disaster scenarios, and where there are crossings with relevant third parties, roads, towns, etc. This signage indicates that there are buried structures, that they should not be excavated and informs of the toll-free line 018000 to which they should call if they require more information or to locate the buried line.

In the past, this signage had not been systematically installed due to physical security problems in the areas through which the pipeline passes (Figure 10).



FIGURE 10: IMAGE OF PREVENTIVE SIGNAGE AT RELEVANT SITES. Source: Ocenasa.

- **Works with CAC**

The Community Action Councils (CAC) are social organizations, legally constituted in Colombia, non-profit and of solidarity nature, voluntarily integrated by the residents of a place, and that for OCENSA are contractors of civil works of low complexity (erosion control, minor stabilization works) and grass cutting. This program seeks to improve relations of trust with the Communities in the pipeline's area of influence, strengthen the administrative capacities of these domestic

entities, invest the surpluses from the works carried out in projects of interest and contribute to the company's long-term sustainability.

- **Grass cutting and ROW clearing**

Colombia is located in a tropical zone and the growth of vegetation is very fast, so the grass cutting is carry out to preserve the ROW clear in order to view it during the tours and allow access for maintenance should be done at least once a year. These low complexity works are regular performed in collaboration with Community Action Councils (CAC).

In many areas of overgrown vegetation, some have become trees, for this reason the company developed a plan to carry out a forest inventory and request to take advantage of them. It is considered that to cut a tree it is necessary to request an authorization, when its diameter exceeds 4" to 1.5 m in height.

3.2 Legal Component

It has two issues that must be developed to strengthen the company's legal position in relation to its easements:

Negotiation of ROW easements: where the pipeline runs and the relevant private access roads, where they have not yet been set. In several sites, easements were not negotiated since the construction of the pipeline, because at that time the land was considered vacant lot or with a false property; nowadays, they already have legal owners with whom it is necessary to set the easement document.

Removal of structures: Some housing and permanent structures have been within the ROW for many years, the risk criteria in the past did not consider their removal. Currently, it is considered a prioritized process of identification, appraisal, negotiation and demolition.

3.3 Environmental Component

The pipeline, since it is a very extensive linear structure, crosses several parks and nature reserves, whose management plan must be agreed with the environmental corporations and owners of the reserves. In particular, the pipeline crosses significant environmental zones such as the Mamapacha páramo, with the presence of páramo vegetation, and the Las Quinchas national natural park, a tropical rainforest with presence of animal species and protected endemic vegetation.

3.4 Social Component

All Municipalities, by law, must have land-use plans (POT) in their jurisdictions, OCENSA communicates with all municipalities to ensure that the pipeline infrastructure is considered and set criteria for the removal of constructions and the authorization of new structures, in such land-use plans.

3.5 Risk Component - Process Safety

Ocensa has set 21 Potential Disaster Scenarios (PDS) in accordance with Colombian Decree 2157 of 2017. These scenarios contemplate populations or institutional infrastructure where a significant number of people gather that may be impacted by the pipeline in the event of a loss of containment.

OCENSA sets focused attention Plans, training and preventive signaling, as well as control works derived from risk analysis to mitigate the potential effects of an unforeseen situation.

4. CONCLUSIONS

- Due to the geographical location of the oil fields with respect to the export port, the OCENSA pipeline crosses a branch of the Los Andes mountain range where there is a combination of geohazards.
- Colombia's social and economic development has led to the expansion of urban, commercial and farming areas that previously had no such purpose. This has meant that the so-called third party interference threat has become the main technical hazard to be considered.
- The existing management system has been successful, but it must adapt to the new challenges that arise as a result of urban expansion, economic interests, updated laws and regulations, and new technologies.
- The ROW Strategy seeks to complement the existing management system, to update and strengthen it. It has five action components: Technical, Legal, Social, Environmental and Risk.

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FIGURE 7: Flow of soils over a ravine. The mass was dammed for a large rock under a bridge. Source: OCENSA, aerial patrol.



FIGURE 8: Demolishing of the rock under the bridge. Source: OCENSA



FIGURE 8: Monitoring of the crossing place with UAV's technique. The mass was 0,9m under the plate of the bridge. September 2023. Source: OCENSA.

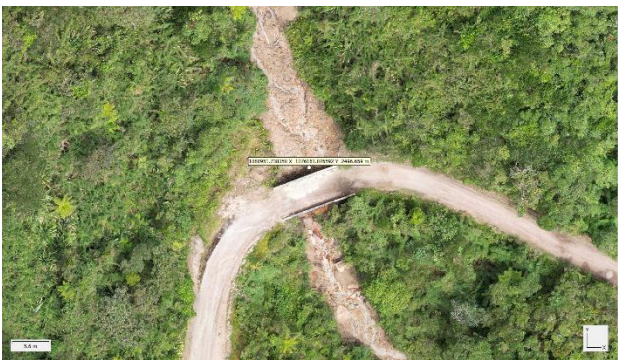


FIGURE 9: Monitoring of the crossing place with UAV's technique, multitemporal analysis. The mass was 2,7m under the plate of the bridge. October 2023. The height of the mass is gradually descending. Source: OCENSA.