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CASE STUDY TGP: IMPLEMENTATION OF CENTRAL DATA PLATFORM AND APPLICATION DEVELOPMENT FOR FIELD INSPECTION IN GEOHAZARD MANAGEMENT

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ABSTRACT

The Transport System by Pipeline of TGP in Peru spans from the Amazon rainforest, crosses the Andes Mountain, and finally descends towards the coast of the Pacific Ocean. The PTS has been in operation since 2004 and has pipelines for Natural Gas (NG) and Natural Gas Liquids (NGL) transportation. The combined length of both pipelines exceeds 1400 km.

This pipeline system faces various natural challenges due to its location in a complex geological, geotechnical and climatic environment. The geohazard identification, mitigation and monitoring generates a significant amount of information related to factors such as rainfall, ground movements, underground water levels, topography, pipeline stress, rock and soil characteristics, among others.

The administration, processing, and analysis of this big amount of information is impracticable using traditional methods and technologies. Therefore, TGP has implemented a centralized data platform utilizing BIG-DATA technology to store and process the information generated. This platform includes the stages of identification, risk analysis and definition of actions to be implemented for the mitigation of these geohazards. It is also integrated with TGP's Geographic Information System database.

This case study will present progress in areas such as: i) definition of processes to be systematized, ii) Centralized database architecture and technology, iii) integrations with other systems or data sources in TGP, iv) Data recording through mobile applications (used directly in the Right of Way - ROW), v) visualization and processing of geotechnical monitoring data (topography, rainfall, strain gauges, inclinometers, and piezometers), and vi) correlations between different processes of Integrity and Geo-hazard management, allowing for the determination of risk levels and the conceptual definition of intervention in the RoW (geotechnical works or maintenance). Finally, a predictive model for the management of Geo-hazards in TGP's system is currently under development, considering all the information from the beforementioned Data Lake.

Keywords: Central Data Platform, Data Lake, Model, Geohazard

NOMENCLATURE

CDP	Central Data Plataform (Data lake)
GIS	Geographic Information System
NG	Natural Gas
NGL	Natural Gas Liquids
PTS	Pipeline Transportation System
ROW	Right of Way
TGP	Transportadora de Gas del Perú

1. INTRODUCTION

The PTS of TGP consists of two parallel pipelines, one that transports Natural Gas (NG) of 730 km and another Liquid Natural Gas (NGL) of 560 km, starting in the Amazon basin in Malvinas (Cusco) and ending the NGL in the Lobería Beach (Ica) and the NG pipeline in the City Gate located in Lurín (Lima). Figure 1 presents the longitudinal distribution of the project.

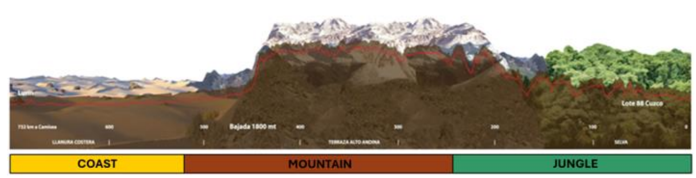

FIGURE 1: PROJECT´S LONGITUDINAL DISTRIBUTION
Source: TGP (2023).

The geological and climatic characteristics of the territory along the PTS route set it apart in terms of geotechnical and operational complexity when compared to similar systems worldwide. Stretching from the heart of the Amazon rainforest to the highest point of the route at 4,860 meters above sea level in the Peruvian Andes (Sierra region), the ROW goes throw a rugged terrain, which is exposed to over 7000 millimeters of annual rainfall and ultimately descends towards the Pacific Ocean coast where the pipelines encounter a tough wind erosion environment and powerful intermittent water course crossing. The natural challenges create a significant operational complexity and generate a significant amount of information related to geohazards, triggering factors and mechanical conditions of the pipelines.

The management, processing, and analysis of this substantial amount of information is impracticable using traditional methods and technologies. Therefore, TGP has implemented a centralized data platform powered by BIG-DATA technology that stores and processes the information generated. This platform includes the stages of identification, risk analysis and definition of actions to be implemented for the mitigation of these Geo-hazards and is interconnected with TGP's Geographic Information System database.

2. GEOHAZARD MANAGEMENT

The geohazard management process at TGP follows the steps outlined in Figure 2. These steps involve gathering a significant amount of information through data registration and monitoring. These data include field inspections, piezometer and inclinometer readings, topographic monitoring, strain gauges, in line inspections (ILI), as well as aerial imagery and high-resolution digital elevation models. All this information continuously converges at the evaluation stage. To efficiently handle, integrate, and drive maximum benefit from these data, the use of modern tools that facilitate such processes are imperative.

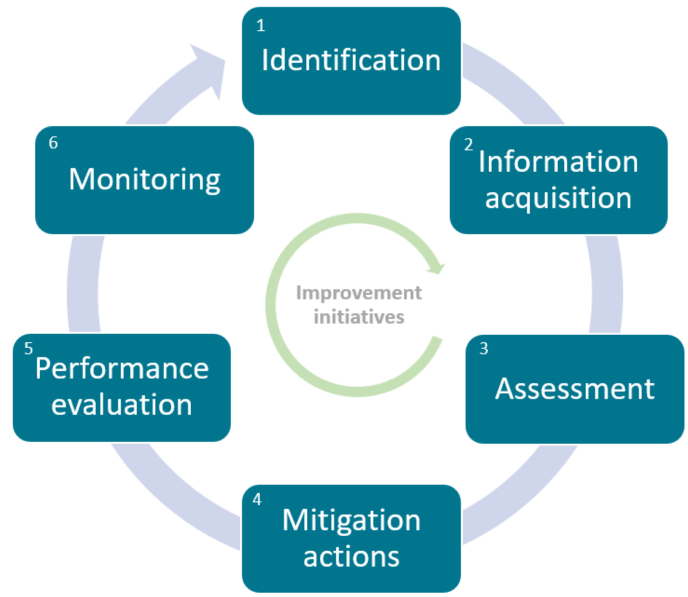

FIGURE 2: GEOHAZARD MANAGEMENT PROCESS
Source: TGP (2023).

3. CENTRAL DATA PLATFORM (Data Lake)

The solution adopted by TGP to address the challenges involved the implementation of a centralized data repository. In order for this platform to fulfill effectively its purpose, it was necessary to consider technical specifications such as: storage of both structured and unstructured data, enabling future scalability on a large scale, and incorporating connectors to various existing systems like GIS, SAP, SharePoint, among others.

Consequently, a big-data solution was pursued, leveraging the Azure cloud infrastructure, incorporating open-source components and a modular architecture that facilitates easy scalability according to the evolving needs of TGP. This approach aligns with the characteristics of Variety, Volume, and Velocity, thereby ensuring an optimal solution for the management of geohazards in the pipeline transportation system.

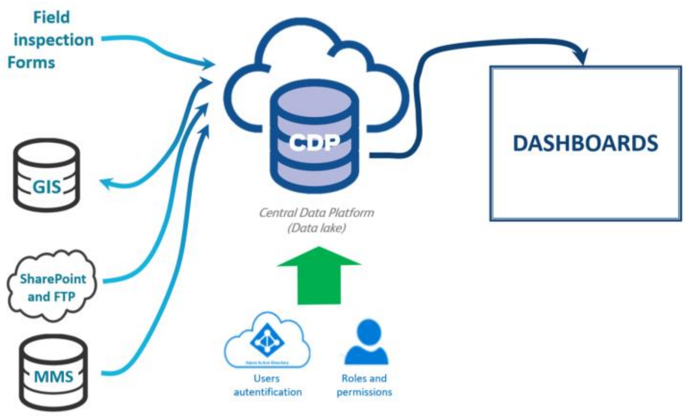

FIGURE 3: ARCHITECTURE AND INTEGRATION WITH OTHER DATABASES
Source: TGP (2023).

The CDP is integrated with TGP's Geographic Information System (ESRI technology). The Data Lake incorporates the following integration services:

- One service dedicated to acquiring GIS layers containing up-to-date and consolidated information related to the pipeline, encompassing centerlines, stations, valves, kilometer post, landslide data, water crossings, flooding incidents, aeolian erosion occurrences, settlement instances, and ground slide events.

- An API REST service enabling the submission of geohazard event coordinates to GIS, resulting in the retrieval of a georeferenced map. This geospatial data can be exported as PDF files.

- A geoprocessing service developed in Python that facilitates the transmission of geohazard events and approved forms from the CDP to the GIS platform using JSON files. Once received, these events are georeferenced and seamlessly incorporated into the GIS database, ensuring synchronized updates across both platforms.

4. ACHIEVED DEVELOPMENTS

Following the implementation of the central data platform, progress has been made in geohazard management in terms of administration, integration, and data analysis. One of the achieved goals was to conduct field inspection using electronic devices with digital forms. These forms are synchronized online and automatically loaded with structured information onto the platform. This facilitates viewing all the inspections, status of each form, and at the end of the process, the time taken for each responsible (developer, reviewer and approver).

FIGURE 4: GEOHAZARD DATA COLLECTION IN FIELD INSPECTION
Source: TGP (2022).

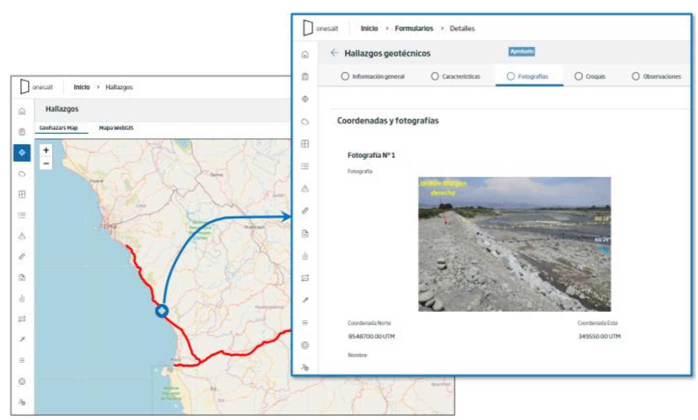

FIGURE 5: FIELD INSPECTION DASHBOARD IN CDP
Source: TGP (2023).

Field surveys conducted with mobile forms enable efficient processing for evaluating anomalies, defining mitigation actions, and creating maintenance plans. An algorithm has been developed to separate less significant findings that require routine maintenance tasks from those for detailed investigation by geohazard specialists. The algorithm is based on TGP's experience in geohazard management in jungle and Andean Mountain environments. It was designed for landslides and scours at river crossings considering geohazard identified, magnitude and distance to the pipeline. This streamlines and directs the efforts of specialists towards risk assessment in priority sites.

The CDP automatically develops three essential deliverables in draft version for the annual mitigation action plan. These deliverables are: i) summary of geotechnical findings, ii) conceptual maintenance plan documents by section of the RoW and iii) a technical conceptual document about main geotechnical works. These deliverables mentioned save specialists' time in preparing the documents, which focus mainly on a review prior to final approval.

The platform's implementation was accompanied by software developments that automate the processing of raw monitoring data, from rain gauge, inclinometers, piezometers, strain gauges, and topographic instrument. An example of this can be observed in Figure 6, which illustrates the processing of topographic monitoring data at a specific location. The figure demonstrates how each graph automatically provides information on accumulated displacements. Also, it can be possible to see the annual displacement rates for each topographic mark.

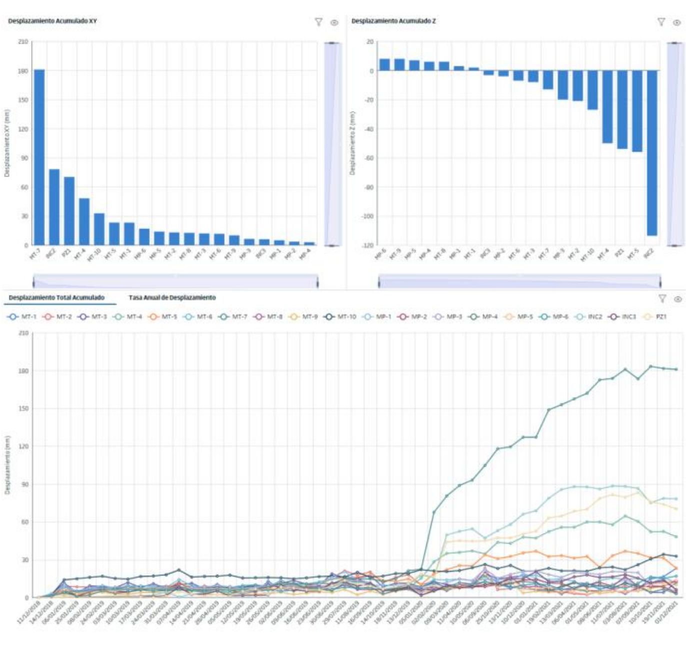

FIGURE 6: CUMULATIVE DISPLACEMENT PER LANDMARK
Source: TGP (2023).

The achievements attained through the stored data within the Data Lake are visualized via dashboards, offering simplified views of the key indicators in TGP's geo-hazard management.

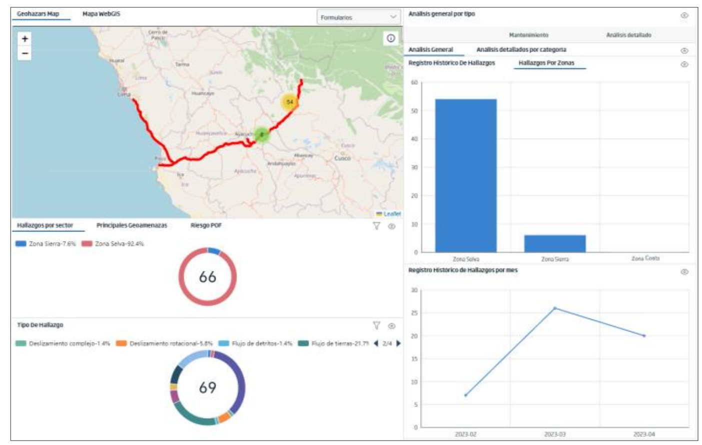

FIGURE 7: GENERAL DASHBOARD OF GEOHAZARD RESULTS IN DATA LAKE
Source: TGP (2023).

5. CHALLENGES AND NEXT STEPS

With the implementation of the Data Lake, the registration, automatization, and advanced data analysis activities have been improved for the definition of geohazard monitoring and mitigation activities to maintenance the integrity of the pipelines. The following steps are oriented towards consolidate the current process supported by CDP and the development of models capable of proposing a condition for the prediction of possible occurrences of geohazards. Likewise, it includes an escalation towards the management of other technical threats and activities of the operation that are associated with pipeline integrity and efficient allocation of resources.

6. CONCLUSION

To extract the most value from the data generated in geohazard management, TGP has chosen to implement a central data platform. The acquired platform is a big-data solution, hosted on the Azure cloud, incorporating open-source components and a modular architecture that facilitates easy scalability according to the requirements of variety, volume, and velocity.

The achievements are linked to storing geo-hazard management information in data lake, field inspection through mobile forms, generating preliminary maintenance plan documents, and automated processing of monitoring data. This allows reducing analysis times and making technical decisions.

The forthcoming steps are centered on harnessing and increasing the data stored within the platform by developing algorithms that enable advanced data analysis, creating models to foresee potential geo-hazard occurrences and administering resources more efficiently.

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