

## PIPELINE INSPECTION WORKFLOW USING ARCGIS: FROM PLANNING TO ASSESSMENT

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### ABSTRACT

*The integrity of pipeline infrastructure depends, among other factors, on effective management of geotechnical risks. Routine and geotechnical inspections are essential for identifying threats, assessing severity, and guiding mitigation. Nova Transportadora do Sudeste (NTS) enhances this process through a structured workflow supported by GIS tools. Technologies like ArcGIS Workforce improve field coordination, allowing efficient assignment of tasks and real-time monitoring. Survey123 enables teams to collect georeferenced data, record observations, and attach photos on-site. This information is dynamically visualized in ArcGIS Dashboards and ArcGIS Experience Builder, allowing specialists to monitor inspection outcomes and identify high-risk areas quickly. The need for inspections arises from various monitoring systems, including weather monitoring, optical remote sensing, and geohazard risk models, which can flag potential threats that may affect pipelines and their associated assets. To ensure that risks are properly assessed and mitigation actions are effectively prioritized, methodologies such as the GUT Matrix (Gravity, Urgency, and Tendency) are applied. This integrated approach improves communication, optimizes resource use, and strengthens the integrity and reliability of pipeline assets. By combining ArcGIS Workforce, Survey123, and Dashboards, NTS establishes an efficient and consistent inspection system that supports long-term risk management.*

Keywords: GIS, Inspection Workflow. Risk Assessment

### 1. INTRODUCTION

Pipelines remain one of the most reliable and cost-effective methods for transporting oil and gas over long distances. Their buried nature offers advantages in safety and efficiency compared to other transport options, yet it also exposes them to risks that are often difficult to detect. Among these risks, geotechnical threats—such as landslides, soil subsidence, and erosion—stand out as major contributors to pipeline failures. According to the 12<sup>th</sup> EGIG report [1], ground movements were

responsible for approximately 19.3% of recorded incidents in onshore pipelines between 2013 and 2022.

Because ground-induced stresses can apply significant lateral and vertical loads on pipelines [2], managing geotechnical hazards along the right-of-way is a critical component of integrity programs. In response, many operators have developed dedicated monitoring systems and risk mitigation strategies that combine remote sensing, in-situ instrumentation, and modeling techniques to track changes in terrain and flag potential issues before they evolve into failures.

Still, no monitoring strategy is complete without verification in the field. On-site inspections provide essential confirmation of alerts generated by monitoring tools and are key to understanding the actual conditions around pipeline infrastructure.

The importance of conducting field investigations in known susceptible areas is emphasized in API RP 1187 [3], within the Level 2 Assessment, which highlights the value of this step for confirming geohazards, assessing the potential level of impact, and understanding the characteristics of geohazards to support decision-making.

The efficiency and effectiveness of these inspections greatly depend on how well they are planned, executed, and integrated into the broader risk management framework. Incorporating technology into the workflow—especially tools that streamline data collection and centralize information—is vital for accelerating response and improving decision-making.

Recognizing these challenges, this paper aims to present the implementation of a more dynamic and structured inspection model based on the ArcGIS platform. By using a combination of tools such as ArcGIS Workforce, Survey123, and Dashboards, it is possible to schedule inspections, collect georeferenced field data in real time, and visualize inspection outcomes alongside operational and environmental datasets. This integrated approach has enhanced the company's ability to prioritize risks, coordinate field teams, and follow up on mitigation actions with greater speed and precision.

## 2. INSPECTION WORKFLOW

The development of a structured workflow for field inspections, supported by ArcGIS tools, has brought significant improvements in the planning, execution, and analysis of geotechnical inspections along the pipeline right-of-way.

The process begins with the use of **ArcGIS Workforce**, where inspection activities are planned and assigned to field teams according to the specific motivations, that can be divided into different categories:

- **Routine Inspections:** Programmed inspections along the rights-of-way, with different frequencies, to identify new features or anomalies that can affect the integrity of the assets.
- **Geotechnical Inspections:** Programmed inspections focused on known geotechnical occurrences or susceptible areas, to evaluate their increasing or necessity of mitigation.
- **Weather Alert Inspections:** Inspections based on weather alerts from meteorological monitoring, caused by forecasted or observed high volumes of rain.
- **Remote Sensing Alert Inspections:** Inspections based on change detections identified on remote sensing monitoring, as Optical or LiDAR monitoring.
- **Geotechnical Instruments Alerts Inspections:** Inspections based on alerts from geotechnical instruments, such as piezometers, inclinometers, tiltmeters and others.
- **And others.**

Inspectors receive task notifications directly on their mobile devices, including detailed information about the location, purpose of the inspection, and necessary actions. In the field, data is collected through **ArcGIS Survey123**, using standardized digital forms tailored to each type of inspection.

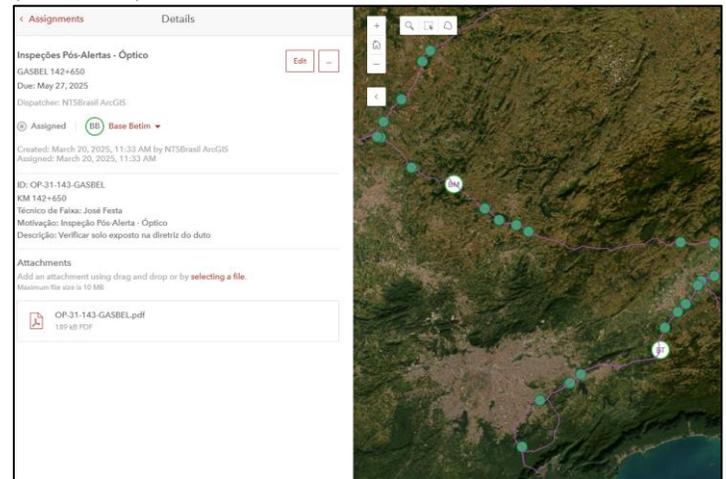
Once the inspections are completed, the collected data is made available in real time on **ArcGIS Dashboards**, enabling fast and visual analysis by technical teams. This integration allows for immediate decision-making and prioritization of mitigation actions.

In addition, **ArcGIS Experience Builder** supports the creation of customized web applications that consolidate information from multiple inspections, improving access and communication across different areas of the organization. The entire workflow—from task assignment to data visualization—is automated, ensuring better use of resources, improved reporting, and increased safety.

## 3. INSPECTION PLANNING

Proper inspection planning is crucial for timely and accurate recognition of geotechnical risks along pipeline rights-of-way. Traditional planning methods often rely on static schedules and fragmented communication between office teams and field inspectors, which can lead to inefficiencies, delays, and

inconsistent data collection. To overcome these limitations and optimize the inspection process, it's possible to use **ArcGIS Workforce** as the core platform for coordinating field operations (FIGURE 1).



**FIGURE 1:** ARCGIS WORKFORCE PLATFORM: INSPECTIONS PLANNING.

As a mobile-enabled application, field activities can be managed and supervised using this tool with a high level of control and flexibility. Through the platform, inspection programmers are able to assign specific tasks to ROW (Right-of-Way) inspectors, defining the location of each inspection, its priority level, the underlying motivation, and the specific elements to be evaluated. Deadlines are established based on the urgency and severity of potential threats, ensuring that inspections are carried out in alignment with risk prioritization strategies.

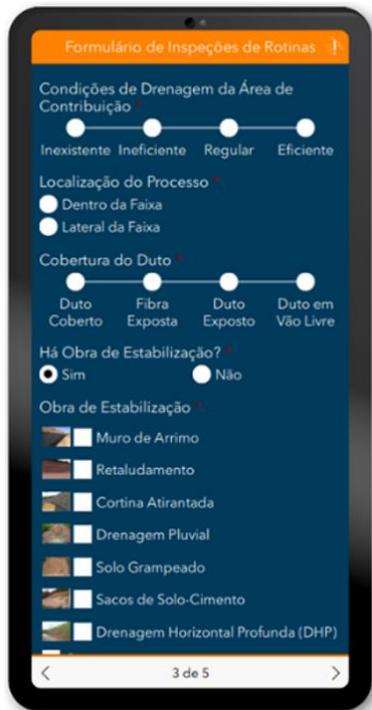
ArcGIS Workforce also supports the inclusion of attachments, like maps, guidelines, or technical references, that help inspectors to understand the context and expectations of each task. Once an activity is assigned, inspectors receive a notification on their mobile device and can immediately access all necessary information to perform the inspection efficiently. After completing the activity, they mark it as done, allowing planners to track progress in real time and move forward with the next steps.

A major advantage of using Workforce is its integration with other ArcGIS tools, such as Survey123. This connectivity allows for a seamless transition between task assignment and data collection, ensuring that each inspection type triggers the appropriate digital form. It streamlines the workflow, reduces mistakes, and helps ensure that field activities are carried out in a consistent and standardized way.

## 4. FIELD DATA COLLECTION

In the field phase of pipeline right-of-way (ROW) inspections, the use of **ArcGIS Survey123** (FIGURE 2) plays a critical role in standardizing and streamlining data collection. Survey123 is adopted as the platform for structuring field forms,

enabling the documentation of geotechnical occurrences in a detailed and georeferenced format.



**FIGURE 2:** ARCGIS SURVEY123: FORMS FOR DATA COLLECTION IN FIELD.

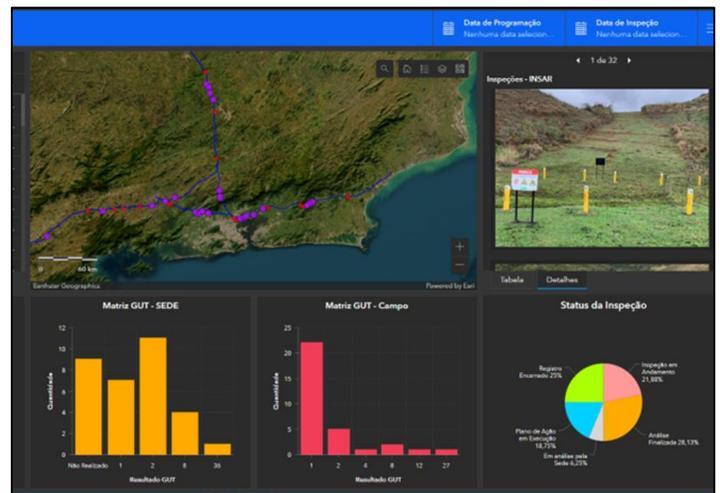
The surveys are developed to include dynamic content, such as location capture through embedded maps and GPS coordinates, photos taken in real time, descriptive texts, and predefined fields to classify the nature and severity of observed features. These intelligent forms not only guide field personnel in completing the necessary information but also ensure consistency across inspections, reducing the risk of omission or subjective interpretations.

Once a survey is submitted, the data is instantly synchronized (when online) with the central GIS environment, where specialists can access, visualize, and begin analyzing the information. This real-time flow of data enhances decision-making agility, especially in situations where rapid response is required. Survey123 is directly integrated with ArcGIS Dashboards, allowing the collected data to be translated into interactive visualizations—such as maps highlighting inspected segments, summary charts of risk classifications, and photographic records of field conditions.

Additionally, the tool supports the generation of automated reports, which can be customized and exported as needed, significantly reducing the time between data collection and communication with other technical or decision-making teams. This integration reinforces the inspection workflow by ensuring that the information gathered on-site is immediately available for evaluation and action planning, supporting a proactive and risk-based approach to pipeline integrity management.

## 5. DATA VISUALIZATION

Once field inspections are completed, the collected information is automatically integrated into ArcGIS Dashboards (FIGURE 3), where it becomes immediately available for analysis by technical teams. This real-time visualization enables a quick understanding of field conditions and supports faster decision-making, particularly when prioritizing mitigation actions. By combining geospatial data, photographic records, and structured forms submitted through Survey123, the dashboards offer an intuitive overview of inspection results, highlighting critical areas and emerging trends that may require urgent attention.



**FIGURE 3:** ARCGIS DASHBOARD: INSPECTIONS VISUALIZATION AND ASSESSMENT.

The dashboards also serve as a central platform for tracking key performance indicators, inspection coverage, and the evolution of geotechnical risks over time. Their dynamic and interactive nature allows users to filter data by region, inspection type, or risk level, facilitating more targeted analysis. Because the dashboards are directly linked to ArcGIS Pro and other GIS applications, the visualizations reflect the most up-to-date data without requiring additional processing or manual updates.

To improve communication across teams and make information more accessible, customized web applications are built using ArcGIS Experience Builder. These applications consolidate inspection data across different teams and projects, allowing users from various departments to explore and interpret information relevant to their roles. This integration streamlines internal workflows and ensures that decision-makers across the organization have access to consistent and reliable information.

This integrated approach—combining Survey123, Dashboards, and Experience Builder—strengthens the inspection workflow and supports better risk management. It ensures that insights from the field are quickly transformed into action, helping direct efforts where they’re most needed and

contributing to the long-term safety and reliability of the pipeline system.

## 6. INSPECTION ANALYSIS & RISK ASSESSMENT

The scheduling of inspections and deadlines is based on the detection of areas vulnerable to geotechnical events, identified through different remote monitoring methods employed by NTS. These inspections are planned for ROW inspectors, who collect field data using a specific form within the Survey123 tool. Different types of geotechnical concerns require personalized field approaches and distinct sets of data to be collected.

Inspection results appear in real time on the dashboards assigned to each case. The analysis is performed by qualified professionals in the office, using data collected from all field inspections conducted by NTS. Risk assessments are carried out on Survey123, the same platform where inspection results are submitted and stored. Evaluations must be based on the evidence identified in the field, photographic records, occurrence descriptions and the field GUT matrix. In addition to field data, geotechnical team include additional information to support risk assessment, for example, rainfall volume during the period that led to the alert.

With all the data, the occurrence is evaluated using the GUT Matrix, that is a prioritization tool developed by Charles Kepner and Benjamin Tregoe in the 1980s. It assists in defining deadlines for mitigation actions or new inspections based on three factors: Gravity (G), Urgency (U), and Tendency (T). Each factor must be rated on a scale from 1 to 5, with 5 representing the highest level of criticality. The scores should be assigned based on the following TABLE 1 that shows the GUT matrix used for risk assessment.

**TABLE 1:** GUT MATRIX USED AS A PRIORITIZATION TOOL FOR GEOTECHNICAL EVENTS

	<b>GRAVITY</b>	<b>URGENCY</b>	<b>TENDENCY</b>
<b>1</b>	Not serious	Not urgent	It will probably not get worse
<b>2</b>	Less serious	Less urgent	It will get worse in a long term
<b>3</b>	Serious	Urgent	It will get worse in a medium term
<b>4</b>	Very serious	Very urgent	It will get worse in a short term
<b>5</b>	Extremely serious	Extremely urgent	It will get worse fast

Gravity refers to the potential impact the occurrence may have on the integrity of the company's assets. Urgency defines the timeframe within which the issue must be addressed, or the acceptable delay before action is taken. Finally, tendency assesses the likelihood of the occurrence worsening over time.

The assessment results are stored together with the inspection data, as a continuation of the forms. These results support the definition of action plans and timelines for problem resolution.

Based on the inspection assessments, it is the responsibility of the designated geotechnical professional to define the action plan, in case the occurrence requires monitoring or intervention. Action plans must be based on field findings, historical data, and, most importantly, the GUT matrix defined.

NTS has a procedure in place that outlines how to define the action plan for each case. The main examples are shown below:

- **Row technicians' inspection:** occurrences that require monitoring to assess potential developments.
- **Geotechnical inspection:** occurrences that require on-site evaluation by geotechnical professionals for the definition of mitigation or retaining structures.
- **Geotechnical studies:** sites that require additional information (e.g. topographic surveys, SPT tests, etc.) or specific geotechnical studies to assess stability and determine appropriate interventions.
- **Development of executive project:** sites with geotechnical occurrences that require mitigation measures to prevent risks to asset integrity.
- **Emergency intervention:** geotechnical occurrences with critical risk levels that have already caused damage to pipelines or ROWs, or are at imminent risk, and therefore require immediate intervention.

Every action plan must include a deadline. This deadline should be established by the geotechnical professional responsible for defining the actions.

## 7. CONCLUSION

In conclusion, the integration of GIS tools into the inspection workflow has proven essential for enhancing the management of geotechnical risks along pipeline corridors. By streamlining data collection, visualization, and decision-making, it was possible to establish a more agile and informed approach to risk mitigation. This structured system not only improves operational efficiency but also reinforces the long-term safety and reliability of its pipeline infrastructure.

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