APSENSING.

Pipeline Monitoring - TPI & Leak Detection

Romania

Project Overview

BRUA (Bulgaria – Romania – Hungary – Austria) is a strategic natural gas transmission corridor with the ability of permanent bidirectional physical flow which aims to diversify natural gas exploitation in the Eastern European region. The corridor allows Romania to access natural gas transportation routes from the Caspian Sea to Central Europe and facilitates the exploitation of additional gas resources in the Black Sea.

The BRUA project comprehends several phases. In the first phase, the construction of a 479 km long pipeline in Romania in addition to three natural gas compression stations (SCG Podișor, SCG Bibești, and SCG Jupa) was agreed in 2017. The initial capacity of the pipeline is set at 1.75 bcma, which will be further increased in the future phases to 4.4 bcma. The project is developed by Transgaz, the technical operator of the national natural gas transmission system in Romania.

The pipeline has a diameter of 32" and a design pressure of 63 bar, while each of the gas compression stations is equipped with 2 compression aggregates for operation and backup with the possibility of bidirectional gas flow. Along the total pipeline route, a Fiber Optic Cable (FOC) is laid for communication and monitoring purposes.

Completed in 2020, the BRUA pipeline section in Romania is routed in areas with considerable construction and agricultural activities in addition to a threat of landslides in some areas. In order to detect any potentially harmful Third-Party Intrusion (TPI) activities in the vicinity of the buried pipeline in addition to gas losses, the owner requested the deployment of a fiber optic based Distributed Acoustic Sensing (DAS) system so that the maintenance teams can intervene in a timely manner in case of a threat.

Background

- 479 km long natural gas pipeline interconnector in Romania
- A pipeline area with considerable construction, agricultural activities and landslides
- Requirement of a monitoring solution for third party intrusion and leak detection

Solution & Benefits

- Ten single-channel N5200A DAS instruments with measuring ranges of 50 km and 70 km
- SmartVision software with MapView module and IEC-60870-5-104 protocol interface to SCADA

Figure 1: BRUA pipeline with FOC duct during the installation phase and monitoring cabinet located in one of the valve stations

Solution

AP Sensing's DAS solution has been selected to monitor the 479 km long pipeline in Romania. The monitoring solution consists of 10 singlechannel N5200A DAS instruments with measuring ranges of 50 km and 70 km depending on the distance between the valve stations. Each of the systems is connected to a dedicated single-mode fiber within the FOC, which is installed in a duct and placed at the 2 o'clock position within a distance of approximately 30 cm from the pipeline wall. All sensing instruments are mounted in standard 19" cabinets which are located in ten substations along the pipeline system and engineered by Adrem. Two separate servers with the main operator interface SmartVision are configured to visualize and send the alarm information to SCADA. Figure 1 illustrates the pipeline and FOC duct during the installation phase and a monitoring cabinet in one of the valve stations.

The DAS solution is configured to monitor the entire pipeline system in real time, visualize the acoustic energy over time/distance in waterfall plots, store the measured data on internal disks, and trigger an alarm in the event of a risk. The alarm notification includes

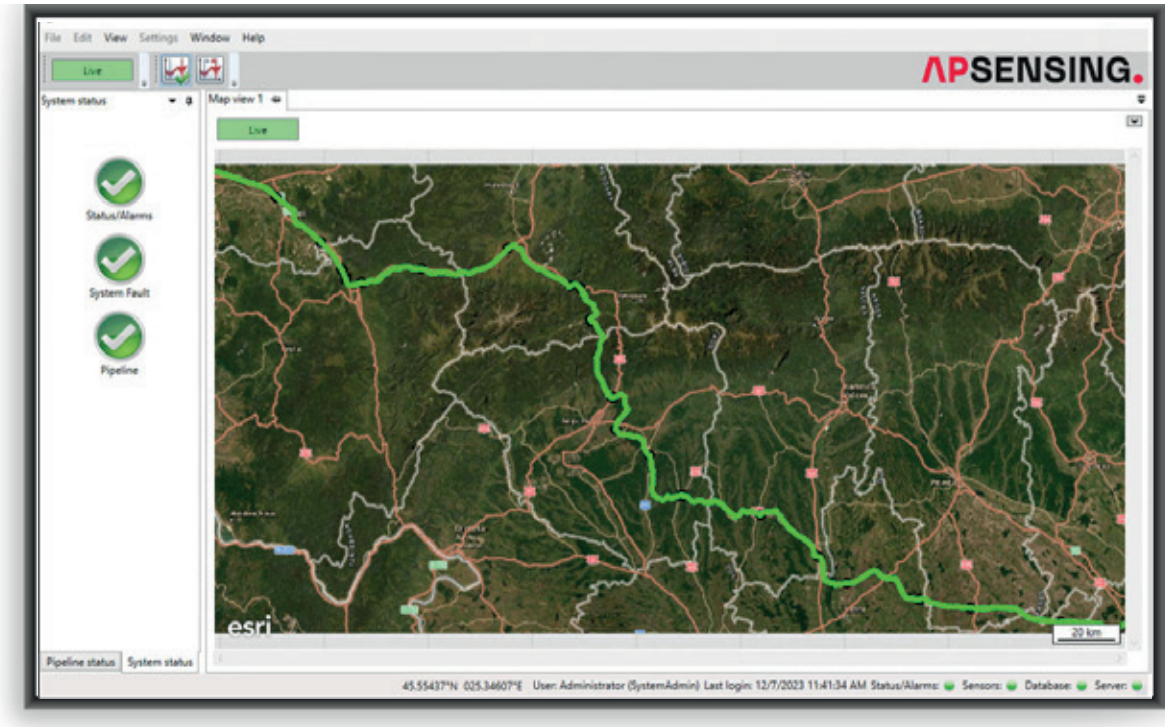

Figure 2: SmartVision interface with a map view of the BRUA pipeline route

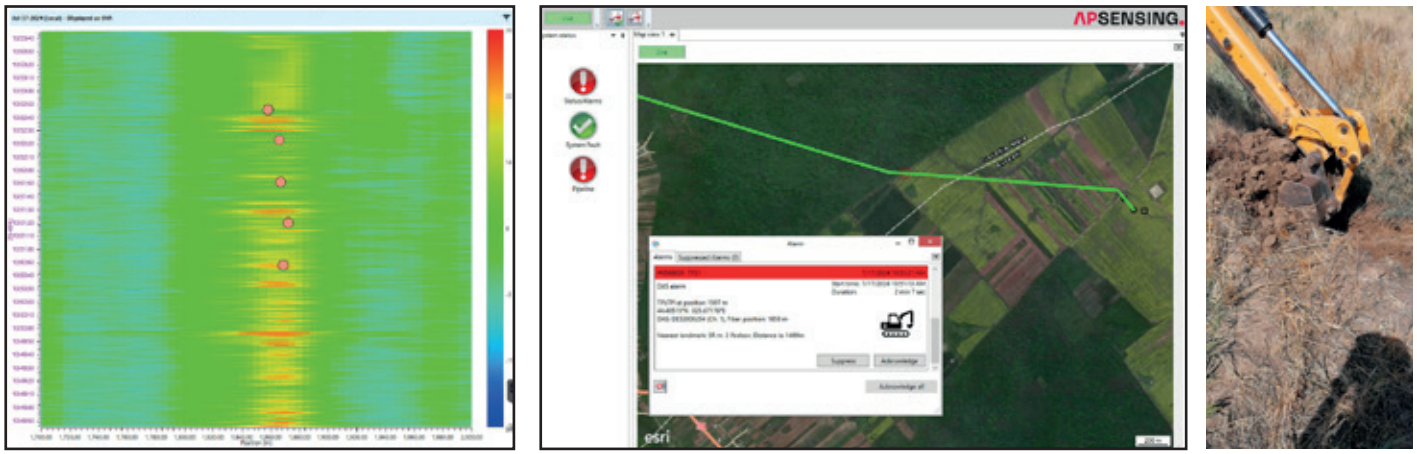

Figure 3: DAS waterfall diagram and alarm notification in SmartVision of a machinery digging test during SAT

information about the type, time, and location of the threat. While detection of TPI events relies on identification of large-magnitude, low-frequency vibrations generated in the ground, the classifier of leak events rests on capturing of high-frequency signals in combination with a temperature change that can be measured by the inherent Distributed Temperature Gradient Sensing (DTGS) technique. In the occurrence of a gas leak, it is expected that a pressure of 63 bar generates a cold spot with a relevant negative temperature change as a consequence of the Joule-Thomson effect.

The alarm notification is visualized on AP Sensing's monitoring platform SmartVision (see Figure 2) and forwarded to the SCADA system via IEC-60870-5-104 protocol. In the case of TPI, gas leak, or fiber break events, the location is highlighted on the map view of SmartVision, and a notification with the event type, time stamp, duration, fiber/ pipeline position, GPS cordinates, and nearest landmark is shown.

Results

In order to simulate real potential threats as part of the Site Acceptance Testing (SAT) procedure, machinery digging tests were conducted at different locations within a distance of a few meters from the pipeline. Figure 3 shows an example of one of the excavator tests including the waterfall diagram of the DAS system and the alarm notification in SmartVision. The signal imprint could be classified correctly by the DAS algorithms, and the location of the activity could be indicated accurately on the map including the pipeline position and GPS coordinates.

Pipeline Inspection Gauge (PIG) tracking is also a feature offered inherently by the DAS system. During the inspecting and cleaning process of the pipeline, the PIG generates in general strong vibrations which are captured by the FOC installed along the pipeline and measured by the DAS system. The vibrations give then an insight into the position and speed of the PIG in real time. Especially in the case of obstructions e.g. due to debris or mechanical damage, the PIG may get

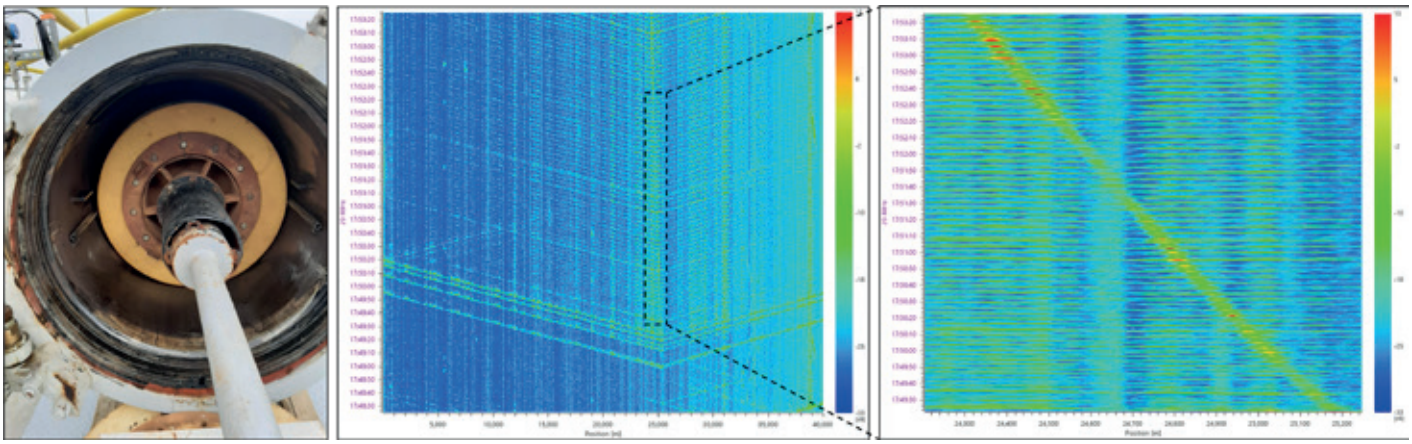

Figure 4: Picture of the cleaning PIG and DAS waterfall diagrams of the moving PIG in one of the pipeline sections

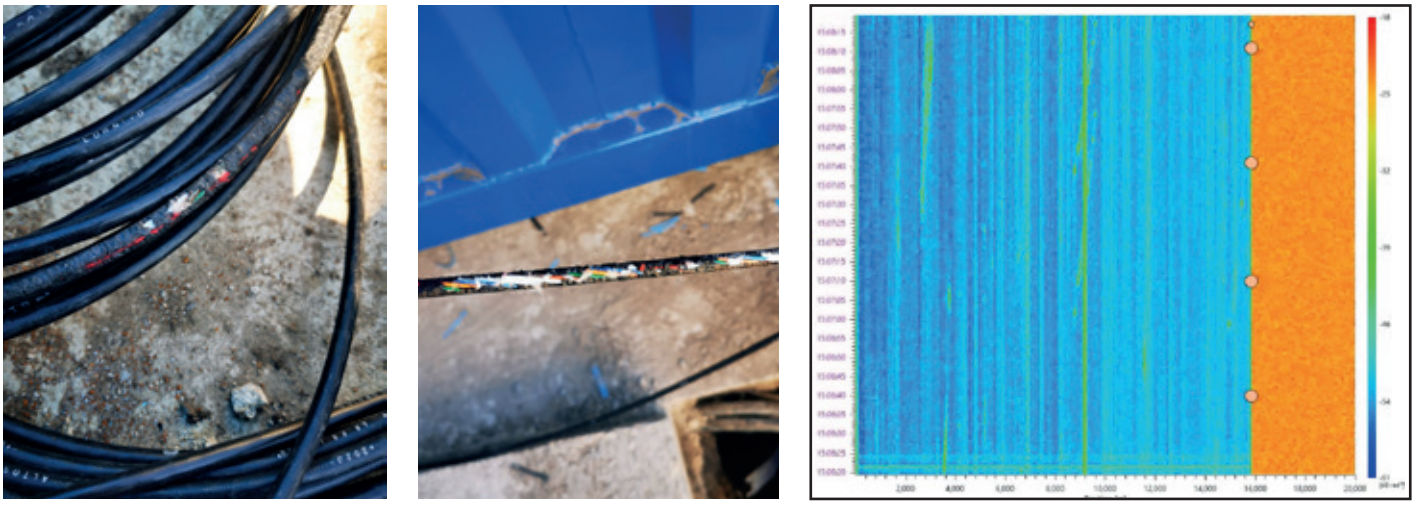

Figure 5: Pictures from FOC bitten by rodents and a corresponding fiber break notification on the DAS waterfall diagram

stuck, and the latest position can be obtained based on the DAS system. This mitigates the risk of losing the PIG and helps the operator to localize the position of the artefact. In the meantime, several PIGging campaigns have been executed for the BRUA pipeline based on utility and geometry inspection PIGs. With the help of AP Sensing's DAS systems, the campaigns could be monitored successfully.

Figure 4 illustrates a utility PIG which was used for cleaning purposes of the pipeline. In this campaign, the PIG travelled a total distance of 410 km within 40 h. The waterfall diagram shows the signal imprint of the PIG, moving at approx. 10-12 km/h and generating Negative Pressure Waves (NPWs) travelling at a velocity of 430-450 m/s.

During the commissioning phase of the monitoring solution, the sensing fibers suffered several breaks due to different reasons, such as rodent bites, landslides, etc. Owing to the inherent OTDR functionality of the DAS systems, the fiber breaks could be detected and localized accurately. In fact, the fiber-to-asset mapping process conducted over the entire 479 km route length helped in removing the mismatch between the fiber and pipeline length for proper localization of events, narrowing down the positioning accuracy to approximately the gauge length of the 70 km. An example of a fiber break encountered during the commissioning phase is shown in Figure 5, where the DAS signal dropped abruptly, and clear signs of rodent bites were subsequently identified on the FOC at the alarm position. It is worth mentioning that the DAS system still offers continuous monitoring of the asset until the fiber break location.

Conclusion

The implementation of AP Sensing's DAS monitoring systems has proven to be an efficient solution for TPI events detection and PIG tracking in pipeline applications. In fact, since commissioning of the solution, several real activities near the pipeline have been correctly detected.

Additionally, fiber breaks due to rodent bites and FOC manhole damage by landslides could be localized accurately, offering another tool for the maintenance team to save time and react promptly.

Moreover, pipeline cleaning and inspection processes used the ability of the DAS systems to provide valuable information about the position and velocity of PIGs during the entire campaigns and in real time.

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