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Satellite-based pipeline monitoring at MITNETZ GAS

Validation of ground deformation and vegetation monitoring from space

Case Study

About MITNETZ GAS

MITNETZ GAS is a central German gas network operator. The company operates gas networks with a total length of around 7,000 kilometers supplying an area of roughly 14,000 km2, in the federal states of Saxony, Saxony-Anhalt, Thuringia and Brandenburg. MITNETZ GAS is innovation-friendly, as Commercial Director Christine Janssen explains:

"We are seizing the opportunities of digitalisation.
Today we are already eagerly shaping the future of energy for the people of tomorrow."

An example of the company's spirit of innovation is its determination to build smart grids. At the moment, MITNETZ GAS is testing the operation of a hydrogen network that could one day supply the chemical industry in Bitterfeld.

MITNETZ GAS aims to reliably and competently ensure the supply to the people in the target area. To ensure a highest standard of quality, the company is regularly evaluated and certified in accordance with international standards by independent third parties such as TÜV Süd.

Large-scale distributed networks are complex to monitor

In order to meet these high standards, it is essential to monitor the network as comprehensively as possible, for concrete damage on the one hand, and risks from environmental influences on the other. Such risks include, among other things ground deformation and vegetation encroachment.

Ground movement leads to stresses in the pipeline

Ground deformations can be dangerous for underground pipelines. Continuous, slow ground movements are not an unusual phenomenon and do not pose a problem for underground pipelines as long as the movement runs uniformly in one direction. However, in some areas such as regions with mining activity, ground may shift in opposing directions, or a section of the pipeline may rise, fall or shift horizontally significantly faster than another. In such cases, stresses occur in the pipelines, which can cause damage and lead to supply interruptions.

Roots can damage pipes

Vegetation poses a further risk to pipelines, as the roots of certain tree species such as sycamore or robinia, can damage the pipelines. To counter this risk in a timely and reliable manner, it is important to have a complete and up-to-date overview of the trees and bushes in the network corridor, as well as information on the distance between the vegetation and the pipeline.

Higher costs or heightened risk?

Since gas networks are distributed over a large area, seamless monitoring is a major challenge. Regular manual vegetation monitoring methods, such as driving along the route, or helicopter overflights along the pipelines, require immense logistical and administrative effort. Depending on the frequency of data collection, this results in either considerable costs or a tolerance for higher risk.

The large scale of the coverage area is also a challenge when evaluating ground deformation. The subtle and slow changes are not visible to the naked eye. It is true that known risk areas are regularly monitored by surveyors, however continuous monitoring along the entire route is not a viable option with this method, due to the high cost.

In the MITNETZ GAS network area, there is another challenge for targeted data collection. The area features a number of abandoned shafts from past mining activities, which are not always accurately documented by the public authorities. It is therefore possible that sections of the network are subject to an unknown higher risk of harmful ground movements.

Satellite-based monitoring with LiveEO

LiveEO monitors infrastructure networks for external risks using satellite data. Satellite monitoring has significant advantages over conventional monitoring approaches.

A constantly updated data set

Nowadays, almost every point on Earth is overflown several times a day by Earth observation satellites that record data about the state of the Earth's surface. These satellites belong to different constellations and operators. The result is a huge, constantly updated data set about the condition of the Earth's entire surface. With satellites, up-to-date data is always available even for large widely-distributed areas.

A favorable cost structure

Another advantage is the lower cost per measurement point of satellite data as compared to conventional measurement methods. This is especially true for geographically distributed areas, since the cost structure of satellite data is constant, whereas for onsite measurements the logistical effort increases significantly with the size and remoteness of the target area.

LiveEO has developed a technology that automatically acquires satellite data from various sources for a defined area and analyzes it using artificial intelligence (AI). LiveEO then processes the raw satellite data into human- and machine-readable information.

Different sensors for different applications

Using data from multispectral optical sensors, the solution can reliably detect the location and condition of trees and map this information graphically using a geographic information system (GIS). The system automatically determines the distances of the trees to the pipeline.

InSAR satellites on the other hand use radar technology to record the distance of the Earth's surface from the satellite. From the data, LiveEO creates a precise elevation profile of the observed area. Because the satellite is always in exactly the same orbit, LiveEO can determine changes in ground elevation over time, with millimeter accuracy. By incorporating archive data, the system detects trends and provides warnings based on opposing or strong local movements.

Analysis of 160 km high pressure gas pipeline

MITNETZ GAS wanted to validate satellite-based monitoring as a new method for monitoring underground pipelines. For this purpose, the network operator selected a stretch of 160 km of high-pressure gas pipelines, which was monitored by LiveEO in a corridor of 40m on either side of the line using optical and radar satellite data.

The selected high-pressure gas pipeline is routed through forests and fields as well as through built-up areas. The area south of Leipzig is characterized by former mining, so unexpected ground deformations are possible.

Ground deformation analysis

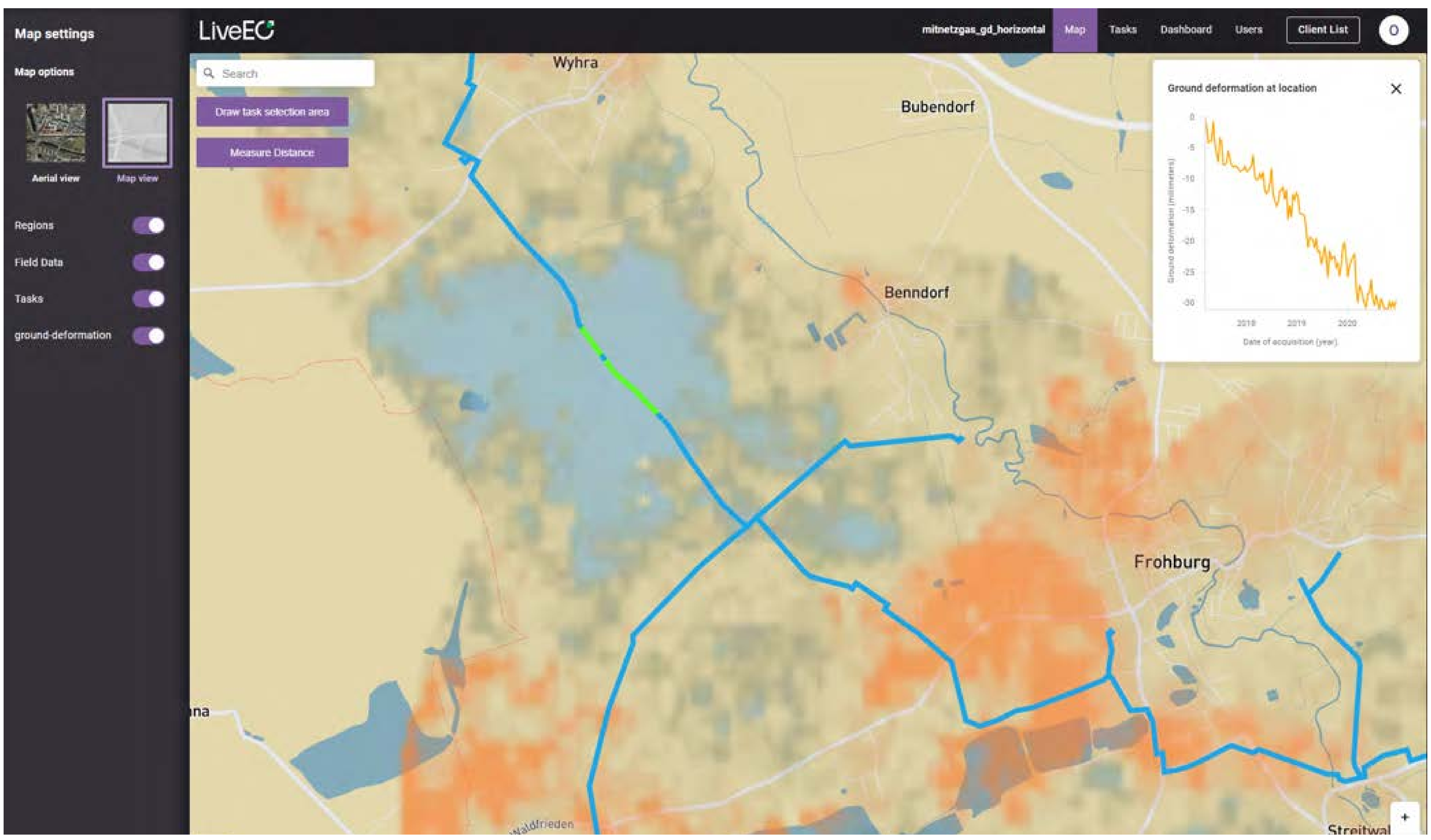
Data from the European Space Agency's Sentinel 1 (S1) satellite were used for ground deformation analysis. The choice of flight direction was based on the coverage of the area to be monitored, the completeness of the archive, and data availability. Historical data from 2017 onward were used to identify trends that have emerged over a longer period of time. The resolution of the data was ~25x30m on average.

The data were adjusted by LiveEO to take into account seasonal effects that lead to the variations in ground level. These effects are removed to determine movement from non-seasonal causes, and then reintegrated to derive absolute movements.

The results of the analysis were made available to MITNETZ GAS via LiveEO's web application. Ground height changes and the pipeline route were drawn on a map of the network area. In the analyzed corridor, ground deformations can quickly be identified using color coding. MITNETZ GAS defined risk classes for individual line sections.

The different risk classes indicate on the map which route segments have seen the most ground movement.

>10 cm/year → high criticality = red line
>5-10 cm/year → medium criticality = yellow line
2-5 cm/year → low criticality = green line
< 2 cm/year → not critical = not line color



Vegetation detection

The vegetation analysis was based on public and commercial satellite data with a ground resolution of 3m x 3m to identify vegetation in the vicinity of the MITNETZ GAS network. For this purpose, LiveEO detects vegetation in a corridor of 40 meters to either side of the pipelines. Based on training data created manually by LiveEO for the MITNETZ GAS supply area, LiveEO's machine learning algorithm detects vegetation height.

Based on these results, the horizontal distance between the detected vegetation and the pipelines was determined. As with the ground deformation analysis, the vegetation analysis results were made available through LiveEO's web application.

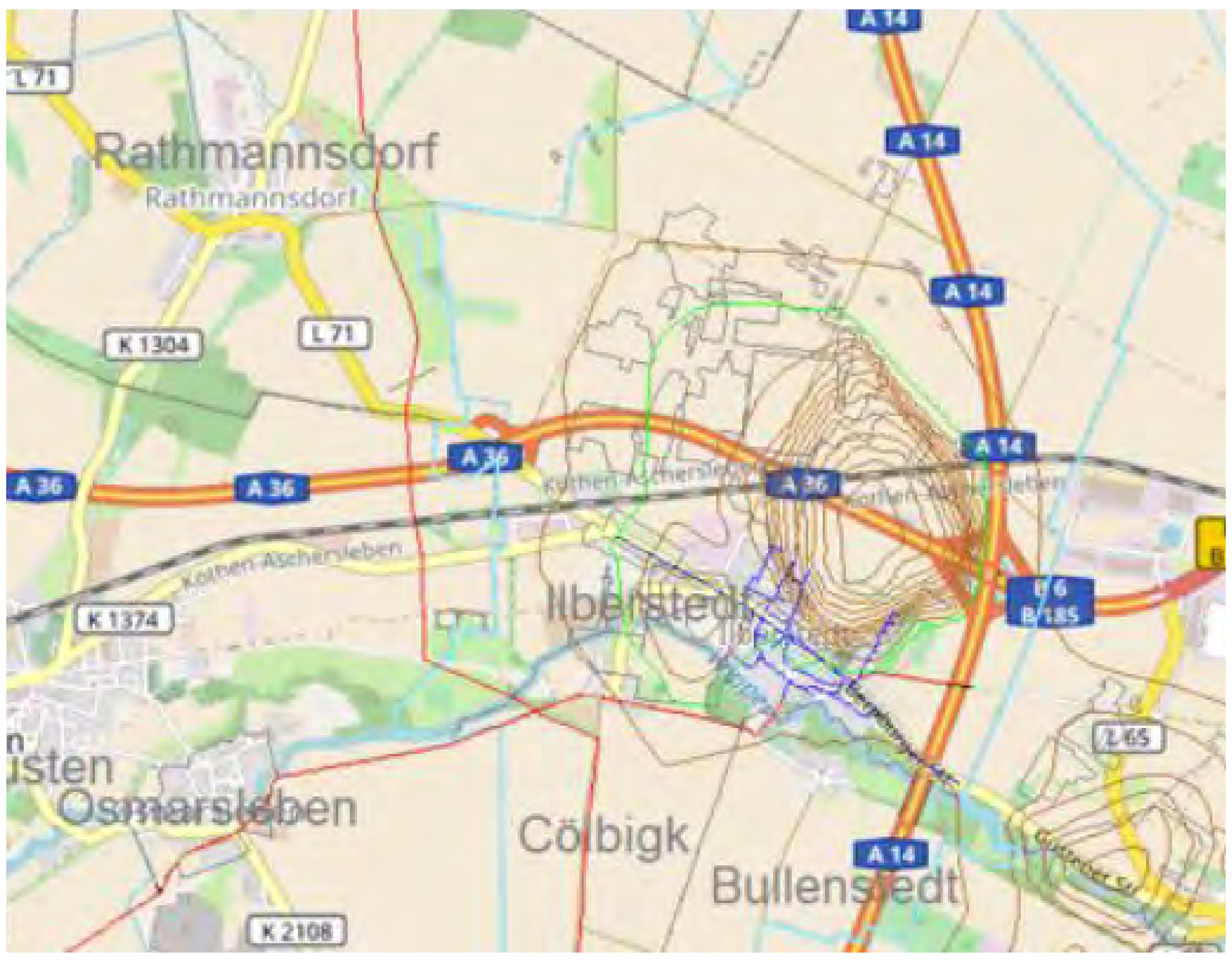
For each point of vegetation exposure, the system automatically created a vegetation management task. MITNETZ GAS has defined risk classes depending on the degree of vegetation exposure, which serve to prioritize the tasks and identify the high-risk segments at a glance:

3 m → high criticality = red line
5 m → medium criticality = yellow line
10 m → low criticality = green line
> 10 m → not critical = no line

Validation and conclusion of MITNETZ GAS

Ground deformation

In order to establish the validity of the ground deformation data collected by LiveEO, MITNETZ GAS compared the data for part of the area with an existing ground deformation analysis using conventional methods. The measurement results of LiveEO are congruent with the conventionally collected data. MITNETZ GAS concluded that the satellite-based ground deformation analysis is suitable as an indicator for ground movements.



Vegetation analysis

To validate the vegetation analysis, 225 data points were randomly selected. The results were verified on site by MITNETZ GAS employees. As a result, MITNETZ GAS was able to establish a 92% rate of "very good" or "good" analysis results using LiveEO's solution. This showed that vegetation can also be reliably analyzed by satellites.

Recommendation for continuous network monitoring

The results of the validation by MITNETZ GAS clearly show that the use of satellite-based infrastructure monitoring is suitable for vegetation detection and ground deformation detection use cases. The possibility of continuous remote monitoring of the network is especially attractive for the network operator.

Risk factors for the entire network area can be monitored continuously over longer periods of time. Thus, potentially critical route segments can be identified at an early stage and verified on site. Continuous remote satellite monitoring by LiveEO can make the operation of MITNETZ GAS' gas pipeline network safer and the maintenance process more efficient.

In its final summary, MITNETZ GAS comes to the conclusion that the use of satellite data for continuous monitoring is to be recommended.

LiveEO

SATELLITE-BASED INFRASTRUCTURE MONITORING

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