# Unique GNSS based Structural Health Monitoring

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**Key words:** Bridge surveying; Engineering survey; GNSS/GPS; Positioning; Risk management

**SUMMARY**

The increasing age and load demands on critical infrastructure - such as bridges, tunnels, and transportation networks - present significant challenges for civil engineering and public authorities. Ensuring long-term safety and enabling timely interventions requires the early detection of structural changes. In this context, digital monitoring systems are becoming increasingly important as a complement to traditional surveying techniques such as total stations and tilt sensors. Among these, GNSS-based (Global Navigation Satellite System) monitoring offers compelling advantages in terms of real-time deformation tracking and cost-efficiency. But can such systems truly deliver millimeter-level accuracy?

As part of a research initiative, the OpenLab research bridge in Bautzen, Germany, was selected as a testbed for innovative condition assessment technologies. The 45-meter-long structure was officially inaugurated in spring 2025 by the Federal Ministry for Digital and Transport. The project's objective was to develop and evaluate a GNSS-based monitoring concept capable of capturing structural deformations under real-world loading conditions with extremely high accuracy - either in real time or near real time.

In collaboration with TU Dresden and navXperience GmbH, a prototype GNSS system was installed in summer 2025. The system comprised calibrated antennas, low-cost GNSS modules, and advanced data processing algorithms. During a series of load tests conducted in September 2025, the system successfully recorded all relevant deformations in real time. These results were validated against geodetic reference measurements, confirming the system's reliability and precision. Remarkably, the measurements achieved millimeter-level accuracy - once considered technically unattainable for GNSS-based methods. The findings of this project underscore the potential of GNSS monitoring as a valuable enhancement to existing measurement techniques. It is well-suited

not only for targeted structural assessments but also for continuous long-term monitoring. Future work will focus on integrating AI-supported data processing to manage high-frequency measurement series and on extending the approach to other fields such as structural diagnostics, environmental engineering, and Earth observation. This research study demonstrates the growing significance of digital measurement technologies in infrastructure monitoring and offers a practical, forward-looking contribution to the digital transformation of the construction and engineering sectors.