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Complying with Rail Directives for Geo-Monitoring in Germany

Achieving Redundancy by Combining Total Stations and IoT-based, Wireless Tiltmeters

Rail infrastructure is subject to change and evaluating how these changes impact the safety of railway services is key.

In Germany, the regulatory framework for monitoring is provided by the 883.8X00 series of directives issued by Deutsche Bahn AG (DB).

This article aims to show how the demands of these directives, such as clear task descriptions, monitoring of external geometry and high reliability through redundancy, can be achieved in practice.

The Deutsches Institut für Normung (DIN), the German standardisation body, regulates the planning, implementation, evaluation and documentation of monitoring measurements via DIN 18710-4.

The requirements and conditions for deformation monitoring must be defined in a task description and implementation must be mapped out in a measurement programme. The description defines what objects should be observed, the minimum and maximum deformations, the precision required, the measuring frequency, accessibility, safety, warning and alarm parameters and the form and frequency of results and documentation.

The Geo-Monitoring Directive

For measures affecting the rail system, DB states: *"By means of geomonitoring, possible changes in the spatial position (rigid body movement) and/or internal shape (deformations) of railway tracks and points, constraint points of the line, buildings [...] and other installations are recorded [...] and documented."*

If changes have occurred or are foreseen, a risk analysis and assessment must be carried out in accordance with Ril 883.8100. It shall indicate whether monitoring should be undertaken and, if so, its extent and purpose.

The directive states: *"According to the same procedure [risk analysis], the dispensability of geo-monitoring must be demonstrated."* The directive requires changes in external geometry to be recorded.

Two requirements of the 883.8X00 series of directives are that geo-monitoring must detect, document and, if necessary, report changes in the external geometry, and it must be set up in a redundant manner so the malfunction of a component does not prevent measurement results from being available.

Many monitoring installations use total stations or inclinometers as measuring sensors. Neither of these instruments alone can fulfil the two requirements of 'superior' and 'redundant'. Total stations are robust but complex systems. A technical defect is unlikely but cannot be ruled out.

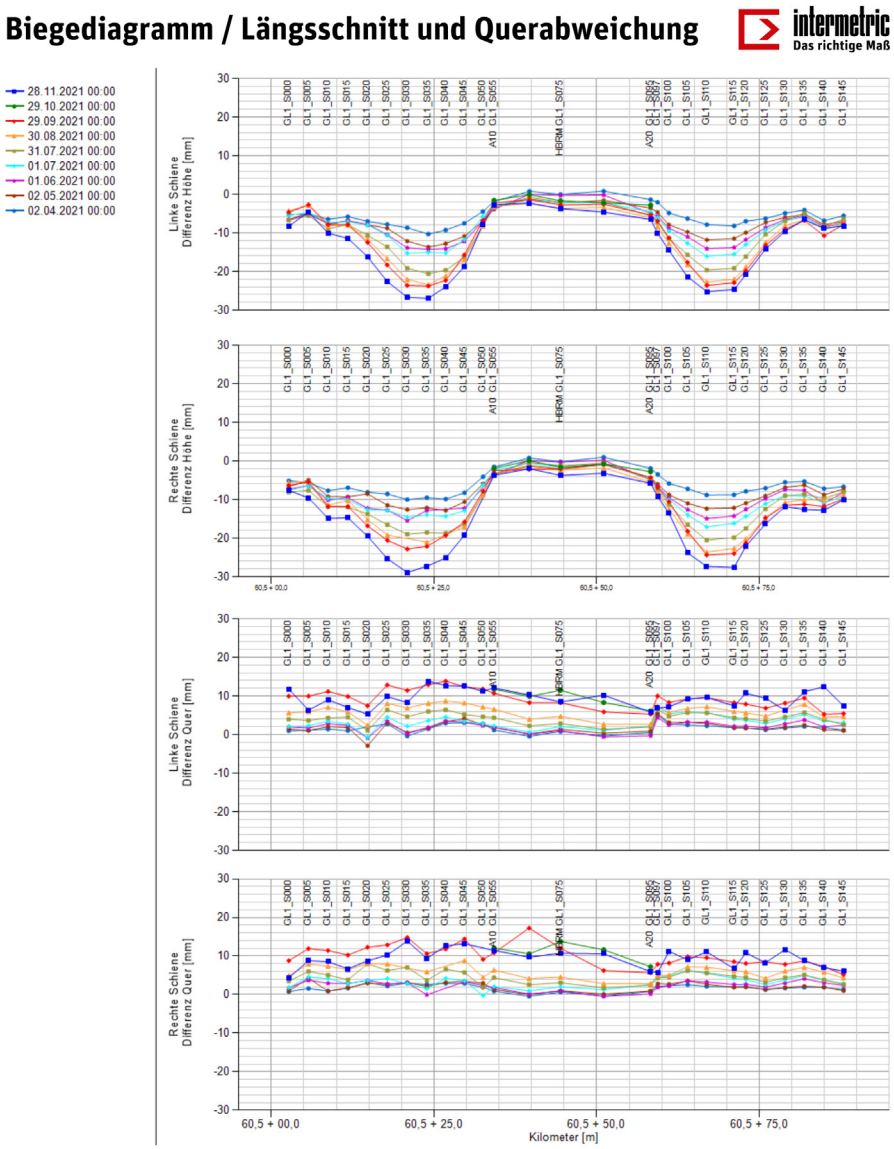
Furthermore, total station measurements are subject to changing weather conditions, as their measuring principle is optical. They may not be able to measure in

heavy fog or snowfall. Adding more total stations does not solve the problem.

Biaxial tiltmeters measure changes in inclination in two perpendicular axes, such as the longitudinal and transverse inclination of a sleeper. The monitoring system establishes the reference to the absolute elevation through a chain of such sensors, up to the stable area.

If one of the intermediate sensors should fail, an assessment of the absolute elevations of the entire chain is no longer possible. Due to the nature of the system, tiltmeters cannot detect changes in position. In principle, monitoring systems based purely on tiltmeters do not meet the requirements.

Some geo-monitoring installations use both types of instruments and display the results in juxtaposition. An integration of the measurement results usually does not take place.



Railway track instrumentation for combined geo-monitoring

Redundancy

The 883.8X00 series of directives does not define the term 'redundancy'. However, it is required that the system delivers reliable results even in the event of a single component failure.

We speak of good redundancy when all redundancy components are approximately equal and the measurements are independent. This increases the reliability of the results and probably is what the authors of Ril 883.8000 intended.

Intermetric's iGM.NET geo-monitoring system integrates total stations and biaxial tiltmeters and thus fulfils the requirements of Ril 883.8000. The independence of the measurements is assured by the different measuring principles of the total station and tiltmeter.

Total stations determine the outer and inner geometry of the railway track and tiltmeters take measurements regardless of weather conditions. On railway tracks, two prisms and one biaxial inclination sensor are fitted on every fifth sleeper.

Each sensor type monitors the other, which leads to truly independent compliance. Long-range, wide-area network radio allows battery-operated tiltmeters to transmit values to a central gateway for months with no maintenance.

Reduction of Interference

Passing or stopping trains, track marshals and maintenance work on the tracks can lead to temporary visual restrictions between the total station and the target. A good

geo-monitoring system will react to such situations and repeat the measurement.

The repetition routine should be as configurable as possible, as is the case with iGM.NET. Not every measurement can be repeated within the same period. Individual failures are counteracted by sufficient instrumentation and a suitable evaluation method may mitigate the effect of failures.

It's possible, for example, to compensate for a failure by interpolation. It is technically more correct and computationally more stable to apply a weighted network adjustment to all measurements.

The network adjustment not only compensates for measurement failures but also provides statistical information about the quality of measurements and deformation magnitudes.

If there is a failure of the total station subsystem, for example as a result of extreme weather conditions, the network adjustment based on inclination measurements still provides the elevation information required.

Practical Experience

In infrastructure projects involving railway tracks over a large area, monitoring usually covers a large area and lasts for many months. The geo-monitoring system must detect the entire settlement area to reliably identify large-scale deformation.

This can only be accomplished by total stations, ideally combined with tiltmeters. These provide uniform deformation statements over the project period, based on the superordinate co-ordinates of each object point. This is the only way to consistently monitor the track status over months or even years.

The large-scale geo-monitoring system collects results over the entire measurement period in an unchanging frame of reference. This is a prerequisite for reproducing track position at any time, independently of the size and extension of the deformation and extent of track alignment work.

Changes and How to Visualise Them

Results should be prepared such that relevant information is rapidly captured. It is important that project-specific diagrams and tables be generated in the same format so they can be compared with no risk of confusion. The external reference of results should be clearly indicated on each display. The presentation results on a suitable web portal ensures the 'availability of results' required by the directive.

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Das richtige Maß

Redundant geo-monitoring on four tracks