Challenges and solutions in modern infrastructure maintenance

Guest article by Gritt Hannusch

Today, the maintenance of railway infrastructure is almost inconceivable without the intelligent use of data. Operators and service providers are faced with the challenge of ensuring the safety and reliability of rail transport despite growing demands and limited resources. Modern technologies, especially AI-supported systems, play a key role here. They enable precise condition assessment and predictive planning of maintenance measures. The systematic collection and analysis of data optimises the entire life cycle of the infrastructure, reducing operating costs and increasing efficiency.

The efficient maintenance of railway infrastructure is of crucial importance for the safety, reliability and cost-effectiveness of rail transport. In view of the growing demand for mobility and the increasing load on the rail network, operators and maintenance service providers are facing major challenges. Maintenance measures must not only be planned and implemented in line with demand, but also efficiently with limited resources.

All infrastructure operators in the rail transport sector face the same challenge: the availability of the infrastructure must be guaranteed. At the same time, wear and tear and the need for predictive maintenance and servicing are increasing with the higher utilisation.

Today, modern software systems are available to companies and offer support in making the right decisions regarding the choice of maintenance strategy in order to maintain or restore the functionality of the infrastructure over its entire service life.

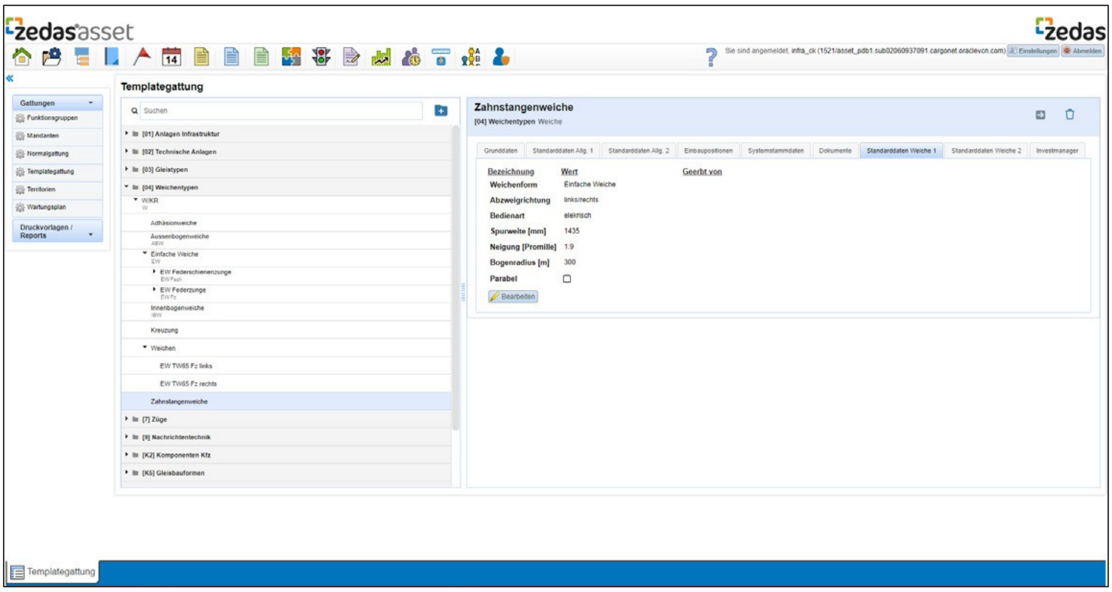
In principle, you can choose between different maintenance strategies, namely the following:

- the time-cyclical
- the load-dependent
- the condition-based
- predictive maintenance.

The prerequisite for this is always to have a data pool. This provides a daily updated image of the status of the systems and maintenance proposals at the same time.

This meaningful data pool is created when:

- All assets, including their components, are stored in the system (Figure 1). Assets are classified by category in order to assign specific attributes to the respective category and to be able to describe maintenance strategies. The use of category templates makes it easier for the user to define the necessary attributes.
- system-specific master data and additional data are assigned t o the system. Data specified by the respective type template is flexibly supplemented by freely configurable additional attributes. These additional attributes describe the specifics of the system and represent essential information that has an influence on the status determination. This gives the user great flexibility to describe the special features of their systems (Figure 2).
- Measured values and meter data can be imported directly via interfaces. Measured values from measurement campaigns, measured values recorded as part of inspections and manually collected condition scores are imported into the system via standardised interfaces and mobile devices and assigned to the geolocated systems or system components. Stored limit and threshold values are used to evaluate the data.
- Faults and defects recorded directly on site at the system



SCREENSHOTS (3): ZEDAS

Figure 1: Classification of systems and their components in the software system for assigning specific attributes and maintenance strategies.

and classified. Faults and defects are recorded directly on site as part of corrective and predictive maintenance measures.

Flexible stored defect catalogues are used to standardise the recording of defects and faults. The user is guided through the fault tree. Maintenance recommendations are linked to fault classes. These standardisations form a basis for further decisions on maintenance measures to be derived. The intelligence of a modern app supports the user by:

- Automated object recognition, i.e. the identification of objects in the field (e.g. masts, power boxes, roads) as part of fault detection or fault rectification or regular maintenance measures;
- Suggestions from the system for filling in the fields for recurring faults and similar measures;
- Simplified handling of filters thanks to the option of describing filter settings in natural language;
- Simplified search - search query / search terms in natural language.

In order to assess the condition of infrastructure systems as accurately as possible and to use this information for automatically generated maintenance recommendations, a range of methods are available that are being used more and more widely:

- Automatic detection of damage patterns in the recorded data after test and inspection drives/flights;
- Ultrasonic and eddy current testing, automatic detection of fault patterns (head check, squat, spalling, rail corrugation) - AIFRI funding project (see box);
- Recording of relative track position data, automatic detection of error patterns such as subsidence, cant errors, corrugations, long waves;
- Use of drone images, e.g. of overhead lines, tracks for automated fault detection;
- Rail profile scanning, automatic detection of defects such as depressions, break-outs, cracks, fractures, missing screws;
- LiDAR scanning (surroundings), automatic detection of real and potential clearance violations, such as vegetation (trees, bushes, branches), objects (masts, pillars, roofs of bus stops, ...), changes t o embankments.

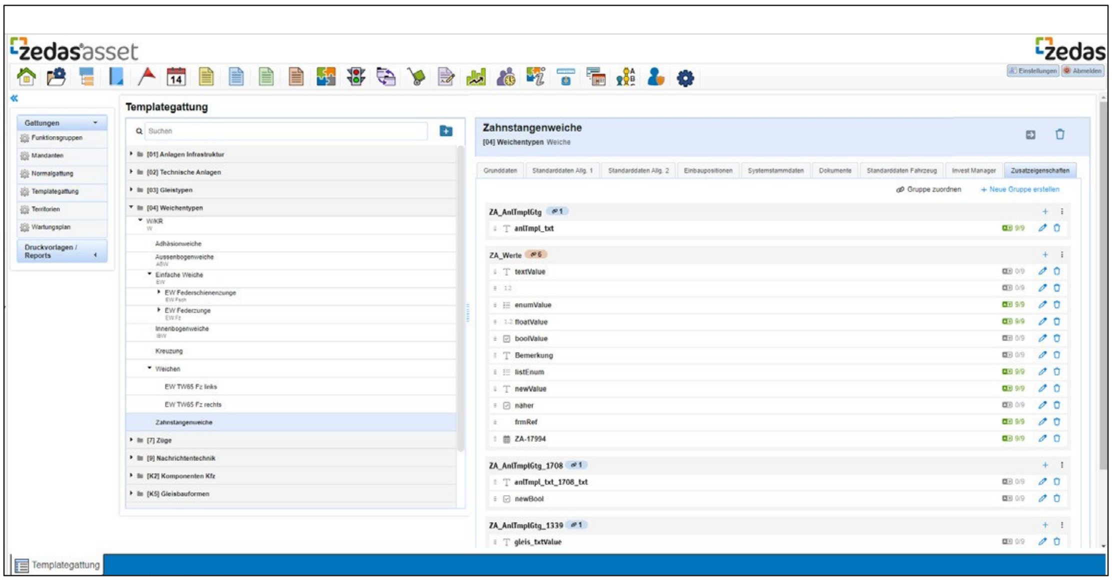


Figure 2: Screenshot of the additional field configurator for the flexible assignment of additional attributes

The results of all data surveys are imported via generic interfaces such as Zedas Asset - an asset management system for the maintenance of railway infrastructure - and linked to the systems and system components.

All incoming data is analysed and evaluated in its context, thus enabling a transparent presentation of the system status from various perspectives at all times. Various methods are used for this purpose, from simple limit value comparisons to mathematical scientific methods utilising the possibilities offered by artificial intelligence.

Condition, load and wear forecasts for routes and route sections are determined on the basis of test and measurement data (pattern recognition).

These data treasures from the maintenance measures carried out complete the picture and are integrated into the analyses.

The determination and documentation of the system status also enables historical observations and the use of data for trend analyses and forecasts. Changes to the railway infrastructure can also be depicted for past periods. This means that an image before and after each maintenance task carried out.

Information from construction measures (conversion or new construction) can be imported via standardised GIS interfaces and processed automatically by the system. This means that all the information required for maintenance planning is available to the responsible departments as soon as the routes have been handed over.

Maintenance measures are derived as a result of the condition analyses and forecasts. All due maintenance measures are graphically displayed both in lists and visually in the Spatial Asset Viewer module (Fig. 3). Automated support from the system is a significant advantage for the further planning of the execution of the measures, which helps the maintenance manager to fulfil ever more challenging tasks with increasingly scarce resources.

Specifically generated dashboards

Modern technologies support the analysis of data in specifically generated dashboards. Decisions on maintenance strategies have a significant influence on the life cycle costs of a plant

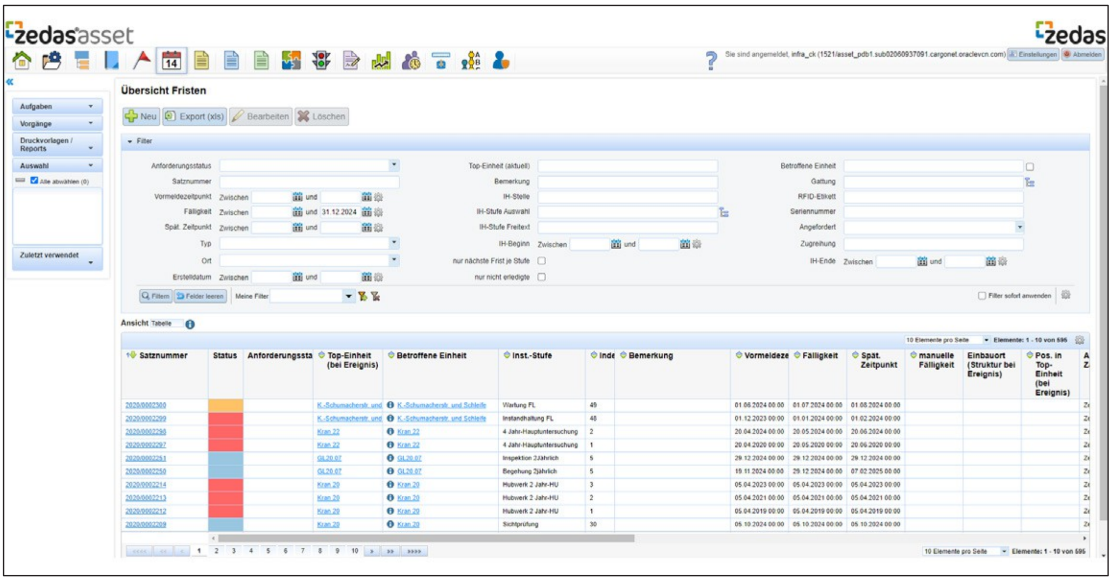


Figure 3: View for analysing and visualising maintenance data

and thus on medium and long-term investment planning. Investment planning games in the Invest Manager module can be used to illustrate the correlation between the development of maintenance costs and investment requirements and thus influence investment decisions. If Zedas Asset is used in fleet and infrastructure maintenance, data from both areas of the company is fed into the data pool and enables further analyses of the interaction between routes, vehicles, overruns, environmental factors and any disruptions or changes in condition that occur.

Modern technologies enable the user to retrieve information from the system easily and flexibly. Data analyses and their evaluations are becoming increasingly complex. In addition to conventional analysis methods, the use of modern technologies such as AI is essential in order to efficiently analyse huge amounts of data.

This is a necessary and logical step in order to realise the potential of the "data gold" obtained and make it usable in daily maintenance processes.

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The AIFRI funding project

The AIFRI project (AI-based analysis of rail inspection data for optimised maintenance planning), funded by mFund, an initiative of the Federal Ministry for Digital and Transport, aims to develop an IT tool that enables the efficient use of data collected from inspection runs. This includes data acquisition from eddy current and ultrasonic testing systems, their analysis and support in decision-making and visualisation.

The project, which runs from December 2021 to November 2024 and is funded with around 1.9 million euros, includes partners such as DB Netz AG, the Federal Institute for Materials Research and Testing, the software company Zedas, TU Berlin and the testing company Vrana. Thanks to AI processes, maintenance processes should not only be made more efficient, but also more precise in order to sustainably improve the quality and safety of the rail network.