Fig. 1 Data form the basis for predictive maintenance of railway systems.

Predictive maintenance of railway infrastructure systems

Digital management systems for linear railway infrastructure assets

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An economic railway system maintenance requires clear cost targets as well as quality agreements. Modern companies have identified the resulting potential as a strategic sucess and value added factor. For reliable and economic railway operations, railway infrastructure systems must be available at all times and have to meet all safety requirements. The service life of tracks, switches and traction current installations is to be maximised, reliability and availability is to be increased. Conventional maintenance practice has its limits. Modern maintenance must therefore be able to provide optimum support to employees with information regarding the condition, maintenance recommendations and forecasts. In the digital age, analysis of existing information from measurement and operating data and maintenance information plays an increasingly important role.
The aim is to provide all the information, analyses and forecasts for each type of asset needed to decide on an ideal maintenance strategy.

Merging existing data and evaluating them comprehensively

Regular monitoring of the rail road condition is indispensable for a perfect maintenance strategy. However, the aggregation and evaluation of data from different sources, such as on-site visits, inspections, measurement runs, video runs or repair are a challenge for every operator, owner and maintenance officer of railway infrastructure assets.

The use of a digital asset management system such as zedas®asset provides support for the complex maintenance management. Being an analytical information system, the software is able to collect and analyse data and „bring it to life“. Based on the structured railway infrastructure assets and components, all relevant process, operating and

measurement data can be monitored, analysed and managed in an asset management software solution. This also includes the display of the railway system condition including the history of all assets.

By default zedas®asset supports the transfer and integration of infrastructure measurement values and condition assessments from test trains, switch measuring systems and other expert systems as standard. To achieve the greatest possible independence from the different manufacturers of measuring instruments, the solution has several interfaces. This allows the user himself to transfer measurement data into the system, independent from the measuring device. This allows him to freely choose the measuring instrument manufacturer and prevents license-dependent stand-alone solutions of the measuring system providers. All maintenance-relevant information on defects, failures, inspections, deadlines, orders, measured values or limit value violations are displayed and monitored in a centralised manner. In maintenance schedules, not only inspections and maintenance are automatically entered, which are cyclical or dependent on the load, but also condition-dependent due date prognoses based on analysed railway infrastructure data. In this way, intelligent derivations such as deadline maturities ("smart data") can be generated from this mass data ("big data"). The generation of work schedules as well as check lists for the budget planning is possible, as well. Performance times, materials and spare parts can be additionally assigned to the work steps, in order to plan resources in a forward-looking manner. For all tasks, order-related information can be integrated with reference to rules and manuals. Mobile apps, which can function either online or offline, allow auditors and mobile service teams to record data continuously digitally.

Keeping data centrally offers the possibility of examining the relationship between all information in order to provide the user with targeted up-to-date information, e.g. on the asset status, current defect or fault behaviour, necessary maintenance and possible malfunctions.

The system provides comprehensive evaluations – from weak-point analyses of individual systems and components to the entire railway infrastructure, from the current asset status to a forecasted status, from individual work packages to the entire maintenance process. The aim is to provide the best possible transparency and support for the planning and execution of the increasing maintenance requirements throughout the maintenance process.

Zum Autor

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Fig. 2: Malfunctions, maintenance and condition information are recorded by employees

Predictive maintenance thanks to intelligent data management

The amount of data transmitted from track measurements should be analysed automatically and promptly. This is the only way to turn big data into smart data, which provides profitable information. The large amount of data from different sources is automatically merged. Any deviations and trends hinting at a significant change can be seen immediately. A single combined index provides information about the critical areas and the measured variables or parameters causing the problem. The focus is on more precise predictions about the condition and remaining useful life of infrastructure objects. The aim is to plan necessary maintenance measures including resources more efficiently, to increase the availability of railway infrastructure assets and to detect imminent failures in advance.

In order to decide when and with which fundings measures are to be taken, key figures alone are often not sufficient. Complex analyses are required, e.g. regarding status degression, costs and duration of the entire action plan, as well as consequences resulting from non-availability. The condition/cost index, or ZKI (in German: Zustands-Kosten-Index) for short, serves as a supporting tool for decision-making in this context. This index combines defined factors such as operating classes of tracks, asset classes and route categories in a complex proprietary assessment scheme based on the experience gained from the use of the zedas®asset asset management system. A general rule to apply here is: the higher the index, the more urgent the action. Examples for points taken into consideration for calculations are as follows:

- Costs of preventive and corrective maintenance
- Forward-looking prognosis (fig. 3)
- Safety speed (classes) and load (tonnes or number of axle passages per time period)
- Availability including redundancy
- Turnover of routes ordered by priority
- Condition index based on changes to the measured data as an objective criterion for manual inspections

As result, the analysis software offered a forward-looking prognosis. Using multivariate analysis methods, a prognosis on the remaining useful life (RUL), the time until the next failure to be expected, can be given based on the data on the wear development and maintenance history. The following applies in this context: The more precise

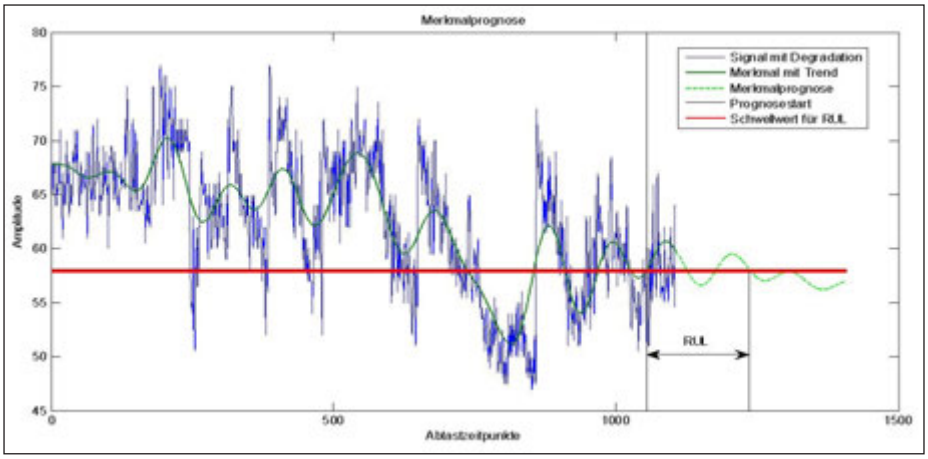

Fig. 3: Forecast on the remaining useful life (RUL)

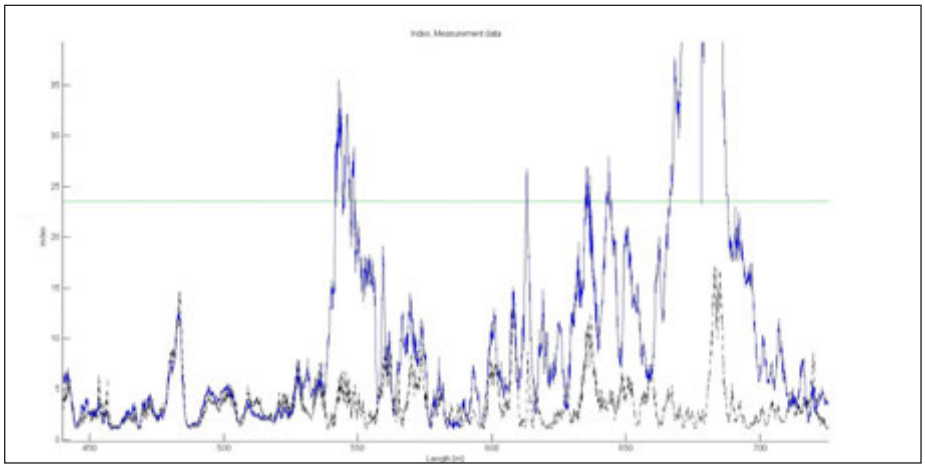

Fig. 4: Example condition index

and comprehensive the historical data (with reference to load and to external influences) are, the more exact the prognosis will be.

The most important instrument for analysis and control is the zedas®asset Track Analyser. It enables to linearly represent (ribbon-like) the geometry of a route, including provision of the most important information on tracks, switches, crossings, overhead line, signal and safety technology, as well as obstacles in the structure gauge. Status information and measured values related to exact geographical location, incl. occurring limit value violations, can be visualised via different selection criteria.

In addition, information on planning, implementation of and feedback on jobs as well as assessments and statuses can be included in the consideration. This enables the user to exactly analyse of the overall status. This will then form the basis for decision-making concerning the optimal planning of measures to be taken. Standardised interfaces to existing systems, extensive reports on evaluation and especially the visualisation of the object status in the diagram of the tracks support the user.

Optimised maintenance cycles with minimised repair effort

A reliable forecast on the course of wear and the probability of malfunctions of railway infrastructure systems as well as the extrapolation of due dates for maintenance planned on the basis of time and load, enables maintenance capacities to be optimally planned and strongly fluctuating loads to be prevented. Early and long-term scheduling of maintenance prevents bottlenecks in maintenance. Using Resource Manager, required operating materials and specialised staff can be better planned and conflicts arising from unforeseen repairs can be displayed and resolved. Failures due to malfunctions are thus minimised and downtimes are reduced. Better planning of maintenance measures enables a targeted use of resources and optimised spare parts management. For example, the system‘s timely recognition of requirements enables order proposals to be created at an early stage, the need for excessively high minimum stocks to be avoided and components and materials to be ordered in good timely manner while taking delivery times into account. The time for having to wait for spare parts deliveries and thus delays in completion of the work is reduced.

Stay on top of things with well thought-out dashboards

The integrated dashboard function allows to provides user and workstation specific real-time evaluations. They support the user with all relevant information of daily business at a glance. Conspicuous features on the assets, budget overruns, staff capacities, resources, defect and malfunction statistics are visualised. Information on the status of the asset in process, processing status of relevant work packages and next planned activities can be retrieved and displayed. Due to the timely feedback of completed activities and the required performance times, a transparent display is available at all times for the individual employee as

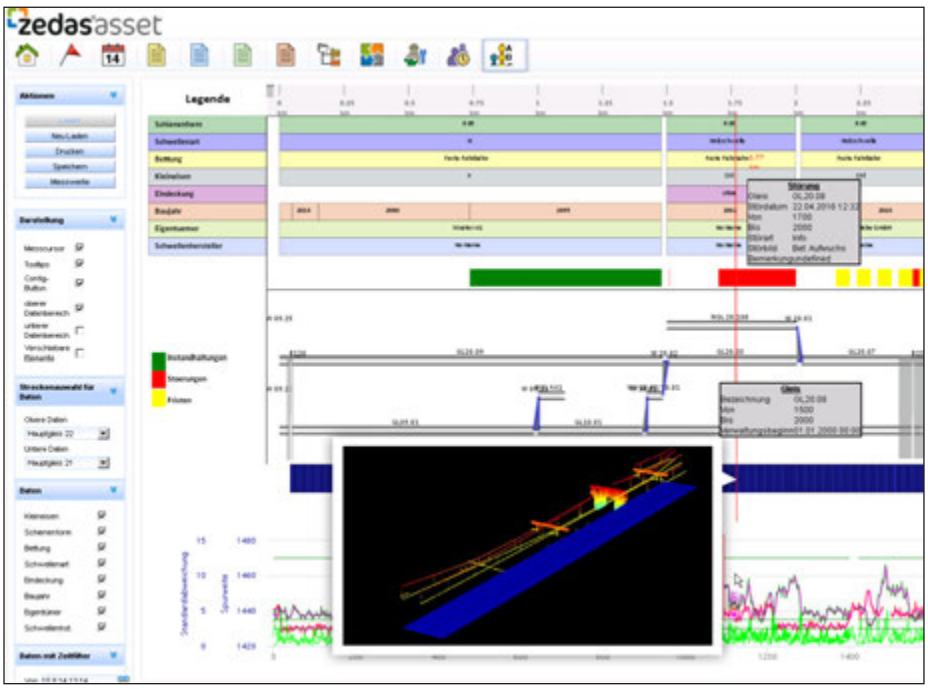

Fig. 5: The Track Analyser displays route geometry, construction, measured values including limit value violations and the clearance gauge

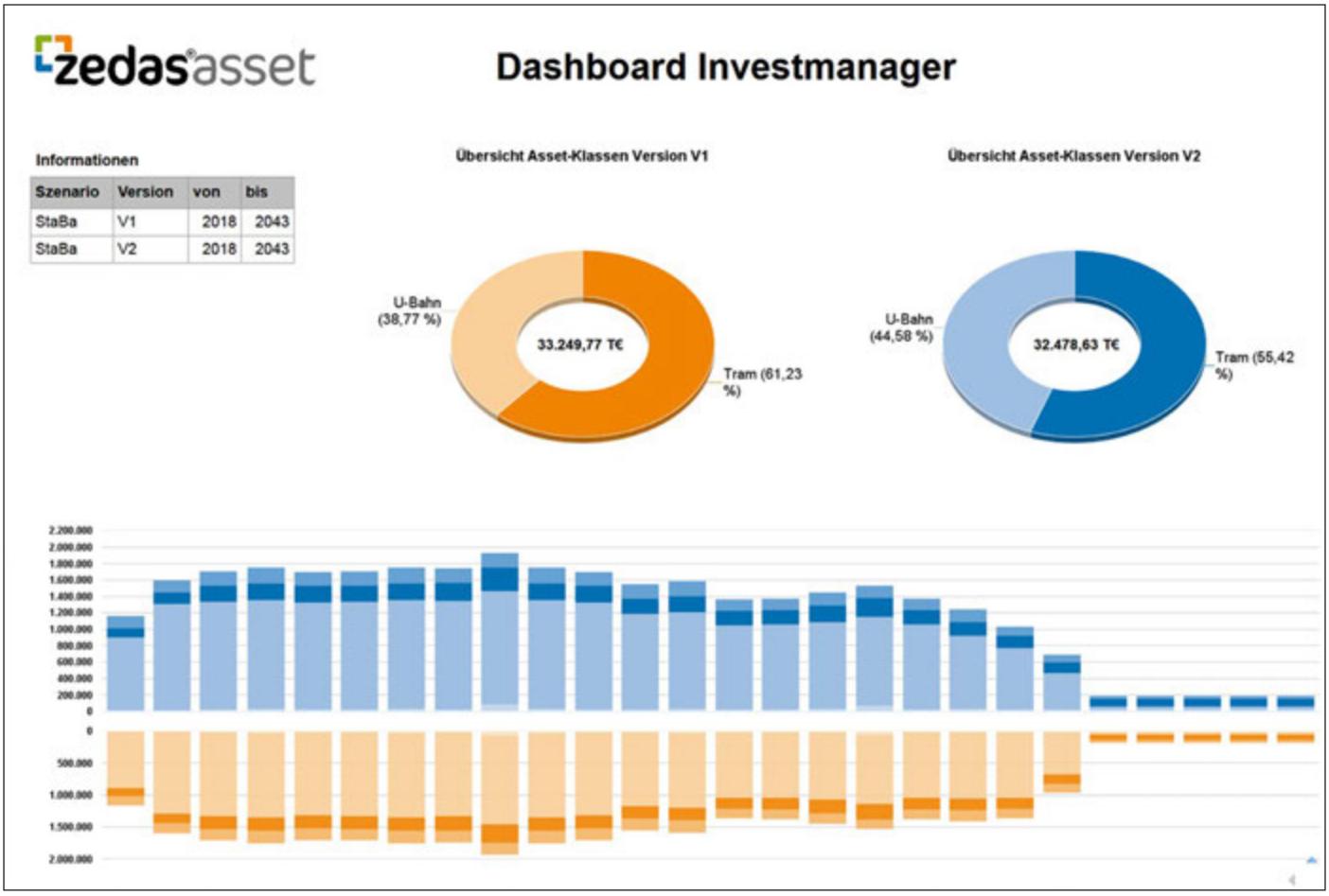

Fig. 6: Data analysis enables sound forecasts

well as for the administration. Delays in processing are detected immediately and measures can be derived.

Investment planning in railway infrastructure companies

Especially investment and budget planning on the basis of reliable data constitutes a challenge for many rail companies. AAn asset management system can also be used in this case, as by the analysis of existing data also advanced applications for longterm future demand and investment planning for asset management will be possible. The basis for this is the asset-related maintenance history. This includes the following data: Information on the life cycle of railway infrastructure assets, costs for corrective maintenance and predicted costs for preventive maintenance. The Invest Manager analyses this data and links it to flexible parameters such as price increase, influence of ageing and strain on the maintenance costs and determines a basic cost scenario for the investment requirement. This can be adjusted by the planner using freely selectable factors and parameters. In this way, several planning scenarios are created that serve as a basis for decision-making and can be compared with each other. A comprehensive graphical dashboard helps to evaluate the results.

Conclusion: Big data becomes smart data

Railway infrastructure companies are permanently faced with the challenge of making decisions regarding measures for improvement based on status information and key figures. When these measures are completed and how they are to be financed is a complex consideration taking into account the degree of change in condition, costs and duration of the measure as well as consequences resulting from non-availability. The use of zedas®asset enables a universal and transparent process from the identification of a situation over the planning of necessary measures to the execution and invoicing of the work, to the sustainable evaluation and documentation of the results. Accordingly, the use of the system also involves an weak point analysis and thus a sustainable continuous improvement process. Long-term data storage allows a statement on the behaviour over the entire life cycle of the infrastructure objects with the aim of determining the technically/economically optimum time for reinvestment and gaining planning security. A conventional data acquisition by timely inspection of the system plus by an extensive automated data acquisition enables a consistent monitoring of the condition of the infrastructure. A reporting system that can be configured for different groups of addressees provides the necessary processed data to enable decisions to be made.

Summary

Predictive maintenance of railway infrastructure

Digital asset management systems can significantly optimise the maintenance process: They enable targeted planning of all maintenance activities and higher asset availability. Railway infrastructure operators receive precise predictions of future failures. Asset management systems bring together all data in the maintenance process centrally and evaluate them continously and consistently in all directions. The user always has an overview of the current status of his systems. On the basis of the data, predictive maintenance becomes possible; this avoids iunneccessary maintenance appointements and unplanned downtimes.