# Maintenance 4.0 in rail transport: From Big Data to Smart Data

## *Obtaining and analysing condition data and key indicators for asset management in railway companies*

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Mr. Mayer has an important business meeting in Frankfurt am Main. Alone for ecological reasons, he has chosen to travel by rail and so, following a timetable app, gets on the train at Berlin Central Station at 8:31 a.m. His appointment is at 1:00 p.m. and his app assures him he should be at the reception desk by 12:47. It is now 11:05 a.m. and he has been waiting for 10 minutes in Göttingen, while a technician works on the locomotive up front. Finally, the train moves off again. The rest of the trip goes smoothly and, just in time at 12:55, he is shaking hands with his business partner in Frankfurt.

What Mr. Mayer does not witness is all the background data processing behind the rapid maintenance response. At 9:45 a.m., the control centre namely receives a fault message generated automatically from the transmitted vehicle data – a problem with the ventilation system. The on-board software system notifies the dispatcher that a component is threatening to fail (Fig. 1). In his computer system, the dispatcher immediately assigns the corresponding job to the closest maintenance team. The service technician receives a message on his mobile device along with an order for urgent repairs on the train coming into Göttingen at 10:55 a.m. The necessary replacement part and a checklist of work steps are also ready and waiting. He sets off immediately, and gets to the platform on time with the appropriate equipment. He changes the components and, as the train rolls out, immediately reports back to the dispatcher from his mobile device. The vehicle telemetry data, fault and order details, and technician's feedback are now stored in aggregate form in the system. They are archived and used for further analyses (e.g. weak point analysis, fault prediction etc.).

This example shows how economic benefits can be gained from analysing large, inhomogeneous volumes of data, also known as "Big Data", as a key to greater efficiency and economic success. Railway companies have certainly recognised this as a value-adding factor. Yet, they are often lacking the tools to take full advantage of it. A study by McKinsey on the "Internet of Things" (IoT) substantiates this. There is still far too little use of aggregate data, for want of algorithms and tools. Also, it is often hard to identify the value added for the relevant business areas, or the divisions in question do not use the technologies to their full potential, if at all.

Enter Industry 4.0: a future project called into being by the German government as part of a high-tech strategy to expedite the digitalisation of the classical industries. This objective can of course be extended to the railway industry. If railway companies are to reap the benefits of Industry 4.0, they will need to make certain adaptations to their existing processes and procedures. This includes, for example, individual solutions for condition-oriented maintenance, monitoring of LCC and RAMS agreements, or resource optimisation. With new work methods based on end-to-end communication from sensors to mobile devices, Industry 4.0 can be just as easily applied to rail, given automated IT-supported data processing and intelligent algorithms.

In the scope of long-standing cooperation between ZEDAS GmbH Senftenberg (formerly PC-Soft GmbH) and various railway companies, different asset management solutions have been created, for example, for fault detection, order processing, time optimisation and resource planning (encompassing an organised approach allowing a company to maximise asset value or minimise liabilities). The goals of these companies are reliability, availability, maintainability and safety. Focus cannot

**Fig. 1:** Condition data

remain exclusively on minimising maintenance expenditure. Maintenance is not just a cost pool, it is in fact the price of availability.

Accordingly, in the times of Industry 4.0, one has to employ intelligent algorithms to crunch the accruing data and gain valuable information, or in other words create decision-making bases. Big Data then becomes Smart Data. Automated analyses, for example, of vehicle telemetry, event logs, causal analyses and order records should yield valuable insights. Technical diagnostics using multivariate methods can deliver software-supported predictions of CAPEX (capital expenditure for acquiring long-term assets, an important indicator on the balance sheet) and its counterpart OPEX (operating expenditure, the costs of raw materials, operating materials and workers). Multivariate analytical methods examine multiple statistical variables, or random variables, at the same time. Covariance or dependency structures between the variables can thus be recognised and analysed.

Indicators relating to maintenance costs only, without accounting for load and condition, are not meaningful. To be meaningful, data obtained from multiple IT systems at various process stages has to be optimally handled. The main challenge for every operator, owner and maintainer of rail vehicles and railway infrastructure systems is aggregating and analysing data from different origins. The important thing is not the simple acquisition of data, rather its analysis, where constant condition monitoring is prerequisite for choosing the best maintenance strategy. zedas®asset is an industry-specific tool for obtaining this decision-critical condition information.

**Technical diagnostics is key**

The volume of data transmitted from track measurements or vehicle telemetry must be analysed (preferably) automatically and promptly after its acquisition. Only that way can Big Data become Smart Data that delivers additional, profitable information. The wealth of heterogeneous data is made homogeneous, which can be done automatically for all measured quantities. Deviations and trends that indicate a significant change are immediately discernible. Information comes from a single combined index on the problem areas and the causative variables or parameters.

Error frequency analysis is equally important in technical diagnostics, since it indicates manufacture-related serial defects or reveals errors in operation or maintenance.

**Smart asset management and maintenance**

All relevant process, operation and measured data arising from structured systems, vehicles and components can be monitored, analysed and managed in asset management software. This includes displaying system or vehicle conditions, along with their full life history. All maintenance-related information regarding faults, dates, orders, measured values or limit violations are displayed and monitored centrally. Follow-up times are defined in maintenance plans, which can be initiated periodically or load-dependently, or a condition-dependent expiry prediction can be made based on analysed vehicle or system data. Thus, from the masses of data ("Big Data"), intelligent derivations ("Smart Data"), such as expiry times, can be made. Work plans and checklists can also be generated for budget planning. Work operations, performance periods, materials and spare parts can be assigned in order to plan resources with foresight. Order-related references to rules and manuals (e.g. maintenance guidelines according to VPI08 in the rail vehicle industry) can be integrated for all work tasks.

Economic indicators are calculated in the system, for example total maintenance cost (indicator E1 in DIN EN 15341[1]), which states the ratio of total maintenance cost to asset replacement value as a percentage. The maintenance cost rate is applied to verify maintenance costs upon changes to maintenance objects (turnover) or to plan them for new objects.

**Automatic weak point analysis**

Weak points, or in other words neuralgic points in the vehicle or system, are examined in greater detail working from the calculated maintenance data. Weak point analysis, technical fault management and condition assessment are the bases for an indicator system for "fault and damage analysis" in conjunction with the "condition-event-cause key". A technical condition assessment is made that, in addition to the type of damage and degree of damage according to the condition classification, takes into account the overall conditions of the individual case. It also categorises the damages into classes, where type and number are freely definable. Companies most commonly limit themselves to 3 classes in the form of a "traffic light" system (with green/amber/red representing good/acceptable/bad). The analytical results from the technical condition assessment are made available via integrated reporting.

**CCI – Cost/Condition Index**

Economic maintenance of railway tracks and vehicles requires clear cost objectives and quality agreements. Highest priority goes to precisely predicting the condition and remaining useful life of

rail vehicles and infrastructure objects. The aim is to plan the necessary maintenance measures and resources more efficiently and to increase the availability of vehicles, components and systems. Investment and budget planning based on reliable data is a particular challenge for many railway companies.
Often indicators are not enough on their own to decide when and with what funds measures will be taken. Rather, what is needed are complex breakdowns, for example, on condition degradation, costs and the time it takes to complete all measures, as well as the consequences resulting from non-availability. A decision aid in this context is the Cost/Condition Index, or CCI. This combines specific factors into a proprietarily developed complex evaluation system based on experience with the practical application of asset management systems in numerous railway companies (Fig. 2).

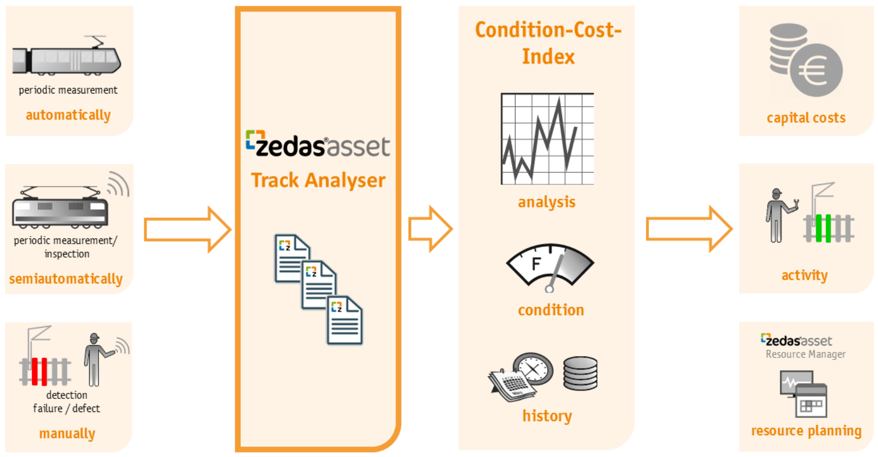


**Fig.2:** Calculating the Cost/Condition Index

Graphics: ZEDAS GmbH

Factored into the calculation are, among other things, safety, speed (classes) and load (tonnes or axle passages over time, engine load ranges, mileage data and operating hours). Adding to this are factors such as availability, including redundancies, turnover according to priorities of scheduled routes, or costs and histories for preventive and corrective maintenance. The analytical software ultimately delivers a prediction. From wear and maintenance history data, using multivariate analytical methods, a prediction can be made of the remaining useful life (RUL), the time until the next expected failure. The rule here is: the more precise and comprehensive the historical data (with regard to loads and external influences), the more accurate the prediction. Practical experience shows that this reliable data history is often (still) lacking. A state of affairs that will soon be a thing of the past, with the coming of Maintenance 4.0.

**Summary**

Railway companies and railway infrastructure companies constantly have to decide what improvement measures to take, based on condition data and multiple indicators. When and with what funds these measures will be implemented is a complex matter, which depends on the rate of change in condition, cost and time required to complete the measures, and on the consequences of non-availability. A helpful decision aid is the Cost/Condition Index, determined through consistent application of Maintenance 4.0 standards. If one is to gain Smart Data from the typical “data graveyards” of Big Data, one must recognise that condition monitoring, diagnostics and maintenance management are a single unit, in the sense of integrated asset management.

**FURTHER READING:**

[1] DIN EN 15341:2007 Maintenance – Maintenance Key Performance Indicators

**CAPTIONS:**

Figure 1: Condition data, ZEDAS GmbH
Figure 2: Calculating the Cost/Condition Index, ZEDAS GmbH