Rail Track Data Base of German Rail – the Future of Automated Maintenance

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SUMMARY

German Rail maintains a global data base where all rail track information is managed in a consistent way. The data base is used as a reference frame for all facilities.

The rail maintenance work leads to geometrical changes in the situation. There are two kinds of maintenance tasks:
Relative track position recovery - separate for plane and height and Absolute track position recovery in 3D.
This is of special importance as all emergency management can only be based on a valid rail track data base, and the ongoing building activities have to be synchronized with the maintenance activities resulting from the measurements.

In this paper the concepts of the maintenance concept and appropriate tools are described and maintenance examples are demonstrated.

ZUSAMMENFASSUNG

Die Deutsche Bahn AG unterhält zentral eine konsistente Streckendatenbank. Der Datenbankinhalt wird als Bezugsystem für die gesamten Anlagen verwendet.
Bei der Instandhaltung findet eine periodische Überprüfung und Korrektur der Lage- und Höhenveränderungen. Es ergeben sich dadurch zwei Hauptaufgaben der Instandhaltung.
Die erste ist eine relative Gleislage-Wiederhehrstehlung nach Lage und Höhe unter Berücksichtigung der Nachbarschaft. Die zweite ist die absolute 3D Wiederherstellung.
Beide Aufgaben erfordern Aktualisierungskonzepte und Prozeduren für die Gleisnetzdatenbank die einen hohen Grad an Konsistenz und Aktualität gewährleisten soll.

Ein funktionierendes Sicherheitsmanagement nur auf der Basis einer ständig aktuellen Gleisnetzdatenbank funktionieren kann. Die bevorstehenden Bau- und Umbauaktivitäten sollten mit dieser der Instandhaltung als Ergebnis von Messungen abgestimmt werden.
In den vorliegenden Beitrag werden die Konzepte der Instandhaltungstools sowie dazu passende Beispiele präsentiert.

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1. INTRODUCTION

The main railway tracks as a typical linear object have individual lengths of several hundreds of kilometers by passing more than one reference systems. The different coordinate systems used nation-wide lead to inhomogeneous and inconsistent data bases and documentation. The inhomogeneity of the reference frames has historical reasons. These frames have different orientation and scale. This leads to serious difficulties in the alignment which can be regarded as a connection to the corresponding state reference systems in their overlapping regions. Therefore it is necessary to establish an unique reference frame.

2. TRACK MAINTENANCE SCHEDULING MODELS

The most of the rail systems in Europeby automated production equipment of high capital value. This equipment operates efficently in situations where long lenghts of track are refurbished in a continuous process. The real time positioning information of the equipment is very important in emargency situations and should be integradet in the database.
The main characteristics are:

- Optimum track maintenance scheduling
- Grinding programs
- Profile recognition and other track condition inputs
- Risk management
- Database integration

In respect to the track maintenance there are two types of defects.

- Matched geometry and force defects
- Geometry defect without a corresponding force defect

3. TOOLS

It is of special importance to make the process of data acquisition efficient and at the same time to guarantee consistency. This can be achieved by strict definitions of points and elements, and by efficient tools for alignment calculations and transformations.

3.1 Reference Frame

The objective of the German Rail is to use its own homogenous reference frame *DBREF* for its surveying tasks. DBREF has been computed from about 6000 GPS obervation sites along the DB railway tracks. (Schmitz, M. et all. 2004). The homogeneous transition between

DBREF, ETRF89 and the reference frames of all 16 German states (DHDN/STN) has been realized using the Geo++®GNTRANS transformation tool which includes also the height transformation (DHHN) and a geoid model.
The information about the coordinates from the previous, but still used official coordinate systems and coordinates derived from satellite surveying must be transformed into DB_REF and vice versa.

3.2 RTK Data Collector

For speed up the acquisition and achief a betther density and quality of the control data two new methods are used.

3.2.1 Low speed data aquisition.

For all tasks that require a precise survey of the track positioncontrol during new construction and reconstruction a RTK System is useble (Figure 1). This includes:

- marking out of tracks and turnout systems
- acquisition of differences between planing position and actual position
- track net database (GND of German DB AG)

Figure 1: GPS RTK Data Collector-GNBAHN Geo++®

3.2.2 High speed data aquisition

Real time data can already be obtained readily from recording equipment mounted on service vehicles. This approach of data processing has a potential for an overall reduction of track maintenance and renewal costs.
That automated machine-based measurement using EM-SAT-vehicle can detect even long-wave level and curvature errors up to 250m.

With conventional track surveying, the position of the track is determined by means of fixed points-benchmarks (fig. 6). This is a labour-intensive process that can be reduced by using innovative measuring techniques. Using the EM-SAT track pre-measurement car in conjunction with GPS satellite positioning is an alternative to conventional fixed point surveying, with fixed points being replaced by GPS reference points.

3.3 Automaticaly Railway Detection

- Railway-calculation on the basis of measured or digitized points
- Error analysis and detection of measurement errors
- Curvature-calculation

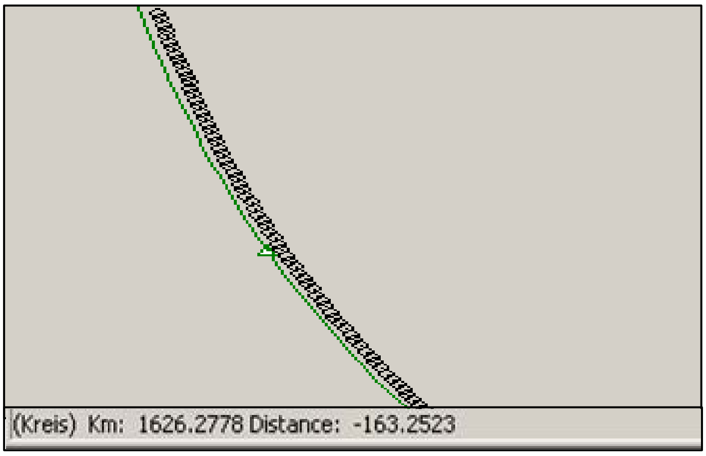

Figure 2: Railway optimization in plane and height

The maintance characteristics can be based on the comparison between of the the geometry (fig.2) or between the curvature (fig. 3)

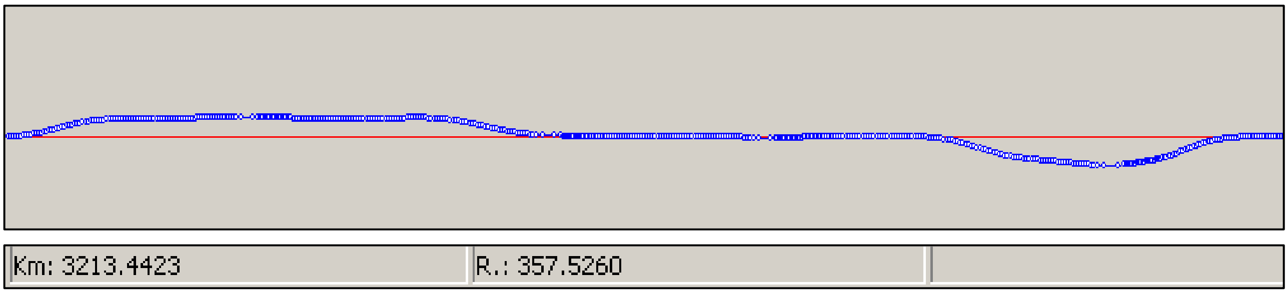

Figure 3: Winding off the curvature

- Transformation of inhomogen railways to a homogen system (ETRF89)
- Detection of inhomogeneities and alignement to the homogen system
- Railway optimization with editing of elements and parameters (figure 2)

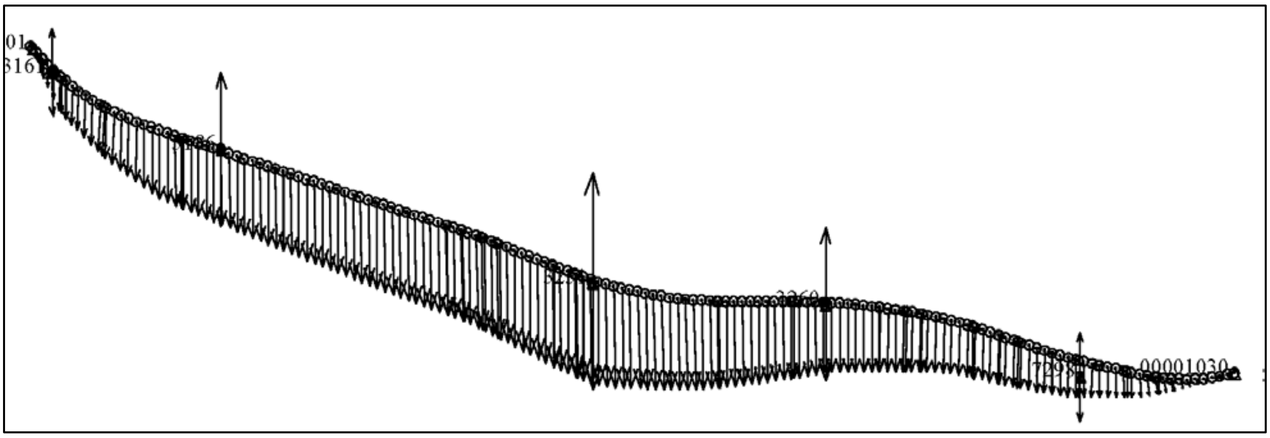

Figure 4: Conversion of an inhomogen railway to a homogen system

It is important for a transformation to maintain the local relationships in the vicinity of the coordinates. The adjacent metric properties can be changed while mapping the coordinates into another coordinate system (Fig. 4).

3.4 Data Transfer

Typical tasks which have to be supported are reconstruction of certain rail lines, the change of alignment as a result of the rail maintenance or the construction of a new line which has to fit into existing parts. All these tasks require the complex modification of the data base of rail objects. In order to avoid inconsistencies the data needed for the modification have to be extracted from the data base (Fig. 3), modified according to the requirements of the specific task, and then transferred to the data base. For modification, specific independent programs will be used, and then a data base transfer table will be prepared to ensure consistency via suitable checks. In order to avoid any loss of information during the data base exchange procedure, each data set of the transfer file corresponds to a data set of the data base relational tables.

This concept has been realized in the program system VERM.ESN (Adelt, Milev, 2002) .The system has a modular structure. A specific advantage of the program system are its features for highly precise calculations. In order to satisfy the consistency requirements, the accuracy of the coordinates of the points should be better than 10^{-6}m and the precision limit for the tangent directions should amount to 10^{-7}gon.

The aim of the alignment is to find the curvature parameter in each point of the track. This can only be achieved in a stepwise manner, namely by introducing elements, because of the the numerous geometrical constraints the alignment has to fulfil. Due to the specific maintenance requirements the definition of rail alignments is based on the chainage alignment and the actual alignment of the right or left rail. Due to the complexity of the maintenance tasks of alignment the actual task can only be carried out in sub-tasks. After-wards the result has to be merged in a consistent way. This approach requires a specific structural information. For a number of tasks a three line alignment model – chainage and

right and left rail - will be sufficient, for complex data, however, a seven line model is necessary. There, the vertical alignment and the super elevation is additionally required.
Based on this measured track geometry and vehicle accelerations, the force predictions are more than adequate to provide the basis of a performance measuring regime.

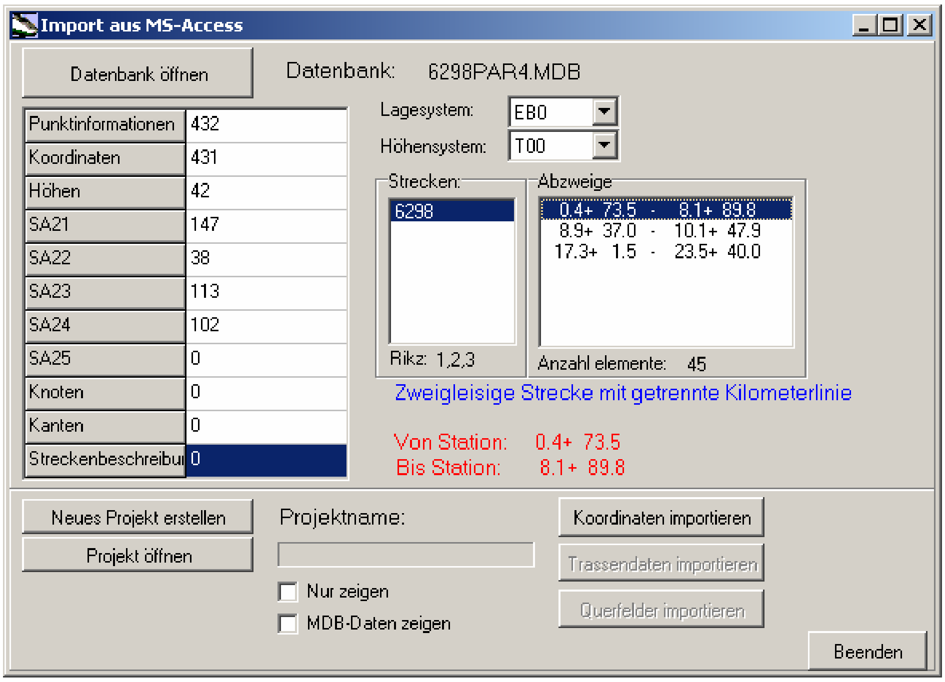

Figure 5: Structure of a data base import tool

3.5 Benchmark Drawings

For the construction companies the benchmark drawings are of primary importance. Fig. 6 shows a typical benchmark drawing.

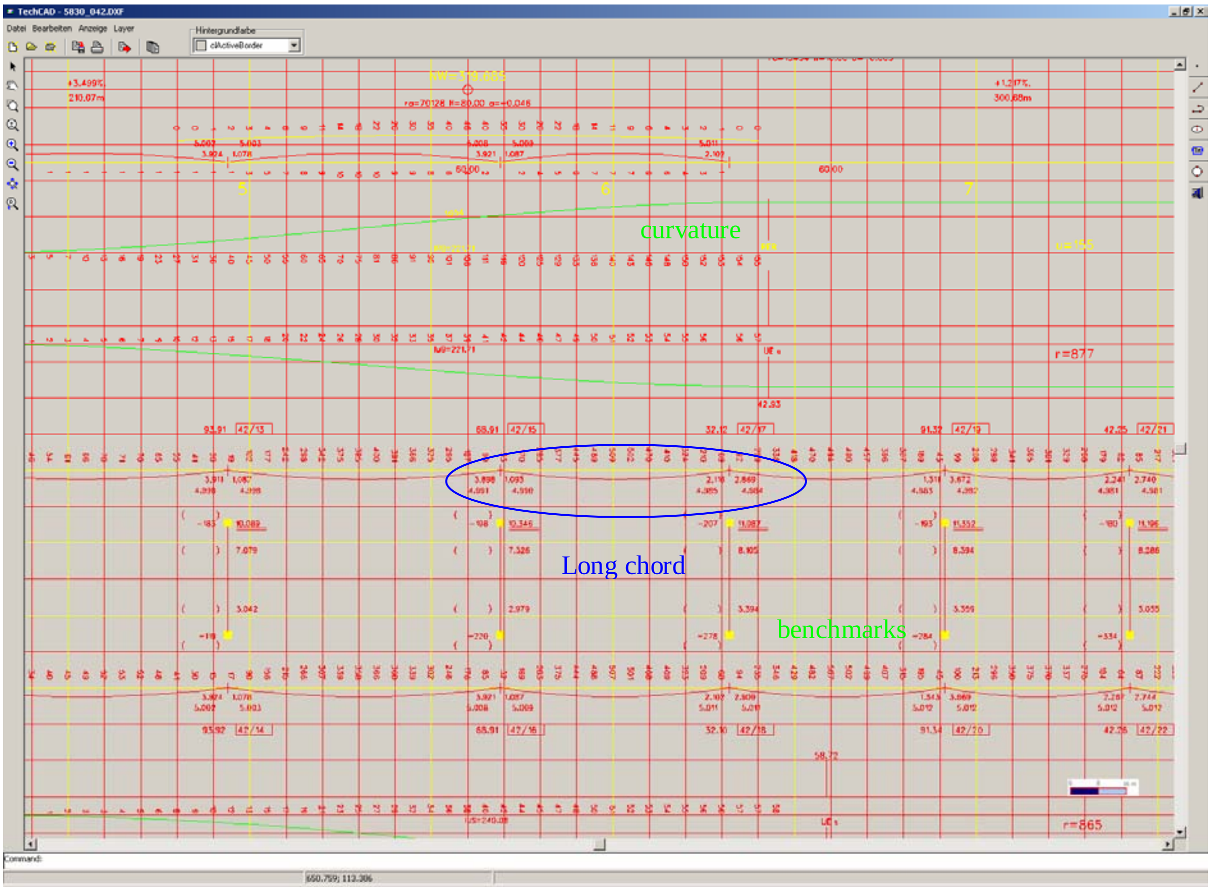

Figure 6: Ttrack benchmark drawing

4. CONCLUSIONS

When maintaining complex geometric situations with long transactions and strict consistency requirements like in a rail network data base it becomes necessary to reduce the absolute geometrical information to a minimum and reference the objects in a relative way. This approach proves to be powerful and reliable.

It makes a sense to substitute the homogeneous reference frame for linear objects, especially for rail tracks, and use the new reference frame for their GIS solutions.
It is strongly recommended not to make this change before the handling guidelines, tools and the technological work flow are developed.

The only straightforward approach is to develop an adequate model for cost attribution based on a proper understanding of the interaction between vehicle and track, the site specific engineering data and the development of verifiable algorithms which relate track geometry deterioration to the properties of the track subgrade and the vehicles passing over the track.

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BIOGRAPHICAL NOTES

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