POLISH ACADEMY OF SCIENCES - MATERIALS SCIENCE COMMITTEE
SILESIAN UNIVERSITY OF TECHNOLOGY OF GLIWICE
INSTITUTE OF ENGINEERING MATERIALS AND BIOMATERIALS
ASSOCIATION OF ALUMNI OF SILESIAN UNIVERSITY OF TECHNOLOGY
Conference Proceedings
11th INTERNATIONAL SCIENTIFIC CONFERENCE
ACHIEVEMENTS IN MECHANICAL & MATERIALS ENGINEERING

Autonomous track geometry diagnostics system

J. Madejski

Division of Materials Processing Technology and Computer Techniques in Materials Science,
Institute of Engineering Materials and Biomaterials, Silesian University of Technology
ul. Konarskiego 18a, 44-100 Gliwice, Poland

The paper presents the background of the Diagnostic Analysis for Railways and Trams (DART), automatic diagnostic analysis tool for the track geometry measurement data - as separate track data files or track data read from the database. The diagnostic module indicates the "weak locations" in the track, which can be further analysed in detail by the diagnostician. DART track diagnostician’s computer assistance system helps to save some 90-95% of labour consumption.

1. INTRODUCTION

Current practice indicates that only the information provided by geometry cars and track gauges in the form of plots of particular track parameters and its synthetic coefficients, supplemented with the engineering analysis of the track history and regular visual inspection, feature a basis for taking the sound decisions regarding the type and scope of the track repair at the particular location [1].

Nevertheless, the experience shows that using pure statistics of defects in various classes, instead of making use of the real track data, like exact location of defects, local conditions, substructure type, etc, does not allow the infrastructure maintenance services to evaluate fully the track condition. One more deficiency of this statistics is that it separates different types of defects: twist from cant or vertical irregularities, or track gauge from its horizontal irregularities. The track, however should be perceived as an entity with its design data and geometry linked together. More to that, horizontal irregularities should be taken into consideration along with the condition of the track superstructure, and the horizontal irregularities with the stress values in rails.

The problem is even more important as many hundreds or thousands of kilometers of track have to be analyzed at the District level. Synthetic track condition coefficient merges, in fact, the information about the geometrical quality of track with its other attributes, like rail condition, rail joints, rail fixing, ballast, sleepers, and dewatering. Therefore, the defect found is reflected by the synthetic coefficient of the track condition J. More than a decade of hands on experience proves that this information, when used together with the knowledge of the track design (permanent way and substructure) and its historical values of this coefficient with the history of track maintenance, may help to specify the type and scope of the repair [3, 4].

2. DIAGNOSTIC SYSTEM DESCRIPTION

The autonomous diagnostic system consists of tow main modules: the track geometry data source and the knowledge base. All measurements made by PKP geometry cars in Poland are stored in the database. All this data features the basis for track improvement plan development by Infrastructure Management. The stationary data processing system is used for re-playing the geometry car readings to evaluate the effect of line speed limit on the line quality evaluation, and for analyses of the track condition changes in time [2, 4].

The system users can specify queries pertaining specific tracks, Districts, or quality of the entire lines from the entire railway network, with the averaged values for the entire network. Therefore, the track quality synthetic coefficients feature the powerful tool for forecasting long term track quality changes, effects of the repairs done, influence of the local conditions, and evaluate the economical justification of the particular track maintenance strategies.

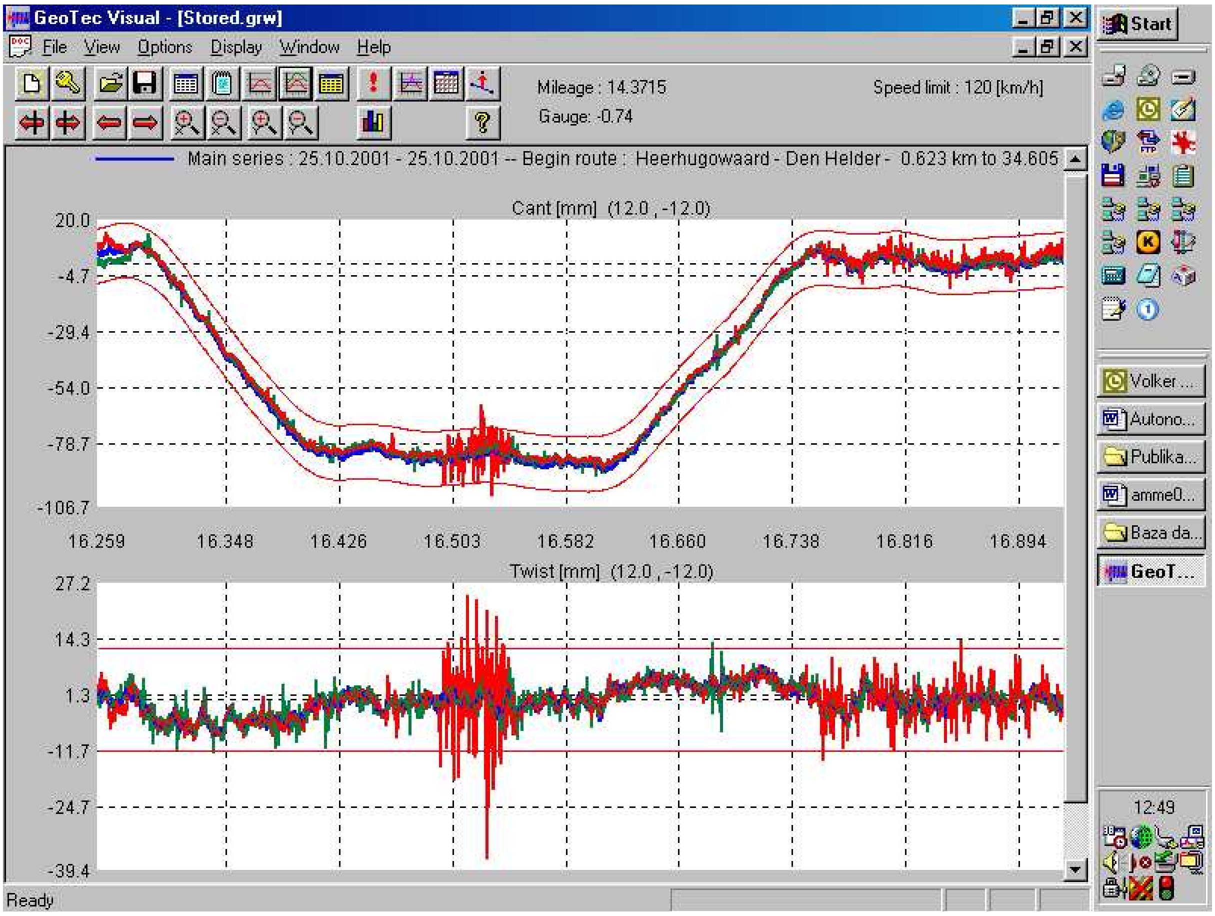

Fig.1 Historical track geometry readings

This database has been developed for storing data about the track condition, collected using the microprocessor based track gauges. The system consists of two subsystems: database with a model of the railway network model, and the database with the measurement results. An important feature of this database is its capability of storing the real track geometry measurement results along with its design specification, so comparison of the actual track geometry and the theoretical one is possible. Moreover, it is possible to compare many “historical” readings of the track to detect the rate of its deterioration in terms of particular parameters and/or the track synthetic quality coefficients [5, 6]. All measurement results acquired using track gauges are pre-processed before storing in the database, so that diagnostic analyses do not require the user to look for any specific readings [4].

2.1 Track geometry database

An important feature of this database is that the presentation tools operate on tables with the synthetic coefficients only. No information whatsoever on the track geometry details are needed at this level. The “bird’s eye” view of the railway network makes it possible to concentrate on the general trends, no matter from what measurements come the data. The integrated approach will make it possible to use the geometry car readings along with the data collected by track gauges. An example of the GeoTEC potential is illustrated in Fig.1 in which measurement results are shown for a Dutch railway line before tamping, immediately after tamping, and two weeks later – after stabilizing the track.

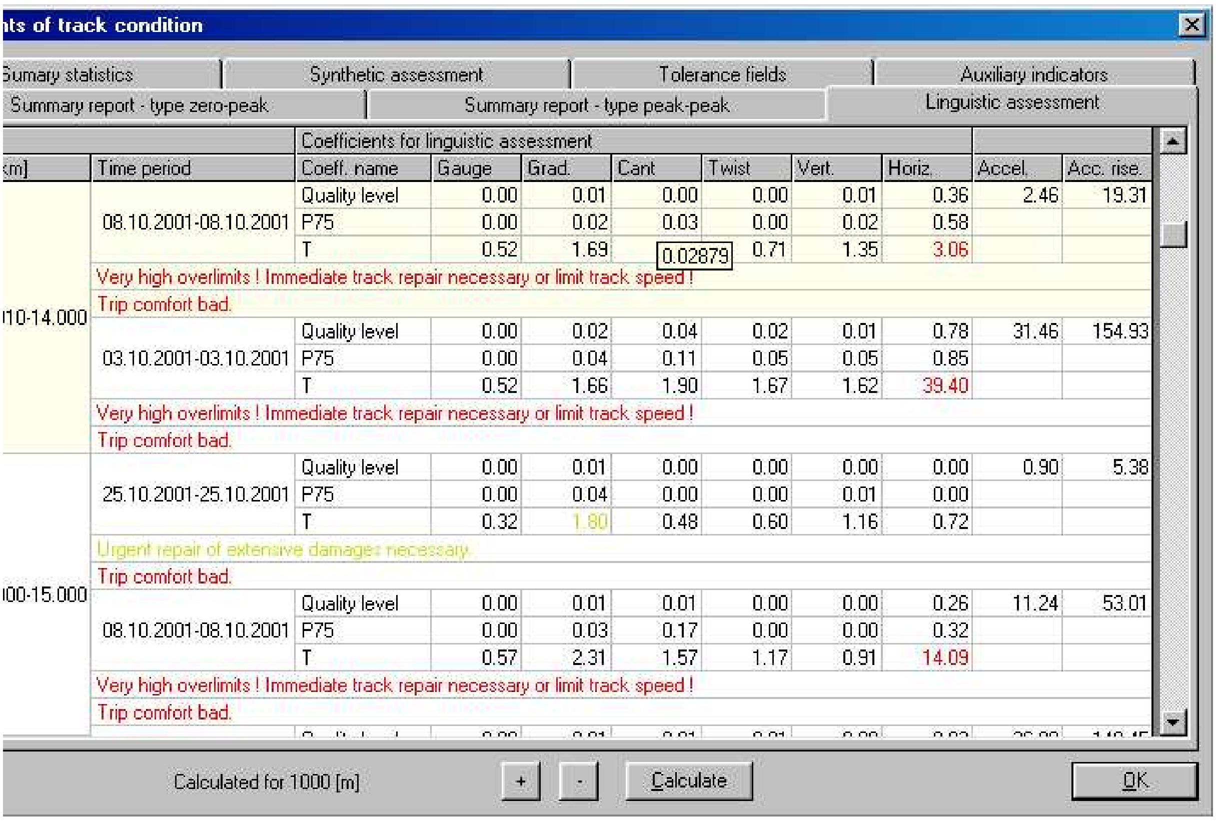

Fig.2 Exemplary track geometry analysis with maintenance procedure recommendations

2.2 Knowledge base

The knowledge module is endowed with expertise concerning the topology of the railway network and the track maintenance procedures and technology. It offers two main services:

- Data abstraction and filtering: abstractions from the track gauge and geometry car data, like geometrical parameters, W5 and J parameter values [1], as well as calculated accelerations of a material point travelling along the track.
- Maintenance task ranking: given an estimated track condition, diagnostic knowledge is used to assign right track improvement technology to the particular track segments.

An example of the track maintenance domain knowledge embedded in the diagnostic system:

```
IF      track defectiveness is low
  AND   acceleration is low
  AND   coefficient P75 for the track is high
THEN    There is a high probability that the track geometry tolerance
        coefficients' values will be exceeded soon
  AND   track does not require repair yet
```

The system diagnostic capabilities comprise three functionalities:

- the *where* module: indicating where the problem in the track develops, even before the parameter values exceed tolerances,
- the *why* module: explaining the cause and severity of the problem,
- the *how* module: being the knowledge base for determining the right track maintenance

3. CONCLUSIONS

Detailed analysis of track geometry parameters' plots assists taking the right decisions pertaining making urgent local repairs, i.e., to ensure safety of train operation. The knowledge of the synthetic track quality coefficients is required to take the economically justified decisions connected with planning of major overhauls of the longer track sections. These decisions call for analysis of the track geometry changes in time. This analysis may be carried out by the dedicated software for management and analysis of the track measurement results acquired for track gauges and geometry cars.

BIBLIOGRAPHY

1. H. Bałuch, "Quality Management of track repairs", Problemy Kolejnictwa, Fascicle 130, Warsaw, 1999, 5-24 (in Polish).
2. J. Burghardt, M. Iwaszkiewicz, J. Madejski, "System for the Real Time Railway Track Geometry Parameters Evaluation", Proc. of the 7th Int. Sc. Conf. on Signal Processing Applications & Technology, Boston, Massachusetts, USA, October 7-10, 1996, vol. 2, 821-1825.
3. J. Madejski, J. Grabczyk, "Track and Rolling Stock Quality Assurance Related Tools", Proc. of the Int. Sc. Conf. on Computer Aided Design, Manufacture and Operation in the Railway and other Advanced Mass Transit Systems - COMPRAIL 98, Special Session on Safety of High Speed Trains, 2-4 September 1998, Lisbon, Portugal, published later as a chapter in a book: "Structural Integrity and Passenger Safety" - Wessex Institute of Technology, 1999, 85-114.
4. J.Madejski, J. Grabczyk, "Continuous geometry measurement for diagnostics of tracks and switches", Delft University of Technology, The Netherlands, International Conference on Switches: Switch to Delft 2002, March 19-22, 2002, (in print).
5. IRIS – System Description, Erdmannsoftware GmbH, 2002 (unpublished manuscript).
6. TRIS – System Description, Volker Stevin Rail & Traffic, 2000 (unpublished manuscript).