HOLISTIC APPROACH TO TRACK CONDITION DATA COLLECTION AND ANALYSIS

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Abstract

Track geometry measurements are made using the manual tools, microprocessor based portable instruments, and geometry cars. However, no measurement method or tool without data logging feature, is capable to collect all data that would be necessary for the detailed diagnostic reasoning in a line or railway network level, being useful only for direct measurement of some track parameter at a particular point. Microprocessor based track gauges, trolleys or self-propelled geometry cars, or else measurements and inspection equipment mounted on the regular trains, can record all aspects of track condition.

Timely use of this data is the source of the cost efficient and rational maintenance decisions. Moreover, the earlier the necessary repair is done, the less expensive it will be. Therefore, expenditures on measurement equipment and data repository systems are the most effective investment – saving costs of possible accidents and costly repairs if they are made late. This is even more evident in the case of track network revitalization, as one has to decide where and what should be repaired first.

Operating safety may be ensured only if the actual track condition is known. This requirement calls for easy access over internet on various platforms to measurement data – current and historical – and also to results of their analyses. These include, among others, also results of image analysis of streaming visual inspection. They can later be reported on plots and tabular reports so that maintenance service can efficiently locate specific locations needing maintenance. Some analyses require application of the artificial intelligence methods.

Keywords: track condition, track diagnostics, track maintenance, video inspection, track geometry

1 Introduction

The safe, dependable track must be a given for all rail transport, be it for a high-speed line or a less used rural line. Review, maintenance, and renewal of track is, therefore, a crucial, but additionally a vital, cost to railways. The search carries on for more cost-efficient ways to maintain the appropriate track condition at the lowest through life cost. One facet of this is to develop strategies which require less track possession time. This is becoming ever more important as rail transport infrastructure owners strive to improve capacity on existing lines. The appropriate maintenance is the governing factor of the long service life of the track components.

The main issue with the preventive maintenance approach being the common approach is that in many cases, corrective action is taken when there is no need, sometimes resulting in unnecessary maintenance. The unnecessary maintenance can become even more costly if the secondary damage happens during the replacement. The condition-based maintenance eliminates this problem, as the repair can be planned at a time that minimizes the impact on track use to use its components to the limit of their service life. Improvements in quality, profitability, and productivity result when this approach is used on capital-intensive assets, like railway infrastructure. This approach requires the continuous stream of reliable data describing the current track condition in as many aspects as possible. The issue now is what data sources should be considered and how should the infrastructure condition analysis results be made available to their relevant recipients.

2 Data sources

There are a number of reliable data sources available nowadays, differing with the scope of information they can provide, volume if measurement data, and their effect on the measured track. Their price and availability feature usually the governing factors for potential users – see Table 1. The main advantages of the affordably priced trolleys and self-propelled carts are that they can be used immediately whenever required, while the costly track recording cars are used mainly for the track network regular inspections [1, 4, 5, 6, 11, 12, 14].

Table 1. Features of various track condition measuring devices and systems.

Features	Trolleys	Self-propelled carts, towed platforms	Track recording cars
Cost	low	medium	high
Measurement systems	1 - 4	1 - 6	16+
Load to the measured track	negligible	modest	full
Operating speed	4 km/h	16 km/h	high
Volume of measurement data	low	medium	high
Track possession	required	required	like a train

Another issue is the volume of the measurement data obtained per shift. In case of the trolleys it may be up to 100 KB, while in case of devices equipped also with the rail head wear systems it may be 100 MB or more. Track recording cars, equipped with video inspection systems may generate even up 100 GB in the comparable time. Therefore, careful planning is required concerning collection of the data, its processing, backup, analysis, reporting, and providing access to the analyses of the measurement data.

The data is collected in various formats, beginning from simple text files (simple manual track gauges, some trolleys), proprietary format track geometry files (most trolleys, and measurement systems of carts and track recording vehicles), and results of video inspection saved as AVI files with the possibility of exporting images to BMP or JPG formats. The video inspection data is usually pre-edited be tagging them with information about line and track ID, actual mileage, date, time, etc.

Another issue is the way in which the data may be used by the diagnosticians. Data collected with trolleys are usually in a form of the separate files for each measurement. They may be compared, merged, yet usually they are collected by the base railway diagnostic unit and only their analysis results are shared with the higher level. The same applies usually to data obtained from the self-propelled carts, while data collected by track recording vehicles are usually stored in dedicated databases.

3 Data storage and processing

Many countries have been exerting significant efforts to improve the potential of the track maintenance systems employed [13, 15, 16]. Making the best use of measurement data collected from all data sources calls for their centralized storage. Good examples of such approach are the turnout database used by the Danish State Railways or the track maintenance database used by Inspectation company in The Netherlands.

Experience shows that, apart from the reliable data collection systems, it is important to develop and implement the efficient IT system that can cope with the huge amount of the data being collected continuously and making possible to process efficiently the collected data. The main tasks may include:

- development and checkup of the inspection schedules,
- checkup of carrying out of the inspections for the selected routes,
- splitting the video streams into the separate images with extraction of the pre-defined infrastructure elements,
- fast viewer for the measurement results,
- marking and classification of the detected defects,
- reporting,
- data archiving,
- making backup copies.

The data storage and processing system for such applications may be developed based on the synchronous or asynchronous models. The synchronous model is best used for:

- query processing,
- when the result is needed for subsequent processing,
- user interface.

The asynchronous model is used in all other cases. This model is used, e.g., for application to application communications. Such approach also hides mismatches in system availability, performance, etc., moreover it is essential for more complex, multi-party interactions.

The Application Server shown below meets all these requirements and important advantages are (see Figure 1):

- a number of users (Clients) may access the same data simultaneously; an important feature of Tier 1 is that only the 'thin' Client applications are used – in fact any device with an Internet browser may be used, be it a PC, Android or iOS tablet, or a smartphone,
- all software used for query and data processing - Tier 2 - is continuously updated, so the users access on-line only the newest versions of applications, so there is no search for the latest versions of data processing software by the users, and any bugs may be quickly corrected as soon as possible,
- databases reside on servers - Tier 3 - with the necessary data backup assured, providing the required data security, short data access and processing time.

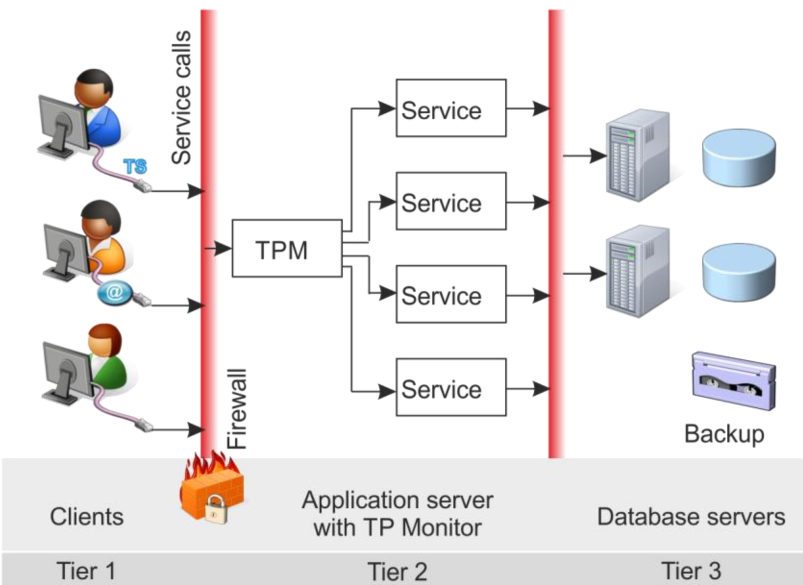

Figure 1. Infrastructure maintenance data system with the Application Server architecture.

Many applications on Tier 2 might include the distributed societies of relatively simple software agents. This approach is present since some time in transportation applications [8, 9].

Most of the inspection data, be it track and turnout geometry readings, and video inspection information can be analysed automatically by the dedicated agents. The goal is to focus the diagnostic engineers' attention on the detected problems, relieving them from the tedious task of sifting through voluminous data. Examples of problems that may be detected by such agents include, among others [2, 3, 5]:

- exceedings of values of the track and turnout geometrical parameters,
- potentially hazardous occurrences of apparently unharmful values of parameters, yet which together may reduce safety of operation,
- determining locations in the track network where its geometrical parameters deterioration trend is either bigger than in other similar locations, or has just begun growing,
- generation of reviews of staff annotations to track defects made during the selected period, e.g., last shift,
- image processing to detect problems with rail fixtures, e.g., missing elements,
- image processing to detect rail head defects.

4 Data access

The track condition data is continuously updated and the latest information has to be available to many different classes of users - an example of the multi-platform user interface is shown using the GRAW WEB Geotec system (see Figures 2 – 5). The system is accessed over Internet, providing access to users according to their relevant access rights.

Figure 2. Exemplary measurement data as presented on a PC with MS Win 10.

There are a number of pre-defined reports available, yet the user can develop custom ones, composed of the basic modules, like chart panels, data tables, images, tamping information, etc.

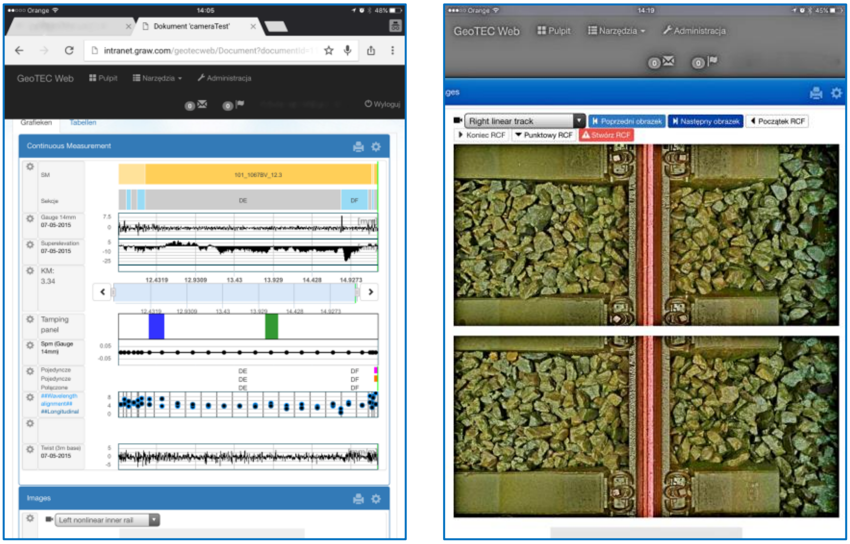

Figure 3. Exemplary measurement and video inspection data as accessed from an iPad tablet with iOS.

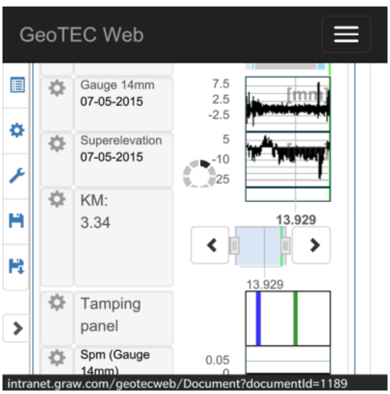

Figure 4. Exemplary measurement data as accessed from a BlackBerry Q10 smartphone with QNX.

Contents of all reports may be viewed also on smartphones. Let us limit our considerations to maintenance and repairs of the permanent way only here. - all information contained in such reports is always up-to-date, so job orders may be issued with no delay, with all defect information available over Internet, taking into account the latest information – and historical as well, if needed.

Figure 5. Video inspection results analysis – synchronised with track geometry measurement, and other data.

The real systems are complex and dynamic with a big number of events and processes, with many organisational levels, and subject to random disturbances. One may name some of these disturbances like new orders which may come based on permanent way inspection on a previous night, those queued already may be cancelled; some jobs may become more or less important with time, according to the dynamic priority rules [7, 8. Moreover, some resources may temporarily become unavailable as deliveries may be delayed, raw materials may be depleted, tools may not be available for some reasons, to name but a few of them: staff may be absent, equipment service life may be reduced due to poor quality or misuse, and many others [9,10].

Track condition data is available which may be collected by trolleys, self-propelled carts, track recording cars – all processed by the relevant applications and presented in the required format. Such processing may be done by maintenance engineers – diagnosticians, and/or – in part – by the artificial software agents..

5 Conclusions

The holistic approach to track condition data collection and analysis calls for the reliable dat asources, efficient data processing software, and readily available user interface. The multi-agent data processing systems may consist of both human and software agents. Therefore, solving the communication problem between these two types of agents is the key issue. One of the solutions is development of the efficient data base systems and an application layer in which the automatic data processing may take place also without human involvement.

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