

SAFE RAIL TRACK BED INSPECTION BY HIGH SPEED RADAR

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INTRODUCTION

The railway is an environmentally friendly and economical alternative means of travel to road and airtravel. To keep it that way, trains need to travel faster and faster on safe tracks which allow a high speed.

Fast track construction is therefore just as important as consistent maintenance. This is a challenge requiring economical decisions. In this regard, the methods of the past no longer provide solutions for today: drillings and diggings alone are not a reliable basis for planning, and are far too slow. Their results are always related to single areas rather than the overall scheme.

SafeRailSystem is a new and intelligent inspection method based on ground penetrating radar (GPR), which enables to reliably locate weak spots such as ballast pockets, ballast contaminations and muddy sections within the ballast layer, the substructure and the soil. This enables the engineer to carry out a limited number of well directed drillings, positioned right in the weak spots located by the GPR. This is the prerequisite for targeted renovation on the basis of a high geotechnical safety, helping to reduce costs significantly. For years this new technology has been applied successfully in many countries worldwide (e.g. Russia, Germany, Austria, Switzerland, France, Sweden, China, Australia, Brazil etc). Since 1993, more than 60,000 km of railway tracks have been surveyed. At the beginning, surveys were conducted with a single channel GPR mounted on a track trolley which was moved at walking pace. In the meantime, our research and development has led to a 4 channel high speed GPR system which can be mounted on a train and operated at a speed of more than 300 km/h. Appropriate modifications on the system hardware and software provide excellent data quality regardless of the high speed.

PRINCIPLES OF GROUND PENETRATING RADAR (GPR)

The GPR method is an electromagnetic reflection method: Radar pulses are transmitted into ballast bed, substructure and soil by a transmitter antenna at frequencies between 200 MHz and 600 MHz. The energy of the electromagnetic waves is partly reflected at interfaces between layers with different dielectric properties and re-transmitted to the receiver antenna. Based on the travel time of the reflected signals and knowing the propagation velocity of the waves in the medium, the depth of the boundaries between layers can be computed.

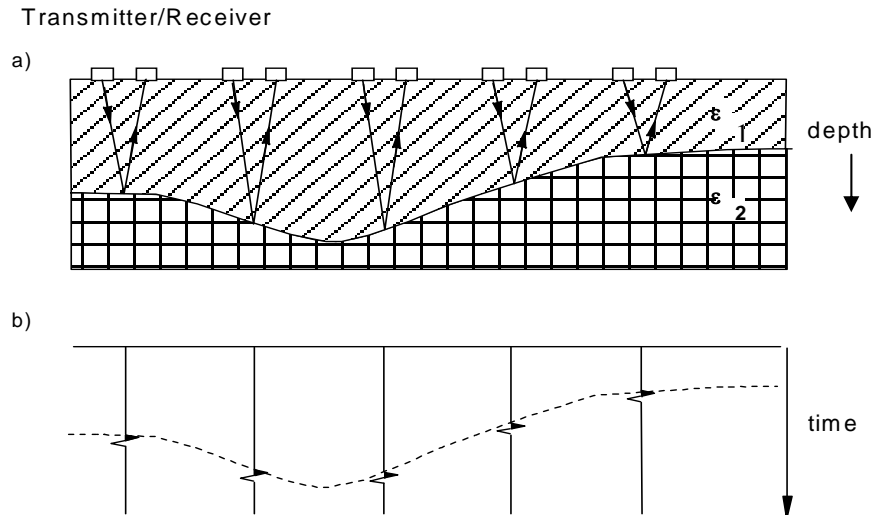


Fig. 1:
 a) Radar waves are reflected at the interface between two media with different dielectrical properties
 b) The travel time of the reflected radar pulses reproduces the interface between different layers

In order to determine the depth of the boundaries from the surveyed travel time of the reflected signals, the propagation velocity of the radar waves in ballast, substructure and soil must be determined. The velocity of electromagnetic waves in the soil is correlated to the water content of the individual material. Therefore it is generally not possible to refer to reference values for certain rock or soil types. Thus, the radar wave velocity has to be determined in the project area.

The GPR method is adequate for the examination of shallow structures or objects in the ground, such as land fillings, cables, pipelines, voids and remains of walls and provides the best conditions for a detailed examination of the ground.

But it is particularly suitable for many railway specific tasks. It offers the possibility of a fast, continuous and cost effective investigation of the geotechnical conditions of railway tracks.

The penetration of electromagnetic waves into the ground mainly depends on the electrical conductivity of the soil and the applied transmission frequency. By using low transmission frequency on low conductive soil, the largest investigation depth can be achieved.

TRACK BED INSPECTION BY HIGH SPEED RADAR

SafeRailSystem is designed to be mounted on any train. This train-borne track examination technique allows conducting measurements on four profiles simultaneously at a max. survey speed more than 300 km/h. The antennae configuration (number, type and position of antennae, frequency etc.) depends on the tasks to be performed. The antennae configuration can easily be modified to meet the specific requirements of customers.

Combining different transmission frequencies will enable to investigate the track from the top of the ballast bed to the soil. The result will be a detailed, 3 dimensional picture of the track.



Fig. 2

Three ground penetrating radar antennae are mounted on a UFM-120 track geometry measuring train. This configuration enables us to survey eGPR profiles in one run (at the axis of the track and on the left and right side of the sleepers). This picture has been taken during measurements on the tracks Istanbul-Ankara and Basmane-Bandırma in 2005. The total length of the GPR profile was more than 1.000 km.

The survey results will closely be related to the following tasks:

- continuous mapping of track bed thickness
- differentiation between clean and fouled ballast
- detection of drainage problems in ballast bed, substructure and soil
- mapping of areas with low bearing strength (ballast pockets)
- mapping of sub grade thickness and its quality
- locating irregularities in substructure and soil (peat, bedrock etc.)

By using 3 to 4 antennae simultaneously, it is possible to obtain cross sections which is important for a continuous assessment of the drainage of the track. The average investigation depth is about 3 m.

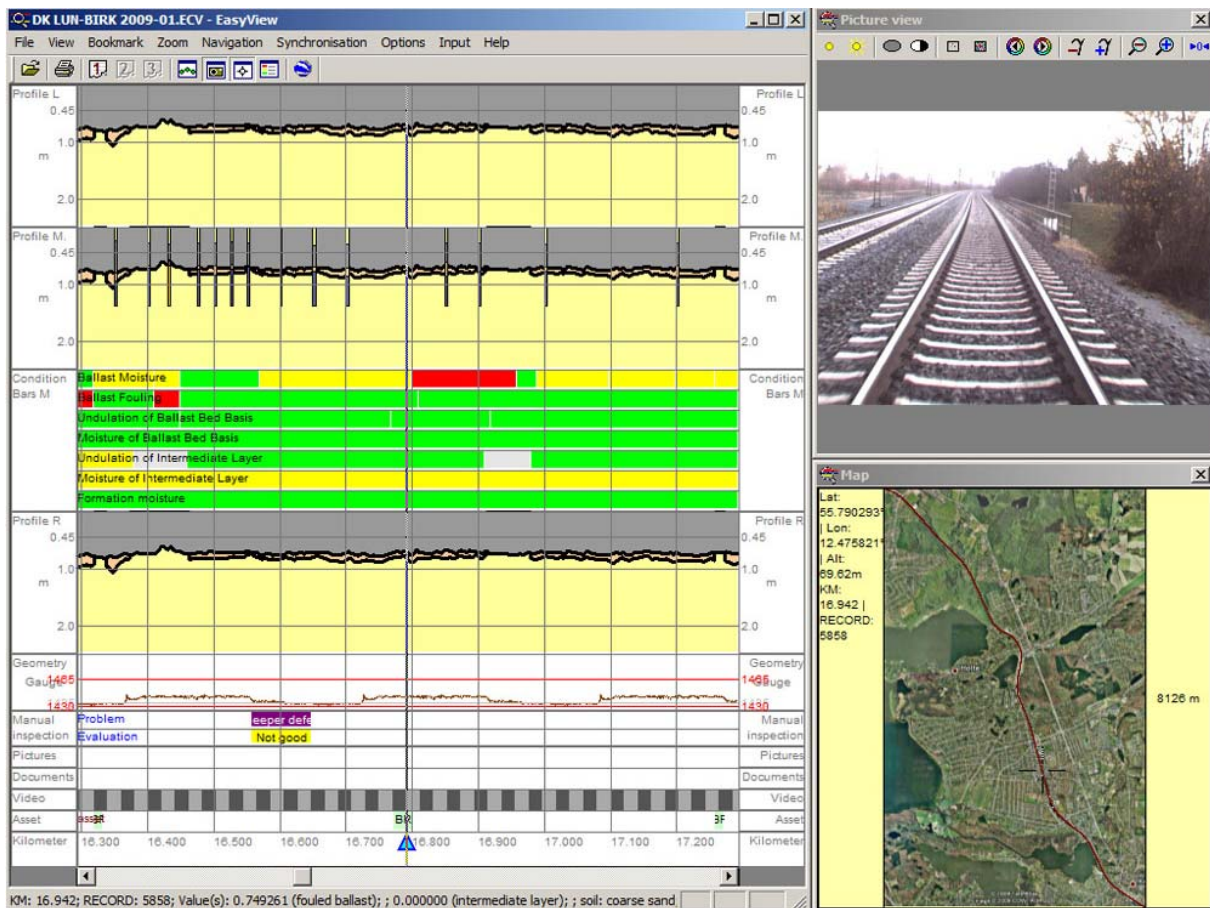


Fig. 3

Example for the integrated Viewer-display of GPR results and track geometry measurements. Track video and track progression in Google Earth are displayed additionally. In addition, the picture to the right contains the graphic view of the track cross-profile for base of ballast and base of intermediate layer, thus providing an important indicator for the cause of eventual drainage problems

SafeRailSystem measurements have been carried out on numerous lines all over the world. Among them there are high speed lines in Germany (Line Würzburg - Fulda), in France (line: Paris-Lille) in The Netherlands (Brussels - Amsterdam) and recently on a new built track in Sweden (Sundsvall-Umea).

SafeRailSystem is not only suitable for surveying railway tracks prior to a renewal. It is also a valuable means for quality management. It is often used for a continuous controlling of renewed track sections with reference to the thickness and quality of ballast bed and substructure.

After surveying, the GPR records will be stored in a database, analysed and displayed with special software. It is also possible to input, analyse and display almost every kind of data records provided by customers (track geometry, tamping frequency etc.).

Thus, they will be able to achieve a high level of geotechnical safety and will also be in a position to save considerable costs and to plan their budgets and reserves soundly and in time.

In the last few years, SafeRailSystem has also been successfully used in various highway projects. These projects have been carried out in The Netherlands for the public highway authority "Rijkswaterstaat" and on numerous lines in Austria for the public highway authority "ASFINAG".



Fig. 4

Three ground penetrating radar antennae are mounted on a survey car which was used for measurements on highways in The Netherlands and in Austria. The survey speed was up to 80 km/h using three antennas simultaneously with different frequencies between 900MHz and 2.000 MHz.

The ideal basis for a detailed and effective asset management.