

Multi-function track recording cars

An objective basis for decision-making makes it possible to set up and implement a sustainable maintenance strategy. Multi-function recording vehicles help to further improve the safety, cost-effectiveness and availability of the railway infrastructure.

The railway companies are responsible for the assurance of reliable rail infrastructure that meets the needs of the customer, as well as safe, cost-efficient and punctual operation of the rail services. The main task of the infrastructure operator is to further improve the safety, cost-effectiveness and availability despite constantly rising volumes of traffic. Measured data provide an objective basis for decision-making. Nowadays these basic figures are provided to a large percentage by track recording cars. Plasser & Theurer is aware of the significance of this and can offer its high competence and experience in finding the very best solutions for the future.

A specific feature of railway infrastructure is the long service life of the track components. However, the service life is only achieved based on a suitable design of the track and appropriate maintenance. Clear bases for decision-making must be drawn up by a coordinated matrix of safety and quality figures. Maintenance strategies are developed on this basis that makes it possible to manage the track assets over a long period. Without comprehensible foundations it is very difficult to obtain the necessary funds for maintenance and renewal.

The infrastructure operators have recognised this and therefore particularly over the past years there has been a change in attitude towards track recording cars. Track recording cars are no longer seen purely as a safety instrument but provide, in the broadest sense, the means to take the right action at the right time. The change in the importance of the track recording cars and the new technological possibilities in

recording technology – and here particularly in video monitoring – have led to strong technological progress in recent years. In the light of this, Plasser & Theurer offers track recording cars with non-contact recording technology and video monitoring options for various sectors of the railway infrastructure (Fig. 1).

1 Principles

The acceptance of track recording cars has changed dramatically in recent years. Originally, the most important function of a track recording car was to detect and localise trouble spots in the track. The focus was placed on finding the anomalies and not on eliminating them. In many instances, the role of the track recording cars had a negative image.

Many railways have introduced a reversal of that trend. Track recording cars are used to optimise visual inspection and the measuring results are used as a basis for decision-making for sustainable asset management. Early detection of anomalies relevant to safety is also the function of the track recording car. However, with consistent use

its main purpose is focussed on the prevention and elimination of faults.

The change in the perception of track recording cars has also been taken into account in international standardisation. For example the European standard EN 13848 no longer defines any limit values for the various measuring signals. Instead it defines intervention limits that enable the user to plan his maintenance schedule in good time and well in advance.

The intervention limits are described according to EN 13848-5 in three stages. The resulting course of action to be taken when the signals are overstepped can be seen from their designation:

- ▷ Stage 1: Alert Limit
- ▷ Stage 2: Intervention Limit
- ▷ Stage 3: Immediate Action Limit

Apart from this fundamental change in attitude, a trend towards the incorporation of new sources of information is also apparent. The railway administrations are increasingly setting store by video monitoring to reduce visual inspection on site. Over the past years the requirement that measuring signals always have to be reproducible has



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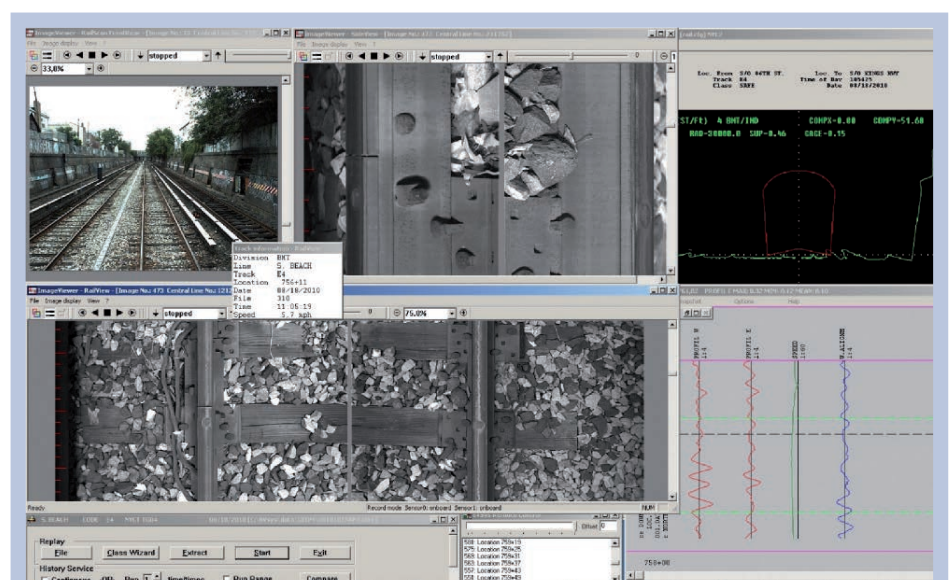


Fig. 1: Off-board computer screen showing synchronised video and track data

also been softened. The highest demands on the reproducibility are placed on the classic track parameters such as track gauge and twist, i.e. in various vehicle compositions and speed ranges the measuring systems must always supply the same result. At the same time, the importance of non-reproducible measuring signals such as the axle box acceleration and pantograph acceleration is increasing. Acceleration peaks are an indicator of a possible trouble spot even though the causes can often not be deduced from this.

The example of Austrian Federal Railways (ÖBB) shows the trend reversal to fault prevention very clearly. In 2000 around 80% of the permanent way decisions were to a large extent based on the experience of the local district inspectors, but in 2010 this figure had dropped to only about 20%. The remaining 80% were made on the basis of the results produced by various track recording cars. It did not happen by chance that in recent years there was a reduction of rail breakage frequency and fewer temporary speed restrictions (Fig. 2).

2 Requirements

The railway infrastructure system consists of various subsystems such as the track and catenary, the control and signalling systems, the power system and other areas. To ensure as few operational hindrances as possible, it is advisable to carry out the measurement of parameters important for the various maintenance operations simultaneously using one and the same track recording car. Moreover, this combined measurement offers the opportunity to perform correlations between different track defects and identify any possible connections or mutual influences. The costs for the operation of a multi-function track recording car are the same irrespective of whether one or several parameters are measured. The cost-efficiency of the track recording car rises with the number of parameters measured per run.

A basic requirement to be met by the track recording cars is the on-line processing of the signals and information.

Work to be done on-board during the measuring run:

- ▷ produce measuring graphs,
- ▷ supply exception reports (km, GPS),
- ▷ calculate track quality indicators (TQI's) and
- ▷ draw up line routing parameters.

The design of the Plasser & Theurer on-board and off-board analysis systems is very versatile and allows simultaneous measurement and analysis of the parameters directly in the track recording car. Another standard feature is the location-syn-

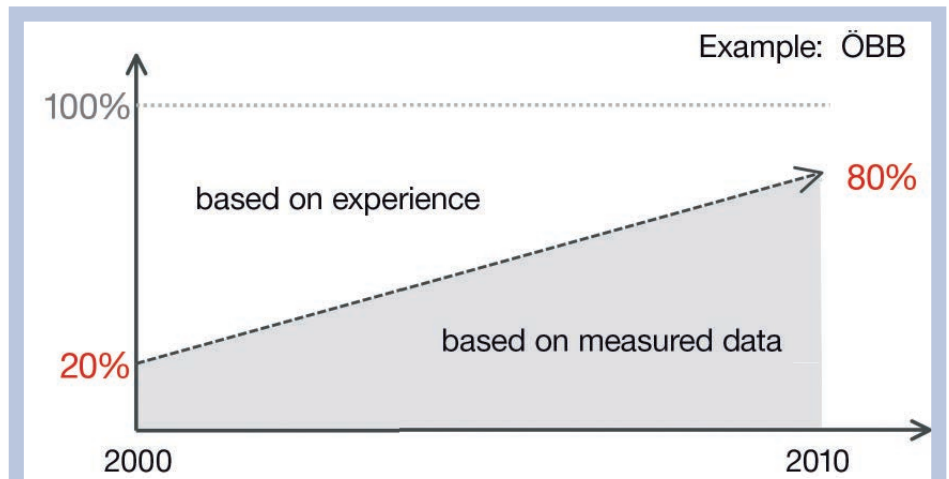


Fig. 2: The influence of recording technology on maintenance performed on ÖBB rose sharply in the last 10 years

chronised display of all measuring signals in the off-board analysis software.

3 Philosophy

High demands are placed on quality and availability when selecting the measuring systems. Plasser & Theurer's philosophy is as follows:

- ▷ only measuring systems with the highest accuracy and availability can provide support for planning maintenance.
- ▷ Measured data and exception reports must be retrievable immediately. Only this can eliminate the risk of derailments.
- ▷ The latest and most up-to-date measuring systems on the market are incorporated.
- ▷ The track is regarded as a system. Measurements of the overhead line system and the track structure can be analysed in a combined way.
- ▷ The focus is laid on quality and availability, and then on the price.

4 Range of products

Plasser & Theurer offers a comprehensive selection of basic vehicles. A clear range of available and combinable measuring and recording systems are on offer. These options make it easy to select the right vehicle with suitable measuring equipment. Common to all models is the high-quality mechanical engineering in conjunction with the latest measuring technology (Fig. 3).

For measuring, recording and analysis of the track geometry, the standard equipment of every track recording car is the track geometry measuring system. This consists of an inertial navigational measuring system with integrated GPS positioning and a dual optical gauge measuring system. Track geometry faults with wavelengths up to 200 m can be recorded, regardless of the measuring speed.

The choice of the ideal track recording car depends on the technical and commercial requirements in coordination with user-orientated equipment. Vehicle design and fittings are carried out in proven Plasser &



Fig. 3: Plasser & Theurer offers a standardised selection of track recording cars

■ Multi-function track recording cars

Theurer quality. These series-built vehicles also meet the safety requirements specified for rail traffic. Mainly standardised construction elements are utilised for design and construction.

All vehicles are fitted with low-emission diesel engines and two 2-axle bogies and with either one or both bogies driven depending on the machine model. The measuring systems can be mounted on either of the bogies.

The bogies utilised are a Plasser & Theurer development and were designed specially for heavy axle loads and speeds of up to 200 km/h. The engine outputs range from 190 kW on the EM 30 D weighing 21 metric tons to a total engine output of 1200 kW on the EM 160 weighing 80 metric tons. Self-propelled machines offer independence and flexibility in operation.

All Plasser & Theurer track recording cars can of course be placed in train consists. For special track situations, the vehicles can also be designed in narrow gauge or broad gauge. Diesel-electric generator sets provide the power supply on board; an uninterruptible power supply unit is installed additionally to protect the measuring and data processing systems. To gain space and at the same time lower axle loads, large vehicles can be designed in two sections as "tandem vehicles" (EM140T und EM160T). These vehicles can also travel on commuter railway systems and secondary lines with low permissible axle loads and the entire network can be measured using one track recording car. For example, three track recording cars built by Plasser & Theurer are in operation in New York City.

5 Criteria when selecting a track recording car

The following main criteria have an influence on the choice of track recording car:

- ▷ Type and number of measuring systems
- ▷ Number of workplaces

- ▷ General space requirements
- ▷ Measuring speed
- ▷ Staff requirements
- ▷ Room layout

The standard track geometry measuring system forms the basic equipment – all other installable measuring systems and/or video recording units and combinations of these systems depend upon the size of the vehicle and the achievable space for the computers and analysis units.

At each of the evaluation terminals the measured data can be retrieved, displayed and printed out. However, an additional, separate workplace is required to operate the ultrasonic rail flaw detection system.

For the average quota of planned measuring runs, it is necessary to select a measuring speed taking into account the length of the track network, volume of traffic on the line and the track recording cars available. The self-propelled track recording cars travel at a maximum speed of up to 160 km/h and up to 200 km/h when hauled.

The vehicles are fitted with sound-insulated, air-conditioned cabins and driver's control desks for both directions of travel. Depending on the size of the vehicle, additional facilities can be installed such as: conference corner, kitchen unit, sleeping berths, washroom with shower and WC, workshop. In addition to the standard crew in the track recording car, there are regional track inspectors or other local staff on board for many operations. The space required is defined by the number of personnel. If the size of the network and the planned operations require stays of several days for the crew on the recording car, then other facilities and sleeping berths must be provided.

The location of the drive engine has a great influence on the room layout. For reasons of space and comfort, it is preferable to install the engine below floor level. The choice of a slightly larger vehicle (longer distance between pivots), which allows the engine to be mounted under floor, will provide a far more generous room layout. This allows more

workplaces (Fig. 4) and measuring equipment to be incorporated and thus raises the cost-efficiency of each measuring run.

6 Measuring and video systems

Not only in the field of vehicle design but also in the measuring systems the customer has the option of choosing from a wide range of standardised and well-proven systems. A selection of these possible measuring systems can be seen in Table 1.

The standard equipment of every Plasser & Theurer track recording car includes the non-contacting track geometry measuring system with integrated GPS navigation and Dual OGM optical gauge measurement to measure, record and analyse the track geometry.

This system measures the following parameters: longitudinal profile of left and right rail, alignment of left and right rail, track gauge (dual measurement), cross level, twist, curvature and curve radius, gradient and position using GPS.

The high-precision, maintenance-free track geometry measuring system is a leader in quality and availability. The results are used primarily for planning the tamping work. From the analysis of the longitudinal profile signal, it is also possible to localise areas with advanced ballast wear and areas with subsoil problems.

The latest laser and video camera technology is applied to measure the profile and wear condition of the rails. The linear transducer with laser transmitters and receiver cameras are mounted on one bogie of the track recording car. The laser units are precisely temperature stabilised, eliminating the need to shield off ambient light from the measuring area on the rails. The receiver cameras capture full cross-sectional rail profiles from the base area to the top-of-rail surface. Rail wear data are used for planning rail exchange, the measuring signals for rail inclination and rail base distance are good indicators for the condition of rail fasteners in tight track curves.

It is also possible to issue the value of the equivalent conicity online. This value is an indicator for the lateral running behaviour of the vehicles. Austrian Federal Railways began early on to develop and implement targeted counter-strategies. The statistics show a clear reduction in areas with increased conicity.

Corrugation and axle box acceleration measuring systems are among the systems most used. Both are parameters needed for planning rail grinding.

Apart from this, it is mainly the ultrasonic rail flaw detection system, the tunnel clear-

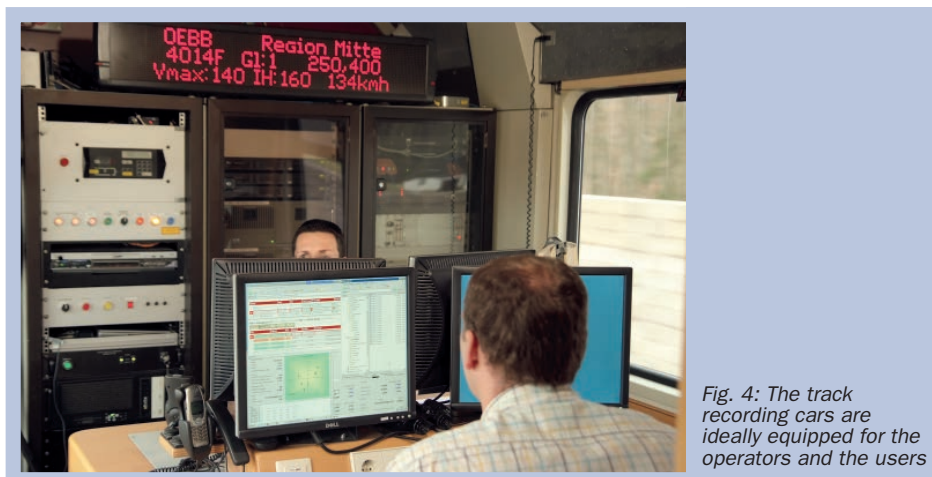


Fig. 4: The track recording cars are ideally equipped for the operators and the users

ance measuring system, the driver's view video system and the track component video monitoring system that are increasingly being ordered. The four systems are described in detail in the following.

6.1 Ultrasonic rail flaw detection system

The ultrasonic rail flaw detection system is used to detect internal rail flaws. The system is mounted on a telescopic measuring axle and is suitable for speeds up to 60 km/h. The sixteen transducers that measure one rail are located in two wheel probes which are guided along the centre of the rail. A separate workplace inside the track recording car is used to operate the system and to analyse the ultrasonic signals. The ultrasonic data are used to generate a side profile of the actual rail (consolidated B scan video image). Pattern recognition software is used to identify and classify the rail flaws. The measuring system supplies location and track information. Off-line multiple run comparison histograms can be created and analysed.

A specially developed wheel probe design leads to highest availability and less water consumption. There is optimal lateral guidance of the wheel probes for better detection of vertical rail head cracks. The system consists of a fully integrated Windows operating system with redundant data acquisition and storage. There is continual further development in the field of pattern recognition and classification.

Above all the following feature is important: the high-tech ultrasonic rail flaw detection leads to an increase in operating reliability. Early detection of cracks originating at the running edge (particularly relevant for the rail flaws known as head checks) is achieved by specially inclined sensors (Fig. 5).

6.2 Tunnel clearance measurement

The measuring system is designed for checking the standard clearance gauge and also the lateral and vertical distances to the adjacent track axis and to station platforms. It consists of a rotating laser scanner mounted on one end of the recording car which measures the distance from the scanner to the track surroundings and to the track bed. Measurements are taken up to 9,000 times per revolution with a rate of up to 200 revolutions per second (Fig. 6). The measured data are stored lined-up with all other measuring data. The system is now used increasingly for measuring overhead line (OHL) systems, as the results of the laser measurement can also be used for OHL position measurement.

The system software simultaneously compares the measured data with up to three

Standard measuring systems

- Non-contacting track geometry measuring system with integrated GPS navigation and optical gauge measurement for recording the track geometry

Optional measuring systems

- Rail profile measuring system (optional: software package for the calculation of equivalent conicity)
- Axle box acceleration measuring system
- Corrugation measuring system (optional: software for automatic measuring of joint gaps)
- Clearance profile measuring system / ballast profile measuring system
- Catenary wire geometry measuring system with pole detection system
- Pantograph for dynamic catenary wire measurements
- Catenary parameter measuring system (tension, pantograph pressing force, accelerations)
- Catenary wire wear monitoring system
- Ultrasonic rail flaw detection system

Video monitoring systems

- Driver's view video system (in direction of travel), if necessary, tunnel lighting
- Video system to monitor dynamic catenary wire position
- Track component video monitoring system (rail surface, rail fasteners, rail fishplates, sleeper condition)
- Third rail video system
- Driver's view video using a thermal imaging camera
- Head check monitoring system

Further parameters

- Temperature inside and outside
- Humidity
- Rail temperature
- Hot box simulation
- Dynamic measuring of rail fasteners (gauge restraint measuring system)
- Profile measurement of live rails
- Measuring of rail noise
- Car body movements

Table 1: Overview of the measuring systems

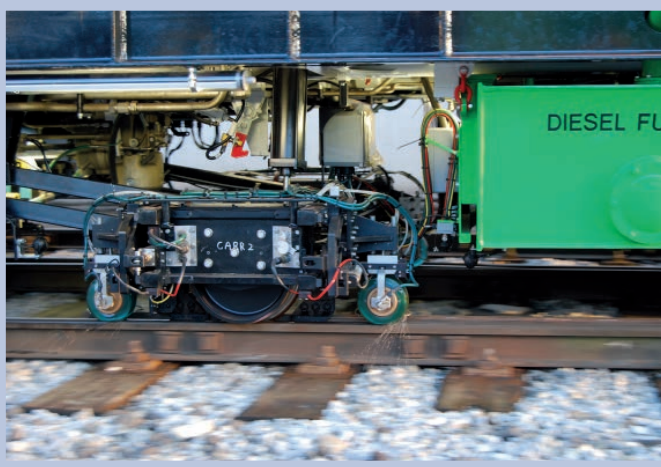


Fig. 5: Modern ultrasonic probe wheels (installed in rubber wheels) are wear-free and have low water consumption

different clearance envelopes in real time. Infringements are shown in the clearance exception report. In curves, clearance profiles are automatically adjusted for vehicle-specific overhang using the curvature measured by the track geometry measuring system. At the same time, the system checks the ballast distribution along the track. By simultaneous comparison of the actual ballast profile with up to three different ballast profiles, the software calculates whether there is an excess or deficit of ballast on any given location and gives the respective quantities.

The laser system presents no danger to

the human eye. It is eye safe and not influenced by ambient light.

6.3 Driver's view video

It is useful to include the driver's view video for a variety of analysis applications. The fact is not surprising that the driver's view video is extremely popular with the railways despite its lack of complexity.

This video system records images of the track, the track surroundings, and the catenary wire structures, as seen by the driver of the track recording vehicle (Fig. 7). One

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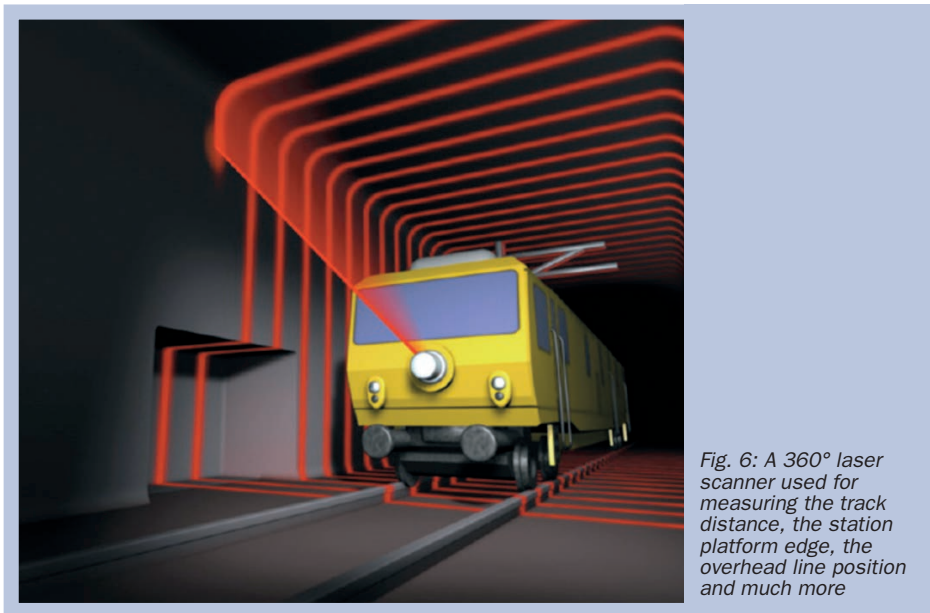


Fig. 6: A 360° laser scanner used for measuring the track distance, the station platform edge, the overhead line position and much more

camera is mounted in each cabin of the track recording vehicle. Only the images of the camera seen in the direction of travel are recorded. Images are recorded in selectable intervals, e. g. every 5 m. The high-resolution images recorded by the driver's view video system provide supportive information when analysing track data and may also be used for inventory purposes. Various illumination systems for the driver's view video system are offered such as the tunnel wall illumination system. This extremely efficient lighting system provides optimum illumination of tracks in tunnel sections.

6.4 Track component video monitoring system

The track component video monitoring system records images of the rail surface, the rail fasteners and the sleeper conditions. The side view track component video monitoring system records images of the rail head side area and the rail web area, and the rail fasteners. By applying real time pattern recognition algorithms to the recorded images, the track component video monitoring systems provide information about visible anomalies such as missing fasteners, wheel burns, rail surface defects, cracked

sleepers, head checks, etc. The optional head check video monitoring system records high resolution images of the gauge side rail head area.

The video monitoring system for the track components monitors each rail using a line scan camera, assisted by an illumination system and a recording and analysis computer. The line scan cameras sample the track laterally in 1 mm and longitudinally in 2 mm increments. The computer system appends the lines, creating images with a resolution of 1 mm x 2 mm (up to 200 km/h; 1 mm x 2 mm; finer resolutions at reduced maximum speeds, i. e. 1 mm x 1 mm for speeds up to 100 km/h). By longitudinally appending the lines recorded by the line scan camera, the system produces high resolution images of the rail surface areas, the fastener elements, and the sleeper areas around the left and the right rails.

The basic system can be upgraded to monitor not only the rail and sleeper area around the rail foot but also monitor an area of ± 750 mm around each rail, thus also recording images of sleeper ends, track centres and concrete sleeper cracks. The head check video monitoring system records high resolution images of the gauge side rail head area, with a resolution of 0.5 mm x 0.1 mm. Utilising two cameras with designated lighting, optimised for illuminating the running edge of the rail, allows detecting and analysing head check problem areas.

7 Summary

The importance of track recording cars has risen continuously over the past years. In the past it was primarily safety aspects that defined the implementation of measuring runs, but now it is increasingly also aspects of quality management and the automation of inspections. As before, safety threshold value exceptions will continue to be displayed on board, but the collected information, measuring signals, indicators and video monitoring results now serve increasingly as a basis for decision-making for the maintenance and renewal work to be carried out on the track and the overhead line. This requires the application of robust, high-precision and available measuring systems in combination with an appropriate on-board and off-board analysis system.

Plasser & Theurer offers the very latest and most up-to-date measuring systems on the market, based on tested and standardised components. More than 180 track recording cars have been built worldwide, but it is also possible to find flexible solutions for all customer.

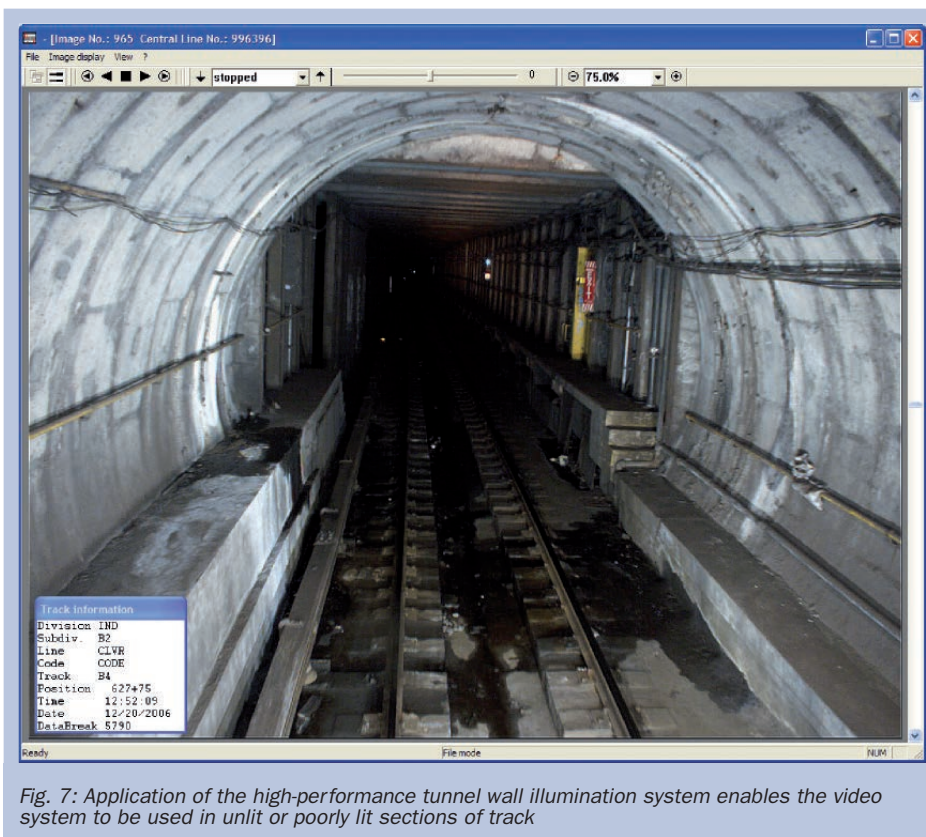


Fig. 7: Application of the high-performance tunnel wall illumination system enables the video system to be used in unlit or poorly lit sections of track