LEVERAGING STATUS-REPORT/AUDIT ON TRACK-CONDITION OF THE WHOLE NETWORK OF INDIAN RAILWAYS – A TOOL FOR LONGTERM CAPITAL INVESTMENT-SCHEMES AND MAINTENANCE-STRATEGIES

CONDITION-MONITORING TECHNOLOGY

VISION OF A SOUND AND HEALTHY RAIL-TRACK NETWORK

By Dr. Frank Wingler, Germany, December 2017

On the journey towards the future, Indian’s political leadership embraces the transformation of Indian Railways to a **WORLD CLASS STANDART RAILWAY**. The objectives are modern Railway Stations, smart Ticketing Systems, refurbished Luxury Coach Interiors, Inter-City Speed-Up by Semi-High and High-Speed Trains on key corridors, a “**Diamond Quadrilateral**” of High-Speed Lines, Dedicated Freight Corridor, world class and eco-friendly Traction Technology, Asset Management, Digitisation, Processing of Big-Data; see agenda of the 2**nd** FUTURE RAIL INDIA SUMMIT, held 7-8**th** December 2017 at Sheraton, New Delhi: **Fostering the futuristic Trends of National Railway Plan of Indian Railways**:
The fundamentals of a railway are its rail-tracks. Without sound and healthy Rail-Tracks of \textit{WORLD CLASS STANDART QUALITY} the envisaged \textit{FUTURISTIC AND SMART INNOVATIONS} will be pending without a proper fundament.

The recent spate of nasty and unwanted Derailment Disasters, killing and injuring Train-Passengers, reveal that on several routes the track-quality is far below \textit{WORLD CLASS STANDARTS} and is not matching the increasing traffic load. They deteriorate faster than they are maintained, rehabilitated or renewed. In this respect India is lacking far behind other railways around the globe.

There is no Railway around the globe other than Indian Railways aiming to become modern, which is still executing such back-rooted tinkering works by composing Long Welded or Continuous Welded Rail Tracks (LWR/CWR) with short 13 m rails poorly welded in the field by AT welding, which therefore are in need of joggle-fishplate bandages. In this respect India is unique around the globe. Such tracks are not sustainable. They need a high extravagancy in costly surveillance, frequent visual inspections and frequent patch repairs and maintainances, in order to keep the trains running.
India wants to go for High-Speed Trains. However, High-Speed Technology is a highly expensive short-cut to move passengers faster and safer between the main cities Delhi, Amritsar, Chandigarh, Mumbai, Ahmedabad, Kolkata, Nagpur, Hyderabad, Bangalore and Chennai, than on the conventional ailing rail-tracks.

India wants to go for High-Speed Trains

Several India`s rail-roads age and deteriorate under the increasing traffic load faster than they could be maintained, rehabilitated, upgraded or renewed. To bring all rail-tracks of the network in a healthy and sound condition, ensuring nearly zero train-derailments, will need high capital investment schemes of long-term certainty. The political leadership embracing global trends should also be aware, how much money will be needed in the forthcoming period of 5 to 15 years and what has to be organised to bring all rail-tracks of the network on WORLD CLASS STANDARDS under the Close-To-Zero Derailment Vision.

A comprehensive upgrade of the whole network and system will need a huge amount of money and structural reforms, and it will take several decades to achieve. Therefore, news about Indian train accidents are not likely to fade soon away.

Modern Railways elaborate a Status-Report or Audit on the condition/status of their full network with regard to their assets-behaviour in order to provide correlations with output quantities and the required financial recourses for re-investment in assets and infrastructure, and as well for maintenance-planning or strategies. Such a Status-Report or Audit could help India to gain information about how sound, healthy and excellent the system is and behaves – or how un-healthy the system is and behaves - and how much money for long-term investment-schemes will be needed in the forthcoming years and what has to be organised in order to bring WORLD CLASS STANDARDS on all tracks of the network.

The task of asset management within a railway infrastructure operator is, above all, to use the available budget-resources as efficiently as possible. Accordingly, the question of the condition of the assets to be managed is essential.
The methodology developed enables a measurement data-based and component-specific status description of the railway infrastructure. This is made possible by innovative data analyses collected through regularly performed track measurements by inspections, monitoring and recording.

In Austria the elaboration of the methodology is based primarily on asset-information/validation and measurement data, which had been collected since 2002 and are now available in a data-base for approximately 4000 kilometres of the Austrian Federal Railways, ÖBB. The database in question had been developed at the Institute of Railway Engineering and Transport Economics at the Technical University, TU Graz, Austria, in time series since 2002. In addition, due to the implementation in the network of the Swiss Federal Railways, SBB, a large number of further validations could be carried out together with SBB's department for rail-track management.

The underlying methodology is based on the development of innovative statistical analyses of different measurement-signals in order to better understand the characteristics of individual signals. These methods were subjected to an in-depth validation process and subsequently aggregated into a descriptive code for the track-component’s intervention threshold, for maintaining ballast and substructure. Accordingly, the methodology is based on a bottom-up process, since on the one hand a specific analysis of the individual measurement-signals can be used for the planning of the measurements on one hand. On the other hand, the aggregated codes also allow parent asset-management, as well as the assessment of different maintenance and capital-investment strategies.

Due to the separate evaluation of the components, such as sleeper and ballast, the necessary scope for a track renewal for the coming years can be determined. In addition, the assessment of the components, such as substructure, makes it possible to estimate at an early stage the proportion of measures for re-investment, which additionally requires a cost-intensive and far ahead planned and organised renovation of the substructure.

Based on this, a long-term planning for the use of funds can be established. The developed methodology also enables the infrastructure manager to benchmark the state of use, which can significantly improve and objectify the allocation of the budget for different subareas of the network.

As part of the dissertation "Description of the Condition of the Railway-Track", the underlying algorithm was developed, calibrated, verified and already applied. So far, the developed methodology has already been implemented within the Austrian Federal Railways, ÖBB, and the Swiss Federal Railways, SBB, to a total of 9000 track kilometers. In addition, successful feasibility studies have already been carried out in Belgium, Denmark and the USA.


ABSTRACT:

Cost pressure forces infrastructure managers to work sustainably and efficiently. Therefore, track engineers face increasing difficulty to carry out necessary measures owing to budget restrictions. Consequently, they should be supported in prioritising. This requires an objective tool enabling proper condition monitoring as well as component-specific, preventive maintenance and renewal planning. Hence, the right measures are to be executed at the right time.

The dissertation deals with a description of the railway track condition. A bottom-up approach provides an in-depth assessment of track using a variety of measurement signals and an aggregated component-specific assessment. Since the approach is based on well positioned measurement signals, it is valid for monitoring specific track sections as well as whole networks. Innovative analyses of various measurement signals form a sound basis to grasp their characteristics enabling a component specific condition evaluation of railway track. The use of historical measurement data allows for an analysis of track behaviour over time.

A thorough validation process, including on-site inspections and excavations, shows that the presented approach is able to evaluate the actual condition of railway track. The assessment of the specific components condition can be used for timely maintenance as well as renewal planning. Based on correlation analyses, the component specific evaluations are aggregated into one holistic quality figure. This enables asset managers to monitor the asset condition network-wide as well as to predict future budget demands. It supports the objectives of benchmarking, which are to determine what and where improvements are called for, to compare how other railways achieve their high performance and safety levels, and to use this information to improve own performance and safety records.

ANNEXURE I:

Excerpts from the technical Railway Paper **GLOBAL TRENDS IN TRACK TECHNOLOGIES AND FAST PACED CONSTRUCTION**; http://www.drwingler.com:

**ONLINE DATA COLLECTION AND PROCESSING; TRAIN BASED IN-SERVICE MONITORING FOR TARGET PLANNING OF MAINTENANCE**

The prerequisite for a proactive Life-Cycle Cost Management Approach with the evolution of the development track-behaviour prognosis is the all-encompassing data collection of the continuous online condition monitored on all track assets; see K.U.Wolter et. al. in Eisenbahntechnische Rundschau, ETR, **7+8**, p. 32-36, 2014, eurailpress, Hamburg, Germany.

Fitting monitoring equipments to commercially operating trains to provide an in-depth analysis of track conditions is increasingly common: see **FROM DATA CRUNCHING TO PREVENTIVE TRACK MAINTENANCE** in International Railway Journal, May 2017, Volume 57, Issue 5, page 52.

The traditionally strategy of Railways and infrastructure managers is to measure regularly track geometry to identify irregularities and inform maintenance works. This data is retrieved by dedicated track inspection vehicles. Recent trend is to deploy on commercially operated trains measurement devices, increasing the frequency of measurements. By using scheduled trains, infrastructure managers can retrieve inspection data every day. Margin of error can be evaluated in a predictive way.

Japan Railways Kyushu 800 High Speed Train fitted to Car Body and Bogies with Equipments providing Data on Track Conditions
The continuous surveillance of Rail Tracks with Recording and Monitoring Systems mounted on regularly running trains is of increasing focus. The Institute for Transport System Technology of the German Aerospace Centre (DLR) conducts the development of modern Data Management Systems for collecting, transferring and telemetry. The data must be precisely geo-referenced according to the track locations. On lines with sufficient global satellite reception the monitoring cars communicate directly with the central databank. The data can also be locally stored and transmitted in intervals by WILAN over the internet at Stations or Depots. For lower data volumes the mobile telephone networks can be used. The System is under trial on Swiss Sections; Lars Johannes et. al. in DER EISENBAHNINGENIEUR, EI, 11, November 2015, p. 12, eurailpress.

The “Continuous Track Alignment Parameter Monitoring” in programmes for TRAIN BASED IN-SERVICE MONITORING for TARGET PLANING OF MAINTENANCE make use of NEWTON’s Law Mechanics.

Newton’s FIRST LAW suggests that any change of velocity of a body under consideration must be associated with the counter-action of a resultant force, which acts on his body. This in turn suggests a relationship between the resultant force and the acceleration of the body. Newton assumed by his SECOND LAW the very simple relation that the resultant force, which acts on the body and causes acceleration, is linear related. The THIRD LAW is the LAW OF ACTION AND REACTION. It states that to every action or force there is an equal and opposite reaction or force. In other words, when a body (rail-vehicle) exerts a force on a second body (rail-track), in consequence the second body (rail-track) exerts a numerically equal but opposite force on the first body (rail vehicle). The laws are useful to analyse mutual track-vehicle interactions and to determine track irregularities and track defects by vehicle mounted ACCELEROMETERS. This means, by measuring vehicle accelerations, the cause in form of track irregularities can be determined. And by continuous track monitoring with repeated runs over the same track, the development of track-defects and track-irregularities, the development over the time of such defects and irregularities, can be measured and the point of necessary interaction by repair or maintenance can be forecasted.
German Railways equipped one of its Intercity Express Trains with acceleration- and rotation-gyroscope sensors mounted on the axle-box for transmitting during scheduled train runs in-service monitoring data of vertical and horizontal alignment defects as so-called “TRAIN BASED IN SERVICE MONITORING for TARGET PLANNING OF MAINTENANCE”. This ICE transmits daily the acceleration rates cum position on its route. The computer evaluates a history diagram, from which a forecast for the further deterioration rate can be estimated. Through the wheel/bogie acceleration rates values measured by Axle-Box mounted Accelerometers and gyroscopic Measurement Sensors the running trains will transmit in future to the Permanent Way Engineer the telemetric data of developing track defects with their exact location in his jurisdiction, how the defects develop with the time and with what rates (dynamic of deterioration) under given traffic load. The Track Engineer will get alarm, when he will have to interfere by repair or maintenance. This method includes also the monitoring of turnouts.

ANNEXURE II:

IMAGES OF INFRASTRUCTURE-CONDITION INSPECTION, MONITORING, MEASURING AND RECORDING:

High-Performance System Solution for Track Alignment Data or Control-Point-based Tamping Survey, AMBERG TAMPING, Switzerland
3D Laser Mapping of Rail Road by artescan, Portugal

3D Laser Mapping Image of Rail-Road
Track geometry recording cars made by Plasser & Theurer, Austria, supply a wealth of information, depending on their equipment and the requirements. Apart from data on the track geometry, this also includes data on the rail profile, wear of the running edge, rail inclination and surface faults of the rails. Modern measuring systems are capable of measuring the clearance gauge and the ballast profile, monitoring the rail fastenings, video inspection and measuring the position of the contact wire.

To obtain the relevant data it is essential to have regular measurements carried out by TRACK RECORDING CARS. These scan the entire line network several times a year. The acquired data can be merged in a track geometry data base and are available for long-term analyses. This provides the planning offices with a valuable instrument. Rates of deterioration indicate which type of action would be the most suitable in order to restore the target geometry of the track and to retain it as long as possible.
Non-contacting measurement under Load at up to 100 km/h with Plasser & Theurer, Austria, Track recording Car EMF1 for Track Surveying and ultrasonic Rail-Flaw Detection incl. Evaluation in real Time

Rail Infrastructure Reality Capture providing 3D Data by “Leica SiTrack”, Germany, for Monitoring 360° Clearance

For the low-quality Indian Tracks (which can only be kept alive by the so-called Fire-Brigade Maintenance Method in order to keep the trains running) IR cannot give up the extravagance of frequent visual trolley or foot-patrol inspections, even if risky and costly. The ailing LWR or CWR tracks composed with short 13 m rails, AT-welds of poor quality and joggle-fishplate bandages need nearly daily surveillance.
Innovative unmanned and remote controlled optical Track Inspection/Mapping; IRIS, Harsco/Protran, USA

Visual Trolley Track-Inspection in India
“Road Master” Turnout Condition-Monitoring System by Voest Alpine, Austria

Turnout Condition-Monitoring could help to prevent such a hazardous Damage, caused on November 22th at Mokama Station near Patna by the Kamla Ganga Intercity Passenger Train, India
ENS CO’s Virtual Track-Walk (VTW), USA, software enables high-resolution track images to be inspected in the office. A key feature is the ability to view synchronized images from multiple inspection cameras along with milepost and GPS. When using VTW to inspect track, built-in tools allow the user to mark defects and identify track assets. The software then automatically tags these with milepost numbers and GPS coordinates. Identified defects and assets can be exported to CSV reports. VTW can be used for conducting visual track inspection and tie grading in the office. Defects identified can be exported to a report that includes milepost and GPS coordinates of each defect.

Railway imaging systems are at the forefront of the ENSCO technology focus. Expertise with high-resolution camera systems and advanced image processing algorithms result in systems with extremely reliable image acquisition and processing capabilities. This approach has been successfully applied to the inspection of a range of track components, including joint bars (fish plates), ties (sleepers), fasteners, rail heads, and overhead wire, as well as track rights of way (ROW). All ENSCO railway imaging systems can operate either day or night to reduce operational interruptions.

Performing walking inspections of a roadbed is time consuming and difficult to manage in high traffic areas. Using the Track Component Imaging System allows railways to automatically collect continuous images of the roadbed from a moving platform. The ability to store these geo-referenced images allows for any area in question to be evaluated from the office. Automated algorithms and processing software accompany this technology for comprehensive office inspection tools. TCIS can be used for detecting conditions such as missing/broken fasteners and grading concrete ties (sleepers).
ENSCO Track Imaging System for virtual Track-Walk

VIRTUAL TRACK WALK (VTW)
High-resolution track imaging inspection

TRACK IMAGING SYSTEMS

ENSCO's patented machine-vision technology, track imaging systems identify and inspect track components and defects.
Virtual Track-Walk Inspection in Office

Track Inspection in early 1900-ties; USA
ANNEXURE III:

Virtual Track Walk II

TVEMA/SOKOL Track Measuring, Diagnostic, Imaging, Recording, Visualization and Data Collecting Systems

http://tvema.com/catalog/systems-complexes.html

High-Speed Systems for ultrasonic Inspection of Rail Condition

The problems at most railway tracks related to high-speed traffic and the increasing number of train pairs that result in the higher track occupancy rate, as well as cost analysis show the feasibility of using mobile systems as primary diagnostic tools. Over recent years TVEMA has made a major technical breakthrough in terms of development and manufacture of various components for NON DESTRUCTIVE TESTING (NDT) equipment installed on mobile diagnostic systems. This breakthrough has dramatically increased inspection reliability compared to manual diagnostic devices which ultimately made mobile diagnostic systems a number one choice.

In most foreign countries the development of diagnostics directly follows the path of upgrading NDT equipment components installed on mobile diagnostic systems. Manual diagnostic systems are essentially not used. TVEMA is actively engaged in refurbishment of third-party carriages. This is achieved through a flexible architecture of all equipment components developed by experienced engineers who created such various systems as:

- NDT inspection bogie;
- power supply equipment for the systems;
- pneumatic equipment;
- various types of tracking systems;
- skid probe systems;
- contact fluid supply system;
- ECHO-COMPLEX-2 multi-channel NDT analyzer;
- computer equipment and control software;
- ASTRA software for automatic analysis of NDT&TD data.

NDT inspection bogie is installed under the carriage body and is intended for mounting of underfloor NDT equipment.

Power supply and pneumatic equipment provides continuous operation of all subsystems. Tracking systems include both rolling friction systems, e.g. NDT bogie TA-1DI and contactless magnetic systems which operation is based on interaction of magnetic fields of the magnet and magnetized rail.
The latter can be mounted both on a dedicated NDT bogie and on a vehicle bogie. Both types of systems are widely used on the railways in Russia and abroad: in Ukraine, Turkmenistan, China, Kazakhstan and Mongolia.

The application of skid probe systems ensures stable operation even in the harshest climatic conditions. Due to simple design the mounting and dismounting of the acoustic unit and the entire system is very easy.

Short travel time of ultrasonic waves in the protector of the acoustic unit ensures the time aperture sufficient for registration of echo signals reflected directly from the discontinuities over the entire rail height thus significantly improving inspection reliability.

The design of acoustic unit and a wide range of transducers produced by TVEMA facilitate the implementation of any ultrasonic checking pattern conforming to the requirements to defect detection in accordance with normative regulations existing in various countries of the world.

The contact fluid supply system ensures a continuous water supply including heating for performing inspection even in extremely low temperatures.

**ECHO-COMPLEX-2** multi-channel NDT analyzer equipped with many ultrasonic channels, its hardware capabilities and control software help to dramatically decrease the impact of unstable acoustic contact and the qualification of operating personnel on inspection results.

This brings to naught the only advantage of wheel-type probe systems – lesser fluctuations of acoustic contact. The software visualises inspection data in accordance with the requirements existing on any railways globally.

**ASTRA** software for automatic analysis of NDT&TD data provides automatic evaluation of NDT results in accordance with the requirements of national and international standards, and automatic generation of inspection reports.

The system is based on the modular design which ensures very simple mounting of equipment on a new mobile diagnostic system and the replacement of certain components during a carriage or railcar upgrade.

The developing high-speed traffic and the increasing number of train-pairs result in the higher track occupancy rate which in turn requires the higher speed of ultrasonic inspection. However, it is commonly known that the speed increase leads to a less stable acoustic contact. Hence, the reliability of inspection is reduced.

It has been traditionally believed that the ultrasonic inspection is limited by the maximum allowable speed and this threshold cannot be exceeded. However, using the extensive experience in the design and manufacture of mobile NDT equipment, in 2013 TVEMA developed a unique high-speed system for ultrasonic inspection of rail condition.

Due to its original design the undercarriage NDT system equipment can be mounted both on a dedicated NDT bogie and on a standard vehicle bogie of the most types of carriages between wheel pairs.

The latter location of NDT equipment is innovative and means that NDT equipment can be used without a dedicated bogie. The system is designed for diagnostics of rails laid in a railway track with 1520 (1524) mm gauge and provides detection and logging of rail
defects using ultrasonic non-destructive testing (NDT) method at speeds up to 140 km/h without reducing inspection reliability.

**All components of the system were thoroughly upgraded or replaced with innovative solutions:**

- contactless tracking system;
- probe;
- pneumatic;
- contact liquid supply system etc.

**Contactless tracking system:**

The tracking of probe systems is performed contactlessly. The system provides precise positioning of probe systems relative to the rail head through interaction of magnetic fields of the permanent magnets of the system with the field of the magnetized rail. The design ensures the maximum value of restoring force when the tracking system deviates from the rail axis.

The advantages of this type of tracking systems are as follows:

- exclusion of mechanical contact of the tracking system with a rail, which could entail appearance of acoustic interference and reduce the life of the tracking system;
- minimizing the effect of the tracking system on the condition of rail head working surface (wear);
- prevention of acoustical contact loss due to ejection of snow or other contaminants (e.g. products of the rail lubricator) in front of the probe system;
- unhampered passing of switches of any design;

**Skid Probe system:**

For control of the rail head the system is equipped with transducers which emit ultrasonic waves under certain taper angles to the working and non-working rail head surfaces. This ensures control of the rail head with single and double reflected beams thus eliminating "dead" areas.

The main advantages of skid probe systems are as follows:

- inspection speeds up to 140 km/h;
- reliable operation in any climatic conditions;
- the design comprises parts made of available materials;
- simple mounting (dismounting) of the acoustic unit (replacement by the crew within 1 minute);
- simple mounting (dismounting) of the probe system (replacement by the crew within 2 minutes);

- use of water as a contact fluid (ecology) and its direct supply under the acoustic units through nipples, thereby minimizing its losses;

- low cost of entire system;

- implementation of various types of ultrasonic checking patterns;

- short travel time of ultrasonic waves in the protector of the acoustic unit ensures large inspection area.

**Multi-channel NDT system:**

NDT system is intended for ultrasonic inspection. Advantageous features of the system include: increased number of ultrasonic channels, implementation of innovative hardware solutions and a broad range of functions of the control software thus providing a new inspection technology which dramatically reduces the impact of adverse factors (unstable acoustic contact, qualification of the decoder) on the inspection results. This solution has finally overcome the inspection speed limit previously unattainable for the ultrasonic inspection systems.

The dedicated software provides the following main functions:

- sensitivity threshold adjustment in the range from -36 to +12 dB;

- user-friendly automatic setup program;

- colour and graphical representation of signal amplitudes;

- simultaneous display of type A and B scans and video inspection results;

- comparison of several inspection runs, etc. The supply package includes ASTRA software for automatic analysis of NDT&TD data both in real time and after the inspection run.

**SOKOL Systems for Track Geometry Assessment**

Dozens of various branded high-speed geometry measurement systems are employed for rail track geometry assessment. Usually each of them is mounted on a special type of vehicle.

**SOKOL** system for monitoring and assessment of track geometry, manufactured by **TVEMA**, is distinguished by the fact that it can be integrated in any mobile diagnostic system irrespective of its manufacturer and dimensions, as there are carriages, railcars, etc. Such versatility, along with high precision measurements and affordable prices make it possible to use this system for rail track geometry monitoring on main lines and receiving-and-departure tracks. **SOKOL** provides the customers with a system, which meets, to the greatest possible extent, their objectives in maintaining the rated performance of any track section belonging to their area of responsibility.
The track geometry equipment constitutes a system of sensors mounted on three or four inspection bogies installed on the body or the frame of vehicle bogies. This design facilitates data logging at speeds up to 100 km/h. Simultaneous assessment of vertical and horizontal positions of both rails with respect to vehicle body as well as of kinematic travel parameters results in precise determination of the track geometry. The system also logs and checks for parameters and components of the track section under inspection: coordinates of kilometre posts, artificial facilities, crossings, switches, etc.

All acquired information is processed in real time, logged and documented for further analysis and for scheduling work in current maintenance and repair of the track.

The data acquired during travel is transmitted to the onboard computer system. This provides the visualization and logging of rail track geometry and its revealed deviations from maintenance standards. The computer system converts the displacements of the measuring instrumentation into electric signals, and based on their analysis, it reveals basic (rated) and additional (non-rated) geometry parameters of the rail track. Furthermore, additional information is acquired relating to speed and time of travel, operator's control actions, logging switches, etc.

Based on the basic and additional information processed, the computer system reveals deviations of rail track geometry from maintenance standards and determines required restrictions of the travel speed. Moreover, all deviations are analysed in quantity and quality and are referenced to particular coordinates.

**SOKO-2 High-Speed Systems for Track Geometry Assessment**

**SOKOL-2** track geometry assessment system is mounted on the bogie frame of any vehicle and intended for high-speed measurement of rail track geometry and rail head profiles with a contactless method at speeds up to 250 km/h.

Precise measurement data acquisition is given due to the combination of two techniques, optical triangulation and inertial techniques.

Optical triangulation with an illuminating laser and receiving video cameras is applied for the contactless measurement of the position and geometry of both rails. Inertial techniques in form of an IMU (inertial measurement unit) provide real time calculation of the required characteristics of motion and orientation parameters in space.

Optionally, **SOKOL-2** can host such additional equipment as video recorder and riding comfort monitoring systems for inspecting the effect of changes in rail profile and track gauge geometry on train travel parameters.

All acquired information is processed in real time, logged and documented for further analysis and for scheduling work in current maintenance and repair of the track.

**SOKOL-2** software can reference the information on actual rail condition to the information retrieved from the database for the particular track section. It automatically compares the parameters obtained with the required parameters, and generates reports and recommendations for operating and managing divisions of railways.

The data acquired during travel is transmitted to the onboard computer system, which provides the visualization and logging of rail track geometry and its deviations from
maintenance standards, as well as the required restrictions of travel speed. Moreover, all deviations are analysed in quantity and quality and are referenced to particular coordinates.

**SVOD System for visual Detection of Defects**

**SVOD** system for visual detection of defects has been designed for automated inspection of permanent way components. **SVOD** system provides for early detection of the permanent way faults which are critical for the rail traffic safety such as joint damages, cracks in the rails and sleepers, etc.

**SVOD** system is installed on any vehicle and can perform continuous automated inspection of all permanent way components within the assembled rails and sleepers. **SVOD** captures and processes high-resolution images from video cameras which are located in the immediate vicinity of the objects being monitored. To provide for efficient equipment operation in all environmental conditions, the system can be equipped with liquid cooling and heating, dust removal, and mechanical external wiper systems.

All acquired video data is precisely referenced to geographic and track coordinates. The system software can compare the data obtained with the data from other diagnostic systems installed on the vehicle.

**SVOD-2 System for High-Speed visual Inspection**

One of the system's basic components is a set of high-speed linear cameras providing image acquisition with resolution of 0.5 mm/pixel at the speeds up to 250 km/h. The novel dedicated illumination system ensures capture of a clear and well-contrasted image at any time of the day and in every kind of weather. A powerful data logging/analysis system provides image compression without loss of quality in real time, thereby increasing the independent total inspection length up to 10,000 km. The range of analytical software provides solutions for customer specified tasks in detection of infrastructure component defects.

The automatic analysis system facilitates real-time, post-processing detection of the following defects:

- rail end batters;
- rail tread shelling in the joint area;
- welded joint damages;
- side steps in rail joints;
- stagger of rail joints for both rail threads;
- abrasion from skidding;
- rail tread cracks;
• missing or damaged clamps;
• insufficient bolt tightening;
• sleeper misalignment and cracks;
• ballast spillage and filling;
• locating and measuring joint gaps.

The system provides for early detection of locations capable of causing deviation in track geometry due to faulty or missing permanent way components, hence improves traffic safety.

In addition to permanent way surface inspection, the TVEMA specialists recommend the installation of a fishplate inspection system, providing for automatic detection of such defects as cracks and lacking bolts. For railways with rail track control systems, the inspection of insulating joints and joint connectors is demanded.

The system is installed on a vehicle bogie and makes it possible to monitor all permanent way components within the assembled rails and sleepers.

**Multi-Channel Georadar System (MGS)**

The basis of railway track safety is, first and foremost, the reliability of its roadbed. Timely detection of deformations which may affect the traffic safety may be ensured by an efficient monitoring technique like georadar measurements.

The multi-channel georadar system (MGS) may be installed on any mobile or manual diagnostic device. MGS can perform high-speed roadbed and ballast diagnostics, which yield detailed information on their consistency.

At high speed, MGS determines the thickness and the lithologic structure of the ballast, ballast aggregate, ballast pollution and high humidity areas. Meanwhile, MGS detects in the ballast layer and the roadbed foreign objects such as large stones, cables, buried permanent way components, etc.

At the same time, the system detects the location of the roadbed soil upper level and its lithologic structure, and it locates in the roadbed weakened areas having reduced density and increased humidity. In addition, MGS locates areas hosting engineering facilities and detects areas with geotextile and styrene foam shields.

These measurements yield highly reliable continuous information on the medium being probed, a so-called georadar profile, or a radarogram. Its analysis assists the operator to make proper decisions on neutralising processes harmful for the roadbed and to schedule the respective repair actions.

MGS systems ensure not only timely detection of potentially hazardous deformations, but also provide unbiased assessment of the quality resulting from track overhaul.
**Gabarit-M System for High-Speed 3D Scanning**

**GABARIT-M** system for high-speed 3D scanning is intended for inspection of tunnel condition, analysis of the ballast prism parameters and checking of compliance with the clearance and inter-track profiles. The system installed on an inspection train or vehicle may comprise a high-speed and ultra-high-speed scanning systems.

The high-speed scanning system can perform diagnostics at speeds up to 140 km/h with sampling steps not exceeding 0.2 m. The system is based on a laser scanner and the phase-shift measurement principle ensuring the least possible measurement error in the entire operating range.

The ultra-high-speed system comprises 1 to 6 ultra-high-speed laser scanners providing minimum inspection sampling steps (0.05 m at 320 km/h) and preserving high image resolution. This system may be employed at high-speed railway sections where it is impossible to arrange traffic gaps for inspection, while the need for thorough and regular diagnostics dictates extraordinary requirements for inspection trains.

One of the basic advantages of both scanning systems is the unique dedicated software. The innovative filtering and compression system makes it possible to use only relevant information, while smart data analysis algorithms and the customer's information system interface modules provide for prompt implementation of the measurement systems in existing diagnostic technologies.

This system, together with modules for interfacing track section databases and modules for information import from other measurement systems ensure a high quality condition of infrastructure facilities.

Software modules generate the following analytical and reported data:

- 2- and 3D mapping of the inspected track section superimposed with videos showing the intrusion of objects in the preset clearance profile: areas and sizes;
- measured inter-track clearance profile;
- localising ballast prism maintenance;
- 2- and 3D imaging of tunnels with automatic detection of wall defects;
- contact wire position;
- out-of-gauge areas report;
- tunnel condition report;
- ballast prism condition report.
IVK-ALS System for High-Speed Measurement of Track-Circuit Parameters

The acronym of this system, unprecedented in Russia, stands for "Measuring and Computer System - Automatic Cab-Signalling".

The system is designed for a high-speed inspection of the track circuits of railway automation and telemetry devices. The system checks the operation of the alarm and control systems of the railway vehicles. Furthermore, it evaluates the value of the residual rail magnetic induction on the way of the train.

The system measures the operational parameters of the automatic cab signalling systems (including continuous and integrated continuous types) and automatic train stop systems (including centralized and modified centralized types). Simultaneously, the audio frequency track circuits are checked. Here, the system equipment provides for the measurement, display, and real-time logging of oscillograms, charts, amplitude, frequency, and time-response characteristics of the eclectic signals in the track circuits.

For each type of the data, there is a separate monitoring and measuring channel. All data is automatically logged and analysed by the dedicated software. The acquired data can be sent to a fixed computer workstation for further analysis and transmission to the common information area of ОАО RZD.

Another advantage of the system is that it can not only generate, but also edit, if required, the standards database, accumulate and analyse the measurement results, store and print out charts, oscillograms and reporting documentation.

IVK ALS system is installed on an inspection vehicle. It can be employed both with an individual locomotive or included in a passenger train on all railways.

KTSM System for Monitoring the Condition of Floor-mounted Equipment

Overheating of box bearings may result in wheel set journal breakage, rolling stock derailment or carriages and/or cargo catching fire. To prevent such emergencies, special floor-mounted hot-box detection devices are employed in railway constructions. The readings of these devices must be continuously monitored. This may be performed, in particular, with a dedicated monitoring system developed by the TVEMA specialists.

KTSM (the Russian acronym for 'Upgraded Hardware System') is an example of the Company know-how, which is unprecedented in Russia. It is intended for automated on-the-fly monitoring of device condition. To this end, hot boxes of a laboratory vehicle are simulated, and the acquired results are processed and analysed by the computer system. The computer system comprises instrumental temperature channels for the working surface of the hot-box simulator and for ambient air at both sides of the laboratory vehicle. A simulator power supply control channel and train radio communication logging channel are also provided.

KTSM-01, KTSM-02 control equipment measures, displays and performs real-time logging of the data and the temperature information for each channel, as well as recording of KTSM voice informer messages via the train radio communication channel. The entire user interface is arranged within a single operator's workstation.
The software makes it possible to display the information on travel route, KTSM stations at the track section, simulator condition, as well as to save and process the inspection results with referencing to coordinates, and to print out reports.

The system prints report documentation. KTSM system provides logging and listening to the train radio communication for the purpose of comparing the recorded information with that received from the station operator or from the voice informer on a laboratory vehicle passing KTSM station. There is an option of building and, if required, editing KTSM station database.

The system is installed on an inspection vehicle. It can be employed both with an individual locomotive or included in a passenger train on all railways.

**SOKRAT System for Rail Quality Control**

This system, unprecedented in Russia and CIS countries, is designed to perform the diagnostics and full inspection of new and used rails at steel mills and rail welding plants.

In the industrial environment, SOKRAT performs instrumental inspection and evaluation of the rail condition, automatically documents findings in electronic and printed form.

The system comprises several subsystems. The NDT subsystem checks the condition of the rail head, rail web and rail base. The geometry inspection subsystem measures the rail height, horizontal wear, scaled wear and corrugation, the camber and skewness of the rail profile, as well as the twisting and the length of the rails and rail bars. SOKRAT also comprises the video inspection system.

The rail profile is inspected by two 2D-sensors. The profile measured by the sensors is compared to the rated values. The result is used to calculate the skewness of the profile, as well as the horizontal, vertical, and scaled wear. The rail corrugation and camber in the vertical plane are measured by four triangulation laser sensors located above the rail head.

The rail camber in the horizontal plane is measured by three triangulation laser sensors located alongside the rail. The rail twisting is measured by four triangulation laser sensors located in pairs under the rail base.

All information is collected via a network at the common server. This information is used to generate the passport for the rail or the rail bar. The NDT data is saved in passport as individual files, while the geometry inspection results are stored as graphic charts with the indication of the maximum and average deviations form the rated values.
Onboard virtual Track Walk

SOKOL System for Monitoring and Assessment of Track Geometry
SVOD System for visual Detection of Defects

High-Speed System for ultrasonic Inspection of Rail Condition
Multi-Channel Georadar System (MGS)

Onboard Computer System providing the Visualization and Logging of Rail-Track Geometry-Data and its Deviations from Maintenance Standards,
TVEMA Track Inspection Vehicle capable of performing complex Diagnostics of Railway-Tracks, including ultrasonic NDT and contactless Track-Geometry Evaluation.

Rail and Rail-Weld ultrasonic Scanning Equipment
Images of mobile Diagnostic, Visualization and Data Collecting Systems:
Visualization of Georadar Track Profile
ANNEXURE IV:

Latest Railway News from India

**Railways use Track Recording Cars (TRC) & Oscillation Monitoring System (OMS) for Detection of Track Defects**

15 Dec 2017 in Category(ies): Posted on 15/12/2017 Categories Civil Engineering, Indian Railways

NEW DELHI: Indian Railways is using Track Recording Cars (TRC) and Oscillation Monitoring System (OMS) for detection of track defects in addition to manual inspection. Ultrasonic Flaw Detection is also done using Single Rail Tester (SRT) and Double Rail Tester (DRT) to check internal defects in rails. Procurement of six nos. Self Propelled Ultrasonic Rail Testing (SPURT) Car for detection of internal defects in rails is also planned.

Further, it has been decided to undertake trial of Ultrasonic Broken Rail Detection (UBRD) System, Rail Fracture & Intrusion Detection System using distributed optical fiber sensing and Loco-Vision Analytics and Rail Integrity Monitor system (RIM) on some stretches for detection of broken rail.

Optical Fiber Cable (OFC) based rail fracture detection system is planned on trial basis on some stretches of Northeast Frontier Railway and North Central Railway.

The implementation of Ultrasonic Broken Rail Detection (UBRD) System, Optical Fiber Cable (OFC) based System and Loco-Vision Analytics and Rail Integrity Monitor system (RIM) shall be decided after successful completion of trial.

This Press Release is based on the information given by the Minister of State for Railways Shri Rajen Gohain in a written reply to a question in Rajya Sabha on 15.12.2017 (Friday).

**Indian Railways to launch Android/iOS App to maintain Online Records of Inspections**

13 Dec 2017 in Category(ies): Posted on 13/12/2017 Categories Centre for Railway Information Systems (CRIS), Indian Railways, IT, ICT, IOT, Cloud, Innovation, Social, Mobility, Telecom, FinTech, Analytics Digital & Signalling Technologies in Rail Sector and OneICT Initiatives of IR, Northern Railway, Delhi Division

NEW DELHI: All records of inspections conducted by the railways will now be maintained online through an App exclusively developed for the purpose.

The “E-inspection App”, which will be launched on the Android and iOS platforms later this week, will make the records of all the inspection activities online, especially those pertaining to safety and passenger amenities.

This would be for all types of major inspections carried out periodically by the railway staff, which includes track inspections, running-room inspections, station inspections, train inspections, coaching stock inspections etc., officials said.

“This will do away with many shortcomings in the manual way of inspection reporting and record keeping,” the railways said today.
The App can be installed by all the stakeholders concerned in their mobile phones or computers. It would ensure a speedy reporting and help send instant alerts to the field via text messages or e-mail for timely corrective measures, officials said.

The other advantages of the app include real-time tracking, data mining, analytics, transparency and ensuring the availability of data across organisations.

“It will be a proper checklist for inspections, development of scorecard to digitise the trends, prioritise the issues on a fact-based analysis, availability of historical data prior to inspection,” an official said.

The app will have in-built software, which will generate various graphs and analytical data automatically. It will also have an option of reporting a matter through actual photographs taken at the time of inspection.

While the App will be formally launched in the Delhi Division this week, it will be extended all over the country in a month’s time.

Battered Railfracture near Bagaha-Bihar, India, on a run down Rail-Track indicating that several Trains had passed over this Fracture without Notice, detected on 18th December 2017 by a local 12 year old Boy

**Message for India:**
Invest more in Tracks of **INITIAL HIGH TRACK QUALITY** resulting in lower Deterioration Rates under given Traffic Load. Then less frequent "Leveraging" Inspections, Monitorings, Recordings are needed, and the expenditures for Repair, Maintenance, Rehabilitation and Renewal become less. Under **OVERALL LIFE CYCLE COSTS CONSIDERATIONS** this will be more economical.
Train-Passengers will be thankfull for less nasty Derailment-Disasters.