GLOBAL TRENDS IN RAILWAY TRACK TECHNOLOGIES, PART II
OPTIMISING THE WHEEL-RAIL SYSTEM
– to keep Railway Tracks sound and healthy
under the Light of
WHAT MAKES INDIAN RAILWAYS SO UNSAFE AND UNECONOMICAL?
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Résumé: To operate a railway safely and to keep it in a healthy condition constant input in maintenance and renewal is needed. India falls short in keeping the Quality of its rail-tracks fit for the traffic load/volume the tracks have to carry. This is one of the underlying factors/conditions for the unsafe and uneconomical operation of Indian Railways. Train-Passengers are killed and injured in nasty and unwanted bad events.

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I. AVAILIBILITY OF RAILWAY TRACKS FOR REPAIRS, MAINTENANCE AND RENEWAL:
The AVAILABILITY OF THE INFRASTRUCTURE and THE DEVELOPMENT OF RAIL DEFECTS have been on the top agenda of the 21th International Convention of the Committee on Railway Technology, Optimising the Wheel/Rail System, held on 25/26th September 2017 at Graz, Austria.

A railway track is subjected to constant dynamic changes by every train that goes. After each train-run the track is not any more the same as before. Repeated Maintenance and Renewal are needed to bring the track back near to the initial healthy status. A Chief Engineer for Permanent Way Works of Sri Lanka Railways have summarized this reality with the sentence: “A Railway Track needs attendance nearly as every train goes”.

Maintenance and Renewal have to be financed, organized and planed over a long period ahead, up to 4 to 15 years. Political leadership, in their more reactive than generative manner with a so-called “fire brigade mentality”, realizes this not seldom only after the occurrence of a nasty and bad event, killing and injuring scores of train-passengers. They are quick to pin culprits to
be made responsible rather to generate far reaching reforms and to look for organizational failures in the system and prevailing unsafe conditions.

The time-intervals between the thresholds for railway track maintenance and renewal depend on the QUALITY of a track. Since a low quality track deteriorates faster than a good quality track, a poor quality track has to be attended in shorter intervals and needs earlier renewal. An indicator for TRACK QUALITY is the deterioration rate of the mutual interacting track-components over the time under given traffic load, in other words: The loss of strength of the interactive track-components over the time under given traffic load.

To keep a railway track on a low quality level – just to keep the traffic flowing next to the doorstep of mishaps - is not only costlier over the Life Cycle, but bears far more risks of unwanted bad events killing and injuring train-passengers.

If trains cannot run or can only run at restricted speed and/or with lower traffic density due to rail-defects, urgent repairs, maintenance and renewal, additional AGGREGATE HINDERANCE COSTS emerge. These are costs emerging, when the rail-track is not available for rail-traffic or if there are constraints of operational availableness. The infrastructure provider has not to pay for all hindrance costs. Those costs are in India left to the publicity and do not find their way into cost-efficiency considerations.

The AGGREGATE HINDERANCE COSTS should therefore also flow in MAINTENANCE and RENEWAL STRATEGIES/STRATEGICAL PLANINGS, although the Infrastructure Operator and Service Provider have not to pay for it in full extend.

TRACK QUALITY is achieved by MODERN TRACK ENGINEERING TECHNOLOGY. Maintenance and Renewal have to be financed and organized; however this falls obviously short in India with the outcome that several routes do not match anymore the traffic load, they have to carry. This is an underlying and prevailing unsafe condition leading to so many nasty and unwanted Derailment-Disasters, killing and injuring train-passengers. A neglected rail road roisters with such bad and unwanted events.

The objective of an optimized strategy for maintenance, renewal, investment and planning is a balance between the availability of the rail-infrastructure for train service and the availability of the rail-infrastructure for repair, maintenance and renewal under overall LIFE CYCLE COSTS CONSIDERATIONS including the AGGREGATED HINDERANCE COSTS (Betriebs-Erschwernis-Kosten).

Studies and audits in Germany, Austria and Switzerland under the so-called “DACH ORGANIZATION” have revealed that under overall LIFE CYCLE
COSTS CONSIDERATIONS including the AGGREGATED HINDERANCE COSTS in the European “DACH-COUNTRIES” less frequent well far ahead planned longer MEGA TRAFFIC BLOCKS and complete LINE CLOSURES for repairs, maintenance and renewal are more economical and therefore more advisable than more frequent shorter traffic blocks.

To achieve TRACK QUALITY of MODERN RAIL-TRACKS is only possible with modern innovative HEAVY DUTY and HIGH PERFORMANCE ON-TRACK MACHINERY. The high investment costs of on-track machinery parks make longer working time necessary to become economical. Much time is needed to retrofit track and machinery before the machinery can proof its benefits. Therefore, the trends go to machineries with a higher work-output.

Short Traffic-Blocks contrast Efficiency. During longer traffic blocks higher maintenance and renewal efficiency can be achieved; however the AGGREGATE HINDERANCE COSTS increase with the duration of traffic blocks.

In Europe Mega-Blocks or complete Line Closures are easier to arrange than in India, since the rail-network in Europe is denser with more alternatives for re-routings/diversions.

Whilst AVAILIBILITY for track works is difficult to determine, NONAVALIBILITY for track works can be easily evaluated.

II. AVAILIBILITY OF RAILWAY TRACKS FOR TRANSPORT SERVICE:

Availability shoes its ugly face, when not any more at disposal (= Prof. P. Veith, Technical University Graz, Austria)!

There is not only the AVAILIBILITY for Track Maintenance and Renewal; there is also the AVAILIBILITY of the rail-routes for Rail-Transport. Tracks of high rail-traffic availability have to be kept in healthy and sound conditions. But this needs high input in capital investment schemes as well as high standards in maintenance and repair management planning, organization and technology. If not enough invested, the neglected tracks answer with low availability and take revenge with nasty and unwanted calamities not only blocking lines but also killing and injuring train-passengers. Track faults have to be eliminated before they end up in a calamity.

Turnouts and Curves, the maintenance and renewal costs drivers, contribute most to disruptions. Modern track-layouts for new railway lines try to work with few as possible numbers of turnouts and crossings by intelligent grade separation of lines and by keeping the curvatures as lean as possible.
III. DIGITISATION IN RAILWAYS:

“DIGITISATION in Railways” is a nowadays often used so-called “Buzz Word”. Digitisation (or Digitalisation) will help to gather and collect the information/data needed for CONDITION BASED and PROACTIVE MAINTENANCE/RENEWAL, STRATEGIC PLANNING, ORGANISATION, APPLICATION, INVESTMENT STRATEGIES and LONG-TERM PLANNING.

The data volumes measured and monitored from infrastructure installations have not only to be collected but also processed by analysis-algorithms, fractal analysis and models and as well by intelligent interpretation through skilled operators. Digitisation ensures that good use can be made of the generated data-warehouses/data-lakes. It will help to handle budgetary recourses efficiently. It helps to evaluate the healthy or unhealthy condition/status of the rail-network and to analyze the effect of diverse investment and asset management strategies as well to find the best time for intervention.

Modern hard- and software solutions have already entered the railway business. Digitisation drives Automation in Maintenance.

By Digitisation complete Rail-Tracks can be scanned and 3D portrayed as a digital model to be used for maintenance decisions and planning’s and for due time actions.

For years, Plasser&Theurer machines have been optionally equipped with the remote diagnosis system Plasser-Datamatic. Depending on the machine model, the machine can be retrofitted with the system as a machine upgrade. Plasser-Datamatic allows the live monitoring of important data on the GPS position, working direction, engine, filling levels and hydraulic pressures. This makes it possible to access the current status of entire machine fleets from the office, living up to CONDITION-BASED MONITORING.

Providing highly valuable information, the data is stored to enable later access. Once it has been analysed, the data can be decoded and translated into specific instructions for condition-based maintenance. With this innovation, “P&T-Connected” is breaking new ground in the railway industry.

Already today, automation is used to facilitate tamping works in turnouts and crossings. However, the quality of the tamping works still depends on the experience and skills of the two operators, who control this complex process. The tamper in the main cabin controls the tamping unit, including the opening width and the tilting motion of the tines, as well as the turntable. The co-tamper controls the lifting and lining unit and parts of the tamping unit in the diverging track as well as the additional lifting unit. Both operators must have extensive knowledge in their special fields.
“Plasser Smart Tamping – The Assistant” supports the operators in most of their tasks. It scans the turnout, generates a 3D image showing its exact position and possible obstacles, analyses the data and suggests actions for the tamping unit, the lifting and lining unit and the additional lifting unit. The operators only have to confirm the suggestions and wait for the next step. However, they can take action at any time and correct the suggestions. To provide sufficient time for changes, suggestions are given several metres ahead of their actual destination.

Quality and form of the documentation of the tamping results have entered a new level. The software makes it possible to react flexibly to the customers’ requirements, providing special formats, such as multi-layer PDF documents.

In addition, transparency in the quality control of tamping works has significantly improved. The infrastructure operator can easily access all relevant quality and working parameters, such as the tine position, tamping depth or squeeze time, digitally and, if necessary, online.

When developing the turnout tamping assistance system a new approach was used. The product was developed and tested using Plasser’s own turnout tamping simulator. Introduced to the expert audience at iaf in May 2017 at Münster, Germany, it was used on the Unimat 09-475/4S N-Dynamic universal Tamping Machine for the first time. Now, Plasser Smart Tamping is being further developed modularly for other tamping units. The aim is to make “Plasser Smart Tamping - The Assistant” available for all new turnout tamping machines and universal tamping machines with standard tamping units as optional equipment by the end of 2018.
The Method of condition-based maintenance can also be applied to the maintenance of entire machines, making a decisive step towards condition-based maintenance and away from maintenance at intervals. “P&T-Connected” provides data analysis and, on this basis, recommends further actions.

In addition to maintenance, the analysis of machine data benefits many other areas, ranging from improved reporting to contractors to the efficient operation of the machines. “P&T-Connected” will continue to deal with these new approaches. The young team is convinced that they will provide solutions. Some of which will already be discussed at “Digitalisation - Harnessing Big Data in Rail” conference.

With the evolution of innovative Heavy-Duty and High-Performance On-Track Machinery measuring all needed data, processing the data on-board or by a remote operator linked over the data-cloud the track machinery, will serve as a robot in executing the needed corrections.

As early as in the second quarter of 2018, Plasser&Theurer will introduce a new solution that is also based on the increasing connectivity of the machines: “P&T-Connected” is currently developing an app that will replace paper service booklets, the Plasser Machinery Maintenance Guide (PMG). Its first version will be particularly designed for the tasks involved in the general overhaul of tamping units.

P&T-Connected will provide the structure and user interface, Plasser&Theurer will provide the machine-related content. The customer can enter its data using the app. In addition to the many advantages for operation, the new app will considerably increase transparency in the communication between the manufacturer and operator. Right from the start, the customer can access all data on the machine’s acceptance and commissioning in the app. Moreover, both the customer’s experts and Plasser&Theurer’s service technicians will use this systems.
German Federal Railways, DB, launched smart turnout diagnosis to be used in pilot operation. Plasser&Theurer evolved an innovative Tamping Machine for turnouts, measuring all needed data, processing the data on-board or by a remote operator linked over the data-cloud and serving as a robot in executing the needed corrections.

With the **IVU.pad**, Swiss Railways have developed a digital workplace. The **IVU.pad** is a reliable companion for drivers, customer service advisors and office-based staff. The mobile app keeps them in the loop - any time and any place. Important documents like duty schedules, handbooks and forms are always available. At the same time, the **IVU.pad** also supports the most important processes: From damage reports to work scheduling. With the **IVU.pad**, heavy briefcases full of papers are a thing of the past.

![IVU-Pad, Swiss Railways](image)

The German Manufacturer Th. Goldschmidt presented on the last iaf, Münster 2017, with the digitalized Systems "**SMARTWELD JET**" und "**SMARTWELD RECORD**" the latest trend in Alumino-Thermic process controlling of AT-Welding. The **SMARTWELD RECORD** records and documents the preheating parameters for **THERMIT®** welding via the **GOLDSCHMIDT DIGITAL APP**. The welder is given the specific individual steps for the welding in a user-friendly way and without errors. This ensures both optimum use of welding materials and that welding is performed to standard. Process parameters can be saved centrally and evaluated using the **GOLDSCHMIDT DIGITAL APP**. This means the **SMARTWELD RECORD** is a digital innovation, contributing towards documenting the high quality of the welding:
IV. ABOUT THE DEVELOPMENT OF RAIL-DEFECTS:

The development of rail-defects had been the subject of the preceding Seminar to the 21\textsuperscript{th} International Convention of the Committee on Railway Technology, \textit{Optimising the Wheel/Rail System}, held on 25/26\textsuperscript{th} September 2017 at Graz, Austria.

Other than road vehicles, a railway runs with steel-wheels on steel-rails on a non-elastic contact area. The contact area is only approx. 3 cm\textsuperscript{2} and subjected to high compression forces of about 40 to 50 kN/cm\textsuperscript{2}.

The wheel-rail contact moves on the boundary of the physical feasibility; sometimes beyond. In-service failures and defects of rails have also to be considered as the result of joint interactions of the track components. The rail
is on the top of a track, and investigators tend to look only on this, although, what is below plays mostly a part in failures (= Prof. P. Veith, Technical University Graz, Austria).

With modern highly powered three phase AC asynchronous Traction-Control Technology (high accelerating and decelerating/breaking forces) the problems of Rail Contact Fatigues (RCF) resulting in Head-Checks, Squats, Studs, Spallings and Roughness increase. Wheel-burns caused by spinning wheels of elder locomotives without traction/slip-control working with a friction coefficient of \( \mu = 0.148 \) are on decrease, whilst head-checks caused by modern traction technology with a friction coefficient of \( \mu = 0.175 \) and higher axle-load working at the slip-boundary are on increase. With slip-traction-control the wheels can spin slightly faster than the run of the locomotive. The wheel-contact temperature can increase to over 700 Degree Celsius. The higher slip-boundaries are good for higher dispatchable tractive efforts and also for the wheels but bad for the rails. "The good old times are not coming back!" (= Prof. Klaus Rissberger, Technical University Graz, Austria).

Defects on the running surface can be eliminated by frequent preventive RAIL GRINDING. One should not wait too long until cracks of head-checks have penetrated too deep over 3 mm. If too late interacted, too much material has to be milled off or the rail has to be renewed in its whole. Rail-Grinding is a cyclic progress. After the elimination of surface defects the process of RCF under traffic stress will start again. Undetected or untreated RCF may result in Rail-Fractures leading to Derailment Disasters, as frequent in India. An undetected rail-failure can end up in a catastrophe, as recently in India on 7th September 2017 near Obra Dam:

![Image of Rail-Fracture at Howrah-Jabalpur Shaktipunj Express Derailment Site near Obra Dam, at 7th September 2017](image-url)
The development of micro-cracks accelerates with the time. Squads can appear suddenly and unexpected and can result in sudden rail-fractures:

![Rail Squat](image1.jpg)

In the aftermath of a grinding cycle the outcome and result has to be carefully inspected (optically and by Eddy current testing), monitored and documented by either the infrastructure provider or the performing client. After Rail Grinding, sometimes surprise defects may prop-up like spallings or break-outs (= Dr. W. Schöch, Speno International, SA):

![Rail-Corrugations and Slip-Waves](image2.jpg)

**Rail-Corrugations** and **Slip-Waves** can cause at the wheel-rail contact accelerations of 20 g (1 g = 9.8 m/sec²) or more, bad for both the track components and rolling stocks:

![Rail Corrugation/Slip-Waves](image3.jpg)
**Slip-Waves** can appear on slab tracks with highly elastic noise/vibration damping Mass-Spring Rail Fastenings, which one finds on Metros.

The **Contact-Geometry** between Wheel and Rail is the all important key. With unfavourable contact geometry more energy is inducted in the rail-surface leading to an increase of RCF. With wear of wheels and rails the contact-geometry becomes worse. The wheel-rail resistance increases with worsening contact-geometry. **Heat Treated Rails** of higher strength (for example R400HT rails) keep the original healthy state longer; an advantage for outer curve rails.

The **R400HT** rail grade is a fine-pearlitic heat-treated rail grade in accordance with EN 13674-1, with a minimum hardness of 400 BHN. Voestalpine Schienen manufactures this hypereutectoid steel grade through its worldwide patented HSH® process under the brand **400 UHC® HSH®** following a special metallurgic approach. Rails of this steel grade are produced in lengths of up to 120 m and are available in all rail profiles of various standards and specifications.

The high-strength **400 UHC® HSH®** rail grade has been very successfully used in tracks with extreme loads for years. It is applied especially in heavy haul transport with axle-loads up to 30 tons and above and has become the standard grade both for curves and for straight track. Also mixed traffic railways with medium axle-loads of 22.5 tons and below are deriving technical and economic benefit resulting from the use of the **400 UHC® HSH®** rail grade in higher loaded curves.
By **Target Grinding** the contact-geometry can be kept at its optimum resulting in less wheel-rail resistance and RCF. “**To optimize Wheel-Rail Interaction has no end**” (= Dr. A. Jörg, Voestalpine Schienen GmbH, Austria).

**Superelevation/Cant-Deficiency** can have an influence on RCF (= Dr. M. Mach, ÖBB-Infrastructure, Austria) especially on ballast-less slab tracks. On high-speed lines with mixed traffic speeds cant-deficiencies in curves leading to a centrifugal acceleration of 0.85 m/sec\(^2\) are permitted. Slab tracks have highly elastic rail fastening systems. The head of outer curve rails tends to bend up-to 2 mm out of the rail-cant, leading to a change in the wheel-rail contact geometry and thus to head-checks.

The curvatures of the private build and maintained High-Speed Line in Netherlands from Amsterdam to the Belgium Border had been originally designed only for High-Speed Trains running up to 300 kmph over a Rheda-type ballast-less track. The HSL-South Project is the largest Public Private Partnership (PPP) contract ever awarded by the Dutch Government and one of the largest high-speed railway projects in Europe to date.

Modern High-Speed Trains have a relatively low axle-load of 14 to 16 tons and are designed as rail-cars with traction-power distribution over the racks. Nowadays also conventional locomotive hauled express trains running “only” 160 kmph, hauled by Bombardier TRAXX locomotives with slip-control asynchronous three phase AC, have to run over the same HSL-South line under a **Mixed Traffic Scheme with a Cant-Excess**. This leads to a high angular attack on the curve rails and to an increase in RCF. More frequent grinding is required (= A. Hertogs, Infraspeed Maintenance BV, Netherlands).

![Bombardier TRAXX F 160MS electric Locomotive for NS with IGBT Type Converter and with brushless asynchronous AC Traction Motors – a Culprit for RCF on the HSL-South Line, Netherlands](image-url)