
The MÁV Central Rail and Track Inspection Ltd.
25 years
25

Presidential greeting

Dear Reader,

2021 is a special date in the Hungarian railway history. We can celebrate on the one hand the 175th anniversary of its existence, on the other hand among our subsidiary companies, the 25th anniversary of the establishment of MÁV Central Rail and Track Inspection Ltd. Therefore this special publication was made, from which we can learn the biggest achievements, the secrets of operation, professional methods and the history of this track diagnostic service firm. We hope that its reading will bring closer to the reader the world of track diagnostics which is mystic, at the same time very logical, building on strict rules, traditions, and in the meantime on modernity and continuous innovation.

What does MÁV CRTI Ltd. mean to MÁV-Volán-group? The ideal operation of Hungarian railway infrastructure cannot be imagined without such a firm, which ensures with its continuous presence, that our passengers and employees could travel on the Hungarian railway tracks always in total safety. There is no railway without safe and stabile railway lines, which demand continuous supervision due to the continuously changing environmental effects and to the passing time.

MÁV CRTI Ltd. consists of a team of committed and enthusiastic experts, in the most successful years, beside the Hungarian tracks they fulfilled also the track diagnostic orders of six European countries. Thanks to their professionality they advanced from subsidiary company to also an internationally acknowledged diagnostic service firm, which produces a huge amount of profit to our country, not only with its reliable services, but also with its value-constructive attitude. Despite their efficiency they never seat back, they intend the obtained income and experiences for newer and newer developments. The Central Rail and Track Inspection Ltd. is one of the “laboratory” of the Hungarian Railways, also an intellectual workshop, which install the most up-to-date international technologies into its everyday operation. And all of this is for the same reason, for which MÁV-Volán-group works together, day-by-day: for the establishment of the modern, reliable and maintainable public transportation.

In the name of MÁV Co. I can guarantee that MÁV CRTI Ltd. continues to enjoy our confidence, as on owner we ensure all support in order that we should remain in such a fruitful connection working for our passengers and employees.

I wish you a good reading!

dr. Róbert Homolya
president-general director
MÁV-Volán-group

Executive greeting

Melinda Bándoli
Mrs. Kelemen
managing director

Our dear Partners,
My dear Colleagues,

We celebrate the 25th birthday of MÁV Central Rail and Track Inspection Ltd.. A quarter of a century is determining even in the life of man, and in case of an undertaking it is much more a significant period nowadays, in our changing world.

In connection with this outstanding anniversary it's worth to review the most important successes and numerous achievements of the passed 25 years, by which the company became determinant track diagnostic firm of Central-Europe by today.

I'm very proud to have been the part and shaper of the development of this undertaking since its establishment, from the compilation of the first business plan, as the second leader of the Company and for about three years as its managing director.

After the establishment, MÁV CRTI Ltd. conducted the track diagnostic activity for the owner MÁV Co. Thanks to the work of the dynamic and committed leader- and expert stock, got to the company, during one-two years with the better utilization of the means of production, the sale of diagnostic services on international market could be realized. In the most successful years, beside the complex examination of the domestic railway network, we could also execute track diagnostic measuring services at railway companies of 6 European countries. The foreign orders won in international tenders, induced greater market participation and greater efficiency, thereby possibility opened for the continuous development, improvements and for the realisation of the newest measuring technique and evaluation solutions. The business plans, development imaginations compiled by the management, received continuous owner support in the course of the years, and the development of producing and measuring technique devices was always in its focus. The most important investment of the passed period, for which we can be rightly proud, is the FMK-008 Rail Diagnostic Train, realized from self-effort.

Income of the Company has increased from the original 0,4 billion forints by today above 3 billion forints, and parallel with this, the number of employees at the establishment time has also increased more than by half.

The continuous development demanded and at the same time made it possible to keep and supply the well-skilled and high-level leader and expert stock. The management has always found it important to ensure the qualitative workplace circumstances and the competitive income, for which the support from the owner has always been received as well. Thanks to the above mentioned items, it can be said that during the passed quarter century the establishment and keeping such an efficient team was successful, where the devoted and committed work of both the leaders and the employees executed on a high-level had played and continues to play a great role in the success of the company.

The high professional appreciation is greatly assisted by the excellent domestic and international work connections formed during the years. CRTI Ltd is regular exhibitor of the domestic and international fairs and exhibitions (e.g. INNOTRANS in Berlin), our experts are continuous participants and lecturers of domestic and international conferences, and they regularly publish in professional journals.

The aim of the company management is serving of the customers on the highest level, the maximum fulfilment of the existing and future latent demands, adaptation of the developments to these demands. At the forming of strategic ideas, plans, always the continuous development, enlargement was and is in the crossroads, to its realization the Company keeps counting on the support of the owners. Our aim, in addition to the high-quality service of domestic railway companies, is to further retrain the foreign market customers acquired during the passed twenty-five years, and in favour of this, the development and procurement of newer track diagnostic railway vehicles.

We thank our owners, partners and customers, and not at last our employees the executed common work by which they contributed to the foregoing successes of MÁV CRTI Ltd.

Melinda Bándoli Mrs. Kelemen
director

Melinda Bándoli Mrs. Kelemen

Melinda Bándoli Mrs. Kelemen acquired her B.Sc. economist diploma in 1980 at company management speciality of Financial and Accountant College, then in 1992 her M.Sc. economist diploma at Budapest Business School. In 1999 she acquired Euromanager diploma at Juristic and Company Management International Institute of European Business School (EBS).

She has been working at MÁV group since 1983, where she spent more than 10 years tracing several grades of the professional ladder, and she left the company for three years from chief accountant position, fulfilling a professional challenge.

From 1994 till 1996 she was the economic director, assistant general director of HM Arm Com Communication Technical Corporation, as member of the board she executed, together with her leader mates the crisis management, profile changing of the firm undergoing a loss.

In the autumn of 1996 at the establishment of MÁV Central Rail and Track Inspection Ltd. she already contributed to the preparation of business plans necessary for the establishment.

She organized and controlled the build-up of the total financial and accounting system of the company. From 2000 she was working as the assistant managing director of the company, from December 2018 she controls the firm as director.

János Béli
retired
managing director

Dear Partners, Dear Colleagues,

We are celebrating the 25th anniversary of the establishment of MÁV Central Rail and Track Inspection Ltd., which is a significant event in the life of the employees of the Company.

The precedent organization of the Company, MÁV Central Superstructure Examiner Office was established on 19th June 1959, 62 years ago. In the establishment of the office a railway accident in 1958, occurred from a rail flaw, interplayed in a great extent, after which the court obliged MÁV for the examination of the inner material of the rails.

During the six decades passed, the railway track examination activity went through a significant conversion. I would especially highlight the conscious developments of the passed 25 years, which brought the success for MÁV CRTI Ltd.

We can be proud rightly of the achieved results, both from economic and professional point of view.

The Company has shown and proved that with diligent work and great expertise it can be the market leader of the region, on the area of track diagnostics. It must be highlighted that behind the successes there is a lot of work. Confidence and the appropriate reactions were necessary to the success, as the result of which the Company didn't falter even in the case of failures.

It is very important for MÁV CRTI Ltd. that its experts should learn the newest technical solutions, innovations and examination methods. One of the tools for reaching this aim is the continuous keeping in touch and co-operation with foreign firms. We have continuous and tight co-operation with research institutes and measuring technical and track diagnostic units of several railway companies, and with domestic and international enterprises.

The correct business approach and prepared professional knowledge of our Customers and Partners contributed to our successes and professional appreciation. It's a pride for all of us, that in the course of working the knowledge, commitment and orderliness of the experts of the Company are praised!

After track maintenance practice of 14 years I joined the team of Central Superstructure Examiner Office in 1990, as a director.

From the establishment of MÁV CRTI Ltd. till my retirement at the end of 2018, I have been serving the superstructure examination activity for 22 years, as the managing director of the Company. The years spent on the area of track diagnostics gave me a lot of experience, delight and success. Thanks to my Colleagues that we could work together and we could learn from each other!

Concerning the future I wish you endurance and further work successes!

János Béli
retired managing director

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25 years in the service of railway safety

MÁRIA ZSIGÓ

MÁV Central Rail and Track Inspection Ltd. (MÁV CRTI Ltd.) was established by MÁV Hungarian State Railways Co. on 1st September 1996. From 23rd February 2017 MÁV-HÉV Suburban Railway Co. acquired ownership-part in the Company

The main activity of the Company are the technical inspection, analysis, in the frame of which there are the inspection of railway tracks, their track- and rail diagnostic measurements and inspections, periodical inspections of bridges, qualification of new and used superstructure materials getting into the railway tracks, evaluation of the measuring and examination results, development of the measuring devices and instruments used for the measurements, and vehicle inspection activity.

MÁV CRTI Ltd. is member of MÁV-Volán-group, and provides track diagnostic services basically for MÁV Co. and in addition, for the track operator organizations of the railway companies in domestic and surrounding countries, which are achievable in the market.

The technological and technical development occurred in the passed 25 years since the establishment in 1996, the changes in the international environment, mostly the joining to European Union, demanded continuous development and conformation from the Company.

The physical- and custom-borders, disappeared in the meantime, have opened and made easier the appearance of the Company in external markets, but parallel with this, the markets of the Company also became more reachable for the profit strong Western-European firms. The competition became stronger which demanded a greater and greater attention regarding the external environment, competitors, and the development of diagnostic and measuring devices.

MÁV CRTI Ltd. plays a leading role in Middle-Europe in the professional life in connection with diagnostic activities, and reached outstanding results also on European level.

Excellent professional connection emerged with the firms producing measuring systems, and with the professional leaders of foreign railway companies. Thanks to the good professional connections the Company is participant and former of the innovations proceeding on the professional area.

The Company regularly takes part as an exhibitor on INNOTRANS international railway vehicle- and transport technical professional exhibition in Berlin, which is organized two-yearly. Its experts take part regularly also on other exhibitions as visitors, and with this, they enhance their professional field of vision.

MÁV CRTI Ltd. is present also on several domestic and international conferences (MÁV Co. Track Maintenance Conference, Non-destructive Material-examination Conference, ÖVG, INNORAIL, SETRAS, UIC HQ, etc.), and in most cases the experts of the company also introduce themselves by professional lectures according to the character of the conference. Besides, they regularly publish in domestic and foreign journals, as well.

In regard to professional forums, for the initiation of the Company and in its organization since 2016 a rail maintenance professional conference has been organized in every year in Sopron, on which the domestic and international experts can share their experiences with each other, regarding the actual challenges of rail diagnostics and maintenance.

The most important events, developments of the passed 25 years of MÁV CRTI Ltd.

In the years following the establishment important developments happened on the area of rail diagnostics. Such were the developments of ultrasonic rail inspection trolleys, commissioning SDS rail diagnostic train set, where along with the renewal of the vehicle, a new self-developed ultrasonic rail inspection system was developed and installed into the measuring car. In that period the Track Diagnostic Expert System (PÁTER) DOS version was worked out.

In the life of MÁV CRTI Ltd. the first activity expansion happened in 1997, the bridge diagnostic division was established, which is still a significant organizational unit of the Company since that time.

At the beginning of 2000s several important events happened, which has an effect on the life of the Company since that time. The new central office building of the Company got ready in 2000, producing better work place circumstances to the employees, and ensuring an appropriate level site for the meetings with business partners.

In this period we renewed the track geometrical system of FMK-004 measuring car, the system bases of which are in use since that time. FMK-007 superstructure measuring car, which is a production of domestic vehicle industry, was commissioned by us also in this year. Track geometrical and vehicle-dynamic measuring systems were installed on this measuring car, which operated reliably till the renewal of the measuring system in 2011.

In the middle of the years 2000s the self-developed rail corrugation measuring system was installed on the SDS train-set, and we replaced the rail profile measuring system procured earlier. The obsolescent manual ultrasonic rail tester device was replaced by the USK-002 device. The replacement of the self-developed ultrasonic measuring system of the measuring car of SDS train-set was realized in 2009.

MÁV KFV Kft. Central office building

As the result of further developments the new track geometrical and vehicle dynamic measuring system of FMK-007 measuring car was put into operation in 2011. With this investment the track geometrical measuring system became suitable for the execution of the measurements, according to the regulations of European Union.

For the aim of the fulfilment of the customers' demands a machined clearance gauge measuring system was procured, which was installed on FMK-004 measuring car in 2012.

The PÁTER software which was developed and realised by the Company, demanded continuous development due to the dynamic evolution of measuring technics and IT hardware and software side, therefore in 2009 the management decided to realize a new program. The development and expansion of the new program is continuously under process since that time. At the beginning of the years 2010s on the area of rail diagnostics, track maintenance experts had to get acquainted with a new rail flaw originating from the rolling fatigue, which appeared at domestic railway companies at that time.

For the examination of this flaw MÁV CRTI Ltd. procured manual and machined measuring system, and collaborated actively in the working out of domestic professional rules and regulation. We procured the manual devices in 2011, and the eddy-current measuring system, suitable for the diagnosis of the fault, we installed on SDS train in 2013.

In 2015 the Company enlarged its field of activity, established the vehicle-inspection group. The expansion of activity ensured a favourable possibility for the procurement of the permission necessary for the authority examination of FMK-008 rail diagnostic train.The SDS train operated by MÁV CRTI Ltd., had capacity problems due to the domestic and international demands, therefore MÁV CRTI Ltd. decided to realize a new FMK-008 rail diagnostic train from his own resources.

The train was realized in the implementation of MÁV-group, it was developed by the experts of MÁV-START Co. and was produced in Vehicle Repair Shop in Szolnok. The measuring bogie, which is important from measuring point of view, was supplied by MÁV VAGON Ltd. The measuring car was commissioned in 2015, the control car was put in operation in 2016. The measuring systems installed on the measuring car (ultrasonic, eddy-current, rail profile) were supplied by foreign companies on the base of the specification of the Company. FMK-008 rail diagnostic train was presented on the INNOTRANS exhibition in 2016.

INNOTRANS exhibition - 2016 Berlin

The vehicle dynamic measuring system of FMK-007 measuring car was further developed by the experts of the vehicle-inspection group in 2018, the force-meters were replaced by accelerometers in favour of the more stable operation.

2019 was extremely eventful in the life of MÁV CRTI Ltd. regarding the new developments and procurements, because at that time the Company acquired the railway company operational permission, and then the railway safety certification. We procured a service automobile, ensured the necessary personal conditions, thereby the railway vehicle maintenance became significantly more favourable compared to the earlier period.

The Railway operation organizational unit was established. The device stock of bridge diagnostic examinations was broadened in 2019 with the procurement of a system executing the complex geodetic survey of engineering structures, the base of which is given by a modern, high-resolution 3D laser scanner equipment.

An important area of the rail diagnostic activity is the manual ultrasonic rail examination and the post-examination of the rail flaws, determined from the results of the measuring car, whose device is the manual ultrasonic rail testing device. In 2019-2020 experts of MÁV CRTI Ltd. developed a new device with serial number of USK-006. The device is suitable for recording the registratums of the flaws, suitable to the demands of the age.

We installed on SDS train a new ultrasonic rail inspection system, which is complemented by a modern linear video-camera system, which helps the recognition and evaluation of the rail surface flaws. The manual eddy-current measuring devices procured in 2011 were replaced in 2020.

In addition to the measuring results supplied by the measuring systems, the position identification of the flaw places and the general track state is very important, therefore after preparation work of several years, we developed and installed a position identification system, based on DGNSS technology, in 2020-2021, which ensures the accuracy of 1 meter.
After finishing the test measurements the Company from 2022 will apply the new position identification system on all diagnostic vehicles.

The procurement of the most important measuring system of the modern geophysical examinations, applied since 2018 on the area of substructure diagnostics, the ground penetration radar (GPR) measuring and evaluation system, MÁV CRTI Ltd. will realize in 2021, after a long preparation work. After this the Company will be able to supply detailed information about the state and quality of railway earth works, with the application of own resources.

The aim of the Company is to be able to execute technical and technological developments suitable to the demands of the age, ensuring with this the full execution of the main tasks. For reaching the targets the Company continues to pay distinguished attention to keep the properly skilled, experienced and committed experts. In the operation of MÁV CRTI Ltd. in addition to efficiency, the service of the railway transport safety stands in the focus in the future as well.

Author

Mária Zsigó
Economic and human leader

Mária Zsigó graduated in 1999 at College faculty of GATE, at economic engineering speciality, at financial specialization, as economic engineer, then she acquired the certified public accountant diploma in 2000.

In 2005 she set up in Autó-Óbuda Ltd. belonging to Carnet-Invest Co. group of companies, as head of the counting group, then in 2006 she became the economic director of the company.

She started her work at MÁV CRTI Ltd. in 2010, at the beginning as head of counting and financial group, then as head of financial and economic division. She handles her present economic and human leader employment since 2019.

Modern measurements of track geometry, vehicle dynamics and clearance gauge with virtual reference point network for positioning

CSABA ÁGH

Traditional and progressive track geometry measuring solutions from the history of MÁV CRTI Ltd.

Track geometrical measuring activity is one of the bottom pillars of the track diagnostical activity of MÁV CRTI Ltd. The regular track geometrical measurements are indispensable in terms of transport safety. The most important measured basic parameters, which characterize the relative geometry of the rails, basically remained and remain unchanged in the course of the history of railway: track gauge, longitudinal level, alignment, cross-level (with another name: superelevation) and twist. All track geometrical data utilizations are built on the above mentioned measured parameters, from the finding of rough faults meaning direct accident danger, till the level of long-term strategic decisions affecting even the whole railway line. At the company establishment, the company had three traditional measuring cars (mounted with sliding and measuring wheel-sensor technology): with a small-size measuring vehicle, marked as FMK-002, AMSLER type (1962–2008), with the measuring car number of FMK-003 (1968–1999) and with FMK-004 measuring car commissioned in 1990, on which also a rotating laser clearance gauge measuring equipment was mounted in 2012. The measuring car marked as FMK-007 commissioned in 2001, examines the geometrical relations of the rails with laser-beam distance sensors, i.e. with a totally contact free system.

For the engineers dealing with track measurement, it was always a challenge to measure the cross-level (superelevation), to which our ancestors developed several ingenious technical solutions, and the development didn't stop yet. In case of FMK-002 we use a corrected pendulum depending from the speed and curve radius, and on FMK-003 there was a gyroscopic pendulum, on FMK-004 measuring car a gyroscope, and on FMK-007 a complex inertial unit takes part in cross-level determination of the track.

FMK-001 measuring car

In 2000 on FMK-004-es measuring car the renewal of geometrical sensor system and hardware and software became necessary due to technical aging. The applied software innovations were also realized in the new track measuring and vehicle dynamic system of FMK-007 measuring car in 2011. At the same time in case of both measuring systems the unification of the office evaluation system was made, which contains several data analyzer and visualizer functions, helping the everyday work.

On FMK-004 and FMK-007 measuring cars used today, industrial printers controlled by high- performance computers cast the graphs and the results of special evaluations on paper, for our customers. We save all measuring characteristics with the resolution of 25 cm, and with the necessary position identification and other infrastructural background information into measuring files. This enormous data mass serves as basement for the exceptionally arborescent computerized visualizing, evaluating, analyzing services, which are offered by our company for our customers, i.e. for the track-network maintainers. In our modern office evaluating system the fault lists and general qualification data according to the different limit value categories and evaluating speed combinations can be resiliently interrogated.

European trends of track geometry evaluation and the solutions applied at MÁV CRTI Ltd.

The globalization and the European Union harmonization made necessary the interoperability and unification among the measuring systems developing differently in the individual countries. The aim of this that the basic data of track geometrical measurements executed in different European countries and the measuring-evaluating principles determining the dangerous local faults should be identical. In order that our company could provide services also behind the state borders, it had to be solved, that we could supply results to our customers in a way (EN 13848-1 standard) which totally corresponds to the methodology of Western–European railways.

Behind the evaluation level of local faults which serves as a basis for everyday operative measures, we have to mention also the next level of the utilization of the diagnostic results. From the measuring results general track state qualifying numbers can be formed which substantiate the strategic decisions and longer-term maintenance and renewal plans. The railway history of the individual European countries, here also produced different calculation methods, algorythms in the course of the past decades. Beside the traditional Hungarian SAD qualifying number of integral principle, our company naturally supply also the measuring numbers, which are standarized on European level (EN 13848-6) on the basis of standard deviation, for the strategic decision making.

FMK-004 measuring car

FMK-007 measuring car

Evaluation of the clearance gauge measurement

Special evaluation solutions of the clearance gauge measurements at MÁV CRTI Ltd.

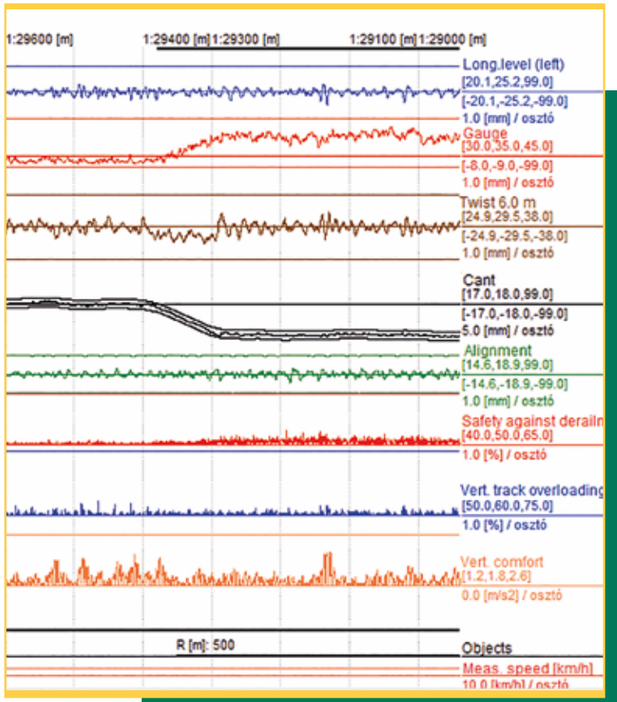
On the railway speciality (professional area) the more and more shrinking human resource refill means problem in several countries of Europe. But the new, mechanized technological solutions of outstanding efficiency discharge many activities which earlier demanded human work. Such as the survey of the objects reaching into the clearance gauge or approaching it, for which the rotating laser instrument which can be operated continuously on the measuring car, gives the solution. Compared to the solutions offered for selling on the market of diagnostical systems and services, the processes developed at MÁV CRTI Ltd. from several aspects are more sophisticated and better conform to the track experts' demands. A common clearance gauge measuring system only records the closest points getting in the way of the rotating laser, compares this with one or more reference profiles, and selects those sites, where any measured point fell into the reference profile, and supply this to the railway company. But the measuring system commissioned by the Company in 2012, associates a photo to each clearance gauge obstacle (also in case of measurement at night), and video record is also taken. Besides, after the automatizable part of the evaluation, our colleagues execute further, deeper evaluations. In the course of the office evaluation work our colleagues denominate the surveyed objects (this can be vegetation, signal, bridge, platform-edge, etc.), then they also execute the filtering of the vegetation. For our customers we hand over also the obstacle list, representing the vegetation, but such a complementary evaluation is also prepared, which ignores the vegetation – as an easily removable obstacle type. In the evaluation of the clearance gauge measurement, the system of minimum diagrams supplied by MÁV CRTI Ltd. means an innovation, which are dynamically configurable and represents longer track sections. With the help of this our customers can overview even a whole railway line, and by the contraction of the many thousands cross-sections they can look at their resultant (i.e. the drawing of the spatial permeability interpreted on the whole railway line). In the course of preparing the resultant our experts naturally take the curve supplement into consideration. Further advantage of the service of MÁV CRTI Ltd against other processes, which offer even high-level geographical information system, lies in the reference system taken as basis. Thanks to the development, the clearance gauge measuring system built in the measuring car, stores the position of the measured objects according to the railway position identification system, which is desired in track diagnostics, specific, and based on hectometer stones.

Not only the checking of the presence of the clearance gauge happens by the clearance gauge measuring equipment, but on the base of the instructions concerning here, we also evaluate the measured data for much bigger profile (5 meter wide) than the standard clearance gauge profile. On the base of objects which can be found in this bigger space parts, the decision is made at the track-network operator about the forwardibility of oversize consignments. During the past years, on the base of customers' demands we reduced the provided measured points, to which innovative software solutions were introduced repeatedly, thereby we eased the data utilization on the customer's side.

Track-vehicle system as a modern approaching mode. Displacement aspect (track geometry) and force/ acceleration aspect (vehicle dynamics) measurements of FMK-007 measuring car

In the up-to-date approach of service engineers working on the railway professional area, the unified treatment of the vehicle-track system must get a place. Track geometrical faults of the same size – due to the shape of the fault, common effect of other adjacent faults, or of the physical build-up of the vehicle running on it – can mean totally different accident dangers, whereas in the track geometrical local faults list they seem to be totally identical. In the professional literature of the past years and in the Western-European diagnostic solutions, the mass utilization of the low-cost inertial units (accelerometers), even on passenger coaches which run according time-table, counts for a hit.

Overtaking its age, on FMK-007 measuring car, a vehicle dynamic measuring system has been operating since the turn of the millennium, which after the last measuring system updating in 2018, executes real time calculations on the base of the signals of 24 pieces accelerometers. We have placed on the axle boxes of the vehicle, on the bogie frames and on the car body on the appropriate places accelerometers, with the help of which – by appropriate physical calculations – the computer determines all the time the forces acting between the railway wheel-set and the track. From the rate of these forces it is possible to deduce on the derailment safety, and on the danger of residual deformation of the track, occurring suddenly. Besides, the system is suitable for the calculation of the vertical and transversal extra loading for the track from the measuring car at every time, and the sensors placed on the car body give an image about the passenger comfort as well.



Track geometrical and vehicle dynamical graphs

Real time satellite section corrections on the base of virtual reference point-network *(illustration)*

Parallel to the vehicle dynamic system, but independently from it, a conventional, contact-free track geometrical measuring system also operates on FMK-007 measuring car, the data mass arising in this way gives a complex image about the traditional (of displacement aspect) geometrical relations of the track, and also about the dangers arising in the track-vehicle system on the effect of different track faults, track-fault groups from the point of view of force and acceleration aspect.

Traditional and innovative solutions of position identification. Satellite-aided mileage corrections on the base of virtual reference point-network

Experts dealing with track diagnostics in the course of the measurement have to face up to a double challenge: merely the precise execution of the measurement is not enough, but also supplying the measured results with trackable position identification data demands significant efforts, in order that track maintenance experts could find and register the discovered faults unambiguously, and could trace their deterioration in time series analysis. In railway maintenance – since the track is a lined establishment – a relative position identification system was developed based on the section signals placed along the track. The satellite (GNSS, GPS) position identification based on geographical co-ordinates had only a complementary role earlier. But the satellite position identification gave the possibility for the refinement of the position data according to the railway sectioning. MÁV CRTI Ltd's development in process concerning this, has an effect on each superstructure measuring car. Position identification solutions applied on the track diagnostic vehicles of other countries generally based merely on the odometer of the measuring car: the measuring car calculates the covered distance compared to the beginning section, given at the start of the measurement, and records the measuring results according to this. But this technology is burden by faults from micro-slidings originating from the rolling on the rail, and from the physical barriers of the optical odometer, which are added in the course of the measurement of several kilometres. We did manually the correction of the faults originating from smaller slides during the last decades, but by the appearance of DGNSS technology, we created the possibility on the measuring cars used by the Company, that we could execute the real-time section corrections during the run, automatedly, on the base of a background data base, developed specifically for this purpose, with an accuracy of 1 meter. The DGNSS-correction on the base of the ground reference stations contains the filtering out of the faults originating from the atmospheric distortion of the signals coming from the satellite, the filtering out of the track faults of the satellites. The GNSS receiver is suitable for receiving the signals beside of the American GPS-satellites also of the European Galileo, the Chinese BeiDou, the Russian Glonass systems and of other satellites. Test measurements are in process also presently before the complete introduction of the new position identification development. The new solution based on satellite, is built on the traditional sectioning solution depending from the odometer. For the application of the new method we have to execute the building-up of the virtual reference point network, with resolution of one meter, which connects the geographical (GNSS) co-ordinates with the position identification system stretched by the railway section stones. This work is in process continuously at MÁV CRTI Ltd. with involving the geographical information data for the all hectometer stones of the country – concerning the MÁV and GYSEV network it will be expectably closed down in 2021.

Non-contact track geometry measurement *(illustration)*

Author

Csaba Ágh
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Track diagnostic department

Csaba Ágh graduated with a degree in infrastructure- engineering (MSc) from Faculty of Civil Engineering of of Budapest University of Technology and Economics in 2012. Since 2011 he has been working at MÁV Central Rail and Track Inspection Ltd. as development engineer, and diagnostic engineer. Since 2018 he is the head of Track Diagnostic Division which is responsible for the track geometric, vehicle dynamic and clearance gauge measurements and for their evaluation. Since 2017 he is a student of the Doctoral School of Multidisciplinary Engineering Sciences of Széchenyi István University, his main research area is the track geometrical sensitiveness of the railway vehicle-track system.

Rail diagnostical services at MÁV CRTI Ltd.

ÁKOS MAROSI

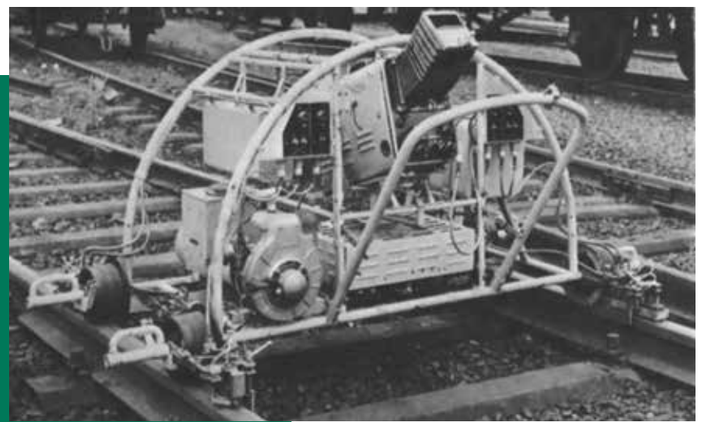
Beside the checking of track geometry the other determinant area of the railway track diagnostics is the regular examination of the rails which are the primary bearing element of the superstructure. This guarantees the keeping of the transport safety on a high-level, and ensuring the necessary data for the track maintenance and for the planning of the economical rail attending work.

The first and maybe the simplest method of the state examination of rails is the visual inspection, about which we can say, that it's even-aged with the railway transport, at the same time it is present till today at the inspections on foot, executed in the frame of track maintenance. The human eye – although it is a sophisticated and precise instrument – is able to detect only the deviations occurring on the surface of the rail, at the same time the significant part of the rail faults starts from under the surface, from the inside of the material structure. Due to this, the developments dealing with the instrumental examination of rails have started at several infrastructure operators.

At MÁV the trials for the instrumental survey of the inner rail defects in the track, started in the middle of the 1950s. At Western-European railways for a long time, there wasn't an unambiguous decision along with the introduction of ultrasonic rail inspection method, but they dealt with magnetic, radioactive isotope, x-ray and ultrasonic examinations at the same time. Most of the foreign railways – similarly to MÁV – on the base of the gained experiences, considered the ultrasonic rail examination to be the most suitable for the detection of material structural defects, cracks occurring in the inner cross-section of the rail.

Manual ultrasonic examinations

At MÁV the bases of the ultrasonic examination were laid down by the predecessor organizations of CRTI Ltd. The first manual instrumental examinations started in 1957, in the beginning with SPG-2 type device, which examined the two rails at the same time, but by today's eye it can be said, that it's rather robust (160 kg). At that time it meant a quite modern rail inspection device for the experts.



SPG-2 type ultrasonic rail inspection device

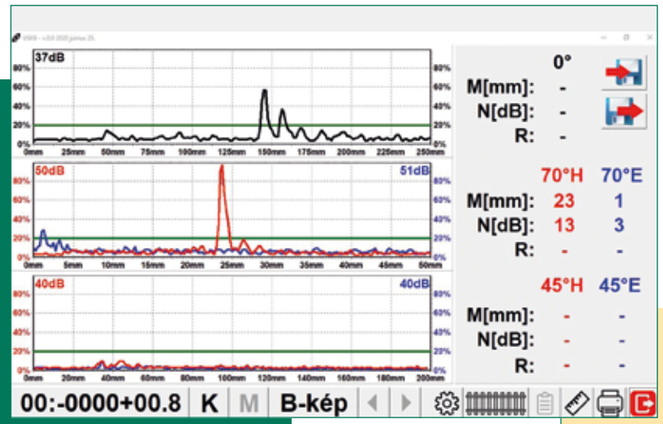
Generations of USK trolleys (USK-001 – USK-005)

This instrument – despite the disadvantages of the two-rail solution – was applied for more than ten years, but the significantly simpler, easier and so more mobile devices of one rail were also tested parallel. Due to the increasing train traffic and operation difficulties by 1970, the SPG-2 instrument was replaced by the ultrasonic rail inspection trolleys (USK), which were more mobile with their altogether mass of circa 20 kgs, and more easily movable devices. With their help the ultrasonic rail examination could be executed effectively, without disturbing the train traffic.

In regard to these instruments our Company can be named not only as a user. In bringing into service of USK trolleys of one rail and in their development, the work of CRTI Ltd's experts and of the predecessor organizations deserves appreciation since generations. Incursion of the USK trolleys started from 1965 with the series of USK-001. The newest rail inspection trolley of USK-006 type name, got ready as an investment almost in our own development, on the base of the existing experiences and demands, armoured with modern electronics which is suitable for the expectations of the present age (visualization of "A" and "B" pictures, recording of record), ergonomically optimised as well.

The well approved basic conception of USK trolleys didn't change over the years. The soul of all the types is a reliable ultrasonic electronic unit, which can be bought on the market, the frame structure of the trolleys, the arrangement of the inspection probes, their forming and their electronic fitting to the ultrasonic unit are prepared by our company's experts. Thanks to the technological innovations the history of the evolution of the instruments appears mostly in the building-up of the ultrasonic electronics. At the beginning analogous, cathode-ray tube, smaller briefcase sized ultrasonic equipment had to be mounted on the trolleys. Later these devices were replaced by digital equipment, with which the size and weight of the devices continuously decreased, the user assisting functions were broadened, the number of examination channels was increased, by which the radiation arrangement became more complex as well.

Nowadays the ultrasonic unit of USK-006 is hip-pocket size. It forwards the signal of 8 inspection channels through USB link to a program, running in an industrial tablet, which transforms the received signals on the screen of the tablet into well interpretable indications for the experienced examiner, in an expressive form, and in case of need also records them. This software was realized in the own development of the company's experts. It contains a field examiner and also an office evaluating function, further on there is the possibility for managing the ultrasonic defect lists and also for the generation of test protocols inside the program. In the course of the years the framework of the trolleys was virtually modified only in small extent, mostly adjusted itself to the ideal placing of the ultrasonic testing probes, electronics, battery units and testing water. But it must be seen that in the planning and production of the framework – behind the above mentioned boundary conditions – the maximum allowable mass, the technological barriers arising from the small piece number, have pressed the firm's experts among rigid frames.



USK-006 trolley and the screen picture of the field program

The excessive great advantage of the own-developed measuring device is, that the finished product can be totally improved for the given task, as the result of continuous testing/developing, with taking the end-users' experiences and demands into consideration, at the same time it's built-up from main pieces, which can be bought on the market. The USK-006 devices from 2020 followed their ascendants' footsteps as respectable successors in the tasks of ultrasonic checking the secondary lines, station tracks, turnouts, and in the secondary examination tasks of the faults discovered by the measuring train, as well.

Mechanical ultrasonic rail examinations

The continuous increasing of the traffic of the railway tracks, and by this the increasing of the loads burdening the rails made the densification of the ultrasonic examinations necessary by the middle of the 70s. The manual testing groups armed with USK trolleys already couldn't keep the step with the increasing need for ultrasonic inspection.

The following news can be read in the 3rd issue of World of Rails professional journal published in July 1976:
"The increased tasks, decreasing the number of the testing staff, and other objective and subjective circumstances in connection with the examinations made it necessary to mechanize the examinations. The earlier gained experiences, prepared economical calculations and financial possibilities made possible the domestic development of the ultrasonic testing car. The car was developed by the Ultrasonic Testing Centre, with the contribution of MÁV Superstructure Testing Office in the earlier years. During the last year the trial test were also finished successfully. The ultrasonic testing car from March of this year executes the examinations on MÁV railway lines regularly. The testing car records the detected defect signals in the course of the examinations on film-tape, whose evaluation and the qualification of the defects is made by the KFF centre."

Rail diagnostic train (SDS)

The rail diagnostic train

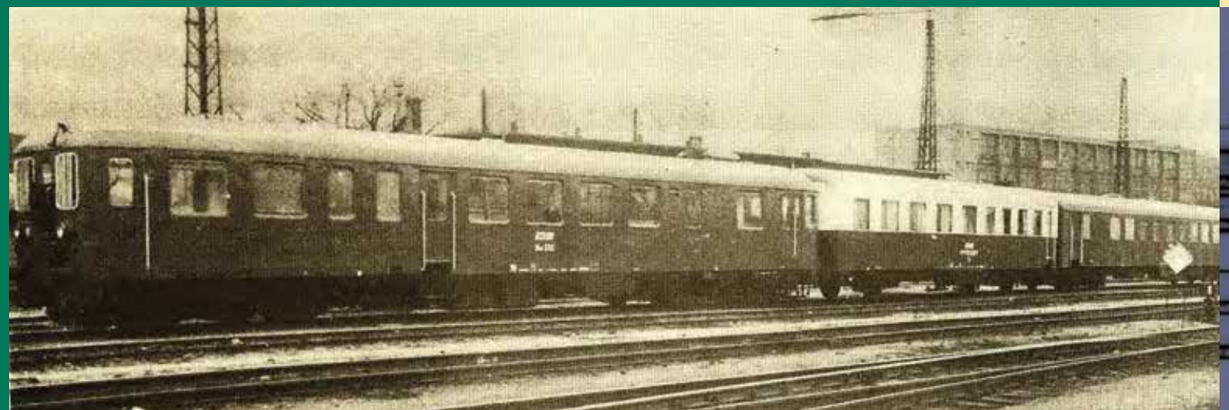
After the commissioning, the UHS train through almost 20 years was able to examine about 10.000 km track per year at a speed of 28 km/h, with the application of 3 ultrasonic channels by rails.

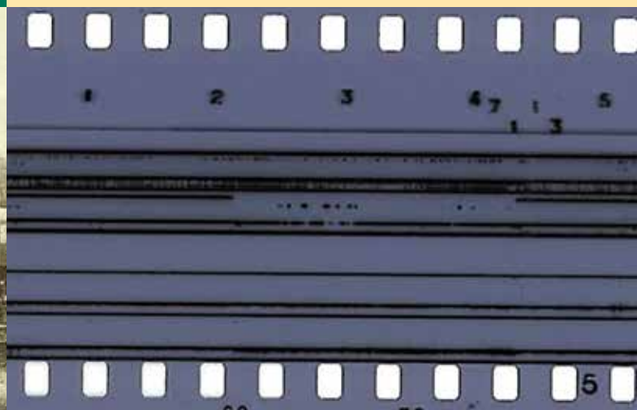
The demand for the further increasing of the testing capacity and for updating the technology, inspired the experts for developing a new ultrasonic inspection train, as a result of which by 1997, already under the flag of MÁV CRTI Ltd. the rail diagnostic train was set into system (SDS).

The new ultrasonic system of the measuring car was developed by the experts of CRTI Ltd., which system made the more complete through-radiation of the rail cross-section to be possible by the application of 5 inspection channels per rail. The developer team consisted of engineers and technicians solving the digitalization of the signals of the system, built-up from the analogue ultrasonic instruments, made it possible to save the inspection signals on hard disc, and the implantation of the evaluation on computerized surface, bidding farewell with this to the film-tape era.

Beside the modernization of the ultrasonic system the suspension of the measuring probes and the guiding structure were also redesigned with the contribution of the CRTI Ltd's experts. Instead of the feeler-plate applied on the UHS, a measuring bogie was installed under the chassis of the measuring car, which ensured along with greater, 50 km/h inspection speed, the positioning of the measuring probes, not only in plain track, but also during running through a turnout.

The first mechanical ultrasonic train (UHS) and its film tape.





By the commissioning of SDS train the effectiveness of the mechanical ultrasonic examinations has increased, and this gave space to the marketing of the service into the surrounding countries. In inner circles a story was mentioned a lot, that the soldering tool was even warm, when the SDS crossed the state border at Hegyeshalom, on its way to ÖBB for an ultrasonic test measurement. The mission was closed successfully, the train and measuring technics took the examination well, thanks to the professional skill and preparedness of the developing and measuring team. As a result of this CRTI Ltd won the tender called by Austrian railways, by this opening the gates of a long-term export marketing.

SDS measuring room - 2009

The CRTI Ltd's own-developed ultrasonic measuring system operated till up to 2008. During this time such new technologies and developer firms appeared on the market, who already offered complete measuring system specified for rail inspection for the customers. Against the expenditure behind the product of such firms, the own development possibilities at a basically service organization, couldn't offer a reasonable alternative, so in 2009 the ultrasonic measuring system of SDS was purchased from the external market, replacing the own-developed technics contained already obsolete elements. By this the ultrasonic technics got renewed.

The new system already applied fully digital technology. In the rack of the measuring room 3 industrial computers received and processed the signals, and connected into the network forwarded them to the evaluating computer. The number of inspection channels was increased also this time, the system was able to manage 10-10 ultrasonic inspecting probes by rails. This beside the traditional radiation arrangement (ultrasonic probes of 0°, 45°, 70°), made it possible to install special ultrasonic probes, which can sweep the outside cross-sections of the rail head. This time the ultrasonic system was complemented for the first time with cameras, recording the images of the rails, by which an effective evaluation surface was realized, which supports in a great extent the work of the ultrasonic evaluating person and the qualification of the rail faults, since the evaluation work could be already started during the inspection, during the registration of the given measuring run. By this, after the examination of one-and-one line section the faults lists became presentable in 24 hours for the customers and secondary inspection groups.

In regard to the mechanical ultrasonic examinations the next milestone was the construction of FMK-008 rail diagnostic train, on which a new measuring system was procured, according to a detailed technical specification, compiled on the base of the gained experiences with SDS train and with the technics used since 2009. Increasing the inspection channels couldn't be left also this time, so nowadays the almost through-radiation of the rail cross-section happens by ultrasonic impulses, 12 by rails, radiated in different angles and directions. Compared to the previous system, innovation is the application of "HC" probes for detection of head-check faults close to the running surface, increasing the maximum inspection speed to 70 km/h (for which also the measuring bogie was redesigned), utilization of more up-to-date video cameras, the interlinked film-frames of which can be looked back also in themselves, and give continuous image of the rails. Furthermore, the controllability of the measuring system by an external program is a novelty, which is realized from a unified Central Control System (KIR=CCS). The new ultrasonic system was installed on FMK-008 measuring car in 2015, with which the company has executed regular, operation-like examinations since 2016.

FMK-008 train – 2021

During the construction of FMK-008 it was already outlined, that on the area of rail diagnostics for keeping the market share, for the stabile fulfillment of customer demands, the capacity of one measuring train will not be enough, hence for the replacement and modernization of the measuring system of SDS, operating since 2009, the negotiations already started in 2017. For the purpose of optimizing the costs of the operation and maintenance of the mechanical ultrasonic measuring systems, and of the harmonization of the ultrasonic technics of the two measuring cars, an ultrasonic technics correspondent with the system of FMK-008, was mounted on SDS train in 2019. The technological development created the bases of a new, exciting possibility, by the automatic image recognition of the rail surface defects, happening by modern linear video camera system and evaluating algorithm. So the co-operation and development with the supplier firm, as a complementation of the new ultrasonic system, started in the direction of a video-based rail fault recognizer system, in recent years.

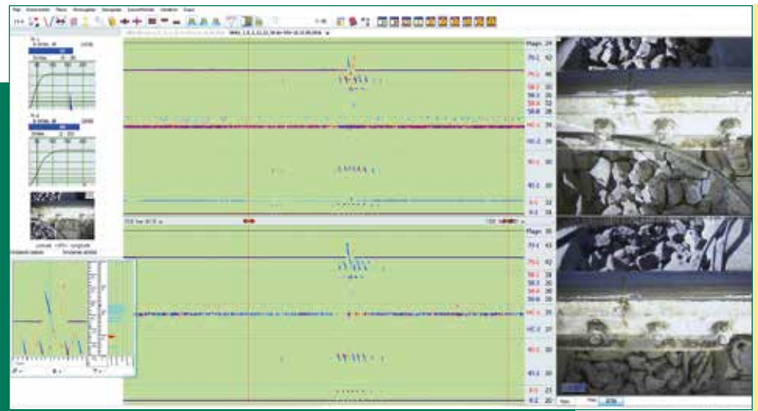
Extension and modernization of the services

Previously we mentioned only the ultrasonic examinations, which is still today the main activity of the rail diagnostic services, and executed in the greatest extent at our company. In order to get a complex image about the state of the rails, the system of ultrasonic inspections is not enough. In the course of the development of SDS train in 1995 the demand was worded, according to which the ultrasonic examination, aimed for the detection of inner rail faults, must be complemented with rail profile and corrugation measuring systems, which survey the geometrical shape of the rails.

So a non-contact rail profile measuring system was procured and installed on SDS measuring car in 1996, which was replaced for a more up-to-date technics in 2004, which has operated regularly since that time, supplying the most important wear characters of the rail cross-section both in graphic form and with numerical data rows. The company created an own-developed system for the measurement of corrugation of the railhead surface.

The further increasing of rail diagnostic services was induced by the appearance of head-check faults, getting into the public knowledge in 2000s, after which accidents happened in several foreign countries, which faults can be deduced on head-check. In the first circle in 2011 two manual eddy-current instruments were procured, then in 2013 the first mechanical eddy-current measuring system was commissioned on SDS measuring car, by which the state of the network became survey-able from the view of head-check defects. For today, due to occurrence frequency of the faults and their rate of growth, the volume of eddy-current examinations closed up to the level of ultrasonic inspections.

Ultrasonic inspection blocks



Ultrasonic evaluation surface of FMK-008 with the video images

Presently on SDS and on FMK-008 rail diagnostic train commissioned in 2016, four-four measuring systems operate (ultrasonic, eddy-current, rail profile and rail corrugation systems). With the utilization of the results supplied by the company, complex image can be get about the state of the rails, and with the regular executions of the examinations, beside increasing the transport safety, the development rate of the individual rail defects can be traced. This information is indispensable for building-up a rail maintenance strategy at a company, which strategy is economic on the long-term and optimal, considering the life cycle costs. For the domestic railway companies these qualified examination and measuring data are handed over also in the PÁTER system.

Challenges nowadays, actualities

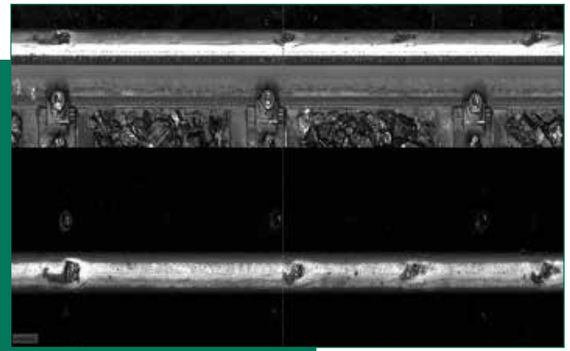
A Rail diagnostic activity compared to the initial date, developed quite a lot, if we think it over, that since the visual inspection, how much the spectrum of inspection possibilities increased. Not only the palette of the applied technologies, measuring systems, instruments was broadened, but the inspection volumes also increased, regularization and operational environment changed, to which factors we have to comply according to many aspects, resiliently if possible. After the examinations a vast of data arise, care must be taken of their evaluation, process, checking, their expressive visualization, handing over in due time, and archive. We lay greater and greater emphasis on evaluation, data processing, and analysing tasks, for the checking of data before handing over, for which several office programs, helping the users were realised recently. These gave a great help for the production of the data formats according to the customer demands, and in the property of graphic surfaces, and defect data bases going back to several years, they expressively highlight on the trends, and ensure a quick overview about the general state of a given line, track section or region.

In itself, taking care of the sea of data is also a considerable task, but for it, that data could arise at all, a lot of preparation work is also necessary. On the two measuring trains all together 8 measuring systems operate. Their maintenance, checking, accreditation and operation on the domestic and foreign railway network demands the harmonized work of many persons.

In recent years in rail diagnostic subject such European standards appeared, which word strict demands in connection with checking and suitability of measuring systems. We have to fulfill also these requirements, and they must be built into our operation, and into the operation of the systems. A process consisting a lot of colourful mosaic cubes must get into its place in a determined time, and must be fulfilled in order that the customers should be satisfied with the diagnostic services of MÁV CRTI Ltd.

Future development possibilities

The applied tools and technologies of MÁV CRTI Ltd. fulfill the modern technics and instructions of present-day, and the demands against



Running surface rail defects detected by linear cameras

rail diagnostics. But it is necessary to pay attention continuously to the development trends of the individual specialities, and to exploit the possibilities in them. By the development of computer technics and measuring technics there is already the possibility to apply methods used and proved on other areas of industry also in the rail diagnostic examinations. In the future there can be a great potential among others in the adaptation of the phase-controlled ultrasonic inspection technology into the railway environment, with which already several firms appeared on the market with concrete technics. The future developments of video inspection systems and evaluation algorithms can be listed here, and also the modernization of the position identification system, by the exploitation of the possibilities of the global position identification satellite system.

Author

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Rail diagnostic department

Ákos Marosi acquired his diploma BSc in 2009, then MSc in 2011 on the Civil Engineering faculty of Budapest Technical and Economic Sciences University.

He started his activity at MÁV Central Rail and Track Inspection Ltd. in 2011, as a diagnostical engineer. Beside the analysis of the inspection data and the development of diagnostic systems from 2013 he co-ordinated the procurement, installation and testing of the measuring technical systems of FMK-008 rail diagnostic train, as a project leader.

In 2013 he acquired the level 2 ultrasonic, then in 2015 the level 2 eddy-current qualification. From 2016 he is the head of Rail Diagnostic Division of MÁV CRTI Ltd. From 2018 with level 3 ultrasonic material tester qualification, he is the controller and the responsible person for the rail diagnostical examinations at MÁV CRTI Ltd. From February 2020 he is a student of ELTE Economic Sciences Faculty MBA training.

SDS- Rail Diagnostic Train

Challenges and experiences of the development of FMK-008 rail diagnostic

ATTILA PLANDER, ÁKOS MAROSI

One of the determinative measuring activities of MÁV CRTI Ltd. is the ultrasonic rail inspection, which is executed by the company from its establishment with a three-parted ultrasonic measuring train, which consists of one measuring car and one-and-one pulling motor-car coupled to its ends.

The measuring car was modernized in 1997, but the pulling vehicles were not renewed mechanically. At its setting into system the rail diagnostic train (SDS) counted to be modern, measuring technically, but its mechanical basic parameters contained several compromise solutions, which could fulfill the increasing inspection quantities only with disproportionately great efforts. Hence for the sake of ensuring the availability of SDS train, beside the two haulers, of Ganz Bb series, five-axle motor-car from 2004, also a third (reserve) Bb motor-car must be set into system. Due to the quantitative demand of rail diagnostic inspection, executed already on four countries' railway network by the years 2010s and regarding the overaged pulling vehicles the Company decided to procure a new train. After the decision several conceptions were born for the realization of the new rail diagnostic train, which received the FMK-008 identification sign, in the course of the preparation. At the preparation of the project, on the base of the 35 year experiences of CRTI Ltd. and its ancestor organizations, in the knowledge of the specified technical requirements, coordinated with the owner, the production of a new vehicle has started.

Special requirements, functions

For the build-up of the new measuring train a feasibility study consisting several volumes was made through several years, on the base of which it became evident, that the user's demands can be realized most succesfully with vehicles transformed from wagons of good state and high bearing capacity. As a result of this mail-cars producted by Ganz-Hunslet and withdrawn from operation, got chosen.

Mail-car, product of Ganz-Hunslet

The significant modification of the mail-cars made it possible to work the measuring train and mechanical expectations most efficiently into the plans, which were schematically the followings.

- Two-parted train consisting of measuring car and motor-car, 120 km/h highest speed. The vehicles of the measuring train must be able to fulfill their tasks also separately (measurement and pulling).
- The collective bearing capacity of the vehicles should make it possible to install a measuring bogie, four measuring systems, current-generating set, cca. 11 m3 inspection water, fuel set of one week, and other measuring train equipments.
- Such vehicle structural build-up, which makes it possible beside the basic measuring systems the application of several measuring modules and later the mounting and dismounting of the measuring systems to be replaced, without a significant modification of the vehicles.
- Application of main parts and subassemblies occurring in great number in MÁV vehicles.
- Vehicle controlling system, built-up similarly to modern vehicles, which makes the modifications to be possible – in a way of software.
- Modern fault exploring, diagnostical and event logging possibilities, application of hardwares and softwares having railway certification.
- At those installed technical functions, where there is technical possibility for this, redundant (double or substitute) build-up (e.g. generators, compressors, heating systems, social equipment, etc.).
- Build-up of the social purpose equipment, during the whole life span must comply with the employees' expectations and must ensure the basic conditions necessary for the readiness rest.
- Planable, preventive type maintenance cycle-order, drawing documentation suitable for component production as well.
- Vehicles must be suitable to the instructions concerning the authority authorization.

Completion of the two-parted FMK-008 rail diagnostic train could be implemented totally in the realization of MÁV-group.

- The Company entrusted MÁV Mechanical Engineering Co. merged in MÁV START Co. by descent on 01.01.2014 with the planning and construction of the two-parted vehicle (motor-car and control car).
- Procurement of one part of the main parts necessary for the implementation was executed by MÁV CRTI Ltd. with the support of MÁV Co. BLI Vehicle Project Centre.
- The measuring bogie was produced by MÁV-Vagon Ltd.

Main stations of the implementation

After signing the contract the events accelerated. In the beginning of 2014 MÁV CRTI Ltd. handed over the two mail-cars to MÁV-START Co. Szolnok VJT plant for the purpose of modification. The tight dateline required stressed work and co-operation from the experts working in the planning, in the procurement of components and in the implementation. It was an important expectation of MÁV CRTI Ltd, that first the controlling car (measuring car) must be handed over, because parallel of the production of the structurally more difficult motor-car, CRTI Ltd. wanted to realize its tasks with installing and commencement of the four sort of measuring systems.

First the engineers, skilled in designing the IC+ cars met the requirements expected from the new measuring train, who had to make the total documentation of an individual controlling car (measuring car) an the motor-car mounted with two Power Pack engine group, and driven bogies, from mechanical aspect which deviated from the earlier one. After cutting down the roof structure and side walls of the cars, transported to the vehicle repair shop, the chassis was cleaned by grain-spraying, then it was qualified. The total modification of the chassis of the measuring car contained such an unusual partial tasks, as the build-up of the connecting parts of the driver's stand, getting on one end of the car, or the mounting of the lifting and fixing elements of the measuring bogie of 2 tons, linked to the middle of the chassis. In the next months beside the roof modification, and the production of new side walls and car-end elements, a lot of such small structural components were produced, which became to be a scenic complex, only after the assemble of the car body in December 2014. Dowelling works executed in the car body also belonged to the detailed work phases, but these were essential for the fixing of equipment and coats later. Since in this work-phase there were already less welding tasks on the car body of the measuring car, experts could start the modification of chassis of the measuring car and the production of its sidewalls. Hereafter the work-phases of the build-up of the motor-car followed the works executed on the measuring car with some months delay. The greatest speciality of the motor-car chassis, that with the modification and with strengthening some of its parts, it became suitable for mounting 2 pieces Power Pack engine groups produced by MTU, and on one car-end here also connecting parts of driver's stand are installed.

The chassis of the measuring car

The vehicle body of the measuring car during the implementation

To the motor-car Ganz Motor Ltd. supplied the 2 pieces newly producted GH-250-2.1.M type driven bogies, which are similar to the driven bogies of BDV electric multiplied unit (EMU) from construction point of view. In the mean time the polishing of the car body, fitting of the chassis, construction of the inner floor, partition walls, and the inner fitting works were finished, and under the car, after maintenance of general inspection level, the original, running GH-250 type bogies were installed back. The measuring car reached that readiness extent in December 2015, that it fulfilled a successful authority examination run as an independent vehicle, and MÁV CRTI Ltd. started the installation and testing of the measuring systems. As a result of the works on the motor-car, the pulling vehicle fulfilled its first test run on 06.28.2016., which was followed by some further test runs till autumn. Then the two-parted measuring train was transported to the international INNOTRANS exhibition in Berlin, organized in the autumn of 2016, where on the common exhibition stand of MÁV-START Co. and MÁV CRTI Ltd. the possibility has open for such a scenic introduction, which is given only to few operation purpose vehicle, produced in Hungary.

On the rail diagnostic train after this, the necessary additional works were executed and the type examination test measurement series, which was executed by the Vehicle Inspection group, which was established by the Company in 2015 as a new activity. Then in December 2016 already the whole train fulfilled the acceptance procedure necessary for the commissioning permission and the authority examination run. At closing the works the size of the executed task became visible, more than 24 000 pcs. drawings and other technical documents were prepared in the course of the construction. Regarding the time of the construction, calculated from the signing the contract (12.2013.) the measuring car two years later (12.2015.), the motor-car three years later (12.2016.) was handed over with authority commissioning permission.

FMK-008 measuring car (December 2015)

INNOTRANS exhibition - 2016 Berlin

Measuring technical requirements and challenges

In the course of the development of the rail diagnostic train beside the mechanical challenges arising from the new vehicle construction, significant attention was payed on the up-to-date realization of rail diagnostic measuring systems, the embodier of the measuring technical function. On the base of MÁV CRTI Ltd's experience of several decades, the newest developments appearing in the course of technological development, and the customer's needs and expectations, the measuring systems to be installed on the train, and the requirements against them, got determined, for the sake of high-level rail diagnostic services, which are suitable to the level of the age. Without the demand of completeness such requirements were the followings:

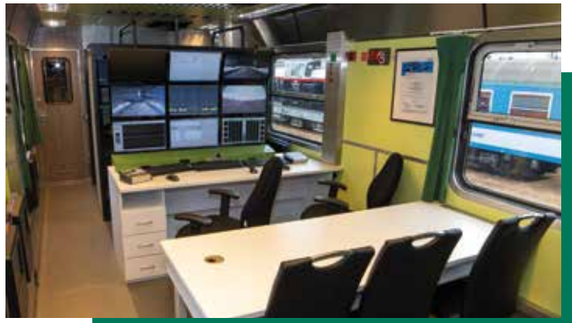
- Detection of the faults which mean high traffic safety risk and require immediate provision, on high reliability level,
- Delivery of diagnostical parameters necessary for rail maintenance work planning,
- 70 km/h minimum examination speed,
- 300 km/ shift day maximum examination capacity,
- controlling of the measuring systems from one surface,
- working up of synchronized, high-accuracy GNSS based position identification system,
- economical, user-friendly, efficient operation of the installed systems.

MÁV CRTI Ltd. coordinated the development tasks connecting to the measuring technics, wording of the technical requirements, execution of the procurement procedures, and installation, commencement of the measuring systems and the execution of acceptance test measuerements.

In the course of the development the measuring bogie, guiding the measuring heads, was redesigned and modernized, a new ultrasonic inspection system was procured and started up together with a video camera system, which records the image of the rails, an eddy-current measuring system, a rail profile measuring system operating on a non-contact laser principle, and a rail corrugation measuring system were installed.

In the course of the project it was an extra challenge for MÁV-START Co., MÁV CRTI Ltd. and the firms supplying the measuring technics, that the installation, starting up and acceptance test measuring works of the measuring systems must be adjusted to the stressed scheduling of the production of the train, in the course of which they had to comply to extreme situations several times. Installation of the measuring devices started with the installation of the measuring bogie under the measuring car in June 2015, then it was followed by the installation of the ultrasonic system in July, and mounting of the eddy-current measuring system in September.

Measuring bogie of FMK-008 rail diagnostic train



FMK-008 rail diagnostic train – measuring car (measuring room, operator's work desk, measuring bogie, eddy-current measuring head)

The row of the equipment serving the track inspection activity was enlarged in 2016, with an own-developed rail corrugation measuring system, and in 2017 with a rail profile measuring system (wich is suitable also for the calculation of equivalent conicity parameter), so in this way the palette of the rail diagnostic services became complete on the train. Regarding that the production of the measuring car had a priority in the scheduling against the pulling vehicle, the measuring car could be photographed with several engine types in the course of test measurement of the measuring systems and on the occasion of test runs of the car.

After the commissioning of the measuring systems beside the own purpose test and acceptance measurements, an international certificatory body, accredited according to EN 17020, executed the checking of operation, whether is it suitable to the measuring technical instructions and standards, and the authenticity of the supplied data. So by 2017 beside the vehicle, the measuring systems also got the green signal, by which the last building stone of a complex development, moving several professional area, having high added value within the firm-group, also got onto its place.

It can be said on the base of the acquired experiences by the design, production and setting into traffic the FMK-008 rail diagnostic train, that the reached results can give a good example also in the future for the MÁV-Volán-group.

Test run of FMK-008 measuring car

FMK-008 rail diagnostic train

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Attila Plander
Head of railway operation

Attila Plander acquired diesel engine driver qualification in 1992, then he finished his mechanical engineer studies in Engineering Industry and Automation Technical College in 1999.

He went into service of MÁV Northern Hauling Office in 1989, where he worked as a diesel engine driver, then he has continued his work since 1995 in MÁV Track Management Center. Utilizing his experiences gained in the operation of measuring trains, since 2000 he has organised the work of the railway mechanical engineering area, as technical executive. In the course of his activity he acquired the high-degree railway professional examination, necessary for supplying the operation area, the practical technical lecturer and accident investigator qualifications as well.

He took part in the creation of FMK-008 rail diagnostic train as an inspiration master and technical expert. In 2019 he was an active participant in the acquisition of Railway Firm permission of the Company, after this he does his tasks as head of railway operation of the company.

Utilization of track diagnostical measuring and inspection data in the planning of track maintenance works

JÓZSEF VÉGI

Effect of the development of informatics on railway track diagnostic

Concept of railway track diagnostics took form during the passed decades, and in the frame of railway track inspection activity it supplies information for the track maintenance experts.

In the beginning the experts mapped the inspection results by manual devices, and recorded the data on paper in different books. By the appearance of the first track measuring cars the measuring diagrams presenting the state of the railway tracks were made, in an analogue way, in one copy, and the measuring data were drawn by ball-pen, then the diagrams were handed over to track maintenance section offices. The track maintenance section engineer, principal engineer, and line manager of the directorates could see the measuring results only in the track maintenance section offices. The development of informatics, and by this the development of measuring technics during the passed decades totally changed this situation, and today already a lot of measuring and examination results can be reached in the competent experts' offices, on the base of entitlement, concerning even the whole network and several earlier measuring data. The results can be analysed with the help of special office softwares and expert system, in the mirror of these the necessary works can be planned. Several such examination methods are applied even today, which were applied also 30 years ago, but the number of obsolete methods decreases continuously, therefore more and more measuring and inspection data will be available digitally for all the experts.

The measuring systems examining the structural elements of the track were developed by now for almost all infrastructure area to be examined, and this is only a question of time, when these will be introduced and for application in case of the railway companies..

Milestones of the development of track diagnostic expert system from the beginning till nowadays

The measuring and inspection devices available at MÁV supplied only analogue data 35 years ago. The first significant step concerning the digital results was brought by the procurement of FMK-004 track geometrical measuring car, which started the operation-like measurements on MÁV network in 1990. The measuring system could already supply digitally the local faults and the measuring and qualifying numbers, characterizing the general geometrical state of the track.

By the headway of the personal computers the possibility has open for that, the experts of professional ancestor organizations of MÁV CRTI Ltd. with involving domestic higher education institutes could create the first DOS based version of Track Maintenance Planning Computerized System (PÁTER). In the program the results of the measurement executed on individual railway lines became already displayable in way- and time based diagrams, and the recording of the results of several measuring periods was also ensured in the system. The realization of different maintenance work proposals has already started in this version, which became complete in later program versions.

Almost at the same time with the establishment of MÁV Central Rail and Track Inspection Ltd. in 1996, the dynamic development of computer technics started, which created the possibility for the further development of the expert system. So after this PATER III, then in the first half of the years of 2000s the program named WINPATER were developed, in which beside the recording of superstructure diagnostical measuring and examination data, the registration of inspection data of track structural elements was also realized. For the sake of a higher-level servicing of the customer's demands the company decided ten years ago to develop a server-client based version, and involved two informatical private firms to the project for the sake of financing the investment. One of the advantages of the new program, that the managed railway network is defined on physical base, and the stored data tie to this physical network. The actual lines of the railway company (starting and end point) fit on the physical network by logical definition, so the incidental railway line re-organizations can be managed more easily and without data loss. Thanks to the continuous, till in process developments executed on the program, more and more new function was realized. About the most important functions we give information in the followings. In 2019 after the resultful management and successful negotiations with the joint owners the **Track Diagnostical Expert System (PÁTER)** got into the property of MÁV CRTI Ltd. in 100%, which has open new perspectives for the further development of the expert system.

Presently the services of the expert system are resorted by two railway companies MÁV Co. and GYSEV Co., their co-workers use the system for analysis of the track state, and for planning the track works.

FMK-004 measuring car

Registration of infrastructure and diagnostical (measuring and inspection) data, their visualization

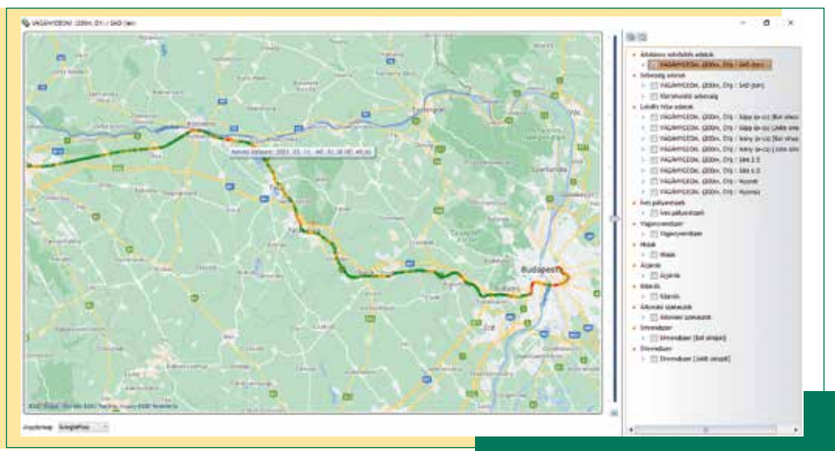
PÁTER program is capable for the registration and management of several dozens of infrastructural data. The track structural elements, track connections, engineering structures and manifold track accessories belong to here. In the infrastructure register we can find technical data concerning the track, such as rail type, sleeper type, different speeds, axle load, gross tonnage rolled through, curve relations, etc.

In the frame of track inspection the examination of the state of the track happens according to several aspects. Such for e.g. the measurement of track geometry, the material structural and profile inspection of rail, which is executed by four measuring systems on the rail diagnostic train, but we have to mention also the clearance gauge measurement and the examination of railway earthwork executed by ground penetration radar. Recording the data of these systems is also possible in the program. Evaluation of the measuring and inspection parameters is executed on the base of the concerning size limit regulation system. With the help of this the places of the

Planning of track geometrical work in PÁTER program

local faults can be given, beside this the measuring and qualifying numbers, characterising the general state, are also determined.

After the execution of the different measurements, relatively in a short time we upload the data into the PÁTER system. It is important to highlight that only qualified data (places of local, measuring and qualifying numbers characterising the general state) are recorded, i.e. all the data don't get into the expert system, for the analysis of them the so-called office programs are available for the users.



Visualization of measuring data on map

In PÁTER system manifold diagram, compilation can be visualized flexibly, in distance-based graphical plotting, which can be specifically configurated to the analysis task. By this the user can look at together the spatial arrangement of the infrastructural data and the state of the track on the base of the supplied data by the individual measuring and inspection systems, which makes it possible to discover the cause and effect correlation.

Management (viewing and modification) of the registers is ensured through an eligibility system which is built-up spatially and in an organizational hierarchy.

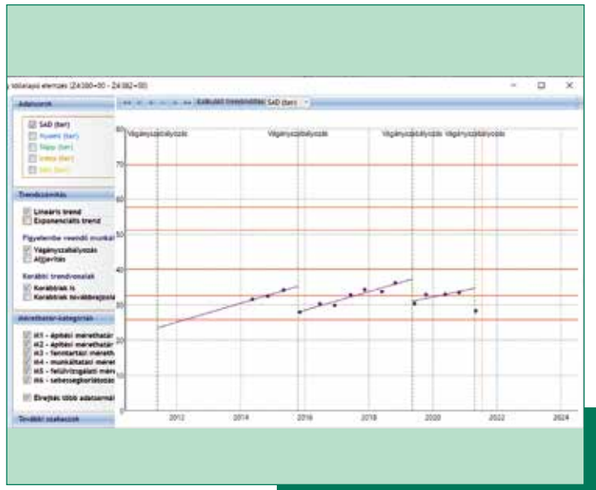
Analysis possibilities of time-based changes of diagnostical data (speed analysis, analysis of deterioration – improving trends)

The system stores the diagnostical data and results received in the measuring and inspection periods in succession. There is possibility for graphical comparison of any two measuring results, and for the analysis of the change diagram. The system is applicable also for the simultaneous visualization of all the stored measuring results. Beyond the optimal graphs quantity from the aspect of perspicuity, the state changing analysis is helped by time-based graphical plotting and trend display function.

Planning of rail maintenance work in PÁTER program

Planning of maintenance works on the base of diagnostical data and size limit instructions

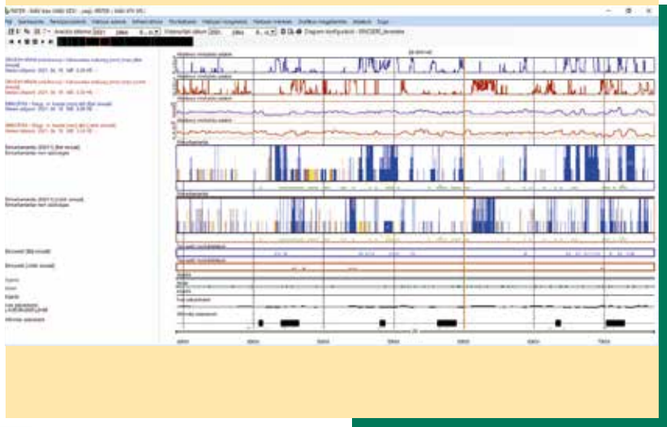
One of the important functions of PÁTER program is the analysis of the time-based changes of diagnostical data and of its trend, since the planning of the necessary maintenance works based on this. The planning happens on the base of the utilization of the qualifying number characterizing the general state, and of the connecting size limits. The program makes proposal for the maintenance works to be executed, and beyond that gives signal for the later expectable maintenance work necessity, with time-based perspective view for several years. This way it gives supporting point (help), for the track maintenance experts for making multiannual rolling plans and resource demands. Presently the program can make proposal for track regulation, ballast cleaning and rail maintenance works.



Trend analysis – Track geometry on the base of SAD qualifying number

Such a function of the program is connected to the maintenance work planning, in which one-and-one concrete technology can be given to the selected maintenance work. A specific cost belongs to the selected technology, and by this there is possibility for the user to make a cost calculation. Our long-term aim that the application of this service in the practice should be utilized in wide range, by this beside the technical planning by the infrastructure operators, also in the course of making the business plans the results from this will be utilized.

Planning of track geometrical work in PÁTER program



Planning of rail maintenance work in PÁTER program

Future possibilities of further development and enlargement of the system

In the course of the developments it was an aim to create such functions, that with administrator eligibility, without programmer work, newer measuring systems and their parameters could be configurated, also helping by this the more and more efficient operation of the expert system. Thanks to the structure of the system there is possibility for increasing the circle of track elements, infrastructure data to be registered, and for receiving newer measuring systems. The system can receive the new measuring systems (e.g. video track inspection system [VPR], ground penetration radar measuring system, overhead line measuring system, etc.), and the measuring data recorded in them, created in digital way, and arranged into appropriate file structure. By this, it is ensured in the PÁTER system, that beyond the track geometrical and rail diagnostical analyses, on the base of the data of the new diagnostical systems, a wider state exploration than the present one, should be available for the experts. The realization of the video track inspection system would make the possibility for paying attention of the track structural state, and the ground penetration radar measuring system can ensure the exploration of places with the substructure faults.

The aim of MÁV CRTI Ltd. is that at the further development of PÁTER program, beyond the increasing of complexity of track diagnostics, the demands originating from the user back-indications also should be fulfilled.

Author

József Végi
technical manager

József Végi acquired civil engineering diploma on Civil Engineering Faculty transport-civil engineering speciality of Budapest Technical University in 1985, then acquired railway construction and track maintenance expert engineer diploma on the transport construction expert engineer speciality in 1988.

In 1985 he stepped into the service of MÁV at Budapest-Ferencváros Track Maintenance Office, where going round the professional ladder of track maintenance area he got to the principal engineer position. In 1992 he got to MÁV Central Superstructure Examiner Office, where he executed research and development tasks. Due to organizational changes since 1993 he controlled the Development Division of MÁV Track Management Centre.

From the autumn 1996 as establisher member of MÁV Central Rail and Track Inspection Ltd. he continued his activity in the same employment, then from 2006 he provided the tasks of the head of division of Track diagnostic division till August 2018, since then he executes his tasks as the technical manager of the company.

Application of geophysical methods in the examinations of railway earthworks

ATTILA GAULAND – BALÁZS TAKÁCS

MÁV CRTI Ltd. since its establishment in 1996 has been dealing with – basically of a soil mechanical nature – railway substructure inspection activity, including:

- soil compactness and – bearing capacity examinations on the field, and
- in laboratory, on the samples taken from the examined soil medium – natural water content – with Proctor-, and grading examinations. Due to the small volume of soil mechanical activity the Company gave up the continuation of this operation.

Since the beginning of the years of 2000s on the professional area, the non-destructive geophysical examinations gradually appeared, so the attention of the company has also turned into the direction of such examinations.

The main activity of MÁV CRTI Ltd is railway track diagnostics, which is supplied by the Ltd. with the execution of rail diagnostical and track diagnostical measurements as well as the analysis of the measuring data. The appearance of superstructural track faults can be often connected to substructure problems, therefore on the part of the Company the demand emerged to provide the ordering railway companies with a newer diagnostic service (geophysical examinations) in order to serve detailed information on the state and quality of the railway substructure in addition to the information of measurements executed earlier.

Ground penetrating radar measurement of railway track with manual device

Also for the optimization of track maintenance, the knowledge of the ballast and the location of layer borders directly under it, and their continuity is very useful. In the course of the construction of railway tracks the geotechnical sampling is not continuous in the practice, but it is taken instead with point-like sampling spacing of 300-500 meters, therefore the soil mechanical examinations don't give a total view about the incidental soil inhomogenities. For this deficiency the continuous ground penetration radar (GPR) examination gives a solution, as a non-destructive geophysical method using electromagnetic radiation.

The basis of the GPR measurement is that a transmitter coil generates electromagnetic signals typically with the frequency between 10 MHz-2,5 GHz, and a receiver coil detects the returning waves. From the incoming times we can deduce for the thickness of the layers, from the returning signal shapes for the contamination of the ballast and for its water content. GPR measurements went through a great development during the passed two decades, from the raw data of a given quantity, twice or three-times more information can be utilized than at the time of the turn of the millenial.

The Company had been executing its service with this new diagnostical method with the application of subcontractors from 2001 occasionally, then from 2018 regularly, while from 2021 the company wishes to develop its own services with the procurement of an own GPR measuring system.

Substructure examinations by ground penetration radar

From the non-destructive substructure examination possibilities, which can be applied in railway environment, firstly the examination method with GPR must be applied. With its help, even with measurements executed in greater length, we can get a continuous primary image about the quality and position of the substructure layer order of the existent, or newly constructed tracks. It can be excellently applied to filter out the local fault places of substructure faulty track sections, on where the further detailed examinations can be focused. This supplies solution for the checking of substructure layer orders realized on the reconstructed track sections, or for the determination of the contamination level of the railway crushed stone ballast, or its soaking.

The domestic substructure diagnostic measurements with modern geophysical measuring technology expand on the following activities:

- Measurement of the geotextile installed into the railway track, detectable by ground penetration radar (so called GPR),
- Geophysical examination of track parts connecting to engineering structures,
- Geophysical examination of substructure faulty track sections, slope surfaces of embankment and cutting.
- Geophysical examination of retaining wall structures.

Mechanical GPR measurement on railway track with Ab-15 motor car

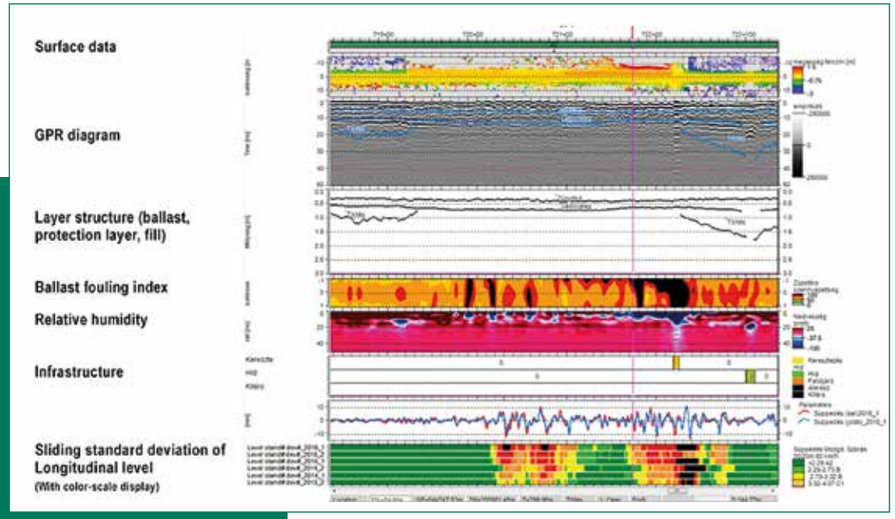
The below mentioned diagram shows the GPR examination results made about the substructure, which contains the radar records (GPR Diagram), the layer thickness interpretable on them (layer system), and the ballast contamination index. The structural change visible in GPR data and the appearance of the places with high ballast contamination, shows a high-grade similarity with the faulty sections appearing in the track geometrical data (moving standard deviation of longitudinal level).

Development of the faults can be observed well also on moving standard deviation of longitudinal level data, synchronized with GPR data. In the ballast, the relative moisture content is also on an elevated level (dark blue) supposedly due to the high-grade crumbling and contamination.

The geophysical examinations also pointed out the advantages of this examination method, since with the help of this, the substructure longitudinal profiles can be recorded on short sections and point-like inspection spots quickly and effectively, on longer section mounted on a railway vehicle by continuously running with track speed. Since the raw radar records (radarograms) received from the examinations on the field can be loaded by other disturbing recorded signals, so-called noises, which can be caused e.g. by metallic objects near the measurement etc., these disturbing signals during the process of the radarograms are removed from the data system. The evaluation comes after this with the help of an evaluating software developed for this purpose.

With the help of the method and with the appropriate selection of dominant frequency of the radar antennas we can record longitudinal and cross-sections, giving image till different depths about the inspected track sections. The penetration depth and resolving power of the method depend on the frequency of the used electromagnetic waves. By increasing the dominant frequency, the resolving power of the measurements can be increased, however the waves with greater energy are absorbed more easily on the different layer borders, and therefore the penetration depth of the examinations can decrease. For the measurements generally the antennas with frequency between 100 MHz – 1 GHz are applied, for the examination of earthwork, ballast, bridge backfills, or track sections in cutting, backfill behind the retaining wall structures, or even the material discontinuity circumstances behind the walls of the tunnels.

At application in railway environment the GPR examination at field measurement must be complemented with further systems, modern position identification system, video camera system and laserscanner scanning the measured railway track and its environment.



Evaluated GPR diagram

GPR examination of retaining wall structure

GPR measurement with manual trolley

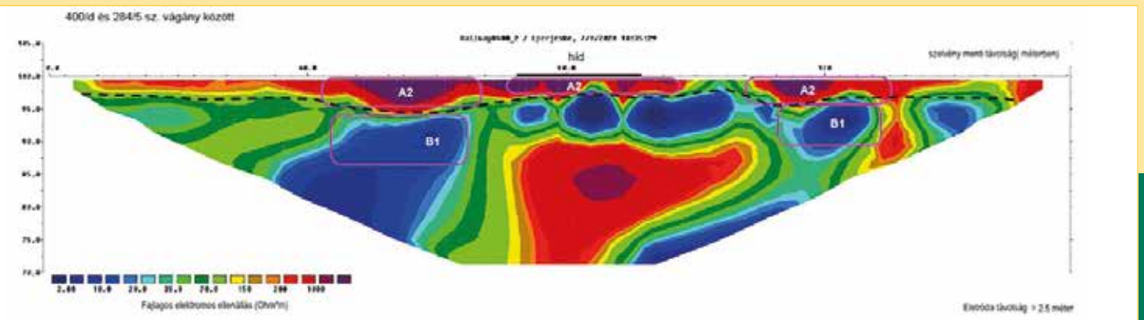
Geo-electric field sectioning

Till now MÁV CRTI Ltd. executed the geophysical examinations by involving subcontractors, but from the autumn of 2021 the Company can execute the significant part of the non-destructive substructure examinations with own GPR.

For the geophysical examination of the railway earthwork along with the GPR, the geo-electrical sectioning (ERT) is also applied on those places, where the detailed determination of the local substructure faults is necessary.

The method can be applied, among others, e.g. for the examination of the conditions of bridge backfills, as it can be seen also in the lower picture, by detailed resistance data the layers with high water content can be demonstrated (signed by blue/green colour, and signed by B1) both in the track and in the substructure. By the method we can get a more detailed image about the longitudinal and depth extension of the drainage deficiencies, and about the incidental inhomogeneity of the track and substructure (sections signed by A2). By the utilization of the geophysical information (GPR+ERT) the faults arising in the substructure can be bordered well, and by this the repairing costs of the faults emerged in the individual engineering structures can be planned.

In case of need such detailed geophysical inspection methods are also applied, as the seismic examination, the own-potential measurement (SP measurements), the Slingram examination and last but not least, the micro gravimetry.



ERT resistance profile

Author

Balázs Takács
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Track material qualifying department

Balázs Takács acquired his earth sciences researcher BSc diploma at the natural sciences faculty of Loránd Eötvös Science University first in 2017, then his applied geophysicist MSc diploma in 2019.

During his university years he took part in several field practices and expeditions, he acquired experience mostly on the area of archaeological, geophysical measurements earlier in Ukraine then in Russia.

Since the finishing of his studies he has been working at MÁV Central Rail and Track Inspection Ltd as geophysicist. He organises, co-ordinates actively the substructure diagnostical works, takes part in the preparation, transactor, and testing tasks of the procurement of new geophysical measuring systems.

Author

Attila Gauland
head of department
Track material qualifying department

He acquired his civil engineering diploma on Constructing and Settlement engineering speciality at István Széchenyi College in Győr in 1996, then he acquired the settlement engineering diploma as a second diploma in 1999.

He joined to MÁV Central Rail and Track Inspection Ltd. in 1997. From 2002 he continued his work in the substructure inspection group, where he executed substructure field measurements and labour examination work.

From 2004 he was appointed to be the head of the substructure inspection group. In 2012 he became the leader of the Budapest group of the Track qualifying department. In this position he organized and co-ordinated beside the examination and qualification of the new and used superstructure materials, also the substructure diagnostical works.

Since 2018he is the head of the Track Material Qualifying department, and he also executes the quality management and risk management tasks of the company.

Visual inspection of M0 highway bridge

New perspectives in the bridge diagnostics

BALÁZS ERDEI

Bridge diagnostic department of MÁV CRTI Ltd. has been executing the field examinations necessary for the establishment and maintenance of the railway and road engineering structures, qualification, checking, the periodical and occasional inspection with complementary instrumental measurement, and the general inspection and test loading of the bridges on the base of the operative Railway and Road Bridge Regulations, for more than two decades.

In the course of the field examinations the simplest, and most diffused way of the exploration and evaluation of the damages and the most obvious method even today is the visual inspection. Maybe the biggest advantage of the method is the economy, since with a relative small expenditure it gives information about the incidental damages already on the spot. But it means a serious disadvantage, that it can be applied only in the case of changes, faults, which are on accessible places and can be seen by naked eye, furthermore it supplies subjective results. We could decrease the general uncertainties in a great extent with the application of practically selected manual tools, measuring devices, instruments and image producer devices.

The bridge diagnostic activity of the Company continuously developed during the almost 25 years, and the target-examinations already extend beyond the bridges on the tunnels, arcades, drainage drifts, and on other engineering structures bearing railway load, according to the customer's demand.

With the development of the devices the examinations became expansible for the whole of the engineering structures, also for their visible and obscured parts. In the course of the detailed, expanding on all structural elements, complete target-examinations, beyond the manual devices,

Pécs station turntable

Three-shafted inspection pit in Dombóvár

different modern, diagnostical equipments supplying digital results, help the exploration of changes, their knowing, the measurement of the extension of the faults and the precise recording of the changes in state.

In the course of making the inspection records we evaluate in each case, that what effect have the explored faults, deficiencies on the safety of traffic and track staff, on the function and usability of the engineering structure, its durability and expectable life span. From 2021 the Fault evaluating and engineering structure qualifying system to be applied in the course of the examination, evaluation and documentation of the engineering structures was introduced in our department. This evaluates the faults, deficiencies explored in the course of the examinations on structural element level, according to the followings:

- **with the State evaluating number (M), expressing the severity of the detected fault, which concerns the state, life span of the structural element;**
- **with the Danger evaluating number (V) expressing the urgency of the intervention, and the danger of the efficiency, which concerns of the engineering structure, the safety of the railway operation and the track staff.**

On the base of the field inspection and measuring results, more unified, objective and independent expert proposals can be made.

On the base of the executed examinations and their results in several cases involving, application of further methods can be emerged, such as e.g.:

- **short-term instrumental target examination;**
- **target examination with loading, and test loading;**
- **non-destructive structural and material examination;**
- **static revision;**
- **long-term instrumental target examination, and application of the monitoring system, which can supply information about the changes in the structure, which changes cannot be seen by naked eye.**

The inspection, short-term, the loading target examination, and the structural and material examination, the static revision, taking the life-span of the engineering structure into consideration, gives point-like information in time about its state, so from that, only the changes occurred between the two examinations or two measurements can be demonstrated. The process of the changes, their development in time, the effects causing them and the connection between the changes is not recognizable on the base of these examinations, measurements.

Test loading of the bridge of Hernád river

In the course of the operation of MÁV Co's bridge stock the appearance and application of up-to-date inspection systems made the possibility for the continuous tracking of the change-state of bridge structures. Also from the operator's aspect it becomes more and more important to determine more accurately the momentary state of the structures, and on the base of the state the expectable life span, and bearing capacity.

We receive significantly more and more accurate image about the changing, deterioration processes, the behaviour of the given structures with the help of instruments - monitoring systems – installed for long-term and operated durably, which are even alterable for real-time data service, analysis and warning, by this significantly increasing the reliability of the inspection system, making possible the forecast of the failures, and helping the keeping of the transport safety and the introduction of the necessary restrictions in time.

Presently on the national railway network there are built-up monitoring systems at seven bridge structures, and in the near future at further four bridge structures remote, installed or built-in measuring equipment will be commissioned. Checking their presence and state, reading, collection and delivery of the measuring data together with the evaluation is the most dynamically developing bridge diagnostic activity, which we execute typically with quarterly frequency.

For MÁV Co. infrastructure business unit it is outstandingly important to ensure the operation of the railway bridges and engineering structures, in this way the keeping of railway transport and adequacy to timetable,

Maros-bridge at Makó *(with the road bridge in the background)*

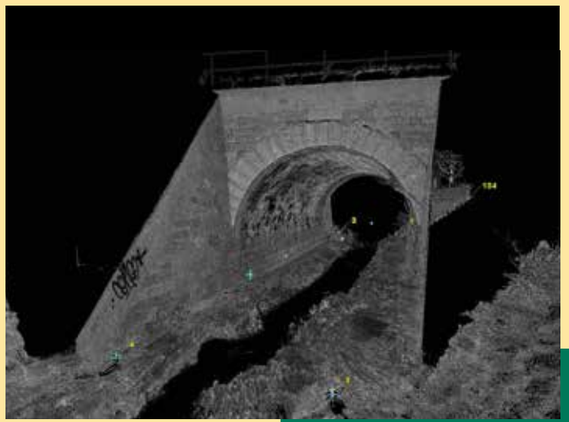

Image of brick-vault made by 3D laser scanner

which are supported by the regular and up-to-date bridge diagnostic examinations. Our aim remains, to help the efficient utilization of the resources available for the bridge management, to which we keep an eye on the continuous development our diagnostic devices and methods.

Author

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head of department
Bridge diagnostic department

Balázs Erdei bridge expert engineer acquired his diploma in 2009 in Bridge and engineering structures specialization in Civil Engineering Faculty of Budapest Technical and Economic Sciences University. He has been working at MÁV Central Rail and Track Inspection Ltd. since June 2009, where from September 2013 he is a group leader.

He acquired in 2014 a corrosion protection expert engineer diploma at Pannon University. His main tasks are the periodical and extraordinary and monitoring examinations of the existing bridges and engineering structures, and controlling and checking of the examinations executed at the renewal, maintenance of the bridges, and of the examinations of bridges and test loadings before putting into operation. In August 2018 he was appointed to the head of Bridge diagnostic department.

Future possibilities of the railway vehicle examinations

CSABA MIHÁLY PÁLFI

Short historical overview of the vehicle inspection activity

The national railway companies generally own an organization, dealing with inspection by measurement of the railway vehicles. The first suchlike organization in Hungary, after the establishment of Hungarian State Railways started up in 1887 with the name of Study and Testing Group, and owned a measuring car in 1892, suitable for traction & energetic and brake tests.

In 1951 the Railway Scientific Research Institute was established (its official abbreviation VTKI, but Vatuki in common language), which operated as the main research institute of MÁV till 1991. In 1963 the Vehicle Experimental Division joined to the organization, which division earlier has been operating inde-pendently for long years. Vatuki was also re-organized according to the new more profit-orientated aspect.
In 1992 MÁV Development and Research Institute (FKI) was created inside MÁV which continued the diversified activity of Vatuki. Inside MÁV Co. after more re-organizations the activity, and by this also the organization was ultimately terminated in 2014.

In 2015 MÁV CRTI Ltd. established the organization dealing with vehicle testing activity for the sake of supplying the tasks necessary for the authority examination of FMK-008 rail diagnostic train, being under production. Without this in lack of domestic testing organization, the acquirement of the authority per-mission of the vehicle would have resulted in a long run-time and high cost. Despite the domestic market demands appearing cyclically the company continues to strive to keep its activity in life.

Presentation of the vehicle testing activity

The first big group of the vehicle testing activity is the **examinations, tying to the authority type permission**, which have to be executed formerly on the base of UIC leaflets, nowadays on the base of TSI-s and EN standards:

- Static and dynamic structural strength tests of railway vehicle car-bodies and bogies
- Quasi-static derailment safety test of a container wagon on test track of reversed curve with radius of 150 m
- Vehicle body distortion examinations, bogie rotating torque measurement
- Static and dynamic brake performance tests, Wheel slip protection test at extreme low adhesion
- Noise tests
- On-track running behaviour tests
- Wheel-rail profile contact (equivalent conicity) examinations

Brake distance measurement in a slip test, soaping of the rails

Quasi-static derailment on an S-curve test track

Pass-by and internal running noise test of FMK-008 measuring car

The **second big group** is the examination based on the measurement of the wheel/rail contact forces, for the judgement of track-vehicle interaction (safety against derailment and the remaining transversal track displacement, vertical track extra loading). This is the basis of the track qualifying system based on on-track running behaviour of the company's FMK-007 measuring car.

Running behaviour test series exploring the reasons of the derailment dangerous staggering of the lo-comotive of MÁV Children's Railway

25 év

The **third big group** is composed of the other fault exploring examinations, e.g., dangerous unloading on wheel (wheel bouncing at a TVG vehicle, dangerous staggering on the Children's Railway), the meas-urements for exploring the reasons of the fracture of monoblock wheel disc with brake block (passenger car of Halberstadt) or the reasons of the abnormal brake disc wears (TALENT EMU).

Vehicle examination activity in the organization of MÁV CRTI Ltd.

The starting of the vehicle testing activity at MÁV CRTI Ltd. in 2015 was the execution of UIC licensing measurements series of a new WSP equipment, which has a revolutionary new principle and much more safe operation, and which is the product of one of the most significant world market leader firm, producing railway brake- and WSP equipment, then the multiannual endurance tests necessary for the authorization, were also inspected by our company. We also actively took part in the on-track tests of magnetic rail brake of new principle of the same brake factory in 2016. This year in 2021, we contributed to the testing series of a brake structure of also new construction, executes on tracks sections with different quality.

Partially bedded magnetic rail brake before the test series

The biggest intellectual and technical challenge was the derailment safety and ride comfort examination series of CAF Urbos tram in 2016, which tram has unusual running gear construction in normal railway applications. In the course of this test series the WRIM-method must be adapted, which is based on merely acceleration detectors, in case of normal railway application it is applied already methodically (like a routine) for the measurement of the transversal and vertical wheel-rail contact forces. It was also a great challenge to work out the simultaneous measurement of the wheel loads of this same vehicle.

Established temporary measuring station for the running behaviour tests of CAF Urbos tram loaded by sandbags

We executed diversified activities for the national passenger railway company: from among the authority type examinations of the new or reconstructed passenger cars, the static strength tests of IC+ fleet, and the brake performance and WSP slip tests of the reconstructed CAF EuroCity and Halberstadt coach were executed by the company. The authority type examination series of third-class coach with dynamic ventilation built by Russians for Egyptian National Railways was executed in 2020. It contained the quasi-static and dynamic derailment safety, noise, brake performance and WSP tests.

Slip test of the first-class IC + passenger car of MÁV START Co. at speed of 160 km/h

Examination of the buffer and coupler interaction of third-class coach with dynamic ventilation built for ENR on the S-shaped test track includes opposed curves with a radius of 150 m, with a section of tangent track of length 6 m in-between

Beside the external orders, the measurements binding to the fleet of MÁV CRTI Ltd. were also executed, such-like the execution the total authority type examination series of the new FMK-008 rail diagnostic measuring train in 2015-2016.

The renewal of the vehicle dynamic measuring system of FMK-007 measuring car, on WRIM-principle, i.e., merely based on the signals of accelerometers, was successfully realized in 2018.

The engineers employed on vehicle testing area, also work on the solution of the technical problems of the vehicles operated by the company, such-like the on-track dynamic strength tests of the driven bogie of FMK-008 railcar, the revision of the driving system of FMK-004 measuring car and the examination of running behaviour problems of Ab railcars.

Traction & energetic test of FMK-008 measuring train on the railway line No. 80

Strain gauges and relative displacement sensors mounted for the measurement of the dynamic strength of the bogie of FMK-008 railcar

Future possibilities of the activity

As shown in the previous chapters, the company with its vehicle testing activity doing alone in the country, contributes in a significant extent to the execution of type examinations, fault exploring and research-development tests, necessary for MÁV-Volán-group.

Aim of the company is further keeping this activity, for the sake of which the company would like to have the accreditation according to MSZ EN ISO/IEC 17025:2018 standard of these activities, in order that the company could correspond to the domestic and international instructions in wider range.

Author

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Csaba Mihály Pálfi acquired a mechanical engineer diploma (MSc) on the Faculty of Transportation Engineering of Budapest University of Technology and Economics in 1993, at railway engineering branch, then he executed the three year-long PhD training of the Department of Railway Vehicles. His research field was the measurement and system identification of railway vehicles as dynamic systems .

He started to work in 1996 in the Development and Research Institute of MÁV, at Vehicle Dynamics Division as a development engineer, then from 2005 he was a development engineer of Railway Engi-neering and Measuring Service Centre (VMMSzK), then from 2010 the head of the Vehicle testing Divi-sion. From 2013 he was the acting leader of VMMSzK.

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A kiadvány elektronikusan magyar és angol nyelven az alábbi címen érhető el:
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