Increasing the efficiency of infrastructure measurement and testing

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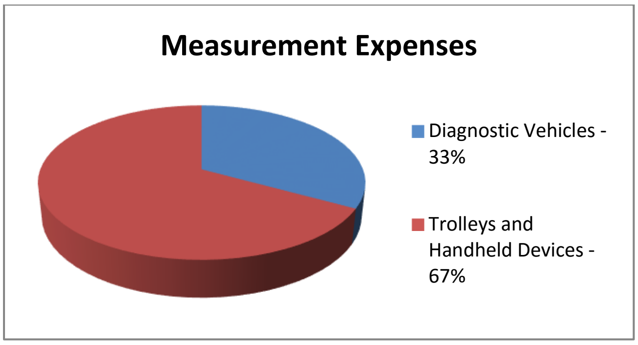
Rapid development of technologies is a global trend, which is nowadays seen nearly in all areas, and the rail sector is not an exception. However, the progress in rail transport development implies a number of new issues, in particular related to the expansion and maintenance of railway infrastructure. Rail transport operators have to deal effectively with consequences of both the additional traffic growth and increase in operation speeds and axle loads, which in turn restrict operators’ ability to guarantee proper monitoring and measurement and, unfortunately, to ensure adequate maintenance. Still, this should not be a hindrance in providing a high level of railway traffic safety and in achieving the highest efficiency.

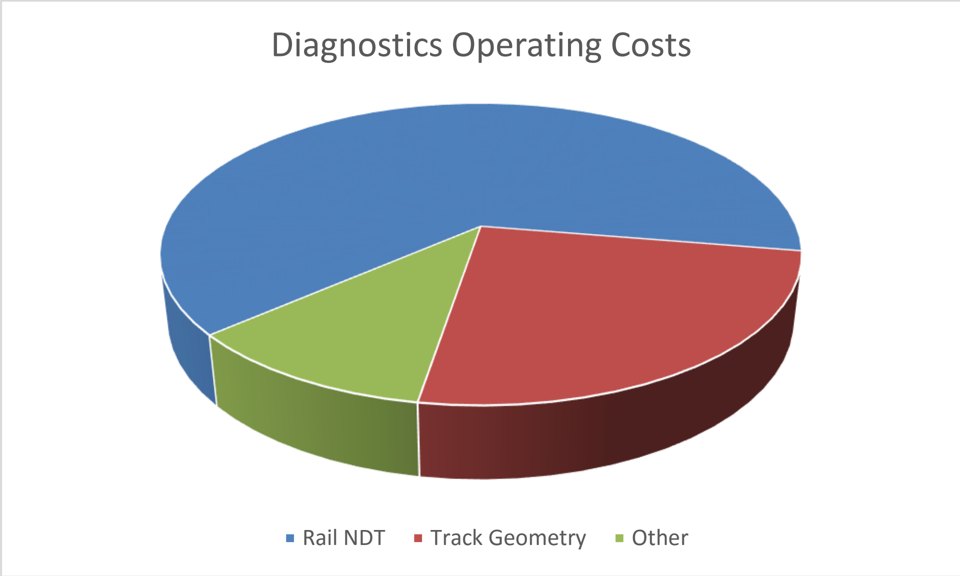
The latest research findings and technical achievements, especially in area of diagnostics, are widely used in most developed railways of the world. Up-to-date measurement equipment is a number of sophisticated sensors, installed on dedicated or commercial trains, and computers with huge processing power, which in combination enable rail transport operators to collect accurate and detailed information on railway infrastructure condition. Manual systems support the mobile measurement units with secondary testing and verification. However, the key questions are whether that is enough to provide the best coverage of infrastructure monitoring and what procedures can be implemented to cut the measurement costs?

The question of efficiency becomes even more actual at large railways, where the fleet of measurement vehicles numbers in dozens and even hundreds. One of such operators is Russian Railways (RZD) with more than 125 000 km of tracks, spread all over the country with the world's largest area. The diversity of operating conditions and poor legacy infrastructure, combined with dense mixed traffic and high axle load, left the mark on the maintenance and particularly on the measurement procedures, causing the requirement for high frequency of testing. For example, just the track geometry must be assessed twice a month by track recording coaches on all main lines all year round, giving in total about 2 500 000 km of measurements every year.

The highest level of safety is set to the top priority, and now RZD owns and operates about 400 vehicular measurement units, including almost two hundred track recording and NDT coaches. In last decade the direction of development was to replace walking sticks and trolleys with mobile systems, but still more than 6 000 NDT and 1 000 track measurement manual devices are in operation, occupying in total over 20 000 staff.



This approach to the measurements leads to positive results, and now Russian Railways is one of the safest railroads in the world with a very low level of incidents caused by infrastructure condition. But at what cost? According to the reports of year 2014, the diagnostics operating costs amounted to approximately €200 000 000, of which 64% and 25% allocated to rail testing and track geometry measurement accordingly. The challenge to RZD is now to decrease this figure without sacrificing the quality of maintenance and safety of railway operation.



Several ways of cost decrease were discussed, but at the end, three main strategies were selected for implementation:

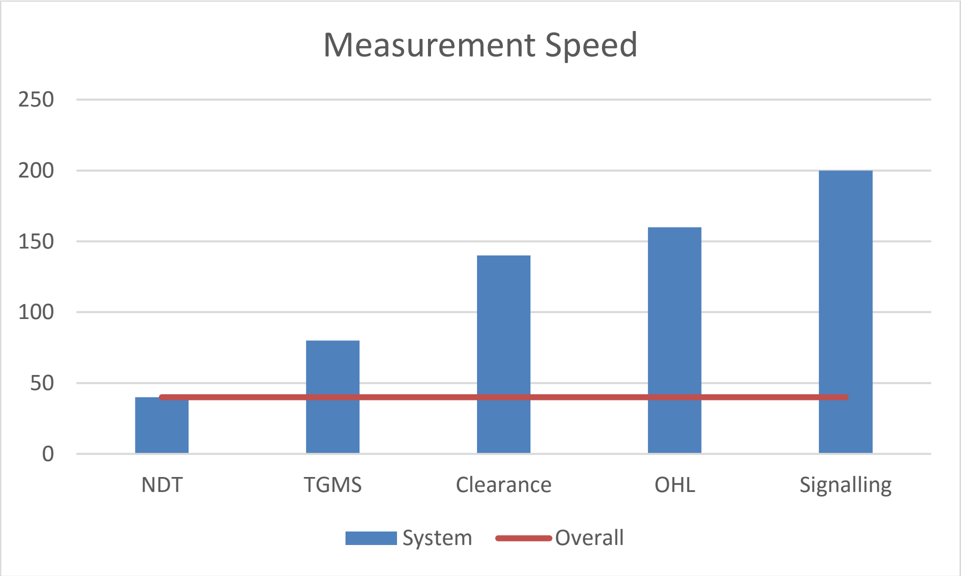
- Extension of the course to replace manual units with vehicular testing
- Focus on the vehicles with the combination of systems
- Increase of testing and measurement speeds

The advantages of the first strategy were proven in many years, but two others were not widely practiced by Russian Railways before. However, from 2008 to 2012 the operator already purchased four infrastructure diagnostic trains from two local manufacturers and has now an experience of work with the vehicles, each having up to 15 various systems measuring at once over hundred parameters.

These trains, named “INTEGRAL” and “ERA”, were designed to monitor the condition of rails, track, permanent way elements, overhead line, signaling and radio network, but first years of their operation showed the specific advantages and disadvantages of this approach. At first glance, the benefits from measuring all the parameters during one run are obvious – save on working windows, traction, staff, and cross-evaluate the parameters to understand the real reason of the defect. And it was true – the staff of the trains is of a higher qualification, but 3 times less in number than the staff of several vehicles measuring the same parameters, and the combination of systems allowed to determine the true reasons of the defects instead of detecting the after-effects and wasting time and money on repairing wrong things.

But the series of drawbacks ruins the idea to replace all existing measurement vehicles with such integrated trains. First, the scheduled frequency of testing is different for most infrastructure elements, and many of them (like overhead line or signaling) do not require to be measured that often. Delivering these data too often does not fit the existing process of maintenance and thus most probably the information collected during the "extra" runs will simply not be used.

At the same time, the measurement speed (or at least the limit set by the operator) varies for different systems. On the network of Russian Railways the lowest testing speed is set for ultrasonic NDT (40km/h), followed by a limit for mechanical versine track geometry measurement systems (80km/h). But the testing of the overhead line, signaling and radio networks are limited only by the speed of the rolling stock, and as usually the systems for these parameters are based on the passenger-type coaches, the measurements can be held at 160-200km/h. Therefore, the operating speed of infrastructure diagnostic train is always limited by the "slowest" system, and for some types of testing, it is not a suitable solution.



Now these trains are used not for the routine inspections, but as a special tool, covering several zonal railways each, to solve special measurement tasks or to control the proper work of regular measurement coaches. And in this sense the infrastructure diagnostic trains are worth their cost – in addition to existing 4 units RZD plans to procure at least one more in year 2016.

Why should RZD then after all this experience support the strategy of combining the systems on the vehicles? The reason is that generally nothing keeps the operator from avoiding all the disadvantages stated above keeping at the same time the benefits from integrated systems.

The solution is in optimizing the number and types of the systems on the vehicles to match various parameters of testing for best performance. Coincidentally, the grouping by the object and frequency of testing is very close to the grouping by the speed of measurement, and the following combination of the tasks and systems can build a synergy when installed on one train:

- Rail testing (ultrasonic, eddy current, corrugation, rail surface inspection) with the speed up to 80km/h
- Track and catenary measurement (inertial TGMS, rail profile, video inspection, overhead wire position and wear, catenary parameters and dynamics) with the speed up to 200km/h[1]
- Permanent way elements testing (ballast profile, inspection of sleepers, clearance gage, ground penetrating radars) with the speed up to 140km/h
- Signaling and radio testing (rail circuits, ETCS, GSM-R, analog radio networks) with the speed of the rolling stock

Such combinations will provide the optimal general performance of the vehicle by balancing the specifics of the measurements, testing speeds and required outputs, including cross-parameter evaluation. At the same time, the installation of all these systems on one train can still be used to save the costs on the purchase and maintenance of the rolling stock, with the corresponding changes in the way of its operation.

This approach is in mind of the managers of other railway operators in Europe too, e.g. the recent public procurements of PKP PLK (Poland), SŽDC (Czech Republic) and MAV KFV (Hungary) included the purchase of separate measuring trains with combinations of systems for rails, track and other infrastructure elements, not to mention DB Netz, who follows this strategy already for couple of decades and procured new measurement trains in 2010s using the same principles.

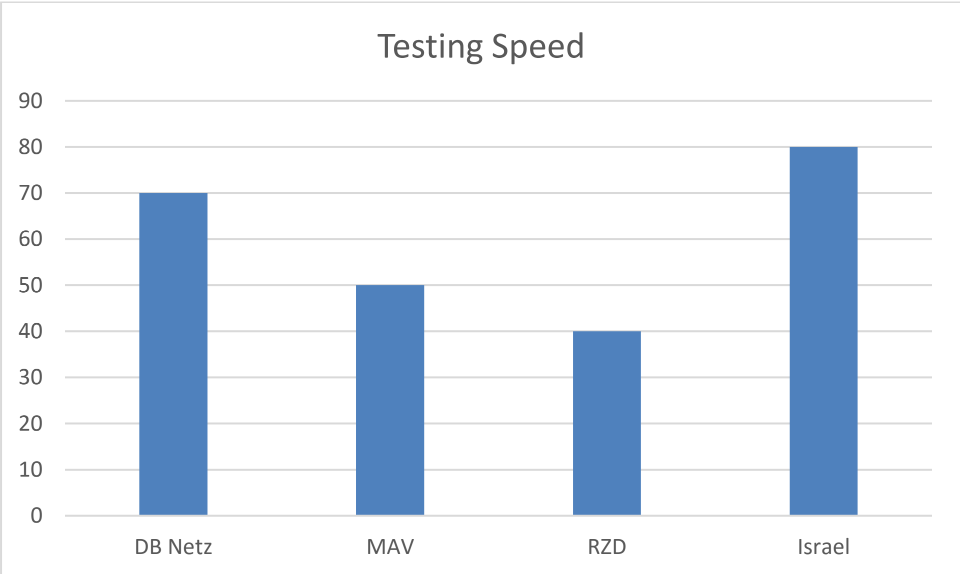
One of the most recent projects of that type with the participation of TVEMA is Czech DJ NDT, created for SŽDC on the base of passenger diesel train in cooperation with Czech, German and Hungarian companies. The train will include ultrasonic and eddy current nondestructive testing systems along with the elements of video inspection and, in near future, rail profile and corrugation measurement equipment.

Another approach to increase the efficiency of measurement procedures is to decrease the time, required to perform the testing. Higher speed means, taking into account the constant frequency of measurement, less vehicles, less staff, less working windows and at the end of the day – less costs.

[1] Faster systems do exist, but they number to around a dozen all over the world and are only used on the high-speed lines on a corresponding rolling stock

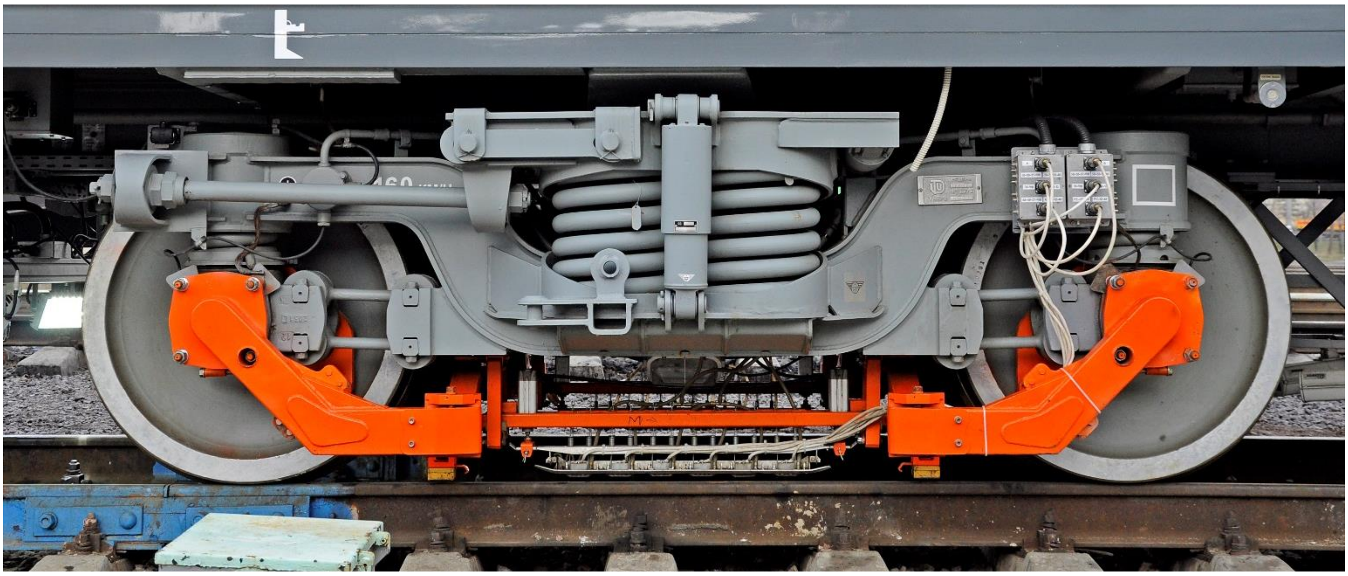
The problem of measurement speed is solved for most of the routine monitoring tasks, but not for the ultrasonic rail testing. Nowadays there is no other method which could ensure reliable nondestructive testing of rails in track, and the laws of physics say that the theoretical speed limit (with current detection norms) is slightly higher than 80km/h. One should take into account that as ultrasonic systems are all using contact method for the input of the wave, i.e. there is a physical contact between the system and the rail head, it is necessary to give an allowance for dynamics, quality of acoustic coupling and other factors.

That is why many railway operators all over the world limit the speed of ultrasonic testing, e.g. 70km/h at DB Netz, 50km/h at MAV, 40km/h at RZD. It is important to note, that the speed limit is not defined solely by the quality of the systems, but more by the variety of the conditions of the rails and environment. Thus, Russian Railways have set the limit of testing, which is 2 times below the theoretical limit, to ensure the reliability of all year round monitoring even at low (down to –40°C) temperatures and high snow level. Opposite example is Israel State Railways, using the same modification of system from TVEMA at maximum theoretic speed (80km/h) in the conditions close to optimal for ultrasonic testing.



However, even the work at maximum speed is the bottleneck for the operators, as it is very painful for traffic controllers to put the slow NDT vehicles into the busy schedule, especially at high-speed and busy suburban or metro lines. The invention of a way to significantly increase the speed of ultrasonic testing was for a long time a dream for many maintenance managers, and finally it became a reality with the development of the new NDT system at TVEMA.

A simple idea along with outstanding experience and new approaches to hardware and software allowed to almost double the operating speed to reach impressive 140km/h. After the factory tests and patenting it was installed in 2014 on a coach named “SPRINTER”, allowing RZD to become the first operator to assess a smart workaround over the law of physics.



First functional tests were performed on the Northern Railway polygon near the city of Yaroslavl with the mission of 2400km in 2015 and they proved successful accomplishment of declared features. Five critical rail defects were found at high operation speed and full conformity with the results of regular NDT coach and manual trolleys was achieved. Afterwards the coach was transferred for further evaluation to Moscow–Saint-Petersburg–Helsinki line, where more than 10 000 km of additional testing were performed, before RZD granted the final approval to the technology. In 2016 three "SPRINTER" coaches will start their operation on the busy lines of Russian Railways.

In spite of high level of non-confidence from the side of the operators, several railways already demonstrated incredible interest in the new technology, and in 2015-2016 "SPRINTER" was probably one of the world most visited diagnostic trains, welcoming track maintenance specialists from France, Italy, Czech Republic, China and other countries.

It is impressive how significant can the economic effect be – operation costs per km for “SPRINTER” are 3 times lower than for regular diagnostic vehicles, and 5 times lower than for portable diagnostic tools. Also due to the process automation the number of crew members decreases 1.5 times in comparison to a typical diagnostic vehicle. One coach can replace up to 40 portable NDT units with staff of 200 persons.

It is important to realize that there was no “one fits all” solution, and the projects presented confirm that saying. A proper solution for the diagnostic tasks of the railway operator can only be found through debates and discussions, combined with the experience of managers and suppliers.