TITLE OF PRESENTATION: STATE OF TRAFFIC SAFETY CONDITIONS AND PROSPECTS OF SAFETY IMPROVEMENT ON THE RUSSIAN RAILWAYS

NAME OF PRESENTER: IVAN S. BESEDIN, JURI M. CHERKASHIN, SERGEY M. ZAKHAROV

COMPANY NAME: ALL-RUSSIAN RAILWAY RESEARCH INSTITUTE, MOSCOW, RUSSIA

Throughout its history the Russian Railways (RZD) made a good progress in coping with traffic safety problems. As a result in 2003 the number of train breakdowns was 7 times as less (6 against 42), the number of train accidents 15 times as less (2 against 30) and the number of penalty cases 3.4 times as less (5,600 against 19,086) as in 1992 (Figure 1 and Figure 2). The number of special penalty cases reduced by more then 3 times (from 2,284 to 726) as compared to 1994 (the first year of their registration).

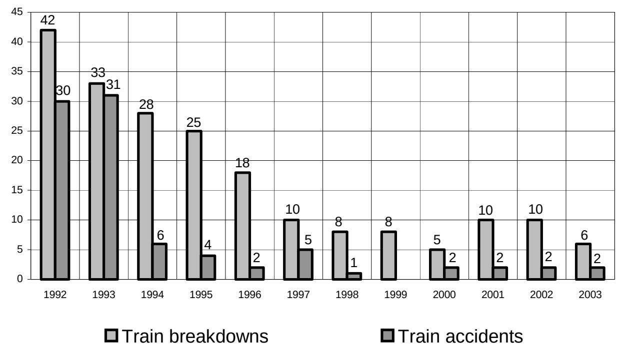

Figure 1: Number of train breakdowns and accidents on the Russian Railways in the period of 1992 –2003

The total train turnover (in all types of traffic) declined from 1,424 million train-km in 2003 to 1,831 million in 1992 (22 percent of reduction). That is why considerable reduction of safety indices is seen if relative ratio is used. For instance, total number of penalty cases as related to 1 million train-km amounted to 10.42 in 1992 and only to 3.93 in 2003 (Figure 2).

It's not only that the total number of violations of safety rules and conditions was drastically reduced in the indicated period, but individual types of violations, including as grave as:

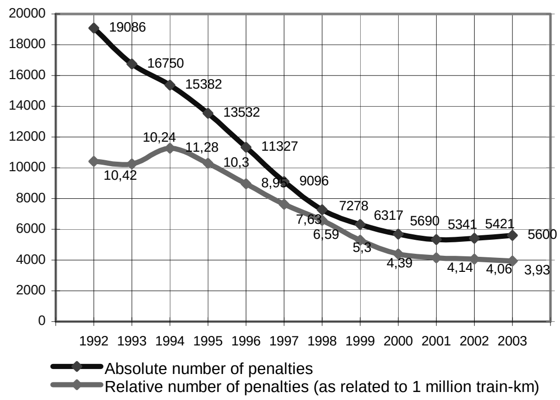

Figure 2: Number of penalty cases in mainline and shunting operations of the Russian Railways in the period of 1992 –2003

- derailment of rolling stock in freight trains (Fig. 3) - from 366 to 72 (more than fivefold reduction)
- passing of prohibitive signals - from 43 to 4 (tenfold reduction)
- breakage of automatic coupling or center beam - from 67 to 12 (5.5 times reduction)
- rail breakage under train - from 692 to 81 (8.5 times reduction)
- derailment of rolling stock under shunting operations - from 522 to 151 (3.5 times reduction)
- collisions of rolling stock in shunting operations - 1,122 to 58 (near 19 fold reduction).

In 2003 the number of derailments in passenger rolling stock was 3.6 times as less (7 against 25) as in 1994 (the first year of their registration as special cases).

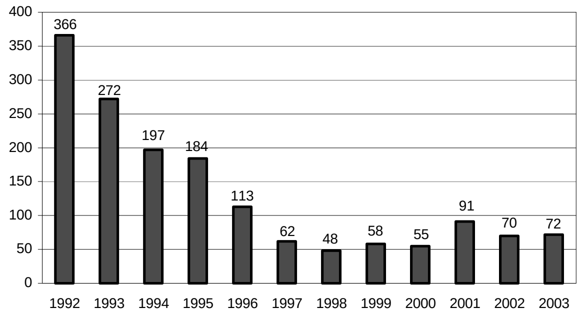

Figure 3: Number of derailments of rolling stock in freight trains in the period of 1992 – 2003

Such results were achieved due to everyday laborious work of the managerial staff of the former MPS-Russia, individual railways, railway divisions and local enterprises contributing to exactness and higher personal responsibility of railway employees, better labor and technological discipline, higher level of professional skills. These efforts were supported by introduction of engineering means of safety in line with the traffic safety improvement strategy of the government.

However the share of empty wagons in the total number of derailed increased by 2.5 times during the reported period, reaching 70 per cent in 2003. The distribution of empty wagon derailments by wagon types for the period 1999-2003 is shown in Figure 4. Most of derailment are on tank- and hopper-wagons (37 per cent and 35 per cent respectively).

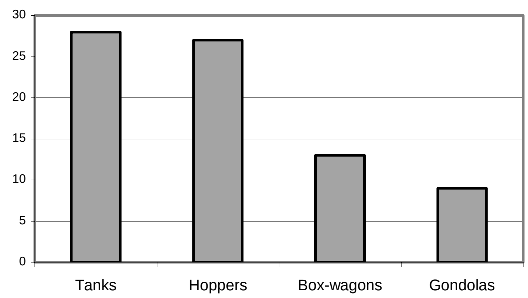

Figure 4: Distribution of derailed empty wagons by their type in the period of 1992-2003

The reason is that hopper-wagons have smaller truck center spacing, higher center of gravity and much higher torsional stiffness of the body. All these factors contribute a great deal to empty hopper-wagons' susceptibility to derailing while passing along transition curves and track-twist sections and being under action of in-train longitudinal compressive forces arising in unsteady train operation regimes. Derailment stability of empty tank-wagons is influenced by higher center of gravity in vertical direction and practically no torsion of the tank.

These features of mentioned wagons are of design-specific character. The situation is aggravated with deterioration of their technical condition of friction wedges, center plate, side bearings and wheel tread.

It should be noted that there are rather few empty wagons (no more than 0.5 per cent of the total wagon fleet) with defects, provoking intensive pitching and hunting, which represent the danger of derailment.

At the same time the number of derailments of empty wagons amounts to 40 – 50 wagons a year. This means that with considerable number of potentially dangerous wagons, derailments occur due to combined action of additional unfavorable factors, such as deviation from track standards, mainly track twists and subsidences, irregularity of track layout, as well as regime of train hauling, especially when using electric and direct braking.

Analysis of empty wagons derailments, charged by line-of-duty investigations against the Track & Structures Service, indicates that their main cause is poor maintenance of track geometry. The distribution of empty wagons derailments in jointed and CWR track sections is illustrated in Figure 5.

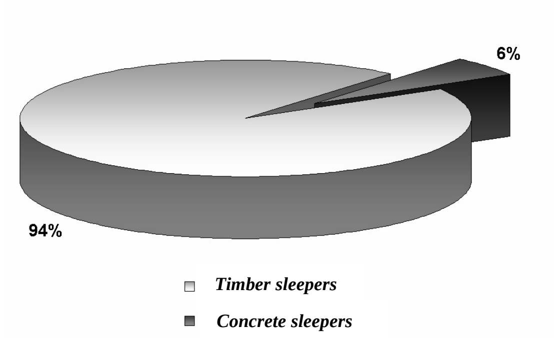

Figure 5: Distribution of empty wagons derailments by sleepers types

It shows that 94 per cent of all derailments of empty wagons occurred on jointed track, representing 65 per cent of the total track length of the RZD network.

Derailments generally were registered on sections with curve less than 850 m. radiuses (Figure 6). About 70 per cent of wagon derailments occurred at speeds exceeding 60 km/h (Figure 7).

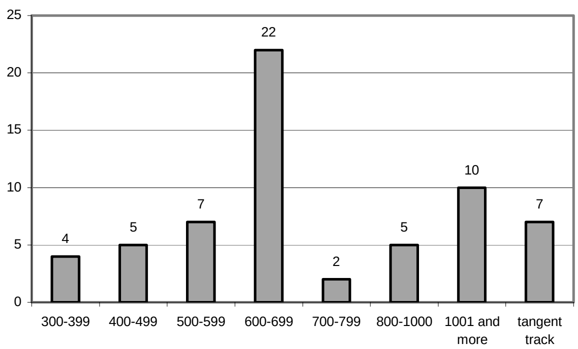

Figure 6: Distribution of empty wagons derailments by curve radii (m)

All this indicate the necessity for stricter track maintenance standards as related to sections with curve radius 850 m. and less, for empty wagons moving at speeds more than 60 km/h. This correlates with study results indicating initiation of intensive hunting of hopper- and tank-wagons starting from speed 60 km/h, especially with worn friction wedges and wheel threads.

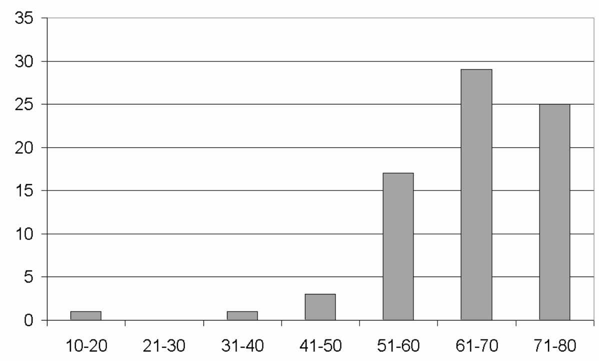

Figure 7: Distribution of empty wagon derailment speed ranges

The analysis indicated that probability of derailments is influenced by climatic factors. As shown in Figure 8, most of the derailments occurred in June-August (about 70 per cent) and under dry weather conditions (Figure 9).

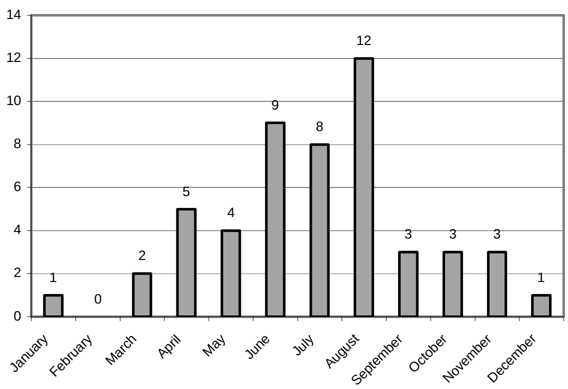

Figure 8: Distribution of empty wagon derailments by-month

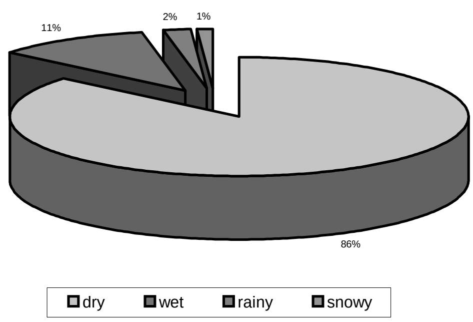

Figure 9: Derailments split by weather conditions

Complex of theoretical and experimental studies aimed at reducing the number of empty wagon derailments have been performed in 2002-2003. In the initial stage of these studies computer simulation of interaction parameters between hopper wagon and track with irregularities. Sequences of irregularities 100 m in length on transition and circular curve track section of diverse radiuses under various wagon speeds were simulated. There were performed more than 20,000 alternate calculations using variable vertical and horizontal amplitudes and lengths of irregularities as well as variable distances between their tops. Derailment stability factor was considered as an output parameter, determined as follows:

$$k_u = \frac{V}{L},$$

where V – vertical force acting from wheel to rail, L - horizontal force acting from wheel to rail.

The results thus obtained are shown in Figure 10.

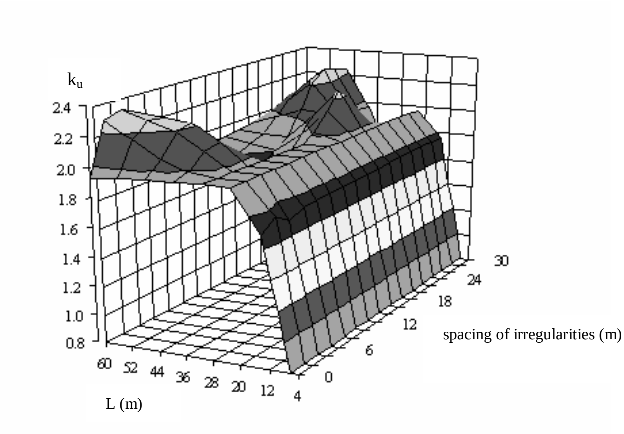

Figure 10: Theoretical estimate of derailment stability factor of a wheel passing the sequence of track horizontal irregularities

To validate the results of theoretical study experimental tests were carried out at the VNIIZhT's Test Center. Combinations of vertical and horizontal irregularities in the transition curve adjacent to the 400 m circular curve while hauling over these irregularities hopper wagons in different condition were tested. To conduct these tests special train consist was made up comprising experimental wagons and mobile laboratory (Figure 11). Special calculations allowed to define track guide mark and to specify braking mode of non uniform train, thus facilitating derailments of empty wagons within its consist. Wagon-track interaction forces were measured from the wagon side and on from the track side. The tests indicated that in the most unfavorable interaction situation with degraded damping in suspension system and track irregularities, speed should be restricted to the 60 km/h level. Otherwise k_u may become less than 1.0 and prolonged separation wheel – rail contact takes place (Figure 12).

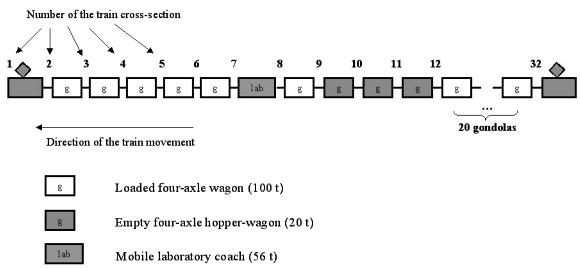

Figure 11: Experimental train consist

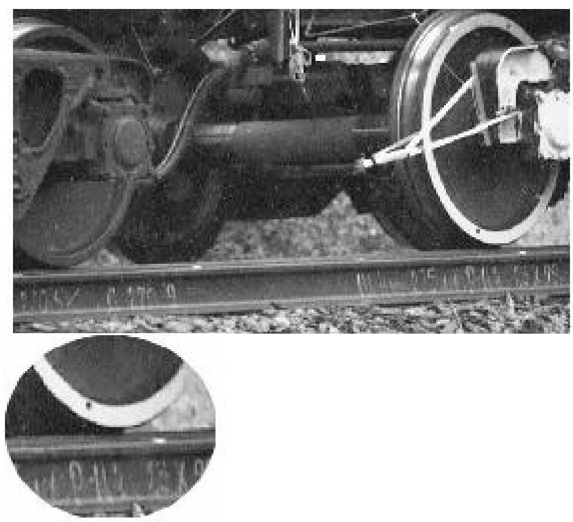

Figure 12: Loss of contact between wheel and rail

Action of longitudinal compressive forces resulting in increase of lateral forces acting from the object to the rail at irregularities thus decreasing wagon derailment stability. The conducted tests indicated that the wheel separation from the rail running surface occur only when there is no lubrication. Lubrication effectively prevents such liftoffs with similar forces involved.

Package of measures basing upon test results was developed to reduce the danger of empty wagon derailments. These included stricter track maintenance tolerances as related to horizontal irregularities, stricter wagon release-from-repair tolerances, newly developed wagon maintenance standards, improvement of wagon repair quality, identification and placing under repair of wagons with identified superfluous hunting and rolling.

However in the late 90-ties general safety situation on the Russian Railways came to stability. The number of serious safety violations does not reduce any more. In 1997 –2003 annual number of train crashes varied in the range from 5 to 10 (see Figure 1). At the same period annual number of freight trains derailments was in the range from 48 to 91 (see Figure 3) and passenger trains – in the range from 4 to 8 (see Figure 4). In 2001 – 2003 some increase in absolute annual number of penalty cases was observed (from 5,341 to 5,600). However there was small reduction in the number of penalty cases (from 4.14 to 3.93) as related to one million train-km.
In 2003 absolute number of penalty cases increased by 11.3 per cent (from 652 to 726) and their relative number – by 1.0 per cent (from 0.215 to 0.217) as compared with 2002 level. The number of train accidents and crashes also did not decrease just as did not their severity. The total number of penalties charged against **Track & Structures Service** increased by 14.7 per cent (from 890 in 2002 to 1,021 in 2003). This Service is one of the two in JSCo "RZD" structure (the other is Service for Commercial and Freight Operations) suffering increase in the number of penalties related to one million train-km (from 0.29 to 0.31 – by 4.1 per cent). Its staff was guilty for two train crashes (from the total 6 on the RZD network).
In 2003 to compare with 2002 there was an **increase** in the number of:

- derailments of rolling stock as operated with passenger trains – from 4 to 7
- derailments of rolling stock as operated with freight trains – from 70 to 72
- breakages of wheelset axle journals – from 2 to 6
- wheel fructure – from 3 to 5
- passenger coach en-route uncoupling due to technical faults – from 45 to 50
- locomotive failures requiring the change for a spare one – from 252 to 299
- signal unprotected job sites – from 36 to 38
- wagon setoff due to roller bearing faults – from 1,122 to 1,214
- in-train self-detachments of automatic couplings – from 100 to 107
- bursting open the switches – from 13 to 21
- track disturbances causing line closure or speed limitation to 15 km/h – from 293 to 401
- derailments of rolling stock under shunting operations – from 56 to 58
- train running over foreign objects – from 13 to 37.

Stabilization of traffic safety in general and annual random fluctuations of the number of different type of safety violations proves that the potentialities of the traffic safety management system employed by the former MPS-Russia, as related to its influence over the rate of traffic accidents and breakdowns, are practically exhausted. If adopted without any modifications by the JSCo "RZD" it is capable at its best to maintain the achieved traffic safety level. Year-after-year repetition of similar traffic accidents and prerequisites to such accidents with the same immediate causes indicates that we face the challenge of **systematic drawbacks**, such as:

- Lack of special-purpose subdivision within the railway transport managerial system dealing solely with traffic safety management problems. As with the existing system, safety inspectors are authorized to perform only safety control functions while responsibility for safety provision is distributed between railway technical and operational services.
- Train breakdowns preventing measures are developed basing upon analysis of already happened violations of safety conditions but not on risk analysis of their possible occurrence in the future.
- In some instances transportation plan is fulfilled at the expense of violation of safety rules (non providing necessary repair intervals and statute-established hours on duty and rest of locomotive crews).
- Prevailing of quantitative before qualitative (including those traffic safety related) indices as far as maintenance and repair of railway rolling stock and infrastructure components are concerned. Wagon service for instance prefer to achieve planned quantity indices at the expense of repair quality.
- In some cases set-up norms are inadequate for carrying out in-corporate routine maintenance of wagons (for instance in regard to wagon inspection at inspection points) or unsupported with adequate performance capabilities of technical facilities;
- Not clearly defined responsibilities related to individual processes and allotted works.

In an effort to eliminate these drawbacks in frame of Strategic Development Program of the JSCo "RZD", discussed at the session of the Company Board on June 11,2004, the set of large traffic safety improvement measures was suggested, including:

1. Establishing Traffic Safety Management System within the JSC "RZD" structure as a component of the Company's **Integrated Quality Control System** based on the ISO 9000 family standards. This measure is the most fundamental one.

2. Revision of legal, normal, technical and technological documents now in force; developing special **technical regulations** covering all the Company's activities aimed to ensure traffic safety of railway transport.

3. Development and testing, before 2007, the Multilevel Traffic Control and Train Protection System, incorporating unified complex system of locomotive safety devices (EKS), system of wayside signaling equipment and track and rolling stock diagnostics, necessary hardware-software complex. Further step-by-step introduction of Multilevel System on the JSCo "RZD" network.

4. High priority development and introduction as related to:

- monitoring facilities intended to supervise over actions correctness of operational staff including locomotive drivers, multiple units and other self-propelled vehicles, station masters and train dispatchers
- occupational selection, primary and advanced training programs for operational staff to be implemented at specialized training centers and base enterprises of railway transport
- traffic safety related railway staff motivation system.

5. Development and upgrading of traffic safety related **social control and responsibility**.

Implementation of indicated measures may allow **annual reduction** in the number of traffic safety violations on the JSCo "RZD" network not less than **by 10 per cent.**, related to one million train-km in all types of traffic.

Implementation of the Strategic Program of traffic safety on the JSCo "RZD" network pursues the goal of achieving traffic safety level with risks of causing damage to environment and human life, health, and property acceptable in terms of existing social values and retaining social image of railway transport as the most safe among all the freight and passenger transport modes. Such an approach will contribute to optimization of traffic safety related costs and finally to better financial stability of JSCo "RZD".