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INDUSTRY REVIEW 2010-2011 | PRODUCTION ACTIVITIES
1435-1520 COOPERATION | BOGIE UNIFICATION | COMPUTER VISION

N O N - P R O F I T   P A R T N E R S H I P   U N I O N   O F

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ABOUT THE ISSUE

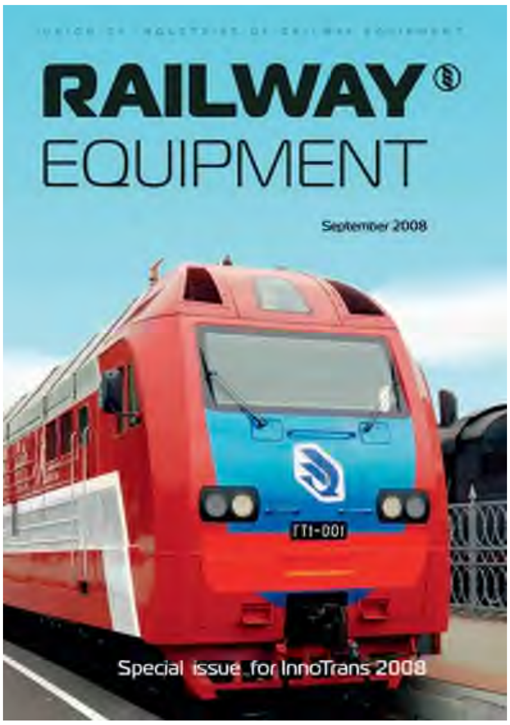
RAILWAY® EQUIPMENT

The Railway Equipment magazine is the leading issue in the Russian railway industry. Established in 2008, today the magazine is published 4 times a year only in Russian so far. For all magazine's issues editors exactly hold by its aim – impartial reflection of Russian railway industry and manufacturers state and development trends.

Published by the Institute of Natural Monopolies Research with the UIRE support, the Railway Equipment quickly attained the great interest and respect from industry specialists. By 2010 the magazine obtained the scientific status. As a result, it became the general publishing venue for materials dedicated to scientific and technological breakthroughs of Russian railway industry. Famous and influential specialists from Russia and abroad publish their article on the pages of the Railway Equipment magazine.

Besides materials about technical, economic and legal aspects of railway industry development, the magazine includes unique statistics covering the recent industry state. Based on official data of Russian Federal executive authorities, Russian Railways JSC and rolling stock producers, actual statistical figures are published on the quarter basis and will be interesting to the all industry enterprises. Published data includes macroeconomic figures, rolling stock production levels divided by the producers, quarter financial results of industry activities.

You have in your hands the third special English-language issue of the Railway Equipment magazine plotted for InnoTrans 2012 International Fair. Inside you will find the information about the latest Russian railway industry and UIRE activities, the translated most interesting materials from Russian-language magazine issues published after previous InnoTrans, industry activities figures of 2010-2012.



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IPEM

Institute of Natural Monopolies Research (IPEM)

объединение производителей железнодорожной техники ОПЖТ

Union of Industries of Railway Equipment (UIRE)

Dear friends!

From the pages of the Railway Equipment magazine special issue I welcome you at the InnoTrans 2012 International Trade Fair of innovative transport technologies. This event has traditionally been symbolic for all the participants of transportation process all over the world: railway companies, manufacturers of railway equipment, carriers, shippers and passengers. The Russian participants lay special hopes on the InnoTrans exhibition as well.

The geographical position of Russia places a strategic challenge before its railways to implement the potential of the world economy growth. As a transport link between Europe and Asia, the Russian railways are obliged to ensure high efficiency and reliability of traffic between the two continents. And the development of railway industry plays an important role in this process.

Throughout the whole global history of the railway communication, Russia has been and remains the advanced country in the sphere of railway transport including creation of railway equipment and accessories. Having gone through a difficult period of economic transformation, Russian transport industry managed to maintain its scientific and technological potential. The innovative products presented by the Russian manufacturers at today's exhibition are a symbol of Russian potential and they give a chance to look into the future. A great contribution to the implementation of the Russian railway industry innovative and technological potential is made by the Union of Industries of Railway Equipment – UIRE, which has been working for five years already.

In two years since the InnoTrans 2010 exhibition, the level of cooperation between the Russian and foreign manufacturers of railway industry has considerably increased. The signing of the Lastochka (Swallow) electric trains supply contract and the presentation of the first Russian EP20 double-current electric locomotive of the fifth generation were the marquee events of the last year. These projects are the result of cooperation between the Russian and foreign manufacturers and are bright indicators of its potential.

The current economic conditions and the entry of Russia into the World Trade Organization open new opportunities to the manufacturers of railway equipment and accessories to deepen their cooperation and exchange of technologies. The Russian Railways JSC is sincerely interested in development of cooperation between Russian and global railway industry manufacturers, which will contribute to the realisation of the global scientific and technological capacity and solution of the problem to provide Europe-Russia-Asia traffic.

Vladimir Yakunin,
President of the Russian Railways JSC

UIRE : 5 YEARS ALONG THE WAY OF INTEGRATION PARTNERSHIP EVENTS

Nikolay Lysenko,
Vice President, Executive Director
Union of Industries of Railway Equipment (UIRE)

In June 2007, the Russian Railways JSC, the Transmashholding CJSC, Machinery & Industrial Group N.V. and Russian Corporation of Transport Manchinery JSC (RCTM) established the non-commercial partnership "Union of Industries of Railway Equipment" (UIRE). The necessity of its establishment was caused by the following reasons:

- implementation of large-scale structural changes in the Russian Railways JSC, which altered substantially the terms of interaction between the producers and consumers of railway equipment;
- low investment opportunities of the separated proprietors and shareholders of the machinery complex that did not allow to satisfy even the minimum needs for new types of the rolling stock and infrastructure components;
- serious obstacle to the development of railway industry enterprises because of outdated production facilities, a basic assets renewals slowdown and introduction of new technologies that required to search actively for the solution for the incipient problems.

Therefore, the necessity to create the organization that would unite the interests of the manufacturers ripened. More than 50 domestic machinery enterprises, scientific, engineering and innovative organisations expressed their willingness to integrate. Literally from the first months of its existence, the Partnership has shown the ability to respond quickly to the emerging problems of the industry and to determine the ideology of joint actions.

The consolidation of the railway equipment and infrastructure components manufacturers efforts for the creation of the new rolling stock generation, which has competitive advantages, high quality, safety and power efficiency were specified as the Partnership mission.

To date, the Partnership includes 124 enterprises from 34 regions of the Russian Federation, which manufacture 87% of all country rail production, and their turnover amounts to more than 5.5 billion euros.

The creation of a new rolling stock line became a serious technological breakthrough. One of the first achievements is the creation of the fundamentally new locomotive, operating on liquefied gas – the GT-1 gas turbine locomotive. This locomotive is developed for driving of heavy freight trains. It has already set a world record, which is included in the Guiness World Records. Last autumn, within the framework of the international EXPO 1520 railway show, the gas turbine locomotive drove the longest (2,053 m) and the heaviest (16,000 tons) freight train in the world. In addition, the largest holdings of the Partnership – Transmashholding CJSC and Sinara Group CJSC with the support of such foreign partners as Alstom and Siemens have created new types of railway rolling stock–electric locomotives EP20, 2ES5 and 2ES10, which have significant competitive advantages.

Fig. 1 Gas turbine locomotive GT-1

At the end of January 2012, a new plant was opened in Tikhvin to produce freight cars on the basis of the Barber bogie, which could well become one of the leaders of the domestic wagon building. At the plants of the Promtractor-Vagon CJSC, Tver Carriage Works JSC, Tikhiv Assembling Plant "Titran-Express" CJSC (TSZ), the family of the manufactured rail carriages was updated. The manufacturing facilities were upgraded substantially at the other enterprises of the UIRE members. This provided a good groundwork for significant improvement in product quality, increase of its safety and competitiveness.

"During five years of its work, the UIRE has signed several agreements on cooperation. The new models of railway vehicles have been created. Now, the goal to achieve 80% localization of foreign novelty production in Russia has been set. This paves the way not only for the development of railways, but also for the creation of new enterprises, and, thus, new jobs for the population of the regions of our country.

Take that competition among the chief designers of the member enterprises of the UIRE, for example. Just that very competition gave a powerful impetus to the development of new domestic models of the railway industry."

Vladimir Yakunin,
President of the Russian Railways JSC

Fig. 2 Prime-Minister Vladimir Putin at the opening of Tikhvin car-building plant

It is worth mentioning that the Partnership reacted to the well-known crisis events of 2008 by its 80 enterprises signing of the Charter of fundamental principles of responsible business in the field of railway industry. According to the leading experts, the actions of the Charter participants became an example for the whole national economy. One of the main objectives of the Partnership is generating a system of technical regulation in the field of railway industry, creating a new regulatory framework (a system of technical regulations and standards in this sphere), and a system of voluntary certification. Now, 32 UIRE standards have been already developed and adopted in the Partnership and 18 testing centres and laboratories in the system of voluntary certification have been accredited.

The UIRE cooperates actively with similar international organisations (UNIFE - The Association of European Railway Industries, AAR - Association of American Railroads, RST - the Institute for US suppliers of railway equipment). Long-term agreements on cooperation have been concluded with these organisations.

One of the priority international activities of the Partnership is to implement the International Railway Industry Standard (IRIS) at the domestic enterprises of railway mechanical engineering. UIRE has established strong relationships with both the management of the IRIS Management Centre and UNIFE. Also UIRE have already held four international conferences to implement IRIS at the domestic enterprises, prepared more than 100 professionals (with the help of foreign teachers) and more than 1,900 ones (with the help of Russian teachers) who can work with this standard.

As a result of this work, the first Russian company that received the certificate of conformity to the International Railway Industry Standard in April 2010, was the Izhevskiy Radiozavod JSC. In 2011, the MTZ Transmash JSC was certified.

Today, more than 50 enterprises and organisations that are planning to undergo the certification procedures in 2012 and 2013 are involved actively in this work. All this allows the Partnership to integrate the work of the Russian enterprises into the European transport system effectively.

In the UIRE 12 specialised committees work actively, including the committees on locomotive and wagon building, on quality and innovation, the Council of the Chief Designers, the Committee on technical regulation and others. Since that time, over 170 meetings of the committees were held, both separate and joint ones, which handled the problem of creating new types of the railway rolling stock, staffing issues, the questions of innovative development, enhancement of the role of designers of the enterprises in upgrading the model line-up of high-performance machinery, development of the system of technical regulations both domestically and throughout the territory of the Customs Union. For the first time in 2011, the Partnership held a competition of the best innovations in the railway industry. To encourage the winners of the competition, more than 4.5 million roubles were spent. The following projects were recognised as the most notable innovations: the GT-1 gas turbine locomotive (VNIKTI JSC), a specialised open top wagon with an axial load of 27 tonne-force for transportation of coal (VNIKTI JSC), all-purpose covered freight wagon with 25 ton-force axial load and sliding sides (Freight One JSC), a vehicle for local track alignment (Kirovsky mashzavod 1 Maya JSC) and several other projects.

Since 2008, the Railway Equipment magazine has been published quarterly with the support of the UIRE. It summarises the experience of the Partnership enterprises on their way of technological renovation of manufacturing facilities and innovative development.

The Partnership cooperates actively with the Russian Engineering Union, in which the Committee on railway mechanical engineering works. A significant part in the activities of the UIRE is given to cooperation with the Federal authorities as for the formation of the new legislative framework. The Committees held the public hearings and discussions of such Federal Laws as ‘On standardisation’, ‘On accreditation of conformity assessment’, ‘On energy saving and energy efficiency improvements’, and the amendments to the Law ‘On technical regulation’.

The Partnership suggestions that provide for the acceleration of scientific and technological progress, the increase of the motivation of the manufacturers to innovative development, energy saving, improvement of quality and enhancement of responsibility for the technical level of the products, are sent to the Government of the Russian Federation, the State Duma and the Ministry of Transport.

On its platform, the Partnership together with the Russian Engineering Union and the Russian Union of Industrialists and Entrepreneurs carried out the public hearings and updating of the following three technical regulations approved today: ‘On safety of the railway rolling stock infrastructure’, ‘On safety of the railway rolling stock’ and ‘On safety of the infrastructure and railway rolling stock of high-speed railway transport’, which form the basis for further activities not only on the territory of the Russian Federation but throughout the Customs Union: Kazakhstan, Russia and the Republic of Belarus.

The implementation of proposals to amend the Tax Code of the Russian Federation as for the recognition of the charges of enterprises for the development of national standards as reasonable expenses that should be included into the cost of production of goods and services is a significant achievement of 2011 which allows to increase considerably the industry participation in the work on standardisation.

With the direct participation of the Partnership, Federal Law ‘On technical regulation’ was amended and, as a result, the government funding for the development of regional and international standards was allowed, besides, the need to create a unified national system of accreditation based on international and European principles and approaches was legislatively determined.

In line with UIRE proposals, supported by the

Russian Union of Industrialists and Entrepreneurs, the amendments to the Code of the Russian Federation on Administrative Violations were made, and for the first time since the beginning of the reforms of technical regulations, the responsibility for failure to comply with the requirements of technical regulations and unfair certification has been established.

Since the moment of its establishment, the Partnership has also carried out an active regional policy. Launched in 2012, our integration Regions project received strong support among the enterprises. Four regional conferences were prepared and conducted, the Agreement on the interaction was concluded with the regional authorities of Tatarstan, the Chuvash Republic, St. Petersburg, Rostov and Omsk regions. UIRE uses the regions potential in the creation of new rolling stock components types, and innovative technologies.

In the future, UIRE will continue to develop the standards and, among other things, to support the approved technical regulations of the Customs Union in the field of railway transport; besides, it is going to participate actively in the formation of the unified national system of accreditation.

Today, the Partnership has already created a solid foundation for the innovative development of the enterprises of the railway mechanical engineering industry and component suppliers. Coordination of their activities to create the new models of railway vehicles, which are not inferior in their characteristics to the best world analogues, will be the essence of our work for the future.■

GERMAN EXPERIENCE FOR RUSSIAN RAILWAY ENGINEERS

The collaborative UIRE and Siemens-Manufakturing workshop “The organization of effective production system, employment modern quality management tools and lean production technologies” took place in German city of Krefeld on 21-22 of June 2012. The aim of the meeting was the discussion of partnership perspectives between the German Railway Industry Association (VDB) and UIRE. Totally 63 people participated in the workshop: 56 (represented 31 enterprises) – from Russian side, 7 – from German.

The workshop program included theoretical and practical sections. The practical one was divided in two days: first day included the demonstration of shop floor, which is specialized on rolling stock production excluding lining and tinting. The education welding area with approbation practice facilities and the final assembly shop floor were also visited by Russian specialists.

On the second day of workshop its participants visited the Wegberg-Wildenrath Test and Validationcenter based in North Rhine-Westfalia Land. This facility allows to provide trials for rolling stock of any dimensions and currents with axial pin burden up to 25 tons and running speed up to 160 km/h. The delegation members also made the introductory tour on one of the trains.

The theoretical session included the reports of workshop participants. It was also divided in two days. First report called "Rational production – Siemens production systems (SPS)" was presented by Dr. Axel Hausmann. According to the report, the aim of Siemens is the global employ-

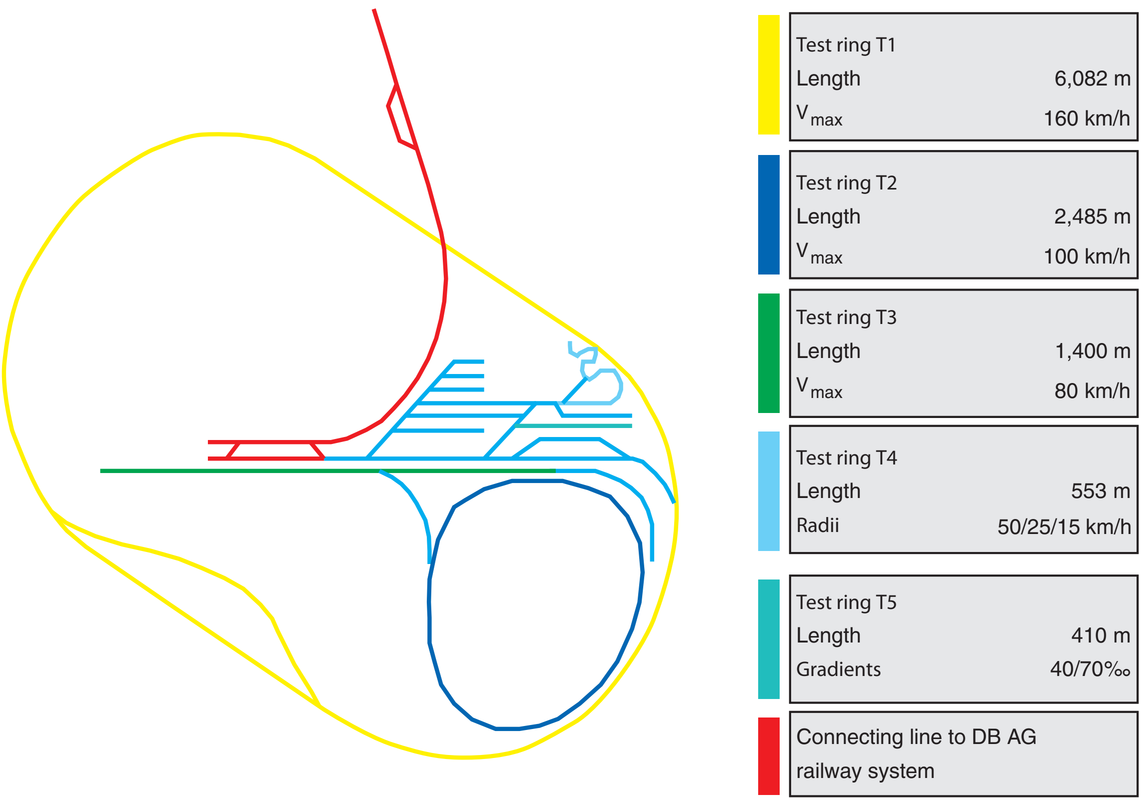

Fig. 1 The scheme of the Wegberg-Wildenrath Test- and Validationcenter

ment of SPS, which represent the structured way for "harmonious" production principles implementation. The offered idea means the obtaining of such working philosophy, activities spheres and methods, which require proper personnel qualification, overarching 5S methodology employment, extensive production reorganization into impurity production system, production employment of production area management and visualization technologies.

Dr. Ronald Perner, Director General of VDB, presented very interesting report "German Railway Industry Association – structure, goals and challenges", which described the history, major activities and events of similar to UIRE organization. VDB (der Verband der Bahnindustrie in Deutschland) is the main German industrial union of all railway equipment producers and components suppliers: at the present day 161 enterprises are the VDB members. The Association was founded in 1991 by the merging of the German locomotive industry (VDL) and wagon industry (VdW) unions. However it has roots dating back to 1877, the year of the German locomotive fabrics Union foundation.

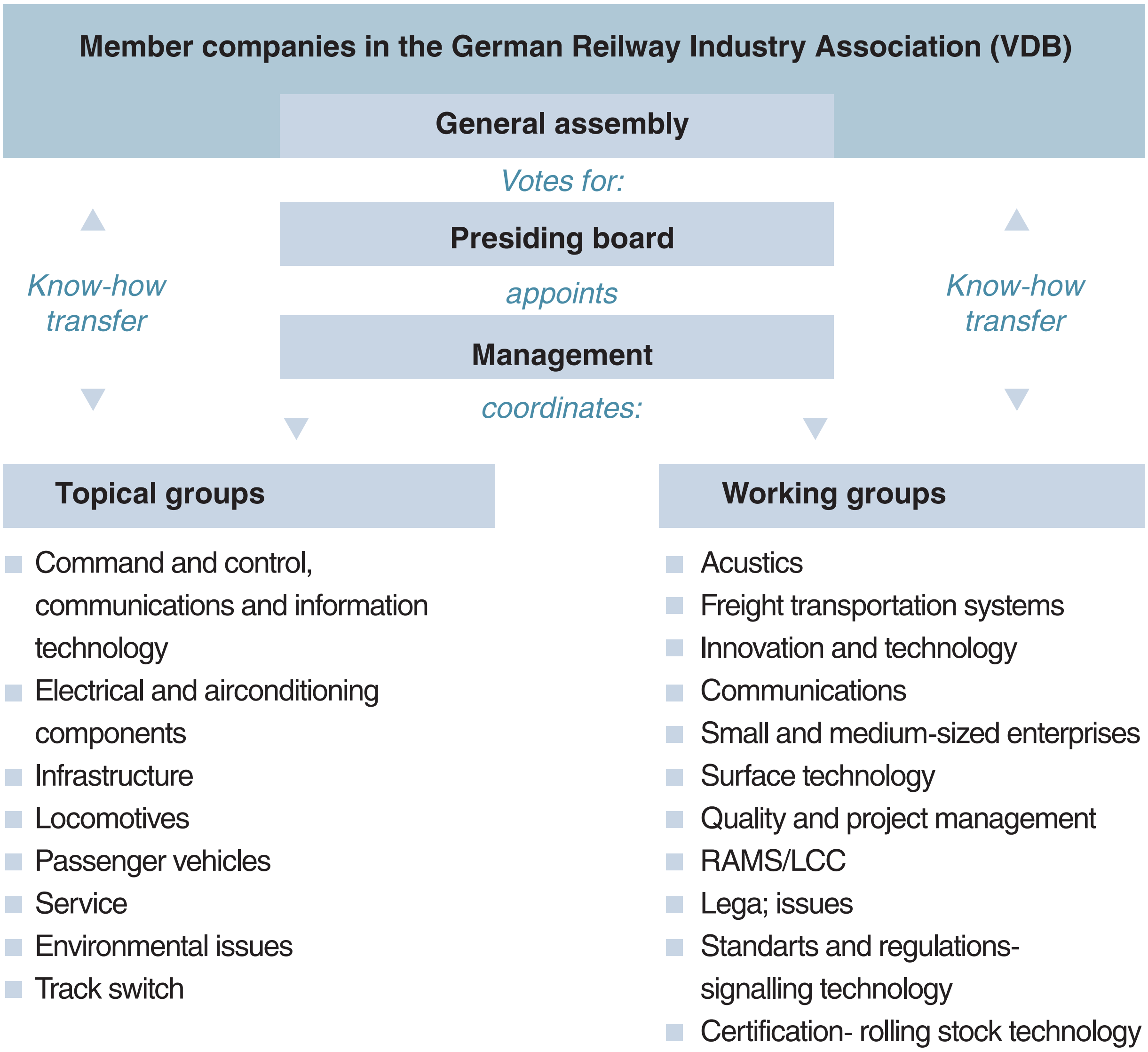

Fig. 2 Organization chart of VDB

Next reports were presented: "National, regional and global DQS certification services", "International IRIS Standard", "MF-KRF Quality management system", "Siemens Krefeld factory projects for Russian railways".

On the workshop basis, discussion between UIRE, VDB and Siemens took place and it was preliminary decided to provide collaborative conference for Russian and German specialists in following October or November. The conference is planned to be dedicated to actual topics of railway industry development and Russia–Germany cooperation. ■

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JSC "RZD Trade" has been operating in the railway industry for more than 15 years. As a result the company has obtained the reputation of a reliable and responsible partner that can offer its clients the most advantageous mechanism of cooperation and can guarantee stable and timely deliveries, as well as reliable execution of contractual obligations.

JSC "RZD Trade" is the largest supplier of rolling stock for JSC "RZD". The company provides JSC "RZD" and its subsidiaries with locomotives, multiple unit rolling stock (including electric trains, diesel trains, rail buses), passenger and freight rail cars. At present time JSC "RZD Trade" implements long-term contracts to supply modern electric multiple-unit trains Desiro Rus, freight locomotives 2ES5, 2ES10 "Granit" and passenger locomotives EP20.

On the centralized basis JSC "RZD Trade" provides subsidiary companies of JSC "RZD" with more than ten thousand nomenclature positions produced both in Russia and abroad. Supplied product groups are spare parts for rolling stock, track materials, metal products and goods of machine-building industry. The partners of JSC "RZD Trade" are rolling stock repair companies, railway machine-building and transport construction enterprises, manufacturers of track materials, railway freight operators and many others.

Being an authorized trade representative of enterprises forming Russian railways group JSC "RZD Trade" is actively engaged in international economic activity. The Company operates in Kazakhstan, Ukraine, Belorussia, Mongolia, Baltic States as well as in the countries of the Western and Eastern Europe, in China, in Guinea, in Cuba and in a number of other countries. Strategic partners of JSC "RZD Trade" are CIS national railways, large transport and manufacturing companies providing deliveries, operation, repair and maintenance of railway equipment and infrastructure. In order to promote Russian railway products and services on the markets of the Central and Middle Asia JSC "RZD Trade" has set up a subsidiary in Kazakhstan, "RZD Trading Company" Ltd.

With the aim to supply wagon-repairing works, subsidiaries of JSC "RZD", as well as other machine-building enterprises of railway industry with necessary components in 2011 there were carried out considerable contracts for importing freight wagons' castings (bolsters, solebars) from China to Russia and importing track materials from Germany to Russia.

Together with JSC "RZD" the Company implements large railway infrastructure projects, such as reconstruction of railway infrastructure in the Republic of Abkhazia, development of railways in Armenia, Mongolia and in a number of other countries.

Today Joint Stock Company "RZD Trading Company" is well-known for high competence, efficient business processes and reliable relations with producers and consumers of railway products in Russia and abroad.

INNOVATIVE DEVELOPMENT OF RUSSIAN RAILWAYS

Valentin Gapanovich
Senior Vice President, Russian Railways JSC,
President, Union of Industries of Railway Equipment (UIRE)

Globalization processes and changes in the traditional world economic ties make Russian Federation to face a problem of rational use of its unique geographic location and rich transit potential. In the present-day economic conditions, creation and implementation of innovative technologies offer a huge resource for improving efficiency of the railroad business, and enhancing the importance and competitive advantages of the railways. The innovative activities of the Russian Railways, which cover almost all operational fields and promote expanding of the market potential of the Russian Railways, are integrated into the company's business development strategy.

Changes in the scientific, technical and technological development of Russian Railways JSC, the country's machine-building complex, and the results from realization of innovative development have motivated the need for elaboration of the company's innovative development strategy by 2015, as well as for development and approval of the Program for the company's innovative development by 2015 by its Board of Directors. The program envisages realization of 12 main lines of activity and contains a set of measures aimed at the development and implementation of new technologies, world-class innovative products and services, and measures to encourage innovative development in key industries of the Russian Federation.

SECURITY MEASURES

Due to one of the key lines of the "System for control and ensuring safety of train operation" the transition to intellectual railway transport is realized, with preserving integrity of control in every link of the traffic process and for ensuring the necessary degree of safety in train movement.

Speaking of a complex for dispatch train movement control at Russian Railways JSC, we should note that its further development is connected with elaboration and implementation of multi-functional systems for train operation control and supervision, based on microprocessor software and hardware complexes meeting high safety standards, including relevant international standards. Top management of Russian Railways JSC has set a goal to improve substantially the quality control functions, as regards performance of technological processes at all of the three levels of dispatch control and increase information integrity through abandoning the practice of its manual input and formation. The set of goals also includes development of integrated diagnostics systems that combine means of detecting and forecasting the status of technical infrastructure and rolling stock.

Today particular attention is paid to the development of the third stage of control technologies which can be referred to as intellectual to the fullest extent because of decision support systems that cannot be implemented without emergence of a new generation of information and controlling systems.

We cannot fail to mention the program for development of line dispatch transportation control systems (Fig. 1), which are entrusted with the task of coordinating car traffic volumes, a task of incredible difficulty when one has to deal with rolling stocks, which are all private now. A spectacular example of that are transport control centers in Oktiabrskaya, Yuzhno-Uralskaya and Severnaya Railways which are equal to their foreign counterparts in terms of functionality.

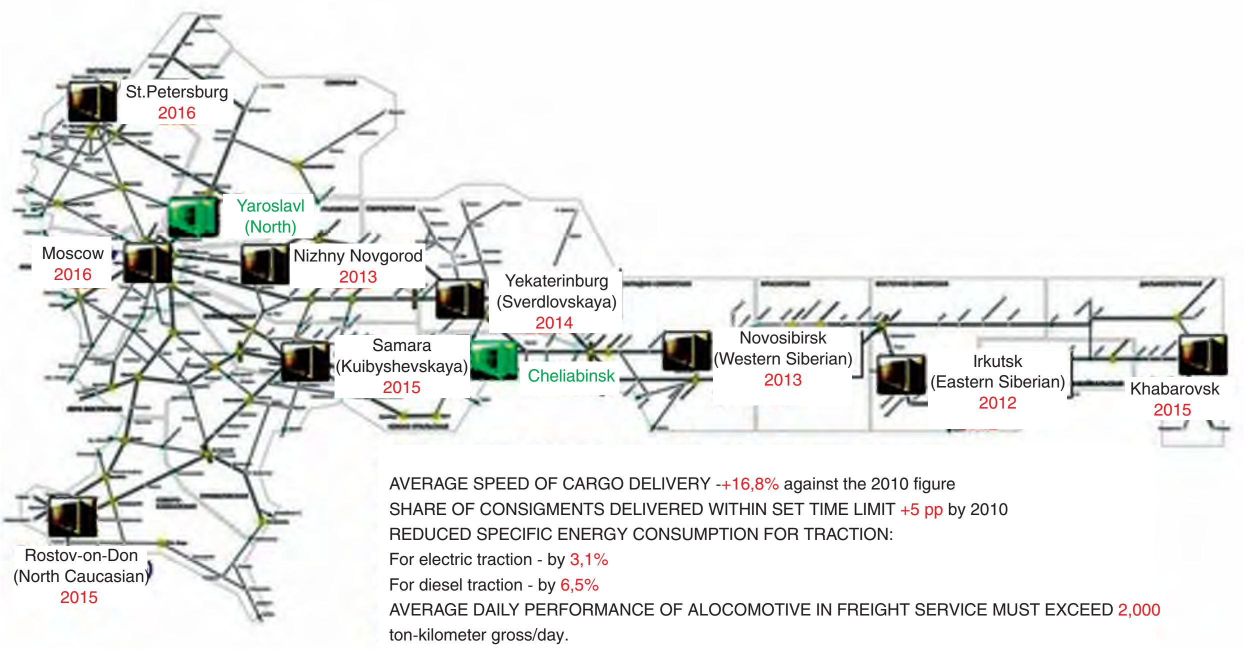

Fig. 1 Development of line dispatch transportation control systems by 2015

Satellite technologies have become an important component of systems for control and safety. Nowadays, our company changed from application of their particular elements to end-to-end innovative technologies for the enterprises of the railway transportation industry. In Russian Railways JSC they are considered not only as one of the elements in the structure of intelligent transport, but also as a national goal of creating an assured and stable market of domestic consumers for the GLONASS system. More than 12,000 GLONASS/GPS satellite navigation devices have been installed on locomotives and railway rolling stock. Based on these technologies, now we control more than 450 passenger trains, track test cars, all fire-fighting trains and wrecking trains, rail-grinding machines and other equipment for track repairs.

We have also created a new product – the "Autodispatcher", an automatic dispatching system for traffic control, designed to ensure high reliability and safety in passenger transportation. The system is integrated with GSM-R digital communications lines, GLONASS satellite navigation system and the ITARUS-ATC Russian-Italian complex. The system will allow dispatchers to control more than two thousand objects at the same time, with more than one hundred of them being mobile objects.

One of the most important tasks of the integrated system is ensuring functional security with account of a set of possible conflicting situations. The logic of computer intelligence allows its memory to keep thousands of data fragments, including routes of all trains on a particular day and peculiarities of their admission to railways with account of infrastructural limitations. Along with traffic safety, transportation and information safety must be ensured as well.

IMPROVING THE SYSTEM OF DIRECTING TRAINS

The task of optimizing train operation is performed in combination with one of the most effective ways of energy-saving – the transfer of passenger trains to optimal schedules. By results of this year's work, 1,200 passenger trains have been shifted to optimal schedules in all major areas of Central Russia and to Novosibirsk. Just by the first half of 2011

8.9 million kWh were saved due to energy-saving measures with automatic driving systems and energy-saving schedules implementation. The task for the next year is to shift main diesel-operated train movement to Vladivostok and from Vologda to Vorkuta to similar schedules. More than 2,100 locomotives have been equipped with universal automatic driving systems to enable such energy-saving schedules.

One of the key lines of activity of train movement control improvement is represented by decisions to implement energy-effective schedules of freight trains (Fig. 2). Experiments conducted in the spring of 2011 in the Yuzhno-Uralskaya Railway have unambiguously confirmed the effectiveness of this technology.

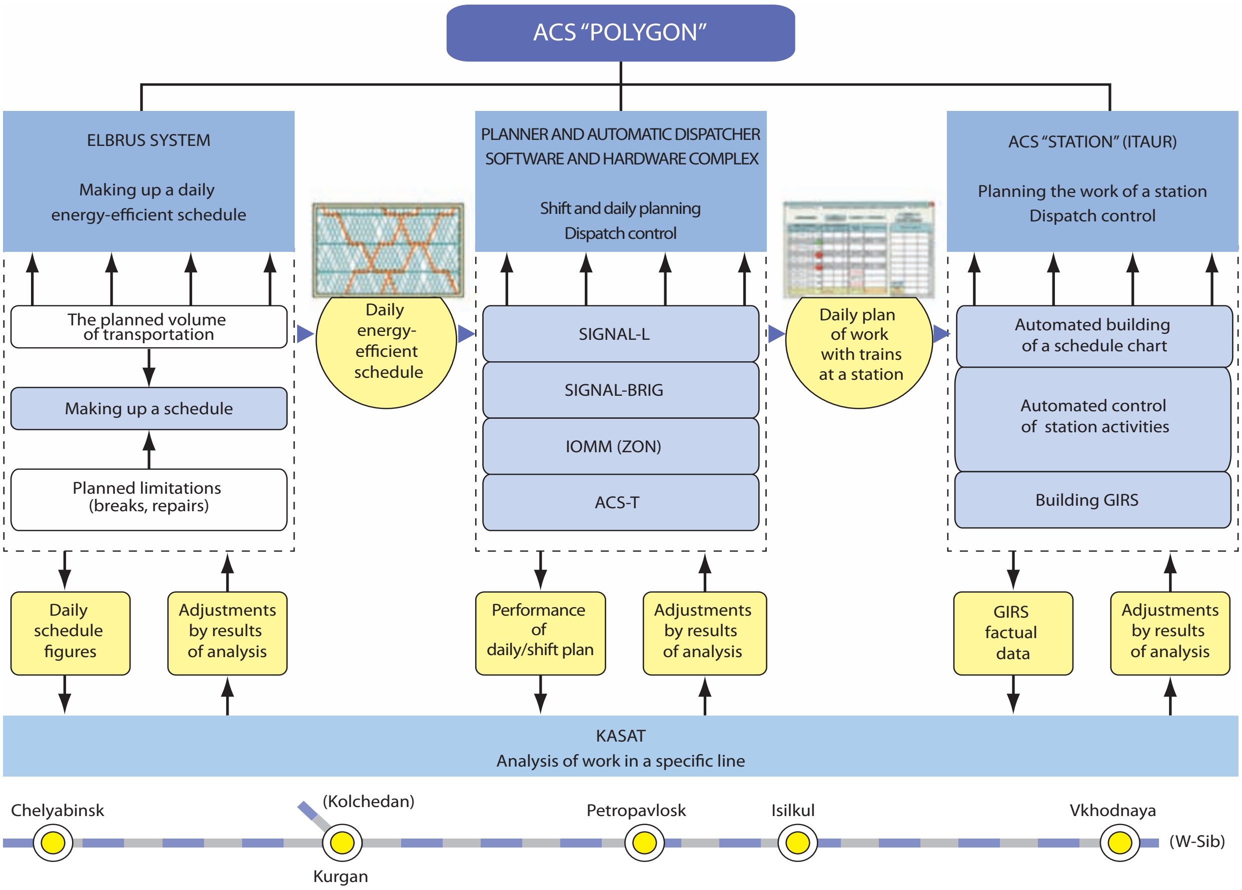

Fig. 2 The system for planning and controlling train traffic volume in polygons of the railway network, based on energy-efficient schedule for freight train movement.

The next stage of development for control of schedule-based train movement should be the ACS "Polygon" system, which is currently under development. It is based on the daily energy-saving train movement schedule, for which allocation of hauling resources and works of technical stations are planned.

INNOVATIVE PROJECTS

Creation and implementation of innovative technologies is a tremendous resource for improving business efficiency, importance, and competitiveness of railways. Due to the Russian Railways' policy of innovative development, the productive, technical, and economic efficiency of railway transport is increasing; the policy ensures reduction of transport costs and fund-raising for development purposes, including development of other industries of the national economy. It does not only allow the state, enterprises of the industry, and investors to feel the financial impact, but also helps to accelerate the social and economic development of Russia.

The company has approved the Program for innovative development based on further strengthening of scientific and technical cooperation with institutions of higher education, the Russian Academy of Sciences, research organizations, state corporations, and leading domestic and international manufacturers. Much attention is paid to such lines of activity as forming and ensuring continuous education process to train railway personnel and educate the younger generation.

In 2011, R&D funding volume have increased by 21% as compared with the previous year's figure (up to 5.7 billion rubles), which makes 0.46% from the planned revenues. In the long view, it is planned to raise this figure up to 1% by 2015.

The need for optimization of the transportation economy along with stricter technical and maintenance requirements to the rolling stock determine the trend of further development for this economic sector. For example, transition of autonomous traction to gas-based technologies is promoted by the first world's line-haul freight gas turbine locomotive GT1 with a capacity of 8,300 kW. This locomotive's life-cycle cost is almost 20% lower than that of a main-line diesel locomotive. Meanwhile, noxious emissions of the gas turbine are more than 5 times lower than regulatory requirements for diesels specified in the corresponding EC directive, and the ambient noise level complies with requirements of state standards. In 2010, the gas turbine locomotive took an operational run of 5,000 km with trains ranging in weight from 7,000 to 9,500 tons, and in 2011 it was sent to the Moscow Railway to continue in-service testing.

Another example of implementing innovative technologies in cargo traffic is the organization of movement of 6,000-ton freight trains over the testing ground from the Kuznetsk Basin to Vanino port with the use of Vityaz diesel locomotive with asynchronous motor. The use of these locomotives will ensure operation of heavy trains along the whole length of the Baikal-Amur Mainline.

It should be acknowledged that by the number of lines, modern foreign-made railway equipment is considerably superior to their Russian counterparts. To overcome this technological gap, much attention is paid to transferring newest foreign technologies. Co-development projects of Russian Railways JSC, foreign and domestic companies allow to create new models of rolling stock with world-class performance ratings.

For example, in cooperation with Transmashholding CJSC and Alstom Transport we have developed a dual-voltage fast electric passenger locomotive of a new generation – the EP20, with the maximum range increased by 250% in comparison with existing models. In December 2010, a production prototype of the locomotive was manufactured; it is currently undergoing check-out testing. It is expected that the production of 200 locomotives will be organized until the end of 2020.

Besides that, electric locomotive 2ES10 “Granite” created in cooperation with Siemens LLC at the facilities of Ural Locomotives LLC in the town of Verkhniaya Pyshma, Sverdlovsk Region is a new step in domestic freight locomotive construction. The use of asynchronous traction and a number of other innovations allowed us to create a locomotive with brand new performance characteristics. For example, the experimental run with a train of 9,000 tons in Sverdlovsk Railway showed that the experimental three-section electric locomotive 2ES10 can take freight trains through the same railroad segments with the weight exceeding by 150% the train tonnage standards established for the existing three-section VL11 electric locomotives. In addition, the life-cycle cost of 2ES10 locomotive is 21% lower than that of VL11. Operation of 2ES10 locomotives by multiple-unit system allows excluding chances for the "fracture" of tonnage freight in their passing the Urals mountain ridge, and accelerating movement of heavy trains in one of the most cargo-intensive lines, Kuznetsk Basin–Northwest. Certification trials currently underway confirm excellent engineering performance of new electric locomotives.

We also continue our cooperation with Siemens LLC in development and supply of 38 Lastochka electric locomotives based on the Desiro platform. The peculiarity of this dual-system locomotive is safe operation in the alpine mode with ruling gradients up to 40%, which far exceeds the requirements implemented in European countries.

We have signed an agreement to create an engineering center for development of multiple-unit rolling stock; the main task of this center is ensuring successful transfer of technologies.

We have created a number of engineering centers for freight wagon construction. Such companies as Tatravagonka JSC (Slovakia) and Knorr-Bremse AG (Germany) participate in our joint projects in creating new freight rolling stock.

With participation of Russian Railways JSC and Tikhvin Car-Building Plant, and in cooperation with our American partners, new models of freight wagons have been developed.

Together with Siemens LLC we are working to create an engineering center to develop modern systems for railway yard control automation, and we are working on modern automation and telemechanics systems in cooperation with Bombardier.

Today, we continue implementation of innovative technologies and technical solutions for infrastructure. The most crucial infrastructural object is the railway track. Implementation of new technologies in railway track system allows prolonging the operating life of superstructure and road foundation, and reduce life-cycle cost while improving safety.

Emergence of new technological tasks in the work of railway transport, shifting freight train movement to firmly established schedules, including in large grounds, and creating a transportation system for organization and holding of the Olympic Games in Sochi required a new innovative approach to development of systems for control and ensuring traffic safety.

In the first place, it is the automated system for high-speed traffic control implemented in the St.Petersburg–Moscow line. Another novelty, which is already in operation is the automatic setup of routes and transmission of data for the automatic driving system over the radio.

Satellite technologies are more and more widely used in the railway network. Even now, they allow to organize the work with the rolling stock, receive, and supervise repairs of railroads. Today all new locomotives are equipped with diagnostics systems that allow controlling the work of locomotives throughout the entire network with a variety of parameters.

Another new trend is the creation of a single spatial model of railway infrastructure. This direction acquires a particular relevance in connection with development of fast and high-speed traffic.

According to expert estimates, the economic effect after implementation of this in the main lines of the country's railway network can exceed 5 billion rubles a year.

INNOVATIONS IN THE FIELD OF FAST AND HIGH-SPEED OPERATION

Innovative development of Russian railways is impossible without implementing the Program for development of fast and high-speed transportation areas, the main result of which for the present day is putting high-speed "Sapsan" trains into commercial operation. Opening high-speed passenger service on the St. Petersburg–Helsinki line on December 12, 2010 determined a new level of international passenger service between Russia and Finland.

In the course of realization of the innovation program, the primary railway ground and strategic guidelines for development of high-speed traffic in Russia have been determined.

The primary railway ground for high-speed traffic is a dedicated railway line in the Moscow–St. Petersburg Railway. In the future, it is planned to develop high-speed railway network in the strategic direction East–West through Moscow, with speed of running set at 350 – 400 km/h.

By the order of the Government of the Russian Federation we have developed a Concept of modernization and development of railway infrastructure with account of construction of dedicated high-speed railways to organize passenger transportation during the World Football Championship, which has been reviewed and approved at the meeting of the scientific and technical council of Russian Railways JSC on June 15, 2011. In accordance with this Concept, we have made corrections to the plan for development of fast and high-speed railway traffic. In addition to existing fast and high-speed lines, it is planned to upgrade a number of existing regular lines to allow increasing train speed to 160-200 km/h, and also update lines to organize faster movement of trains with average speed of 70-90 km/h. It is also planned to organize passenger transportation between airports and cities hosting events of the 2018 World Cup. Within the framework of the Concept, we have determined the required rolling stock to ensure such transportation.

One of the key elements of innovative development is a corporate system of vocational guidance, scientific and technical information, and exhibition activities. A fundamentally new line of activity in this area is the creation of a mobile exhibition and lecture complex (MELC) of Russian Railways JSC, designed to display achievements of the company's innovative development both throughout the railway network of Russia and abroad (onwards in the issue you can find particular article dedicated to the MELC). The MELC demonstrates not only railway innovations or innovations that are directly related to transportation, but it also displays universally acknowledged achievements of progressive mankind. The complex completed its first tour from August to October 2011.

The models exhibited in the train demonstrate the evolution of railway equipment – from the Cherepanov brothers' engine to modern locomotives. The train's exposition also features full-scale specimens including a solar cell battery, a number of LED-based devices, and products made with the use of nanotechnologies.

Finally, we would like to point out that technological modernization and innovative development of railway transport, including realization of programs for energy and resource saving, is seen as a relevant national task for today, and solving it requires a complex approach and suggests private and state partnership to give the country's economy an innovative boost. Joint action by state companies, private business, federal, and regional authorities will allow us to cope with this task successfully. ■

III INTERNATIONAL RAIL SALON EXPO 1520 AND IV INTERNATIONAL CONFERENCE "RAILWAY INDUSTRY. PROSPECTS, TECHNOLOGIES, PRIORITIES"

The III International Rail Salon EXPO 1520 took place in Moscow Region in Shcherbinka on 7-10 September, 2011. It has become traditional international venue for demonstration of brand-new rail equipment. The Salon has rightly gained the high evaluation among participants and visitors of exhibition that numbered up to 14.5 thousand people in 2011. 417 sectoral companies from 25 countries of the world took part in the Salon, 68 units of operating equipment were presented. The main purposes of the Salon were the rapprochement of the manufacturers and consumers of equipment, creating of conditions for closer cooperation of engineering enterprises in the sphere of quality improvement and competitiveness on the world market as well as demonstration of latest achievements of the branch.

The IV International Conference "Railway Industry. Prospects, Technologies, Priorities" took place under the Salon program for two days, within which 891 delegates and 60 speakers took part. The main subject of the conference was discussion of the role of railway engineering in the development of Russian economy. Under this subject, there were considered the issues of stimulating of modern rolling stock manufacturing, ensuring of development of Russian regions by means of railway engineering, prospects of new rolling stock improvement, issues of saving manufacture implementation, increasing of energy efficiency and technological regulation on railway transport.

"Over 50 units of new railway rolling stock were shown to the participants and guests. This is the result of what was made by Russian engineers for the last two years, and this is the equipment that can become the future of railway transport", President of Russian Railways JSC Vladimir Yakunin reported to the guests of the Salon and the conference in his congratulation.

The Chairman of the Transport Committee of State Duma Sergey Shishkarev, the Governor of Sverdlovsk Region Aleksandr Misharin and other representatives of state authorities, transport engineering enterprises and scientific communities also participated in the event opening.

MAIN SUBJECT – RAILWAY TRANSPORT DEVELOPMENT

The work of the Salon started from plenary discussion "The railway transport development in context of Russian economy modernization", where President of Russian Railways JSC, Vladimir Yakunin,

President and Chief Executive Officer of Siemens AG, Peter Löscher, Chairman of the Transport Committee of State Duma of the Federal Assembly of the Russian Federation, Sergey Shishkarev, President of Alstom Transport, Henri Poupart Lafarge, Governor of Sverdlovsk Region, Aleksandr Misharin, Deputy Minister of Industry and Trade of the Russian Federation, Vladimir Salamatov, Deputy Minister of Transport of the Russian Federation, Nikolay Asaul, President of Sinara Group CJSC, Dmitry Pumpyansky, participated.

The President of Russian Railways JSC Vladimir Yakunin notified in his report that an advanced development of infrastructure is required in present economic conditions to resolve the tasks of innovative development of transport and economy in general. As he said, the responsibility for resolving of this task should be extended not only over the companies with state participation, but over all participants of transport market as well.

He also declared that geo-political position of Russia allows it to claim the important role in world economy and that is why there is a necessity of more active use of this potential. However, one of the problems of the industry is aging of the significant part of technical means of the infrastructure and rolling stock. Vladimir Yakunin also notified that for the last years Russian Railways JSC managed to reduce the tendency of production facilities wear by means of upgrading and development of railway transport at the assignment and with the support of state administration.

"The share of Russian Railways JSC in basic assets of the country is 7.3%, the maintenance of which requires respective investments. In 2009–2011 the contribution of Russian Railways JSC in GDP of Russia will amount to 1.9%. At these circumstances, the company ensures 3.4% of the whole volume of investments in Russian industry", the head of Russian Railways JSC underlined.

Vladimir Yakunin considers that in the first place there is the need in cooperation of state, industrial enterprises and transport business to ensure the stable development of railways infrastructure and production resources of regions. He said that Russian Railways JSC is interested in development of regional industrial centres as carriers and largest consumers of domestic products, including products of world transport industry world located in Russia.

The Governor of Sverdlovsk Region Aleksandr Misharin declared in the process of the meeting that a cluster of railway engineering would be created in Sverdlovsk Region. It involves 40 enterprises with over 70 thousand personnel. "The production of 13 new kinds of cars has already been launched", the Governor notified.

The Chairman of the Transport Committee of the State Duma Sergey Shishkarev notified that the repression of economy development and decrease of safety level at different transportations occurs due to aging of capital stock. As at the moment the new kinds of locomotives and rolling stock are already created, it is necessary to construct new separate lines.

The President of Sinara Group CJSC, Dmitry Pumpyansky, in his turn notified that due to upgrading of the rolling stock by Russian Railways JSC and development of domestic transport engineering in general the equipment manufacturers have possibility to plan creation of new locomotives using best foreign technologies.

In the end of the plenary discussion President of Russian Railways JSC, Vladimir Yakunin, President of Sinara Group CJSC, Dmitry Pumpyansky, and Chairman of the Board of Directors of Siemens AG, Peter Löscher, entered into the contract on delivery of Lastochka electric trains. The document provides for the execution of the delivery of 1,200 Lastochka electric trains (Desiro RUS type) for RZD from 2015 to 2020. There has been also defined the formula of prices indexation since 2012. General contract cost amounts to more than 2 billion euros. During 2015, "Ural Locomotives LLC" LLC shall produce 30 five-vehicle electric trains. They assume that first the localization depth shall amount to 35%, and according to contract execution the level of localization shall be brought to the amount of 80%. In cooperative deliveries of components the participation of 80 enterprises of Russian industry is planned.

There was also decided to establish a training centre on the basis of the largest higher educational establishments of the Ural region to prepare engineers for transport engineering. "With reference to the plans of localization of components production the number of employees involved in engineering cluster of Sverdlovsk Region can be increased by 10 thousand of highly qualified specialists", – D.Pumpyansky notified. Moreover the Sinara Group and the company Siemens AG agreed to long-term training of 500 Russian specialists in Germany within four years that would renew domestic engineering school.

In addition, UralVagonZavod JSC scientific industrial corporation" and Freight JSC two achieved preliminary agreements for delivery of 40 thousand units of rolling stock in the amount of 126 billion roubles. In September the companies plan to enter into a contract on annual delivery within four years of 10 thousand units of rolling stock.

PROCEEDINGS OF THE CONFERENCE

Further conference proceedings consisted of discussion arrangements the centre of which were panel discussions "The Role of Railway industry in Russian Regions Development" and "Production of New Rolling Stock: Prospects of Development".

Under the chairmanship of Vice-President of Russian Railways JSC Valentin Gapanovich in the panel discussion "The Role of Machine Building in Russian Regions Development", Director General of Institute of Natural Monopolies Research (IPEM), Yury Saakyan, CEO of Mobility Division, Vice President, Siemens AG, Hans-Jörg Grundmann, President of Alstom Transport, Henri Poupart-Lafarge, first deputy Governor of Rostov Region Aleksandr Nosov, and Director General of UralVagonZavod industrial corporation JSC”, Oleg Sienko, took part. The key subjects of discussion were the role of railway industry in ensuring of industrial growth and stable economic development of Russian regions, issues of railway equipment manufacturing.

There were discussed the issues of creating new models of rolling stock with improved technical and operative characteristics, prospective approaches to upgrading of the rolling stock by means of modernization and localization of manufactures, implementation of advanced technologies with the purpose of satisfaction of present transport market demands during the panel discussion "Production of New Rolling Stock: prospects of development" under the chairmanship of Deputy Head of the technical policy department of Russian Railways JSC, David Kirzhner, and Technical Director of Transmashholding CJSC, Vladimir Shneidmuller. At the panel discussion they also spoke about necessity to upgrade and to modernize the construction of passenger carriages and possibility of equipment of all locomotives with brand-new navigation systems. In discussion proceeding Director General of Institute of Natural Monopolies Research, Yury Saakyan, the chairman of the Board of directors of Tatravagonka JSC, Aleksey Belyaev, Managing Director for CIS of Alstom Russia, Bernard Gonnet, Managing Director of RUSNANO JSC, Konstantin Demetriu, Deputy General Director of technical development of JSC Freight One, Sergey Kaletin, Vice-President of Siemens AG, Dietrich Möller, Chairman of the Board of Directors of Tikhvin Car-Building Plant JSC, Igor Tsyplakov, and Deputy General Director of UralVagonZavod JSC, Andrey Shlensky.

RAILWAY EQUIPMENT PARADE

Railway equipment parade is a unique format of demonstration shows of rolling stock: locomotives of domestic and joint venture manufacturing could show their technical capabilities.

The parade was opened by first show of electric locomotive EP-20 produced by Novocherkassk Electric Locomotive Plant LLC (NEVZ) in cooperation with French company Alstom Transport. Presentation of first in Russia dual-engine electrical locomotive of EP-20 generation, operational speed of which is up to 200 km/h, made great impression on the Salon visitors. The supply agreement for 200 electric locomotives EP-20 was signed by JRussian Railways JSC and Transmashholding CJSC in May of 2010. First passenger electric locomotives of the first series will be received by railways already in 2012. Certainly, in the first place the deliveries of such locomotive are interesting for serving the

Olympic Games in Sochi. Such electric locomotives are more powerful on the one hand and on the other hand are less expansive as for their technical maintenance and scheduled repairs.

Those were followed by legends and innovations of Russian locomotives construction – reconstructed steam locomotives, modified and newly developed electric and diesel locomotives. Special attention was paid to veterans of railways – the steam locomotives, they were of no less interest to the visitors that new developments. They include the freight steam locomotive of EU series (had been built from 1912 to 1957), 11,000 units

of which were produced, freight locomotive of L series (had been built from 1945 to 1955) in line of 4,199 unites, and passenger steam locomotive P36, one of 251 units built from 1950 to 1956. However, if the railwaymen cannot be surprised by steam locomotives of E and L series, P36 which arrived from Zlatoust was met with storm of admiration, because that is the legendary steam locomotive, the most perfect and recent model of domestic steam locomotives construction. The very steam locomotives ran with Red Arrow up to the year 1957, having made the schedule faster, from 11 hours to present 9, driving at speed of 120 km/h. Also there were presented the freight electric locomotive of 2ES10, passenger diesel locomotive of TEP70B series, freight electric locomotive of 2ES4K series, freight diesel locomotive of 2TE25A series.

The show was accomplished by gas turbine locomotive GT-1: the first in the world gas turbine locomotive that operates on liquefied gas. The participants and guests of EXPO 1520 were shown the longest and the heaviest train with unit draft in the world, driven by GT-1. The length of record long train is 2,053 meters; the weight is 16 thousand tons. With this indication GT-1 is already registered by the Guinness World Records. The first section of gas turbine locomotive is a reservoir with the fuel; the second is the turbine and power plant. Such locomotive allows reaching the unbelievable capacity (8.3 MW) and to drive a train of 18 thousand tons, which is the world record for single locomotive. The Salon visitors could see how much is that with their own eyes – GT-1 drew 180-car train around the circle, the running of which took about seven minutes. A new world record was established in front of the Salon participants.

Among other first shows it is noteworthy to mention the presentation of experimental model of shunting diesel locomotive TEM-TMH, produced by Bryansk engineering plant CJSC BMZ (a part of Transmashholding CJSC). It comprises a range of technical innovations used not only in Russia, but also in Europe. In particular, they applied the composition modularity that allowed installing the tower drivers' cabin and low nose compartment. The shunting diesel locomotive TEM-TMH is equipped by electric transmission of alternating and direct current, electronic control system, synchronous traction Siemens Drasov and engine Caterpillar 3512B DITA (or 3508 B DITA) with the capacity of 1455 kW (or 970 kW). Locomotive is developed in cooperation with Czech company CZ LOKO is meant for heavy export and shunting works at the 1520 mm territory with the speed of 100 km/h. ■

COOPERATION WITH THE INTERNATIONAL UNION OF RAILWAYS

The International Union of Railways (UIC) is one of the leading international nongovernmental organizations, created in 1922 and having headquarters in Paris.

The Russian Railways JSC ranked among founders of the UIC. However, in connection with the World War II and the subsequent division of Europe on two blocks, participation of the Russian Railways JSC in the UIC has been stopped.

At the beginning of the twenty first century, the output of the Russian Railways JSC on new markets, participation in large international investment projects, as well as an indispensability of progress of relationships with other railroad companies of the world have demanded restoration of a full membership of the Russian Railways JSC in the UIC.

At the 68th session of General Assembly of the UIC passed on June, 12th, 2006 in Montreal (Canada), all members of the UIC unanimously had approved the entry of the Russian Railways JSC into the Organization as the full member.

Fig. 1 Vladimir Yakunin and Jean-Pierre Loubinoux are greeting each other at the XII International Rail Business Forum "1520 Strategic Partnership"

At present time, the Russian Railways JSC is a member of three key directing bodies of the UIC – Executive Council, Asian and European Regional Assemblies.

Being the founder of non-commercial partnership “Union of industries of railway equipment” (UIRE), the Russian Railways JSC together with the industry aspires to realize, within the limits of participation in the UIC, following objectives:

- Acceleration of technical progress and technological rise of the railway transport.
- Assistance to introduction of high technologies and the best practice on the Russian railways.
- Realization of strategic priorities of the Russian Railways JSC international activity.
- Expansion of access on the market of the international passenger and cargo communications.
- Developing interoperability of the infrastructure and rolling-stock between railways of different standards.
- Developing high-speed rail.
- Improving traffic safety and security.
- Decreasing environmental contamination.

The most progressive international standards introduction in the field of quality (first of all, the IRIS standard) in cooperation with UNIFE.

The Russian Railways JSC realizes consistently the coordinating role which is directed on levelling of balance of interests of the European and non-european members of the Organization. So, on July, 9th of current year, the president of the Russian Railways JSC Vladimir Yakunin has been nominated to the UIC chairman for next 2 years by the decision of the 80th session of the UIC General Assembly.

UIRE sincerely congratulate Vladimir Yakunin on this nomination and consider, that his activity in the UIC will raise the railways competitiveness.

The official nomination of VladimirYakunin for the UIC chairman will take place on the 81st session of General Assembly (on the 12th of December, 2012, in Paris).

Fig. 2 Valentin Gapanovich and Henri Poupart-Lafarge at the XII International Rail Business Forum "1520 Strategic Partnership"

Vladimir Yakunin, President of Russian Railways JSC

SCIENTIFIC-PRACTICAL CONFERENCE "RAILWAY INDUSTRY: ENGINEERING SOLUTIONS AND DEVELOPMENT"

On April 25th, 2012, in the Renaissance Moscow Hotel, the scientific-practical conference devoted to the state and development prospects of Russian railway industry was held. The event was organised by the non-commercial partnership Union of Industries of Railway Equipment (UIRE) with the support of the Institute of Natural Monopolies Research (IPEM).

The conference was attended by about 300 people: managers, leading technical specialists of the enterprises that manufacture railway rolling stock and its components, representatives of the State authorities and expert and scientific community.

The aim of the conference was to exchange the views among the industry experts, form the benchmarks in the sphere of development and implementation of new engineering developments, and identify the key trends in technological development for the medium-term prospects.

In his welcoming speech, **Vladimir Yakunin**, President of the Russian Railways JSC, made special mention of the UIRE work aimed at improving the quality of railway equipment and infrastructure and underlined that "rail transport is of great importance to the economy of Russia." "Nineteen industries provide development and functioning of the Russian railways," - said Vladimir Yakunin. He also stated that the Russian Railways JSC has to be engaged in uncharacteristic for its activity, namely in carrying out in-depth diagnostics of the supplied products, including new ones. In his opinion, it is the manufacturer who should be responsible for the quality and safety of the product and its components, and this principle should be built into the price that determines the operating costs throughout the entire life cycle. "We have already agreed that the manufacturing companies will take the locomotives on after-sales service," - he added.

The head of the Russian Railways JSC also emphasised that currently the main task of the Russian railway industry is the creation of modern competitive rail industry. First of all it concerns power rolling stock.

Valentin Gapanovich, Senior Vice President of Russian Railways JSC, President of UIRE

Then, the floor was taken by Valentin Gapanovich, Senior Vice President of the Russian Railways JSC, President of UIRE. In his presentation, he highlighted the main directions of intensification of the use of railway infrastructure up to 2020, which consists in:

■ introduction of heavy-tonnage and long freight train traffic;

■ increase of rehandling in the main marshalling yards;

■ increase of average speed of traffic of expedited freight trains and passenger trains.

He also drew attention to the necessity of existence of the power rolling stock in accordance with the general scheme of the network development for the period up to 2020.

Name	Number of locomotives	
	2015	2020
Electric freight locomotives	7,253	7,660
direct voltage	3,336	3,447
alternating voltage	3,917	4,213
Diesel freight locomotives	2,959	3,193
Electric passenger locomotives	2,180	2,276
direct voltage	898	902
alternating voltage	1,132	1,186
double voltage	150	188
Diesel passenger locomotives	593	612
Diesel shunters	5,550	5,757
Purchase in 2011 – 453 units	Required purchase – at least 700 units per year (from 2015)	
Investments in 2011 – 37.0 billion roubles	Required investments – 93.0 billion roubles per year *	
Total – 754.0 billion roubles, including: 2012-2015 – 289.0 billion roubles, 2016-2020 – 465.0 billion roubles		

** in prices of 2011. From the presentation of V.A. Gapanovich, Senior Vice President of the Russian Railways JSC (Editor's Note)*

Vladimir Salamatov, Deputy Minister of Industry and Trade of the Russian Federation, spoke about the importance of work on harmonisation of the Russian system of certification and standardisation with the international and European normative documents. This work is particularly important for the development of trade relations within the Customs Union and WTO.

On the expiration of the plenary meeting, the discussion continued at four separate profile sections, where the Conference participants discussed in more detail the problems and prospects of development of locomotive engineering, passenger rail carriage building and urban rail transport, wagon building, production of track machinery and infrastructure components.

The conference adopted the final resolution containing recommendations to the bodies of the state power to improve the conditions of development of the railway industry and recommendations as for the directions of further work of UIRE in the area of supporting the development and implementation of the new engineering developments.

The "Locomotive engineering" Section

Discussion topics:
- perspective requirements for the locomotives on the Russian railways;
- main directions of improving the efficiency of the locomotives;
- methods of shortening the term of "running-in" of the new model of the locomotive to diagnose structural imperfections;
- strategy of development of locomotive services;
- road-transferable locomotives and machines;
- shunting locomotives for industrial enterprises.

The "Passenger rail carriage building and city rail transport" Section

Discussion topics:
- perspective requirements for passenger rail carriages of locomotive traction and for railcar rolling stock ;
- what kinds of rail carriages will be necessary for the passengers (reserved seats, compartments, first-class sleepers);
- methods of power supply and heating of passenger rail carriages;
- technical solutions to improve the comfort of passenger rail carriages;
- expediency of creation of rail carriages of different classes of comfort for electric trains;
- trends in the tube carriage and tram development.

The "Freight wagon building" Section

Discussion topics:
- freight wagon bogie unification;
- development of innovative freight rolling stock and its components;
- development prospects for the market of repair of freight wagons;
- modern technologies in the manufacture and repair of freight rolling stock.

The "Production of components for infrastructure and maintenance vehicles" Section

Discussion topics:
- perspective requirements for the components of railway industry and equipment;
- implementation of quality management system at the enterprises producing the components;
- measures stimulating the creation of the components of new generation. ■

JSC "KIROVSKY MASHZAVOD 1 MAYA", RUSSIA

JSC "Kirovsky Mashzavod 1 Maya" is rich in traditions rising from the century before last. The plant was founded in 1899 and has successfully passed its way from repair of wagons and steam locomotives to manufacturing of the state-of-the-art hi-tech railway equipment. At present, JSC "Kirovsky Mashzavod 1 Maya" is the only company in the territory of Russia, CIS and the Baltic states designing and producing diesel-electric and hydraulic rail-mounted cranes and one of the largest manufacturers of track machines for construction, repair and maintenance of railway tracks.

The products manufactured by the JSC "Kirovsky Mashzavod 1 Maya" is in demand not only in Russia, but in many other countries within the former Soviet Union and beyond. Cranes and track machines are supplied to Kazakhstan, Belarus, Ukraine, Tajikistan, Armenia, the Baltic states, Turkmenistan, Uzbekistan, Iran, Libya, Cuba, Mongolia, etc. In 2012, for the second year in a row, the JSC "Kirovsky Mashzavod 1 Maya" was announced the winner of the competition "Best Russian Exporter" in the branch of railway transport means, held by the Ministry of Industry and Trade of Russia.

One of the main directions of activities of JSC "Kirovsky Mashzavod 1 Maya" is crane-building. The company carries out serial production of a wide range of rail-mounted cranes: diesel-electric cranes with lifting capacity 16, 25 and 32 tons and hydraulic cranes with lifting capacity 80, 125 and 150 tons, capable of performing a set of handling, construction and installation, emergency recovery works at the railroad. The cranes manufactured by the plant can be operated in various climatic conditions ranging from the far North to the tropics and hot deserts.

General Director
Sergey Golofaev

The second major area of activities of the company is manufacture of track machines capable of high performance fulfillment of a set of works in construction, repair and maintenance of mainline railroads and approach lines of industrial enterprises.

You can obtain the detailed information of the range of products manufactured by the company and its technical data of the products on the website of the JSC "Kirovsky Mashzavod 1 Maya": www.crane-kirov.ru

THE RUSSIAN RAILWAYS JSC MOBILE EXHIBITION AND LECTURE COMPLEX AS AN INNOVATIVE PRODUCT OF THE COMPANY

Since August 2011 an unusual train – mobile exhibition and lecture complex (MELC) of the Russian Railways JSC – runs in the Russian railroads network. It represents a specialized train, which has railcars with issue-related expositions that reflect the history of establishing and development of national railways and demonstrating modern innovative projects and technologies implemented on the railroads of the country. They represent the models of the rolling equipment and maintenance vehicles, rail infrastructure, energy-conserving systems, operating simulators. One of the railcars is designed for conference and lecture holding, including the usage of 3D videos demonstration devices. State Atomic Energy Corporation Rosatom, State Corporation RUSNANO JSC, foreign firms, that took part in a project, present their production in the train together with the Russian Railways JSC.

While seeing the innovative train off, the President of the Russian Railways JSC Vladimir Yakunin noticed, that it is impossible to count on the modernization of the national economy without a strong development of the research and development complex. The Russian Railways are creating the conditions of the innovative development not only for railway vehicles, but also for many of related industries, consolidating the efforts of the fundamental and applied sciences, the manufacturing enterprises and investors. The project of creation of the mobile exhibition-lecture complex, realized by the company, is appealed to stimulate the interest, first of all of the youth, to acquire the technological and natural sciences, directed knowledge in order to inspire for scientific and technological creative work.

The complex is aligned to increase the efficiency of the usage of the scientific and technological information, the support of innovative developments, holding of the specialized exhibitions, conferences and seminars, organization of mobile platforms for experience exchange and for further collaboration of the representatives of different branches and business structures, federal and regional government executive authorities, scientific community.

There are 12 railcars with an original interior design: 9 exhibitional and 3 service-householding in the train. The MELC personnel accounts for 20 employees. The qualified specialists-guides introduce to the visitors the presented exposition. During the trips even conductors became the experienced guides and successfully learned a second profession.

THE RAILCAR "INNOVATIVE DEVELOPMENT OF RUSSIAN RAILWAYS JSC"

In this railcar you may get acquainted with the history of development of the railway vehicles of Russia since 1837 till nowadays, see the reproductions of the retrographies, the historical notes, the copies of the archive documents, the model of the famous model steam locomotive P36, that was in the head of the common known "Red Arrow" and "Russia" trains. The exposition reflects the main directions of the innovative development of the company, that were provided by the White book of the Russian Railways JSC. The special focus is put on the development of the speed and high-speed running in Russia. There are the models of the double-voltage high-speed electric train "Sapsan" ("Velaro Rus"), that runs the line St. Petersburg–Moscow–Nizhny Novgorod, the "Allegro" ("Pendolino SM6"), that is exploited in the international traffic St. Petersburg–Helsinki, the double-voltage speed electric train "Lastochka" ("Desiro Rus"), that will provide a service to the participants and guests of the XX Winter Olympics in Sochi, and then work in regional communications. The models give visitors the opportunity to appraise the interior design and comfort.

THE RAILCAR "THE ROLLING STOCK AT RUSSIAN RAILWAYS"

The exposition of the railcar contains the massive models of modern locomotives, railcars, trackway and other railway technics. Among them there is the gas turbine locomotive GT1, created by the Russian specialists, with 8,300 kW capacity, that runs on liquefied natural gas. As a part of the dynamic exposition of the III International railway fair EXPO 1520 in September 2011 the gas turbine locomotive drove a train consisting of 170 loaded cars with a gross weight of 16 thousand tons. In the nearest years the serial production of these unique locomotives will be organized.

Freight locomotives are also represented by two-section eight-axle direct-voltage mainline electric locomotive 2ES10 "Granite" with an asynchronous engine with the maximum capacity of 8,800 kW and direct-current mainline electric locomotive with collector railway motors 2ES6 produced by Ural locomotives LCC of Sinara Group CJSC. In 2011 "Granite", consisting of 3 sections working in multiple-unit system, ran a train from the Yekaterinburg-Sortirovochny station through the Ural Mountains to the Balezino station with a record for this section weight of 9 thousand tones. Bryansk Engineering Plant CJSC (BMZ) demonstrates the diesel freight locomotive with an asynchronous engine 2TE25A "Vityaz" with 2x2500 kW capacity and the shunting diesel locomotive TEM18DM. Three-section "Vityaz" ran the train set of cars of 6 thousand tons from Taksimo station to the Vanino coal terminal, showing the capability to run the train sets of universal weight through all the north lateral way. The unusual exhibit item – two-axial shunting diesel locomotive TEM31 with a panoramic view cabin, built in Yaroslavl electric locomotive repair plant (YERZ) by the design of VNIKTI JSC with a usage of many innovative solutions.

Among the passenger electric locomotives the one that captures attention is the innovative speed dual-current locomotive EP20 with an asynchronous engine, designed at Novocherkassk Electric Locomotive Plant (NEVZ). On its platform the entire line of electric locomotives, designed for different kinds of field operations, will be created. Another newly-designed and already well-known on Western-Siberian and Oktyabrskaya roads passenger electric locomotive EP2K produced by the Kolomensky zavod JSC is designed to substitute electric locomotives of ChS2 and ChS2T series. The establishment of the commuter passenger equipment is reflected by the electric train ED4MKM-Aero for intermodal transport (to the airports) and the rail bus RA2.

The exposition also represents the model of special open car with the 27 tons axial load designed for coal transportation, the hopper car to transport mineral fertilizers, the multiple-unit platform for large-tonnage container transportation created in the collaboration with the Tatravagonka JSC. Also the track crane with increased lift capacity UK 25/25, the streamlined semitrailer KAMAZ 65116 to work as a multiple unit with truckbeds, high-productive ballast cleaning machine SchOM-1200 and other technics are demonstrated.

THE RAILCAR "RAILWAY INFRASTRUCTURE"

The exposition of the current car consists of the functional panorama-models, which demonstrate the design of the stations, the rail crossings, the railway sub-station and other infrastructure objects. The track facilities are represented by constructions of ballast and ballastless railway track, the lubricating device for railings, the models of modern heavy-duty track machines for repair and maintenance of the railway, the new diagnostic facilities of the state of track superstructure and other. Here you can also get acquainted with the model of railway complex on the Baikonur spaceport, that demonstrates the delivery of the rocket to the launching platform with booster lift, the Military Railroad Missile Complex (ICBM, SS-24 «Scalpel» Mod 3 (PL-4)), the reduced copy of the terminal 'Airport' of the railway airport Adler–Sochi and others. Also the model of the shifting mechanism, that demonstrates the change of the distance between wheels on the axis during the change of the gauge (Talgo company), that provides the automatic switch of the rolling equipment from the track gage of one size to the track gage with another, is represented.

THE RAILCAR "ENERGY SAVING, ENERGY EFFICIENCY AND ENVIRONMENTAL SECURITY"

To demonstrate a wide range of the exhibit items the exhibition area is divided to several zones with different working directions. These are the system of automatic maintenance and registration of the parameters of the traction equipment, the stationary railway lubricator with the solar module for battery recharging, three positioned traffic light with light-optical systems on LEDs. In the zone, devoted to the environmental safety, the models of the mobile ecological laboratory, thermal devastation (incineration) of wooden railway sleepers, sewage treatment plants on the Vyborg station, different types of acoustic multifunctional measuring instruments "Ecophysics", and also the interactive 3D modeling program complex of railway infrastructure (Record-Model of the Russian Railways JSC) are represented. A huge place in the exposition is devoted to the lighting facilities, that are produced by Russian enterprises and the company. As the exhibition items the samples of the energy efficient production for different variants of usage are represented (street lighting, industrial lighting, trade lighting, office lighting, lighting for household use).

THE RAILCAR "AUTOMATION, TELEMECHANICS AND COMMUNICATIONS. TRAIN MANAGEMENT"

Here you can get acquainted with the microprocessor autoblocking with tonal rail circuits and centralized allocation of the facilities, the automation-equipped working place of the traffic controller (automation-equipped working place of the train division operator of the centralized traffic control of railway points and signals "Setun") and duty attendant of the gravity hump (automation-equipped working place of the operator put by the duty attendant of the gravity hump), the working space of the station duty officer. The model of the working space of the operating and dispatching personnel of the gravity hump is equipped by the complex system of automated control of the sorting process. The models clearly demonstrate how the dispatchers' train communication (train conference circuit circle), radio train communication (radio train communication circle) and public technological connection in the board of immediate technological connection of traffic controller is realized. The fragment of the multiple-access panel gives us an opportunity to imagine, how the operating control center of Oktyabrskaya railway is functioning.

THE RAILCAR "THE ENERGY OF THE FUTURE GENERATIONS. STATE ATOMIC ENERGY CORPORATION ROSATOM"

The exposition of the current car is prepared by the State Atomic Energy Corporation Rosatom and demonstrates the innovative achievements in the sphere of nuclear power technologies. The models provide guidance on the configuration and type of the nuclear reactors, the tight area structure, the performance of security systems with the demonstration of work of protection cores of nuclear reactor and isolator of nuclear fusion, it is also told about the uranium extraction and enrichment. Each visitor would have an opportunity not only to work with the interactive plasma information panel, but also to measure a personal radiation level using a general-purpose radiometer.

THE RAILCAR "NANOTECHNOLOGIES. STATE CORPORATION RUSNANO"

The concept of the exposition is the demonstration of the exhibition items of nanotechnology production. The exhibition zone of the current railcar is filled with the production made by the range of companies of RUSNANO JSC. A huge attention is paid to the effective and economic lighting equipment, to composite and noise deceptive materials. There are a new generation of the cutting tools, an air-cleaning and disinfection system, an accumulator battery using graphene technologies for electromobiles, energy-saving glasses and others represented. The electronic school manual with a flexible circuit in a shatterproof case is demonstrated. The visitor, who is exploring the exposition with a special interactive guide-pad, sees an automatically displayed presentation about the exhibition units while he/she is moving inside the railcar.

THE RAILCAR "CONFERENCES AND LECTURES"

The railcar is used for holding conferences and lectures. Special equipment gives an opportunity to show 3D videos, presentations, thematic films on the screen. There is the interactive model "The starry sky" made using LEDs with low power consumption on the ceiling of the car.

THE RAILCAR "YOUTH AND PERSONNEL POLICIES OF RUSSIAN RAILWAYS JSC. TRAINING FACILITIES"

The videos and presentation materials that are demonstrated on the railcar's monitors get you acquainted with the Strategy of development of the personnel potential of the Russian Railways JSC till 2015, with the program "The youth of the Russian Railways JSC" being provided in the Company, with the system of professional orientation and personnel training, with the development of student construction gang movement, with the work of children's railways. There are some simulators that are really popular among the visitors, installed in the railcar, including the educational simulator for the electric locomotive operator EP1M. On the basis of modern methods of mathematical modeling this simulator reproduces the work of all main systems of the electric locomotive in real infrastructure. The chair of the locomotive driver is installed on a dynamic platform. The feelings, adequate to

the real ones, are gained using the aviasimulator of an aircraft ATR-42, that simulates the airplane's instrumentation system, the atmosphere behind the cabin, hums, system breakdowns, and also the multimedia laser shooting saloon.

Employer's cars provide comfortable living and working conditions for the train service personnel, storage of expository luggage, work of the train's facilities in the conditions of centralized energy supply unavailability, etc.

Even the first tour of the Mobile exhibition and lecture unit, during which it ran through 15 railways, following the route from Moscow to Far East and back, confirmed the demand for the project. On each of the 50 stops in the major cities and micropolitans of Russian Federation the train was met with a sincere delight. The honorary guests of the train were governors, mayors of the cities and other bodies of legislative and executive power, heads of railways. Altogether about 50 thousand of residents of our country, including workers and veterans of steel trunks, students, pupils, pupils of orphan homes and boarding-schools, pensioners and others. Many of the young visitors of MELC after exploring the exposition made decisions to become railroaders, to study in technical, and especially, to transport universities. The high estimate of a project after the first voyage was given by the president of the Russian Railways JSC Vladimir Yakunin during the meeting with the train staff and the lecturers' collective. He emphasized, that the train succeeded, it's mission was successfully accomplished, it stimulated, as it was intended, the interest of the youth for scientific and technical progress, engineering and technical creativity.

At the end of 2011 – at the beginning of 2012 the train successfully made a range of voyages through the European part of the country, to the North-West and South of Russia. At the beginning of January MELC received it's 100-thousand visitor in the Baltic railway station of the country. It's symbolical, that it appeared to be a student of the 4th course of the train management faculty of the Technical college of railroad transport of St.Petersburg. Till that moment the train had already passed more than 34 thousand kilometers, had made stops in more than 80 cities.

The Russian Railways JSC has supported the proposals of railway administrations of the neighboring countries and beyond to send the innovative train to the railroads of those countries to propagandize and spread scientific knowledge in the modern and understandable form, to assist in implementation of innovative developments to the everyday practice.

The Mobile exhibition-lecture complex of the Russian Railways JCS that has already become well known, popular and expected, is going to have many interesting trips with a noble educating mission in future. ■

RESULTS OF THE INDUSTRIAL PRODUCTION CONDITION MONITORING BASED ON THE INDEXES OF THE INSTITUTE OF NATURAL MONOPOLIES RESEARCH (IPEM)

Evgeniy Rudakov
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Institute of Natural Monopolies Research

ABOUT IPEM INDEXES

In the times of the economical crisis the promptness, confidence and completeness of information about the current tendencies play the decisive role for government authorities and business for efficient managerial anti-crisis decision-making. There are two principal methodological approaches to get the basic macroeconomic indicators, such as industrial production index (IPI): classic – by aggregating the primary statistical information ('bottom-up'); and alternative – by correct analytical calculation on the basis of the basic integral reliable data ('top-down').

The Federal State Statistics Service (Rosstat) is in charge of calculation of IPI on the basis of aggregation of the primary statistics. We have numerously pointed in our publications at the disadvantages of IPI calculation using this method. The main disadvantages are concerned with hard and labor-intensive processes of information collection and its further processing. The resource-intensiveness of the process doesn't allow preserving the necessary promptness, and the selection for the calculation contains the data only from big and medium enterprises. It often happens that adjusted indexes that operate all the data integrity differ from the operational ones in many times, especially on concrete categories of type of economic activity. It's necessary to admit the specific features of the production with the long manufacturing cycle: its accounting in IPI takes place in the month of the finishing, although the production is being carried out during a couple of months. In the period of a steady economic growth the results of the calculation distort only a little bit, but in the case of economic instability this gives overdue signals about the real trends. After all the method of aggregation of the primary data doesn't allow promptly taking into account the shadow economy, which dynamics is very dependent not only on the stability of the economic situation, but also, for example, on the state taxation policy.

The alternative analytical calculation of the dynamics of industrial production is possible due to the fact that the national economy is an interdependent system and the steady correlation dependences exist between the basic macroeconomical indicators. The correct finding of these interdependencies allows getting up-to-date and reliable indicators of the industrial development. The indexes of the Institute of Natural Monopolies Research are based on the collateral integral indicators – power consumption (IPEM-production) and loading of freight on the railway transport (IPEM-demand). These data is monitored on real-time basis, they are of a high certainty and efficiency and they allow avoiding many disadvantages of a classic method of IPI calculation.

IPEM-PRODUCTION INDEX

The basis of the calculation of industrial production index (IPEM-production) is the fact that any production process uses electricity as one of product factors.

The model of the index is based on the fact that in short time line the dynamics of electric energy consumption depends only on three parameters: industrial production, weather and seasonal factor – all of these data are available, up-to-date and reliable.

IPEM-DEMAND INDEX

In the basis of calculation of demand index of industrial products lies the assumption: the time of consumption of industrial products corresponds to the moment of its transportation. IPEM-demand index is calculated basically on the base of operational data of loading of industrial products on the rail transport. The data about the loading on the Russian stations are cleansed from the influence of transit and import cargo, but they take export into account. The railroad transport of Russia carries up to 80% of industrial goods (unincluding the pipeline transport), that is why the characteristics of railroad transport's work exactly reflects the aggregate demand parameter for industrial goods in economy. The justification of the calculation is the steady correlation dependences of dynamics of production of different industrial goods with loading of current goods categories to the rail transport.

The model of calculation of IPEM-demand index repeats the model of calculation of IPI of Rosstat, when the index is calculated by aggregation of the data about change of the production in the branch in physical indicators with weight structure according to the share in industrial production in added value. In the model of IPEM-demand index calculation instead of data about the production more operational data of loading are used.

THE AFTER CRISIS DEVELOPMENT

Extremely high dynamics of IPEM indexes in 2010 is explained by the character of industrial growth: after an abrupt slump in industrial production capacity in 2008-2009, a prompt recovering growth is noticed (Table 1, Figure 1).

Table 1. Results of IPEM index calculation 2010-2011

	2010	2011
IPEM-production	8.2%	2.5%
IPEM-demand	8.9%	3.4%
IPI (for reference)	8.2%	4.7%

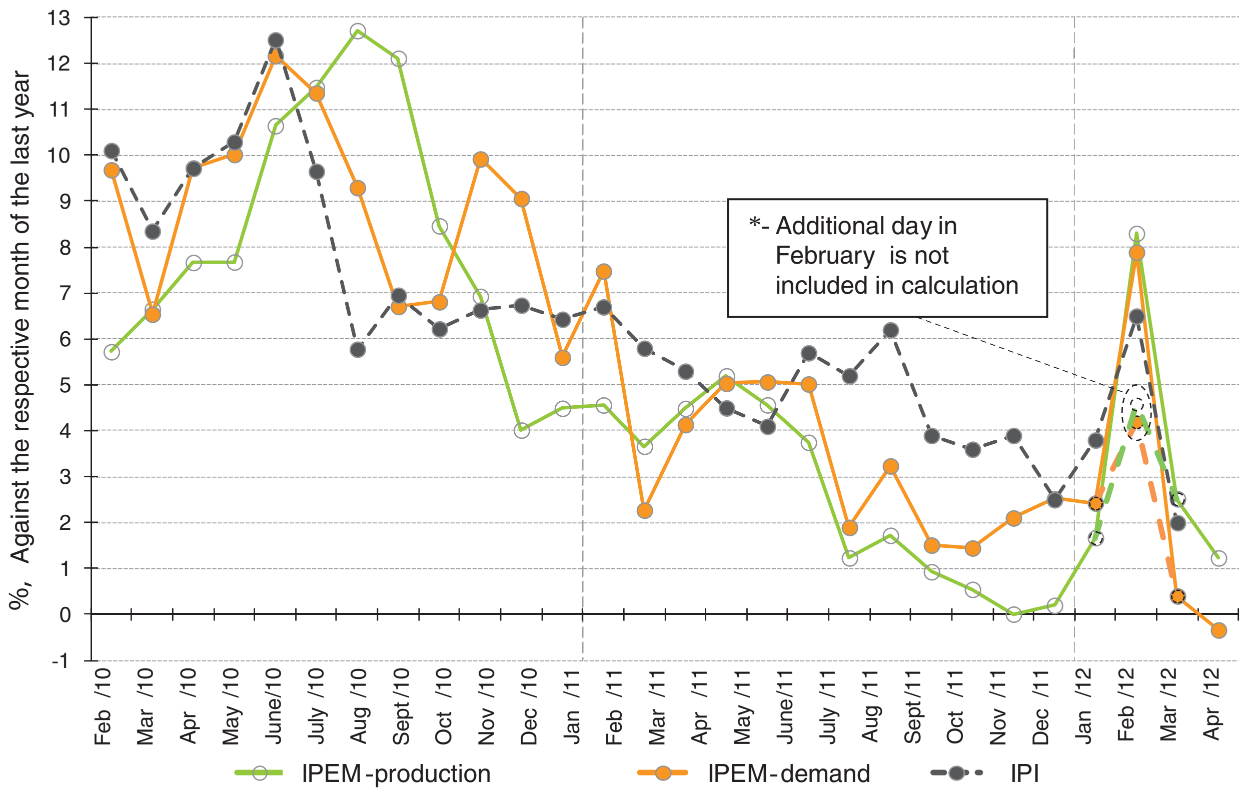


Fig. 1 Dynamics of IPEM indexes in 2010-2011 (against the respective month of the last year)

The character and the structure of recovery growth in industry is principally different from the structure of steady growth.

In case of steady economic growth the dynamics of industrial indexes will be determined by the fast developing sectors. So, in the period till 2008, the main contribution to the dynamics of industrial production was formed by extractive and middletechnological industries due to the fast growing export supplies and successful pricing environment.

In the period of post crisis recovery growth the biggest influence on the dynamics of industrial indexes was made by those sectors that had the maximum depth of product decrease in crisis. So, the locomotive of the growth in 2010 and at the beginning of 2011 were the high-technology industries, which production levels to the precrisis period reached 50 and more percent (Figure 2).

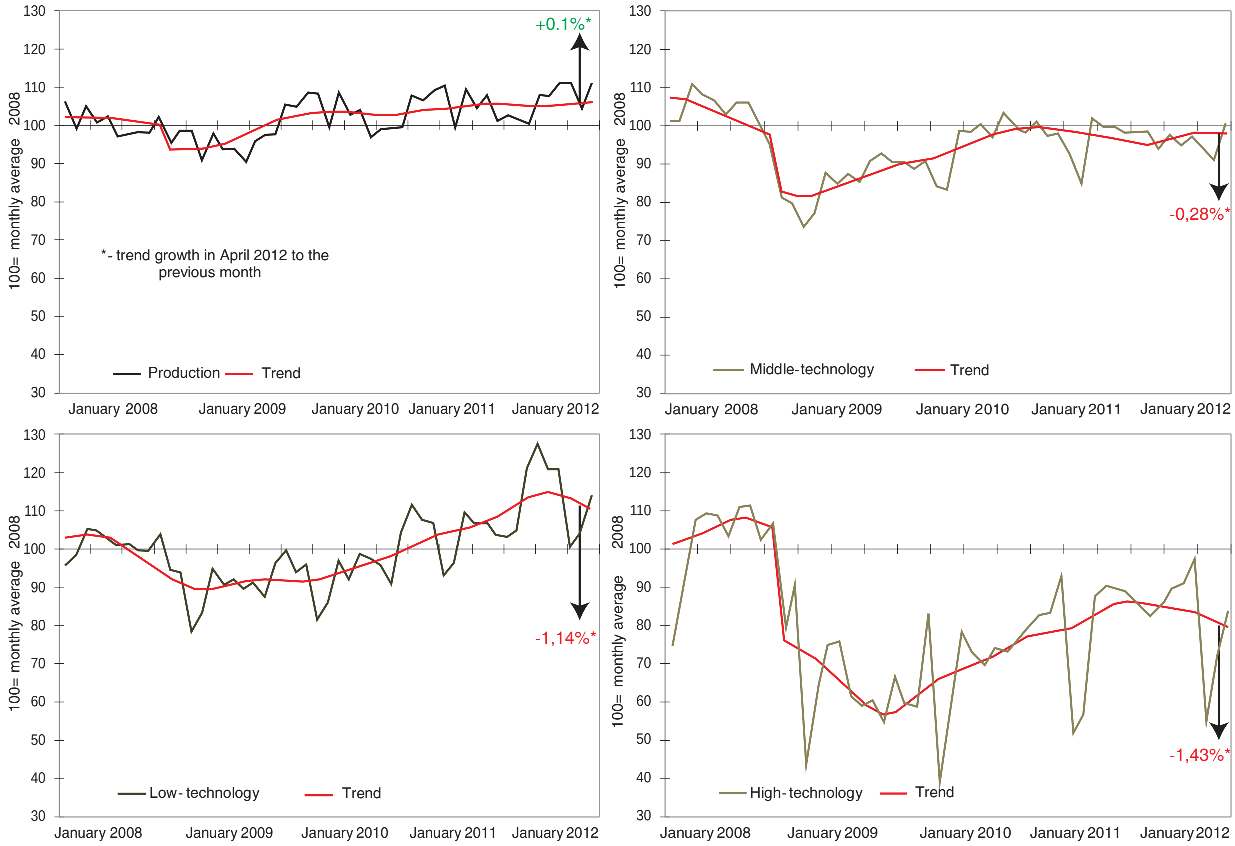


Fig. 2 Dynamics if IPEM-demand index by the industry branches, grouped according to the produceability of production process in 2008-2012 (trend with seasonality correspondence)

The influence of a high-technology sector to the main industrial index was additionally enhanced by the actions of the anticrisis support of the industry taken by the Government. The high-technological industries exactly became their main beneficiaries. And when in 2009 the realization of governmental actions let only to avoid the even deeper fall, in 2010 these actions let to significantly accelerate the pace of the reproduction. For example, the actions taken to support the demand of the automotive industry allowed to compensate significantly about 10 percentage points of additional downward change in index in the branch in 2009 (resulting index growth -55.5%). In 2010 the set of the measures taken to support the demand and the resources allocated for them were increased and provided 50 percentage points of the index growth in automotive industry in addition (resulting index growth +70.4%).

The current situation and the main limitations of industrial growth

The influence of the governmental actions to support the industry started to fade by the middle of 2011, that is when the program of 'clunker' utilization finished. The dynamics of growth started to fade inevitably, and even the record harvests of 2011 that contributed to increase of production growth in food industry and in all low-technology segments, could not significantly influence the industry-wide indexes.

Starting from December 2011, the trend with seasonality correspondence fixes the stable but different-directed movement of production and demand indexes. Such a situation was noticed in the upcoming of 2008 crisis, when the demand for the industrial products began to decrease, and industrial companies worked on the former level of capacity utilization, accumulating the stock balance (Figure 3).

The stock balance is on a high level even now, but the current situation has also another sources. One of the main is the decrease of the transportation index of the significant list of industrial goods (almost all non-massive freight, massive – cement, timber cargo). Growth of the final cost of the freight railway transportation and the deficit of railcars for loading forced many of the consignors to use the alternative modes of transportation, mainly auto, but it's resources are not endless also, and limited, mainly, by the state of infrastructure of the automobile roads.

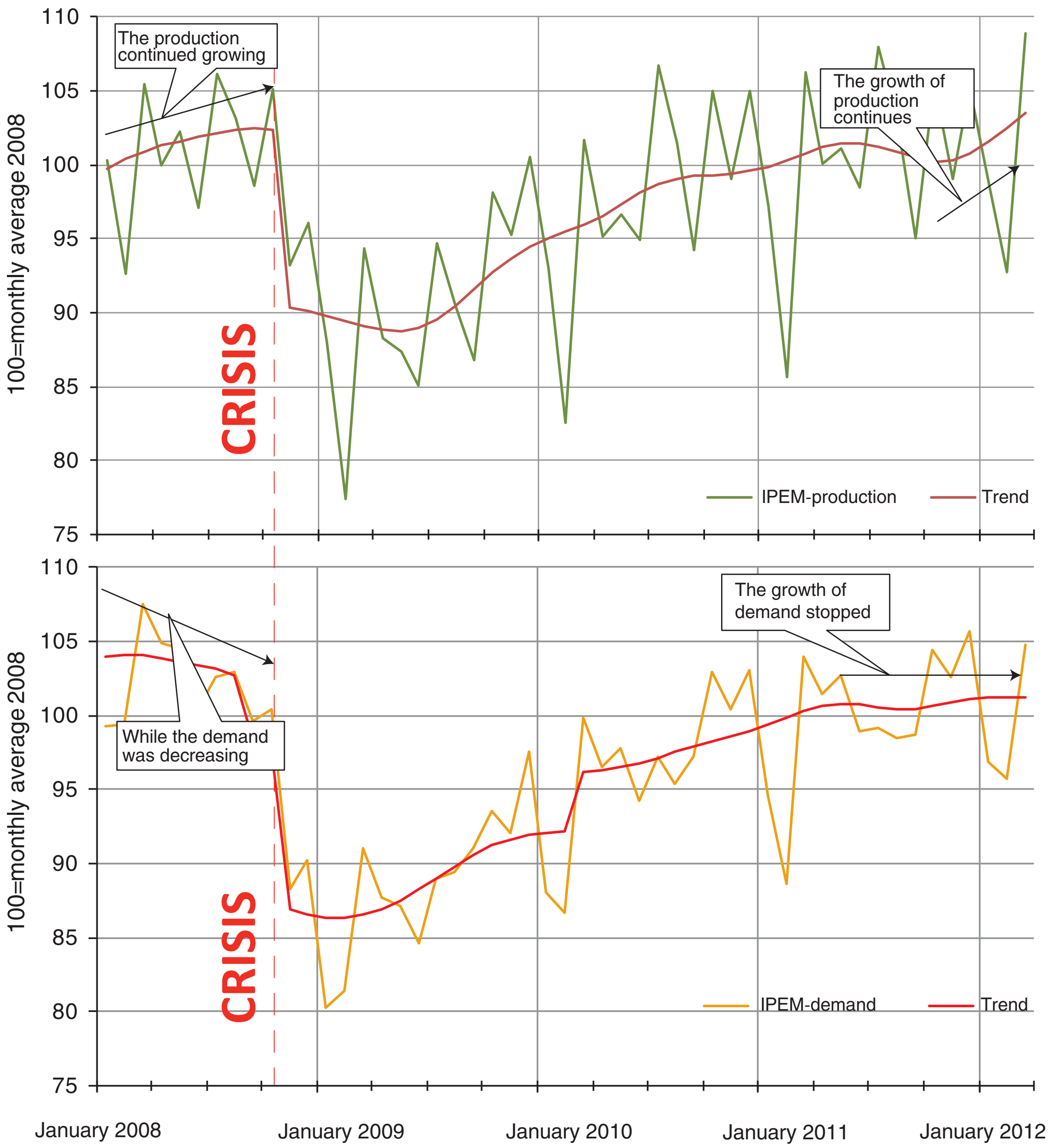
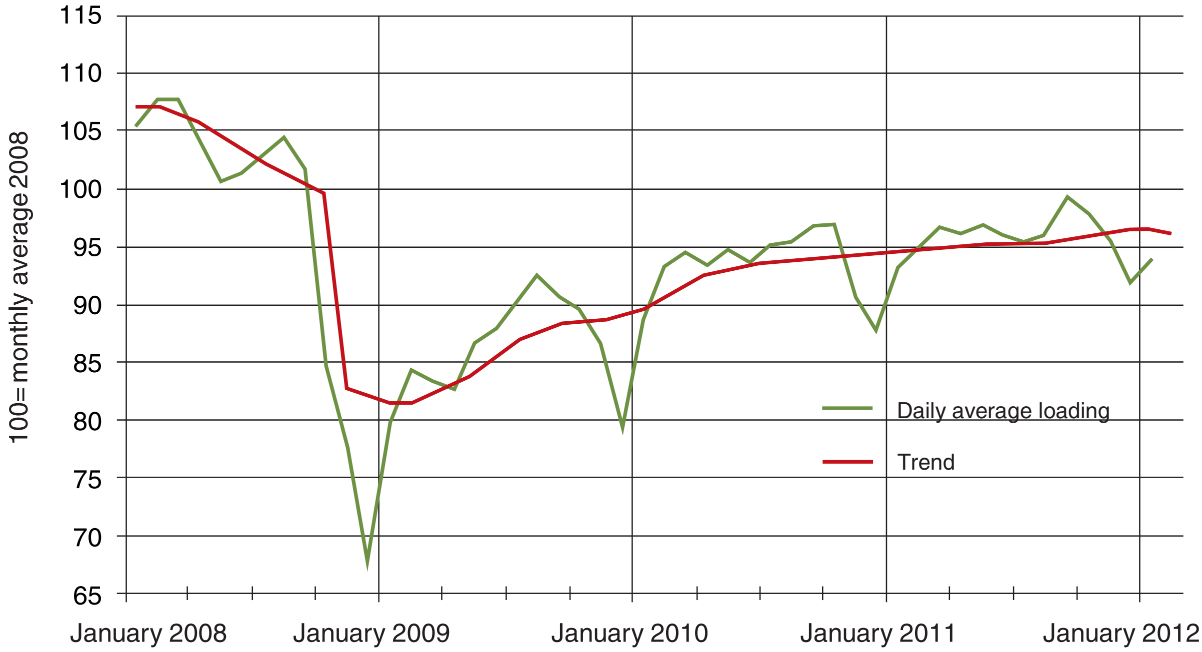


Fig. 3 IPEM index dynamics in 2008-2012 (trend with seasonality correspondence)

The rail transport may even become one of the main limiters of economic and industrial growth in the nearest future, and the withdrawal even of the massive freights from the rail transport is the first signal of mounting limits.

The traffic volumes of railway transport grow much slower than the fleet of cars. The efficiency of cars usage decreases. The volume of produced, but not transported freights grows (Figure 4).



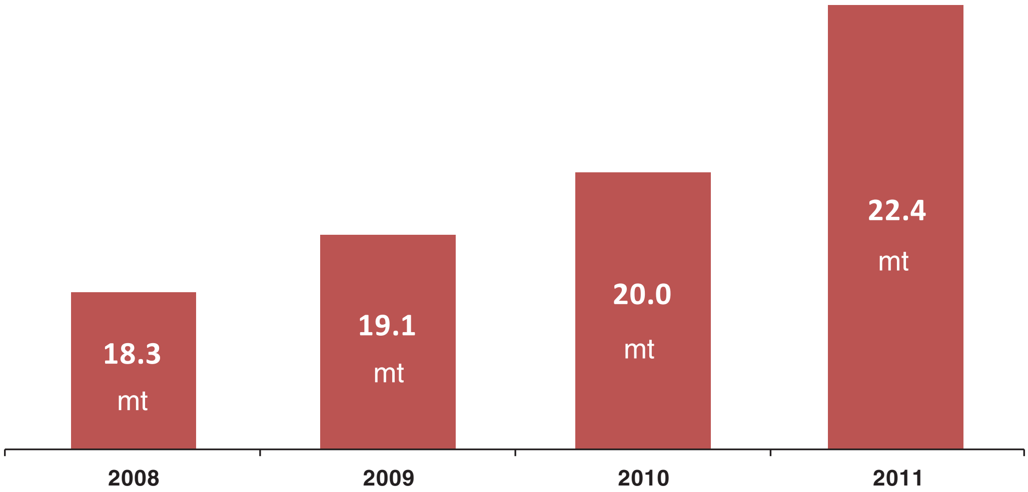


Fig. 4 Dynamics of daily average loading on the railroad transport (trend with seasonality correspondence) and average annual level of freight surplus at consignors depots

According to the assessments of the Russian Railways JSC the maximum growth of freight base that the railways transport is able to facilitate in 2012 – about 2%. The growth of the freight base cannot significantly be behind from the production growth, that is why to achieve the planned level of industrial production (3.4%) it is necessary to facilitate a comparable growth of the freight base. Otherwise the rail transport will act as a real limiter for the industrial and economic growth.

To provide quick pace of industrial production growth the problem solving of the development of railway transport has to become a primary concern.

PERSPECTIVES OF FURTHER GROWTH

Stead and stall the perspectives of growth in industry are connected with the activity of the investment process. Last year in Russia was under the aegis of government and quasi-public investments. The main contribution to the growth of investments was provided by transport and fuel and energy complex – by the industries where the role of the government is determining (Table 2). More importantly, even at the height of the economic crisis in 2009 these two sectors of economy demonstrated a positive dynamics of investments.

Table 2. Structure of investments in fixed capital, 2008-2011

Fixed investments, % Which includes (percentage points):	2008	2009	2010	2011
	9.9	-15.7	6	8.3
Agriculture	-0.1	-1.5	-0.3	0.4
Forestry	0.2	-0.4	0.1	0.2
Metalls production	0.5	-0.9	-0.3	0.2
Chemical industry	0.02	-0.4	-0.01	0.3
Machinery	0.3	-0.5	0.1	0.2
Fuel and energy	1.9	0.1	2.1	2.7
Transport (including pipeline)	3.5	1.5	0.2	4.4
Construction	1.5	-1.9	0.4	-0.4
Other sectors	1.7	-6.4	4.8	-1.3

The inflow of private investments is limited by the significant quantity of uncertainty factors that do not allow planning of investment process. To the questions of entering WTO and still unsettled questions of tariff regulation of natural monopolies (changes in RAB, repeal of benefits on taxes), sequent changes in the rules of electric energy retail market, uncertainties in tax regulation and indistinct perspectives from possible changes in Civil Code have been added. All of that forms cautious attitude to the investments into the Russian economy from the side of private investors, but even some considered steps of new Government, oriented to raise the investment attractiveness of Russia, could rapidly change the situation for the better. ■

1520 – 1435: PROSPECTS FOR COOPERATION

GAUGE USED WORLDWIDE

There was no standard gauge at the beginning of railways construction in XVII-XIX centuries: the administration of each new railway had her own idea of what gauge should be. As a result there could have been several railways of different gauge in one country. Later, as the railway network developed, the roads of different companies began to join and the necessity to reload goods from cars of one gauge to cars of another gauge occurred (and passengers from car to car passing), it often was more expensive than the transportation itself. The essential necessity to find the “golden mean” appeared. But there were several “golden means”.

The world most widespread gauge is the so-called "Stephenson" one ("European", "standard" gauge) - 1435 mm (4 feet and 8.5 inches). The railways of North America, China and many European countries have such gauge. This very gauge was adopted by George Stephenson for construction of the first passenger railway line Liverpool – Manchester in 1826. The English Parliament adopted this gauge as a standard after 20 years, and this very gauge should have been used at the construction of new railways. Subsequently, the gauge of 1435 mm was applied by most part of Europe and at last became de-facto a standard in Europe and North America. Today, the general mileage of "Stephenson" gauge lines is about 720 000 km.

It is noteworthy to mention that one of the first British railway companies, Great Western Railway, used a gauge of 2140 mm. In 1866 the mileage of the railroads on wide gauge of this company was 959 km. There were so-called Gauge Wars for standard of gauge in 1844-1846 in England, but later these lines were reconstructed into standard gauge.

The world second gauge by mileage (227 thousand km) is the one of 1520 mm, which is usually called “wide” or “Russian”. In Russia the gauge of 1524 mm was first used at construction of Nikolaev railway that was put into operation in 1851. Eventually, that the Russian engineers P.P. Melnikov and N.O. Kraft proposed to use this gauge after they visited America before construction of Nikolaev railway (at that time such gauge was popular in southern states of the USA). This size was not chosen by accident: it ensures good stability and efficiency, allows to drive speed faster than Stephenson one. Moreover, 1524 mm is equal to 5 feet exactly, that was convenient for calculations. Important role in such decision played the considerations of defence: it was assumed in such way to prevent the potential enemy from using the Russian railways.

It is interesting to notify that Tsarskoye Selo Railway, the first railrway in Russia, had even wider gauge of 1829 mm.

As opposed to Europe, in Russia the unified standard on gauge was adopted at once and since 1851 the “wide” gauge became unified size at construction of all railways in Russia and then in the Soviet Union.

Since May 1970 to early 1990s the railways of the USSR were transferred to gauge of 1520 mm. It was done with the purpose to increase the stability of the way at exploitation of freight trains, to raise their speed without modernization of the rolling stock. After fall of the USSR this is the standard gauge for all countries formed at its place. The railways of Finland are still using previous standard of 1524 mm.

The so-called "cape" gauge of 1067 mm or 3,5 feet is inferior to "standard" and "wide" by popularity. About 112 thousand km of "cape" lines are used in scores of countries, mainly in Japan, South Africa and Australia. In 1945, as a result of Japan defeat, the railway network of Southern Sakhalin of 1067 mm wide and of 1000 km of mileage was included into the Soviet Union, now – Russia.

The fourth world spread gauge is the "metre" one of 1000 mm. It is the most popular in Brazil, India, countries of South-East Asia and Africa.

Except for the listed gauges, various gauges of different width – from 305 mm (Ruislip Lido Railway in the north of London) to 9 m (in Russia for vessels transportation) – are used all over the world. The most widespread among them are Indian (1676 mm), Iberian (1668 mm) and Irish (1600 mm), general mileage of which is less than 70,000 km – less than mileage of railways with metre gauge.

The tracks with dual gauge, equipped with 3-4 rows of rails (to ensure the movement of rolling stock meant for different width of gauge) are usually used on the border territories, in particular, from Kaliningrad (Russia) to Braniewo station (Poland).

Often, due to territorial peculiarities and specific passenger flow and freight traffic, the railway lines of the "foreign" gauge are not only entering the border station, but also run for a significant distance. Thus, the European gauge, running from Slovakia to Ukrainian Chop goes further through Batevo, Korolevo, Dyakovo to Romania, so that all European trains could go through Ukraine without replacement of wheels set.

Table 1. Mileage of different railway gauges

Gauge	Name	Mileage	Countries
1676	Indian	over 42,300 km	India (42,000 km), Pakistan, Argentina, Chile.
1668	Iberian	14,300 km	Portugal, Spain.
1600	Irish	9,800 km	Ireland, Australia (4,017 km), Brazil (4,057 km).
1524	Wide	7,000 km	Finland, Estonia.
1520		220,000 km	Russia and CIS, Latvia, Lithuania, Estonia, Mongolia.
1435	Standard	720,000 km	Central and Western Europe, the USA, Canada, China, Korea, Australia, Middle East, North Africa, Mexico, Cuba, Panama, Venezuela, Peru, Uruguay.
1067	Cape	112,000 km	South and Central Africa, Indonesia, Japan, Taiwan, the Philippines, New Zealand, Australia, Russia (Sakhalin railway).
1000	Metre	95,000 km	South-East Asia, India (17,000 km), Brazil (23,489 km), Bolivia, north of Chile, Kenya, Uganda.

Fig. 1 Dual gauge (1520/1435), Dzerzhinskaya-Novaya station, Kaliningrad. Source: http://parovoz.com

ISSUES OF INTEROPERABILITY AND TECHNICAL REGULATION

Reality makes the railway transport to look differently at the problems and disagreements both between systems of 1435 mm and 1520/1524 mm gauges and inside of each system.

Today there are three states in the EU – Latvia, Lithuania and Estonia – that have gauge of 1520 mm, Finland – has gauge of 1524, Poland and Slovakia have separate gauges of 1520 mm and also there are some sections in Hungary and Romania. On land passes the EU borders on four states, which are not members of the EU and have the gauge of 1520 mm: Russia, Belorussia, Ukraine and Moldova. The project development on construction of the gauge of 1520 mm Russia – Ukraine – Slovakia – Austria is in the process. We should not forget of Iberian gauge of 1668 mm in Europe – in Spain and Portugal.

All of that roused questions of interoperability as the primary task for the European Union, i.e. the ability of the railway transport to ensure safe and uninterrupted freights and passengers transportation by the railways of unified Eurasian transport space that conforms to maintenance requirements of such roads.

Decisions-making in the sphere of technical regulation in the EU is ensured at the Parliament and Council of the European Union level and made up in the form of Directives, Regulations or other documents, in particular, technical specifications of interoperability (TSI) – execution of which is mandatory for all members of the EU.

Preparation of these decisions drafts concerning the technical part as well as concerning the development of technical documentation including TSI that have direct references to European standards and define the level on technical harmonization and interoperability of the European railways, is executed by the European Railway Agency.

European Railway Agency (ERA) was established in April 2004 by Directive 2004/881/EC to coordinate the technical conditions on technical and exploitation interoperability and safety of transportation, to create the competitive European railway system, to increase the international interoperability of national systems ensuring the required level of safety.

The main purpose of the agency is to assist the

European Committee in implementation of European legislation provisions, focused on the reinforcement of the railways competitive positions by means of technical and exploitation interoperability of different railway systems reinforcement and unified approach to safety as part of all-European railway network "without borders" development. ERA achieves this purpose by means of common technical standards (including TSI) development, working in close cooperation with national state authorities, European institutions, railway administrations, railway industry.

In some areas there is a progress as opposed to other areas. It should be acknowledged that in the nearest future the ensuring of complete technical and exploitation interoperability is not achievable due to significant differences in construction and equipment of technical means operated in different countries.

For example, it would be perfect to have a locomotive fully complying to TSI and suitable for operation on the network of any European country. But at present it is not possible, the major attention is paid to ensuring of rolling stock circulation with no delays on borders that is considered to be an important step on the way to complete operation interoperability.

Directives on operation interoperability of railways have defined the tasks of TSI development for subsystems of railway transport, requirements for their execution and development of certification methods (conformity assessment) of railway system elements to the specification requirements.

TSI directly resembles main parameters, i.e. any regulation, technical and exploitation conditions important from the point of view of interoperability. At that, any main parameter must be connected at least with one of the essential requirements below:

- safety;
- reliability and availability;
- health protection;
- environmental protection;
- technical interoperability.

TSI define minimum and maximum level of technical harmonization for all subsystems of railway transport.

TSI structure allows to define and to describe:

- essential requirements for each subsystem and limits of cooperation with other subsystems;
- subsystem characteristics (functional and technical specifications, operation rules, maintenance rules, personnel qualification, requirements to safety and labour protection and etc.);
- components of operational interoperability (list, admissible characteristics and specifications of components);
- estimation of components and subsystems interoperability, estimation procedures of conformity or suitability for system elements use;
- instructions on the specification implementation, in particular special cases of technical solutions;
- instructions on revision and amendment of the specification.

Requirements concerning achievement of operational interoperability of trans-European railway system refer to design, construction, commissioning, modernization, upgrading, operation and maintenance of the system components, as well as to personnel professional training and qualification.

In the EU putting into operation means receiving of permission for subsystem or its components obtained by the national railway safety authority. The safety authority will not agree for operation, when the authorized certification body does not conduct estimation of the subsystem or its components conformance with receiving the positive results in accordance with requirements of TSI.

The final task means that all elements of railway system must be defined in respective TSI and introduced into legal framework of the EU.

Legal bases of the EU railway system activity are defined by a range of documents below:

- Legal instruments of the highest level – Resolutions of the European Committee, supplements to which are the TSI.
- Before introduction of respective TSI on separate technical issues – the legal instruments of the EU countries in form of current technical prescriptions and standards lists approved by the European Committee. These instruments must be published and be accessible for public.
- Other legal instruments common for the EU, compliance with which is the condition of equipment release to operation.
- Railway system safe operation legislation – Directive of the European Parliament and Council 2004/49/EC dated April 29, 2004 on safety on railways of the Commonwealth and etc.

Beyond the European Union, the Railway Agency is involved in exchange with similar authorized agencies of other regions of the world, for example, with the Administration of railways safety of Australia. As a part of the assignment given to the European Railway Agency on development of technical and operational interoperability of gauge network of 1435 mm and 1520 mm, the regular exchange of information with the Organization for Cooperation of Railways (OSJD) is performed.

WORK OF THE CONTACT GROUP OSJD/ERA

Organization for Cooperation of Railways is international organization established on June 28, 1956 in Sofia (Republic of Bulgaria) on the meeting of the ministers in charge of railway transport. Members of OSJD are the transport ministries and central state authorities in charge of railway transport of 27 countries of Europe and Asia.

According to the Provision on OSJD, other forms of participation on OSJD are also possible, namely as an inspector for ministries and railway administrations (there are 6 of them at present) and as joint venture – for firms and organizations directly connected with railways activity (their quantity is over 30 at the moment). There are Freight One JSC, Neftekhimtrans JSC, Transtelekom JSC etc. among Russian companies joint to OSJD.

The governing body is the Conference of General Directors (responsible representatives) of OSJD railways. The Conference makes decisions on issues referring to trends of OSJD activity as a part of railways and railway enterprises competence. The Conference Meeting is conducted once a year as a rule.

The governing authority of OSJD is the Ministers Meeting that is conducted once a year and adopts decisions on governmental level on all issues referring to trends of activity of OSJD taking into account the offers of the Conference of General Director of OSJD railways.

The main trends of OSJD activity are:

- the development and improvement of international railway transportations, mainly in service between Europe and Asia including combined transportation;
- the formation of the consistent transportation policy in international railway transportations, development of railway transport activity strategy and OSJD activity strategy;
- the improvement of International transport law, proceedings on the Agreement of international passenger service, Agreement on international railway freight service and other legal instruments referring to international railway transportations;
- the collaboration on solving problems connected with economic, international, scientific-technical and environmental aspects of railway transport;
- the development of actions on increasing of railway transport competitiveness with regard to the other types of transport;
- the collaboration on railways operation and technical issues connected with further development of international railway transportations;
- the collaboration with international organizations involved in issues of railway transport including combined transportation.

Introduction of new technical specifications on interoperability for railways of 1520 mm gauge on the territory of the EU countries being members of OSJD and having common border the CIS–the EU with transfer points 1520–1435 mm and 1520–1520 mm has become the reality now. The enclaves with gauge of 1520 mm have already appeared in Slovakia where the line was constructed in 1960s for ensuring the work of metallurgical combine in Koŝice. In 1966 the broad gauge line was put into operation in Poland to ensure large metallurgic enterprise in Katowice. And in 1976 the line between settlements Hrubieszów and Slavkov was put into operation to increase the carrying capacity. There are also small enclaves in Hungary (26 km) and Romania (60 km), the development of project construction of line with broad gauge of 1520 mm from Russia through Ukraine and Slovakia to Austria is proceeded. The gauge in Finland is 1524 mm that requires technical reconstruction of rolling stock used on gauge of 1520 mm. On railways of this country both the general standards applied to other railways of the countries - EU members and private ones for gauge of 1524 mm are operated for a long time.

Carriers and companies governing the infrastructure of these countries directly cooperate with railways of Russia, Belorussia and Ukraine on issues of ensuring of freight and passenger transit towards the EU, Baltic ports and Kaliningrad. At the same time they purchase both separate components and ready-made equipment from Russia and the CIS in the process of railway equipment and infrastructure modernization.

In 2006 the Contact group OSJD/ERA (hereinafter the Contact Group) was established on the initiative of the EU and Baltic states. During the general meetings they decided to make an agreement on conduction of works on analysis of cooperation and interoperability of railway systems of 1520/1524 mm gauge, which are included and not included into the EU, and to consider the question of interoperability between themselves and the system of 1435 mm, as part of this work.

The OSJD members Belorussia, Latvia, Lithuania, Poland, Slovakia, Ukraine and Estonia – support this activity; their representatives entered the Contact Group.

The main tasks of Contact Group are:

- the analysis of technical requirements for technical and exploitation interoperability of railway system of 1520 mm;
- the comparison of these requirements with main parameters of railway system 1435 mm;
- the preparation of technical information needed for resemblance of main parameters of railway system of 1520 mm in TSI;
- the definition of actions for preservation and improvement of existing technical and exploitation interoperability on borders of the CIS–the EU.

The analysis is limited by technical and exploitation aspects of railway system.

The basis of Contact Group work is the Memorandum of Understanding that provides for the establishment of nine general instruments, namely:

1. Set of seven documents on analysis of parameters for technical and operational interoperability

of different subsystems of 1520 mm gauge:

- Infrastructure. Track and track facilities (INF).
- Power supply (ENE).
- Signalling system, centralization, block system and communication (CCS).
- Freight cars (WAG).
- Passenger cars (PAS).
- Locomotives and multiple-unit rolling stock (LOC).
- Operational activity (OPE).

2. Set of two instruments on actions of technical and operational interoperability on the border the EU – the CIS maintenance and improvement:

- Border 1520/1520 (M 1520/1520).
- Border 1435/1520 (M 1435/1520).

Presently, the work on instruments for subsystems "Infrastructure. Track and track facilities" and "Power supply" is completed.

Results of work on comparative analysis of systems of 1520 mm and 1435 mm gauges technical parameters made by the Contact Group in 2007-2009 allowed ERA to recommend for the European Committee to include the railway system of 1520 mm gauge into TSI, developed together with the system of 1435 mm gauge. Following these recommendations published on the web-site of ERA (www.era.europa.eu), the 1520 mm system including into TSI is planned as part of work program for the up-coming years.

It proves that the European Union acknowledged the necessity of the system of 1520 mm gauge including into the legislation of the EU that has been one of the purposes of the Contact Group OSJD/ERA.

Whereby the activity of the Contact Group favours the consideration on the part of ERA of railways of 1520 mm gauge interests both included into the EU and beyond it.

Participation of countries – members of OSJD specialists – in the process of the system of 1520 mm description already allowed to avoid mistakes and misunderstandings and actually influenced the process of the system of 1520 mm gauge entering into TSI that in the end is to allow protecting the interests of railway enterprises and component producers for system of 1520 mm gauge located beyond the EU.

The Contact Group stated that the main parameters of the system of 1520 mm gauge on interoperability can be set forth according to the structure applied in TSI. This is a background for continuation of OSJD and ERA collaboration, and the more precisely will the system of 1520 mm gauge be described in TSI, the more effective its interests will be protected.

Thus, main parameters of "1520 space" railway transport will be taken into account at the TSI development for 1520 mm gauge and will be considered at implementation of the procedure of conformity assessment of the railway products (certification). In prospect, "1520 space" transport will already have normative instruments of the EU, which are valid in legal framework of Europe.

Inclusion of the 1520 mm system into TSI is important for countries not included into the EU (for Russia primarily) both from the point of view of planning and implementation of the development and construction of new lines of 1520 mm gauge projects, in particular the line Koŝice–Bratislava–Vienna, which will be laid on the territories of the EU (Slovakia and Austria) supporting the fifth transport corridor passing on the territories of the CIS (Russia and Ukraine). According to the EU legislation the similar projects will mandatory conform to the requirements of TSI. ■

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In preparation of this article the official materials and interviews of the Heads of the Ministry of Transport of Russia, Russian Railways JSC, European Railway Agency, Railway Administration of the countries – members of OSJD, materials of publications in "World Railways", "RZD partner", "Eurasia New", Railway Gazette International, Railway Transport of Ukraine, "OSJD Bulletin", "Railroader of Belarus" were used.

RUSSIAN MACHINERY: STATE SUPPORT IN CRISIS AND POST-CRISIS PERIODS

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There have been many publications on the ineffectiveness of Russian anti-crisis policy in 2008-2010. The policy is criticized for the fact that the bulk of funds (42% of the anti-crisis package) was directed towards the banking sector. However, there was no proper state control over the use of these funds. As a result, banks made profit on foreign deposits instead of lending the allocated money to the real economy sector. By 2009 the banking sector showed one of the best results among the economic sectors - only 0.8% fall as compared to 2008.

The worst results for the same period were shown by the processing industry (-15.1%) and first of all by the engineering sector (-35%). As of June 2011, the output of the Russian industry was 1.4% below the pre-crisis level (as compared to August 2008, adjusting for seasonality), and the level of machinery and equipment production – by 29.3%, electrical, electronic and optical equipment – by 18.4%, transport vehicles – by 4.9%.

The raiway industry also received the state support, although to a much lesser extent than the banking sector. Is such a strong drop of industrial indexes an indication of state support ineffectiveness or lack of funding? What lessons should be learned from this experience in order to make the industrial policy in the post-crisis period?

The anti-crisis policy of industry support 2009-2010 in Russia included a wide range of tools: from stimulating the demand for domestic products to the direct financial support to enterprises. Comparing it with the industry support policy in other countries, it can be claimed that the Russian government used the most diverse set of tools and embraced a wide range of industries. It became possible because of the financial saving made in the pre-crisis years and to the fact that Russia was not a WTO member (so had no restrictions on subsidies and other prefernces to domestic producers). These facts gave the possibility to directly support the industries most affected by the crisis – car and aircraft production, shipbuilding and other sectors of raiway industry (Table 1).

Despite the large state support, the desired result was not always achieved. The reason was not always in the inefficient implementation of these measures, often it was in the non-competitiveness of the target industry as such. Naturally, this led to low efficiency of measures, adopted to stimulate demand, since the manufactured production was not demanded by consumers. Directly allocated funds were spent to cover the operating expenses rather than for investment and modernization. In strategic terms, the situation did not improve, in such cases it was just preserved due to the numerous financial aids from public funds.

BRIEF INFORMATION ABOUT THE STUDY METHODOLOGY

The model to estimate the measures of anti-crisis support was jointly developed by the IPEM and the Ministry of Industry and Trade of Russian Federation and is based on the assessment of three types of effects:

- direct;
- indirect;
- inverse (negative).

Direct effect is the target result, which was the aim of the taken measure. For measures to support the supply (financial support of enterprises) the direct effect is reflected in financial results, and in our model it is reflected in supported percentage points of the industry profitability, and for

Table 1. Anti-crisis measures of industry support in Russia, 2009-2010.

Type of measure	General measures	Sectoral measures
Supply support (impact on costs) of ventures	Income tax reduction	Change of tax payment schedule (car industry)
	Subsidies to exporters	Subsidies for the purchase of raw materials (light industry, wood products)
	Reducing the growth rates of natural monopolies tariffs	Subsidies for technical re-equipment (aircraft manufacturing, car industry, machinery and shipbuilding, agricultural machinery, light industry, wood products)
	Easier access to credit resources (state guarantees)	Direct funding (aircraft manufacturing, car industry, shipbuilding, defense equipment)
		Reduction of import duties on raw materials and components (aircraft manufacturing, car industry, light, wood products, metal industries, rubber and plastic products)
		Reduction of export duties (metal industries, oil refining, construction materials manufacturing, chemicals)
Demand support		Subsidies to consumers for loans and leasing (aircraft manufacturing, car industry, shipbuilding, transportation industry)
		State procurement, including direct subsidies to state companies (car industry, agricultural and transportation engineering)
		Raising duties (car industry, agricultural machinery, metal industries, chemicals)
Modernization	Tax incentives for innovations	Creation of sectoral strategies (aircraft manufacturing, car industry, defense equipment, pharmaceuticals)
	Development of pilot plants, industrial parks	
	Reconstruction of one-company towns	
	Creation of export insurance agencies	
	Improvement of technical control	

measures to support the demand – in supported percentage points of the index of processing industry (Table 2, and 3). For modernization measures, aimed at long-term effects, assessment of the impact on the development of the industry was carried out. Direct effect on the industry may be compensatory, when the measure only levels the effects of the crisis, in terms of deteriorating the financial situation of the company or a recession in demand for products, or stimulant that is, favoring structural changes. Most measures, taken in 2008-2010 were of a compensatory nature. Compensatory measures provide only short-term effect and do not stimulate the company to overcome the crisis and to continue its further development. Stimulating measures include all measures to restructure and modernize the economy, part of the measures to stimulate the demand, if there is stimulation of innovative demand, part of the measures to facilitate access to credit, if the funds are spent for investment.

Indirect effect is a positive multiplicative effect on related industries in terms of taken measure. The more technological the industry is and the lower the percentage of imported components is, the multiplier is higher. For example, the car industry has one of the highest multipliers to other sectors, but due to the extremely low level of localization of assembly plants, the full effect made on the industry by encouraging the demand was relatively low, and the allocated funds supported not only the domestic auto industry, but foreign companies as well.

The reverse (negative) effects are the negative consequences of the taken measures. Stimulating the demand by providing preferences to domestic producers distorts the competition in the market and could lead to unjustified price increases and increased costs for consumers. The probability of occurrence of adverse effects is higher in cases of direct stimulation of demand - the introduction of protective duties, government procurement. Stimulating consumers to buy domestic goods less frequently has adverse effects. Finally, creation of "greenhouse conditions" at the expense of protection does not encourage businesses to quality development.

Assessment of the effectiveness of anti-crisis measures was based on calculating the "value of state support" (the ratio of money spent related to the results obtained), a qualitative analysis to find out whether the taken measures meet the real problems of industry, as well as by comparison of the anti-crisis policy in Russia with international practice.

TAXATION

Before the crisis, the level of the tax burden in Russia was one of the lowest among major economies. During the financial crisis, the measure to reduce the tax burden on businesses (profit tax was reduced from 24% to 20%) was one of the first to be implemented. At the same time, during the crisis, almost all the countries on the contrary increased taxes, due to the reduction of state budget revenues. Russia, however, managed not to raise but even to lower taxes, at the expense of accrued financial resources in previous periods (Fig. 1).

Table 2. Direct effects calculation results of industry state support in 2009

2009	Manufacturing (D)	Light industry (DB+DC)	Wood products (DD+DE)	Product of Petrolium and Coal (DF)	Chemicals (DG)	Pharmacy(DG 24.4)	Rubber and plastic products (DH)	Other non-metal products (DI)	Metal industries (DJ)	Machinery and equipment (DK-29,3)	Agricultural engineering (DK 29.3)	Electrotechnics and electronics (DL)	Car industry (DM 34)	Shipbuilding (DM 35.1)	Railway Equipment (DM 35.2)	Aircraft industry (DM 35.3)
Direct effects																
Impact on business expences	2.18	0.70	0.72	1.69	1.76	1.18	0.45	0.87	1.29	0.51	0.78	0.47	12.16	8.46	3.47	26.91
Direct subsidy, including:	1.95	0.63	0.38	0.88	1.25	1.09	0.42	0.35	0.87	0.40	0.69	0.39	12.02	8.43	3.38	26.81
Adjustment of income tax	0.50	0.25	0.27	0.87	0.44	1.05	0.29	0.35	0.57	0.35	0.40	0.33	0.00	0.32	0.15	0.33
Adjustment of taxpaying schedule	0.01												0.19			
Adjustment of import duties	0.04	0.02	0.00				0.13		0.0001				0.13			1.19
Adjustment of export duties	0.11			0.005	0.78				0.27							
Subsidies to exporters	0.07	0.01	0.04	0.01	0.04	0.04	0.00004		0.02	0.05	0.29	0.02	0.08	0.51	0.003	1.99
Subsidies for raw materials purchase	0.01	0.28	0.07													
Subsidies for technical rearmament credits	0.01	0.08	0.002								0.002		0.01		0.19	0.09
Direct funding	1.21											0.04	11.61	7.60	3.04	23.20
Implied subsidy, including:	0.23	0.07	0.35	0.80	0.51	0.09	0.03	0.52	0.40	0.11	0.10	0.08	0.14	0.02	0.08	0.08
Adjustment of tariff increasement schedule for natural monopolies	0.23	0.07	0.35	0.80	0.51	0.09	0.03	0.52	0.40	0.11	0.10	0.08	0.14	0.02	0.08	0.08
State guarantees	0.004			0.0001	0.003	0.00			0.02				0.01	0.00	0.01	0.03
Demand support	2.52	0.00	0.00	0.00	0.03	0.00	0.64	0.00	0.96	0.00	35.30	0.00	10.49	0.78	2.64	4.21
Consumer boosting	0.55												1.69	0.78	1.17	4.21
Public procurement	1.21										33.24		5.09		1.47	
Curtain duties	0.76				0.03				0.28		2.06		3.71			
Boosting of related industries	0.00						0.64		0.68							

Source: IPEM calculations, the Ministry of Industry and Trade of Russian Federation and the Federal State Statistics Service

The measure on reducing income tax in Russia was one of the most inefficient in the crisis. The effect of the measures was higher, the more profitable the industry was in the crisis year. However, most of the companies in the raiway industry showed a negative financial result in 2009. As a result, budget losses from the reduction of income tax in the industry totaled 115 billion rubles and almost all the positive effect was in the power generation, mining and manufacturing industries (Figure 2).

CUSTOMS AND RATE MANAGEMENT

Many of the decisions to change the rates of customs duties were made during the crisis. And some of them were temporary (usually nine months), and some – constant. As part of the

Table 3. Results of direct effects calculation of industry state support in 2010

2010	Manufacturing (D)	Light industry (DB+DC)	Wood products (DD+DE)	Product of Petrolium and Coal (DF)	Chemicals (DG)	Pharmacy(DG 24.4)	Rubber and plastic products (DH)	Other non-metal products (DI)	Metal industries (DJ)	Machinery and equipment (DK-29,3)	Agricultural engineering (DK 29.3)	Electrotechnics and electronics (DL)	Car industry (DM 34)	Shipbuilding (DM 35.1)	Railway Equipment (DM 35.2)	Aircraft industry (DM 35.3)
Direct effects																
Impact on business expences	1.20	0.95	0.94	1.03	2.10	1.30	0.64	0.74	1.26	0.51	0.48	0.64	2.24	0.51	6.47	5.71
Direct subsidy, including:	0.96	0.74	0.62	0.95	1.67	1.22	0.47	0.33	0.83	0.37	0.34	0.50	2.01	0.31	6.29	5.28
Adjustment of income tax	0.59	0.32	0.34	0.91	0.90	1.20	0.31	0.32	0.82	0.34	0.09	0.43	0.10	-0.07	0.31	0.38
Adjustment of taxpaying schedule	0.03												0.62			
Adjustment of import duties	0.01	0.08	0.04				0.10		0.0001			0.01				
Adjustment of export duties	0.05			0.001	0.75											
Subsidies to exporters	0.06	0.07	0.20	0.03	0.01	0.02	0.06	0.01	0.01	0.03	0.24	0.03	0.01	0.27	0.45	1.14
Subsidies for raw materials purchase	0.003	0.19	0.04													
Subsidies for technical rearmament credits	0.004	0.07	0.008								0.01				0.20	0.03
Direct funding	0.22									0.007		0.03	1.3	0.12	5.3	3.72
Implied subsidy, including:	0.21	0.20	0.32	0.08	0.40	0.07	0.17	0.41	0.39	0.13	0.10	0.14	0.12	0.17	0.13	0.14
Adjustment of tariff increasement schedule for natural monopolies	0.21	0.20	0.32	0.08	0.40	0.07	0.17	0.41	0.39	0.13	0.10	0.14	0.12	0.17	0.13	0.14
State guarantees	0.02			0.001	0.03	0.01			0.04	0.01	0.04		0.11	0.035	0.05	0.30
Demand support	3.7	0.0	0.0	0.0	0.0	0.0	1.6	0.0	2.5	0.0	2.1	0.0	53.0	0.1	0.0	3.4
Consumer boosting	1.7												31.6	0.1		3.4
Public procurement	0.3												5.3			
Curtain duties	1.7								1.2		2.1		16.0			
Boosting of related industries							1.58	0.01	1.25							

Source: IPEM calculations, the Ministry of Industry and Trade of Russian Federationand the Federal State Statistics Service

measures to reduce the expenses of industrial enterprises during the crisis, import duties for importers of raw materials and components (air, car, light industry, forestry, metallurgy, manufacture of rubber and plastic products) and export duties for exporters (metallurgy, oil refining, construction materials, chemistry) were reduced. To achieve the objectives and stimulate the demand for domestic products by closing the domestic market, duties in the car, agricultural industry, metal industries, chemical industry were increased (Table 1).

Change of customs duties is one of the simplest tools that provide almost instant results both in terms of ease of the financial burden on the costs

Tax rates before the crisis

2008, %	Income tax (corp)	Income tax (for the richest) (pers)	Social tax employer/employee	VAT or sales tax
FRANCE	34.4	51	45/15	19.6
CHINA	25	45	44.5/ 20.5	17
JAPAN	41	50	13.6/ 12.8	5
BRAZIL	34	27.5	28.8/11	25
GERMANY	15.8	47.5	12/12	19
REPUBLIC OF KOREA	27.5	34	14/7.2	10
INDIA	42	34	0/1	12.5
USA	35	35	7.7/7.7	14
RUSSIA	24	13	26/0	18

Tax rates higher than in Russia are highlighted in red, those lower are in blue

Changes in tax rates during the crisis

2009, pp	Income tax (corp)	Income tax (for the richest) (pers)	Social tax employer/employee	VAT or sales tax
FRANCE		+1.1		
CHINA			+4.5/ +2.5	
JAPAN			+0.1/ +0.1	
BRAZIL				
GERMANY				
REPUBLIC OF KOREA	+3.3	+2.3		
INDIA			+12/ +12	-0.1
USA				
RUSSIA	-4			

Tax increase is red, decrease is blue

Fig. 1 Tax burden in major economies of the world before the crisis and its change during the crisis
Source: Forbes, IPEM calculations

of enterprises, as well as of the closure of markets against imported products (Fig. 3).

As part of demand support by reducing the duties, significant effect (relative to the industry) was obtained in the aircraft industry – 1.2 percentage points of 8.4% of the industry's profitability (reduced duties on imported components by 5-20%), chemicals – 0.8 percentage points of 10.9% (reset from 6.5% export duty on nitrogenous and combined fertilizers), and metallurgy – 0.3 percentage points of 14.9% (5% reset export duties on nickel and copper cathode) and others (Fig. 3).

Reduction of import and export duties (demand support) for the state budget is actually equivalent to a direct subsidy, since by reducing the fees, budget revenues fall, by our estimates this is about 17.7 billion rubles, moreover, 5.4 billion rubles of the total come from the reduction of export duties on nickel. That is the sole beneficiary of the measure was Norilsk Nickel JSC. It was a temporary measure and the export duties on nickel and copper cathodes were returned to their previous level at the end of 2009.

Protective duties, by contrast, usually do not cause additional losses to the budget (except for full market closing). Increase in duties coupled with other mechanisms provided the greatest effects in the car, agricultural and metals (pipes) industries (Fig. 3).

Thus, the duties on new vehicles were increased by 5%, on used – by 60-80% (up to the level of protective). As a result, the volume of imports of new cars fell only slightly more than the overall market decline and the share of new imported cars in the market remained virtually the same (46% in 2009 instead of 53% in 2008). While imports of used cars decreased by 96%. "Fresh" used cars virtually disappeared from the market: their share in 2010 was 1% instead of 12% in 2009

Protective duties are one of the easiest in terms of obtaining results and "cheap" mechanisms for the

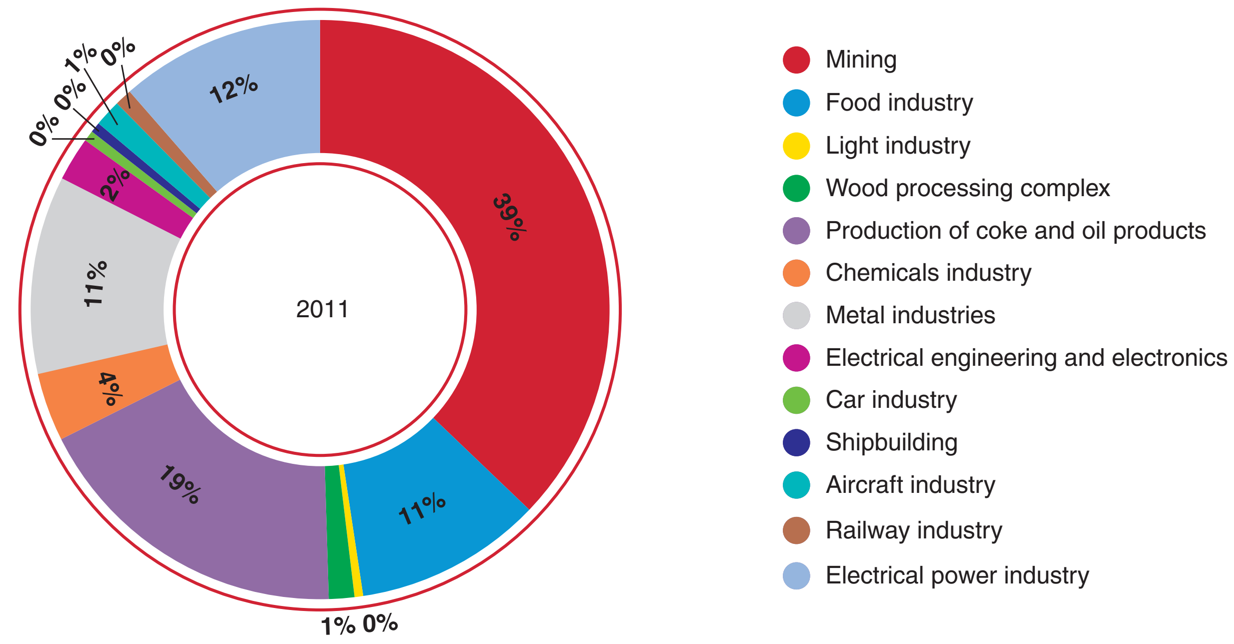

Fig. 2 Effect of reducing the tax on profits for industry (C, D, E of the All-Russian Classifier of Economic Activity Types), 2009
Source: IPEM calculations

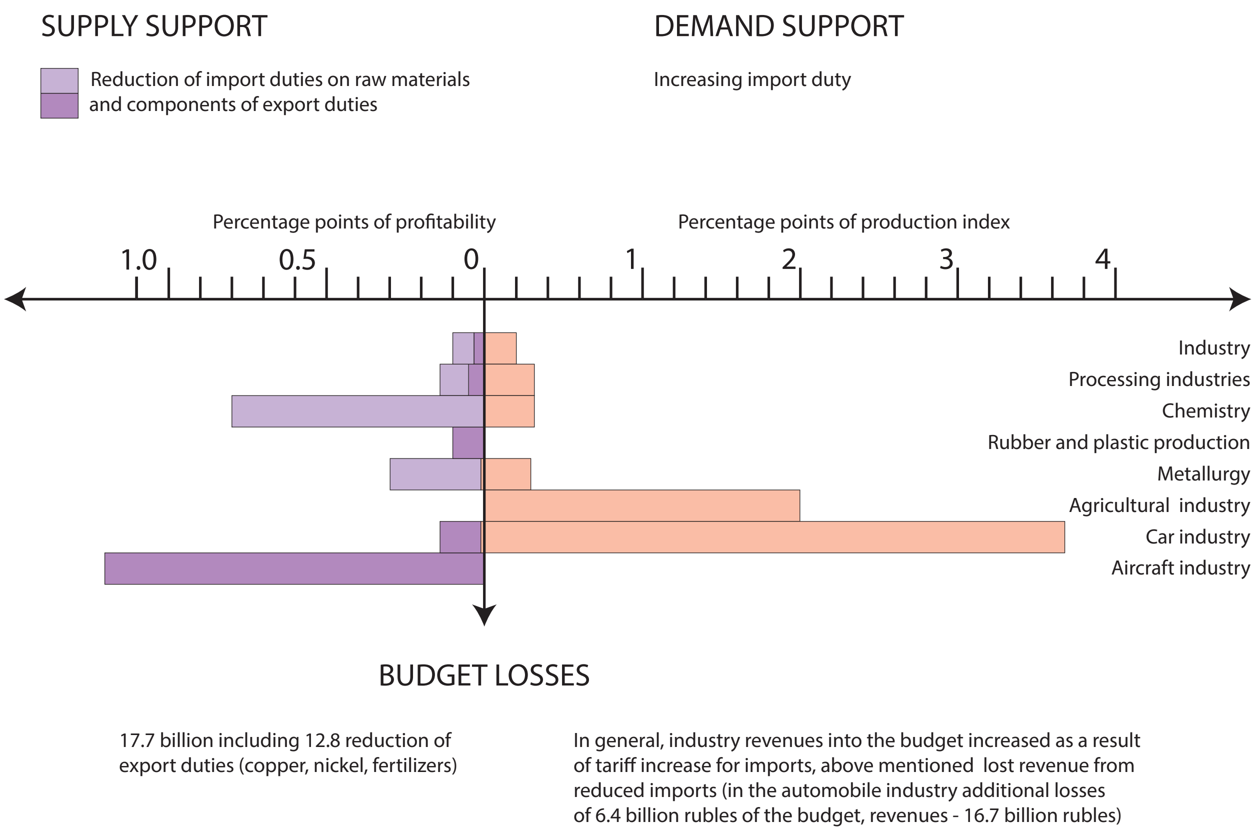

Fig. 3 Effect of reducing the customs duties for industry, 2009
Source: IPEM calculations

state budget. However, this measure has obvious negative effects for consumers, which breaks competition in the market and which most often are expressed by the unjustified growth of prices for the "protected" products. A striking example is the price of cars, the rising cost of which for the year amounted to more than 8%, while the price of almost all components fell (Fig. 4).

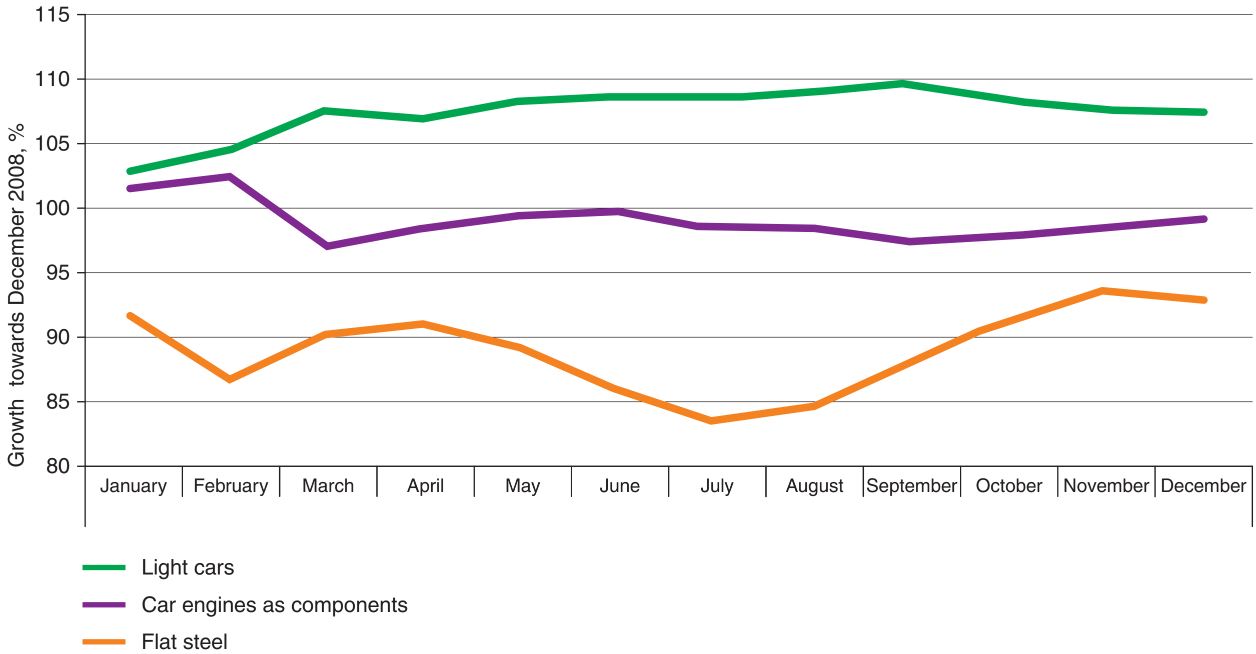

Fig. 4 Comparison of prices for cars and some of their parts in 2009, as compared to December 2008
Source: Statistics Office of Russia

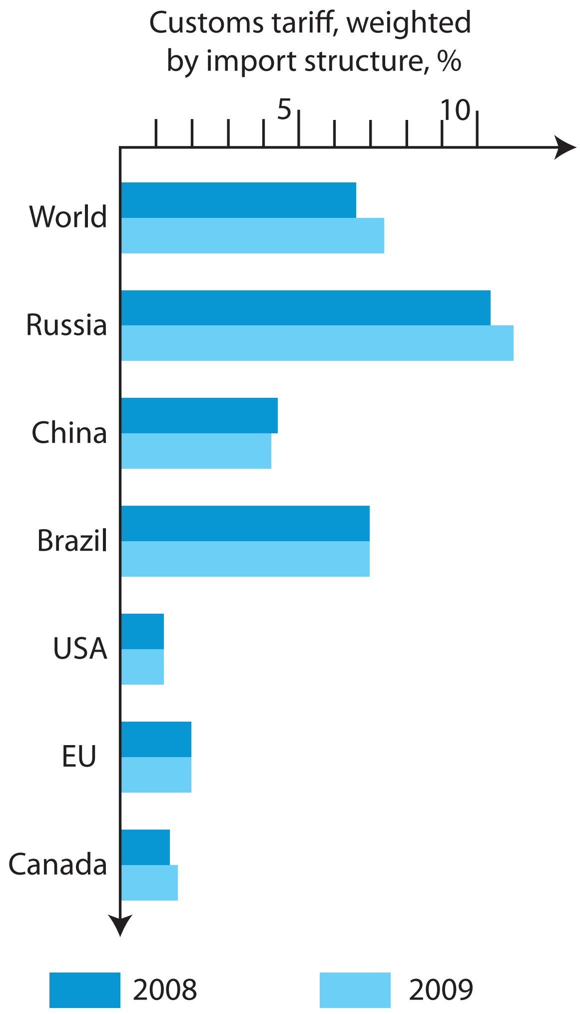

Fig. 5 The average customs tariff in the major economies of the world in 2008-2009 (weighted by the structure of imports)
Source: World Bank, IPEM calculations

The Russian government had the possibility to freely use customs and tariff regulations as an anti-crisis instrument due to non-membership in the WTO. For this reason, the average customs tariff in Russia exceeds the world average, and in particular, is higher than in other BRIC countries, the EU, the USA, and Canada (Fig. 5). These countries did not raise their customs tariffs during the crisis, except for Canada. China's tariff rates in 2009, relative to 2008, were even reduced.

$$T^{I}_{avg} = \sum_{i=1}^{n} T_i \times I_i$$

$$T^{n}_{avg} = \sum_{i=1}^{n} T_i \times P_i$$

where T^{I}_{avg} – average tariff, weighted by the structure of import,

T^{n}_{avg} – average tariff, weighted by the structure of production,

T_i – customs rate for goods i,

I_i – share of goods i in the structure of the country's imports,

P_i – share of goods i in the structure of the country's production.

For example, in China the average customs rates are relatively low, judging by the fact that the country imports about 4.1%. However, if we weight the rates according to what the country produces, the customs barrier will be much higher – 10.7%. The significant excess of the average customs tariff, weighted for the production, over the weighted import is evidence of the effectiveness of customs and tariff policy, since goods that are not manufactured in China prevail in the imports structure.

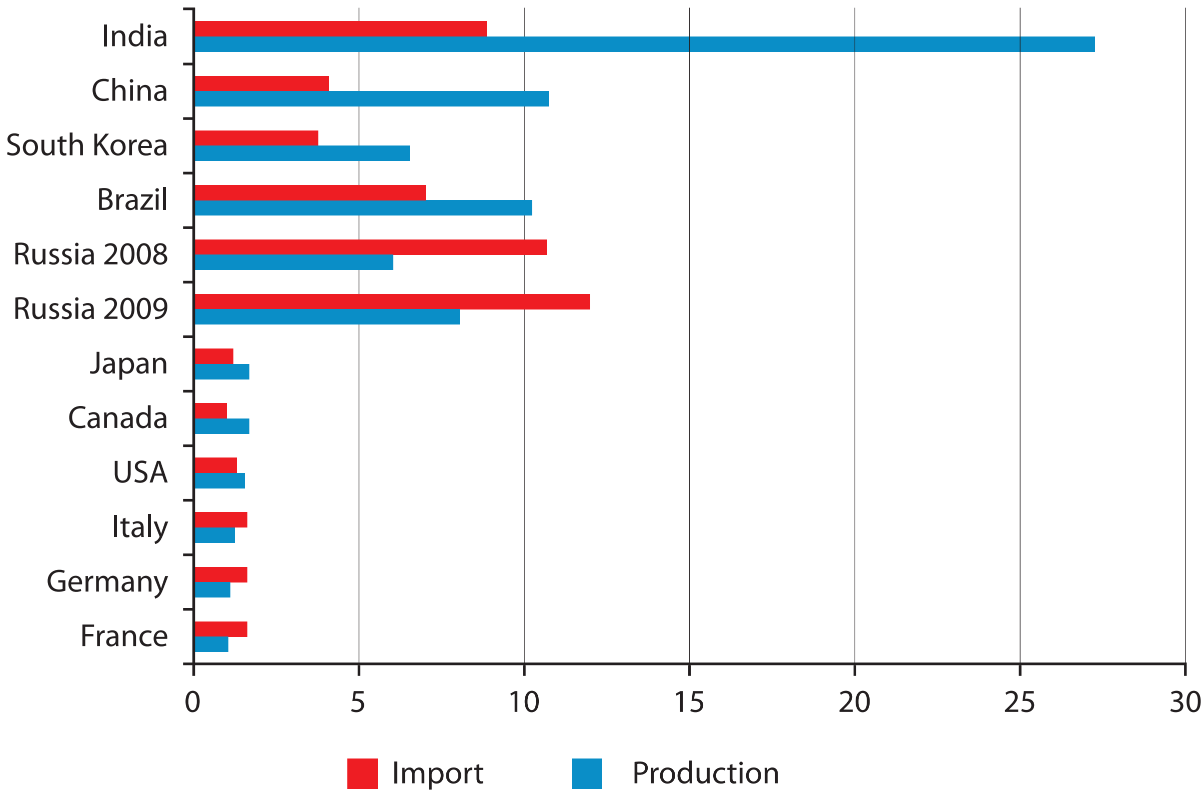

Fig. 6 Average tariffs weighted by imports and production, 2008
Source: World Bank, Rosstat, Federal Customs Service of Russia, IPEM calculations

But it is quite the opposite when we speak about Russia: the average customs tariff, weighted by imports 1.5 times exceeds the tariff, weighted by production (10.7% and 6.0% in 2008, 12.0% and 8.0% in 2009). It turns out that, despite one of the world's highest level of protective duties, this tool is used very inefficiently. A simple example with cars: fees are high – 30%, but still insufficient to give up foreign cars in favor of the domestic cars. Protective duties are a very dangerous instrument of state policy as it violates competition in the domestic market, leading to higher prices and does not encourage entrepreneurs towards innovation and efficiency. It can be used only temporarily – for a period of a specific policy on import substitution. The obtained results of calculations of the ratio of rates, weighted by production and imports, says there is need for improving the efficiency of customs and tariff decisions, raising the rates for the goods for which there are prospects for import substitution and reducing those, where there is not any.

GOVERNMENT SPENDING

Increased government spending in the anti-crisis program was observed in all the economies of the world. The major recipient of government spending, just like in Russia, was the banking sector, improvement of which was to promote the improvement of the rest of the economy.

Directly the real sector was allocated much less. There are three areas where public funds were directed in nearly all the developed countries – automotive industry, construction and innovation. This is not surprising. Car industry and construction are among the highest inter-industry multipliers, and innovation became cheaper during crisis.

Car industry was directly funded by virtually all the countries where there is a large-scale production of cars. This is due to many factors: the vulnerability of the industry, aimed at final demand in times of crisis, high territorial concentration engaged in the industry, a large number of related industries. In 2009, only the lazy ones did not scold the government for the 65 billion rubles, which directly subsidized the automotive industry, to be exact the AvtoVAZ. In fact, if we compare the specific parameters of direct financing of the sector in developed countries per employed person, the amount of financing in Russia was relatively modest, even given the low productivity of labor – 4 thousand dollars per worker in Russia, compared to 80 thousand dollars in the USA (Fig. 7).

In all the countries support of car industry was comprehensive and included both measures of financial support and stimulating the demand. The most popular measure to stimulate the demand was the program of car recycling. The WTO prohibits the granting of preferences to domestic producers, that is why in the U.S. and EU any car (including

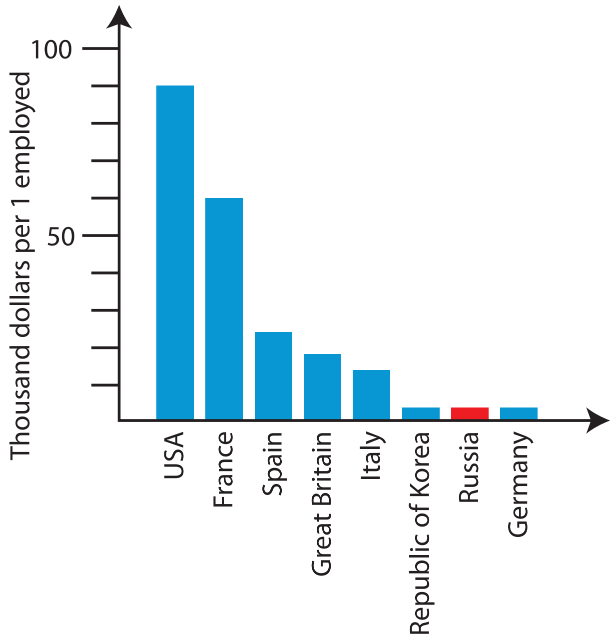

Fig. 7 Volume of direct financing of the automobile industry in 2009 (on returnable and non-repayable basis)
Source: IPEM calculations

foreign-made) could be purchased with recycling certificates. However, the WTO rules were violated by almost all the countries, and for this reason, no country made claims against each other.

There was no other industry similar to the car industry in the scale of state support and complexity of anti-crisis measures, taken by all other branches in foreign countries. In Russia, in addition to car industry, sufficient support was provided to aviation and shipbuilding, agricultural and transport industry, the most capacious and at the same time challenging machine-building industries (Tables 2, 3).

Due to the limitations of the WTO on the direct support of industries, both developed and developing countries, during the crisis, adopted programs to support the construction sector (housing and infrastructure projects). Building roads in the crisis came up during the Great Depression; it is cheaper and helps to engage a lot of people. Construction has one of the highest multipliers, and implementation of projects with the focus on the supply of domestic equipment is strong enough to help stimulate domestic demand, particularly in India and China. In India, large scale employment problems were solved with the help of construction support, often at the expense of road construction with a low level of mechanization. The active promotion of construction in India even led to a shortage of the steel products. In Russia, unfortunately, construction was actually not used as a tool to stimulate the demand, although there was a particularly high potential to support metal industries, machinery, manufacturers of building materials, etc. In this case, measures of indirect stimulation of demand (by consumers) are more effective than direct public procurement and protective duties, and they do not distort competition in the domestic market.

INNOVATION

State participation in the implementation of innovative projects has become an important component of the anti-crisis policy of many developed countries. It has a strategic reason: during the crisis a global redistribution of markets takes place, changing ways of life can happen, leader-countries can be changed. In order to overcome the crisis as a "winner", it is necessary to strengthen the technological advantage. Comparing programs to stimulate innovation in developed countries, it can be concluded that the main directions of state support are energy (search for new energy sources, energy efficiency) and transport (electric vehicles, new types of transport).

Within the framework of the analysis of the domestic industry structural problems [1], it became clear that Russia's risks to get over the crisis as a "loser" and being a lagging behind country are very high. Before the crisis, in conditions of shortage of supply in many markets, the technological challenges of uncompetitive domestic industries, especially engineering, were not so obvious. Amid falling of global demand, competition was increasing; in which Russian manufacturers often lose out to foreigners, mainly due to qualitative criteria. Therefore, according to the IPEM, there is an acute need for a change from compensatory measures, which have a leveling character, smoothing the negative manifestations of the crisis in terms of deterioration of the financial condition of companies and falling demand for products, to the modernization measures.

All the countries, which implemented modernization, first faced the challenge of finding funding and usually solved it with the help of foreign investors. However, Russia does not face such a problem, since domestic business has sufficient funds for investment. Why then is the process of modernization so sluggish?

Let us refer to the ratio of direct and indirect stimulation of innovation on the part of the state (Fig. 8). Russia ranks first in the world by the state's share in funding research and development. And the reason is not in huge amounts of public funding: Russia's share in R&D in GDP terms is a little over 1% while it is 3-5% in the developed countries; this is because of the reluctance of businesses to invest into innovation. There are two reasons for lack of interest of Russian business in innovations – the imperfection of the system to stimulate the development of innovation and lack of competitiveness of innovations in the economy.

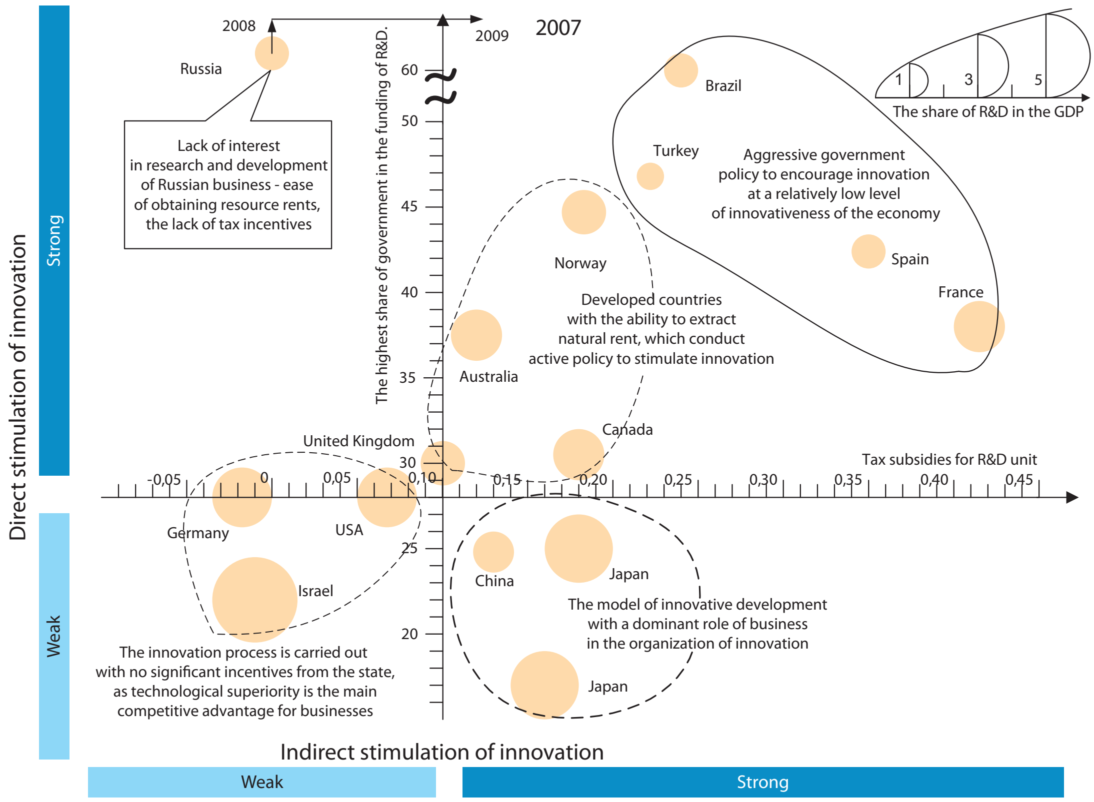

Fig. 8 Direct and indirect stimulation of innovation in the largest economies of the world

Tax subsidies for an R&D unit are calculated based on the OECD methodology as follows:

$$1-\frac{1\text{-tax benefits}}{1\text{-income tax}}$$

Source: IPEM calculations

First – the imperfection of the system that stimulates the innovation development. Prior to the crisis, indirect mechanisms were practically not used in the Russian tax system. A positive step was the adoption in 2009 of measures for tax incentives for innovation; in particular, it was possible to attribute the cost of R&D expenses by a factor of 1.5. However, the incentives for innovation funding remain very low. There is no need to invent anything new here, as international practice allows you to choose from a huge number of already proven mechanisms, those of tax benefits, tax vacations, etc.

Second – lack of innovation competitiveness in the economy. According to the economic theory, the entrepreneur seeks to invest in innovation, as in the future he will be given a competitive advantage and, consequently, greater profitability. However investing in innovation in the Russian context is not so interesting, as there are simpler and more profitable ways of making profit:

- natural resource rent in the energy industry, metallurgy, etc.;
- corruption schemes in the procurement of state and enterprises, which use resource rents.

In order to develop innovative industries, and engineering is one of the main consumers of innovation, business itself has to be interested in it, as the share of state in financing of R&D is already unacceptably high. Business will become interested only in potential profitability of investment, comparable to the business, built on the extraction of natural resource rents. It is necessary not only to strengthen and expand the list of tax mechanisms to stimulate innovation, but also to increase the taxation of branches of first redistribution, in order to reduce their profitability and stimulate capital flowing into new branches of engineering.

INDUSTRIAL POLICY IN THE POST-CRISIS PERIOD

Russian industry began to recover from mid-2009, first due to restoration of external demand, since 2010 at the expense of domestic demand, stimulated by anti-crisis measures of the government, inclusively. Since late 2009, the dynamics of the indices was attenuated, despite the fact that the level of production in industry has not yet reached the pre-crisis level. On the one hand, the potential of another "driver" - recovery of investment activity is not fully exhausted, and on the other hand, it is obvious that the problem is not in the full restoration of certain "drivers", but in the fact that domestic industry, particularly the machine building industry, are emerging from the crisis even more attenuated.

Before the crisis, the problem of non-competitiveness of virtually all technological sectors were not so noticeable, due to the rapid growth of the economy and the deficit of manufactured goods that emerged in many markets. Now, the pre-crisis situation is being repeated in the transport industry, the high demand for carriages, is due to the exceptional market conditions of freight traffic.

During the crisis, during the recession in demand, competition increased, and we began to observe the loss of the domestic market, even in those segments in which the competitiveness of domestic producers was not doubtful (e.g., power machine building). During the crisis, even carriage producers were inferior to the Ukrainian producers with comparable quality but significantly lower prices. Internal demand for domestic manufactured goods on the basis of 2010 rose by 9.8% (estimation based on the IPEM data on transport loading), import - by 36.8%, i.e. by reducing the potential demand in the domestic market, foreign manufacturers have used more than domestic products. In fact, during this crisis, import substitution was observed only in the automotive industry, coupled with aggressive protectionist policies and specific statistics, due to the localization of production of foreign companies in Russia.

The need for major structural changes in the industry is extremely acute, even if we forget about the not so distant prospects of joining the WTO. So far, the only competitive sectors in the industry are those of mineral extraction and primary processing (metallurgy, chemistry and low-tech chemistry, etc.). Focusing only the low-tech industries on competitiveness is the destiny of developing economies. The competitiveness of low-tech industries is determined by the costs, and increase of internal costs is an inevitable component of improving the socio-economic development of the country. Thus, the projected growth in energy prices to world levels will lead to the fact that there will be just one article of costs, slightly lagging behind the level of developed countries - the cost of labor. However, by this indicator we are not competitive with developing countries. Displacement of our country from markets of low-tech sectors by developing countries is an irreversible process and the need for structural changes in the industry is the most acute problem of socio-economic development of Russia. Today the dominant paradigm in Russia is that there is no need for industrial policy, we need general principles of tax, credit, competition, customs and tariff policy. However, according to the IPEM, in the 20 years of market economy, the given paradigm proved to be ineffective, since it results in a gradual loss of technological capacity of domestic engineering.

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COMPETITIVE ABILITY OF RUSSIAN RAILWAYS, ITS CONNECTION WITH DYNAMIC PROPERTIES OF FREIGHT CAR RUNNING GEAR AND THE WAYS OF THEIR IMPROVEMENT

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INTRODUCTION INTO THE PROBLEM STATE. DISADVANTAGES OF THE FREIGHT CAR THREE-PIECE BOGIE AND REASONS OF IT

In the modern conditions of the severe market-based economy, competitive ability and efficiency of Russian railways activity depends upon actual traffic and carrying capacity of railways. It is known that the freight traffic makes the main share into profit. Today Russian railways bear the considerable expenses caused by numerous speed limitations affecting the efficiency of high-speed trains as well as due to car derailing, their detachments due to different failures and other after-effects. Due to the above reasons and some other factors, the level of container transportation via the East-West transportation corridor remains still insignificant (only 1%) as compared with the global movement of goods. At the extended management board meeting of the Russian Railways JSC held on December 22, 2010, Vladimir Yakunin, President of the Russian Railways JSC, stated the need to increase the competitive ability of the railroad transport in the container transportation. He also emphasized the urgent need to increase transportation safety, particularly, at the expense of the prevention of solebar fracture [1]. According to statistics, 2,336 cracks were revealed in freight-car bogies during inspections at check stations of the West Siberian Railway in 2010; it was by 73% higher as compared with 2009 [2].

It is known that the bogie model 18-100 is the basis of an undercarriage for freight cars of Russian railways. As Professor M. Verigo mentioned in due time [3], it is a worsened analogue of American Barber bogie, which was patented in 1928 – about 100 years ago!

Being simple in design and maintenance three-piece bogies have the following number of typical shortages:

- significant unsprung weight and high frequency of free oscillations in the vertical symmetry plane resulting in the considerable force impact to a bogie frame and to a rail, and accumulation of rail dilapidations;
- intensive wear of the "wedge - friction plate" system resulting in the instability and unconformity for the spring suspension dissipative parameters of empty and loaded car;
- insignificant designed gap and friction force between the truck bolster units and the bogie solebar in transverse direction causes an impact interaction of their elements as well as interaction of the solebar with axle box elements. It also causes failure of roller end faces, end face mounting, axle box heating that, in turn, results in significant cases of car uncoupling by the confirmed heating;
- intensive wear of the support surfaces of the mating elements for a bogie and a centre plate arrangement;
- increased, as compared with a Barber bogie, longitudinal and transverse gaps between journal boxes and solebars resulting in the bogie parallelogram shaping at the rail curved sections and, as a result, in the increasing of travel resistance at the sections, flange worn sharp and cut as well as in the increased wear of the side edge of the outer rail head;
- insufficient, due to the above factors, time between repairs, which do not exceed 160 thousand km;
- insignificant reliability of solebars and bugie bolsters caused by casting defects resulting in the solder fracture during operation with severe after-effects.

Due to the above-mentioned structural shortages resulting in low dynamic properties of 18-100 bogie and its modifications, the number of car uncoupling increased in 2010 as compared with 2009 due to the failure of wheel sets and bogies despite the measures, which were taken to update bogies and to equip them with the wheels with increased hardness. Thus, the number of axle box failures was 62,971 (61,169 in 2009 [4]); the number of failures caused by the flange wear exceeded 150 thousand even at lubrication extensive use. Despite the fact that more than 5 million wheels with increased hardness were delivered last year to Russian railways, the number of fails of the wheel tread surface exceeded 180 thousand cases last year. Increased content of carbon and manganese in new wheels which promotes increase of their wear resistance causes at the same time the problems of possible chip formation, difficulties and appreciation of the wheel processing. Significant amount of fails in freight cars due to forced stops of freight trains has resulted in numerous delays of passenger and suburban trains. Thus, in 2010 "more than 3 thousand freight trains and almost 400 passenger trains fell behind schedule through the fault of coach-building workers" [2]. Delays of passenger and suburban trains significantly decrease the attractiveness of the passenger transportation performed by Russian Railways JSC and negatively influence the positive image and the competitive ability of the company.

Such main shortages, as big unsprung weight, spring set significant rigidity, insignificant dissipative forces of the spring suspension during the empty car motion and excessive ones in the loaded motion, various imperfections of wheel sets in combination with the increased rail elasticity modulus, are the reasons causing accumulation of failures in the car undercarriage and defects of the rail upper structure resulting in decrease of their operation life.

Typical defects are metal chipping from rail ends (Fig. 1), fatigue cracks, etc.

Let us note metal chipping in the head of receiving rail, chips, wear hammering of the tread

Fig. 1 Metal chipping in the receiving rail within the joint area at one of Transsib track sections (passed tonnage is 420.2 million tons)

area, significant wear of side edges in the heads of releasing and receiving rail. All these changes indicate the complicated type of the interaction between a rail and a wheel within the joint area as well as the interaction intensity of a wheel with a rail. Such high forces cause numerous rail defects and decrease their operation life. According to the data published by Statistical Department of the Main Computer Centre of Russian Railways JSC, the number of defective rails withdrawn is more than 50 thousand despite the measures taken [5]. Defect No 17 – metal chipping from rail head – dominates and is caused by the interaction impact forces between the elements in the system "rail-wheel". At the cost of one rail more than 28 thousand rubles (≈700 euros), their exchange costs about 1.5 billion (≈37.5 million euros) rubles taking into account the "gaps" in schedule and other expenses. It is also ought to note that 14 million rubles should be spent for the reconstruction of 1 km railroad in the Siberian region caused by the defect accumulation in its upper structure.

"CAR-RAIL" DYNAMIC SYSTEM AND SOME ITS PROPERTIES

Many above-mentioned shortages and problems are caused by low dynamic properties of the bogie model 18-100. As an operation experience shows, its undisturbed motion is not stable due to its design features resulting in more intensive oscillating processes in the "car-rail" system, which threaten the train traffic safety and lead to the above-mentioned after-effects. We would like to note that up to the end of the 60th friction bearings installed in axle boxes have the side play 15 mm relatively an axle neck, thus almost excluding interaction of the wheel flange with the rail head side edge. The wear of the wheel tread surface was the main type of the wheel wear. As a result, the above-mentioned side play, in combination with damping properties of the friction bearing, facilitates the decrease of the body swaying and hunting and, as a result, decreases the interaction forces between wheels and rails in transversal horizontal plane.

During the empty motion of a freight car upon track irregularities, there is an insufficient damping of almost all oscillation forms of a freight car due to the insufficient static deflection, which usually does not exceed 8-10 mm, as well as due to the unavoidable wear in a spring suspension of the elements within the friction pair "wedge – friction plate". It is also reasonable to note the effect of mutual effect of frictional forces perpendicular to each other, which was discovered by Acad. V. Goryachkin [6]: frictional force, which is perpendicular to the preset movement direction (vertical interaction force between a friction plate and a friction wedge) results in the friction coefficient decrease and, hence, in the decrease of the transversal relative track centreline for the horizontal frictional force between a truck bolster and a solebar in the contact between a wedge and a friction plate.

In combination with the existing transversal and longitudinal gaps in solebar junctions with axle boxes as well as between the body and bogie bearers, these factors are the reason of all intensive car oscillations, which decrease its stability against the wheel rolling in a rail head.

Since a car is a complicated mechanical system, re-distribution of oscillating energy may appear in it at certain conditions, which are related to the different symmetry planes [7]. Let us consider one of the most important reasons, which affects the car dynamic properties and which significantly impacts the traffic safety, especially for empty freight cars.

In the most cases, the motion of mechanical system is linearized assuming low oscillations. It is known, that it is possible to consider separately progressive and angular motion at certain symmetry conditions. Usually it is done while studying dynamic properties of railroad vehicles [8,9,10,11].

However, the car body may behave as a pendulum on a moving support since its gravity centre is located higher than supporting points. In these conditions non-linear links may exist between the generalized coordinates of the mechanical system. As a result, the car body motion may become unstable at certain motion speed. To illustrate this statement, let us make the following assumptions. First of all, let us assume (in order not to shade the qualitative aspect of the phenomenon) that the vehicle does not make swaying oscillations. Secondly, let us take the pathway of the left and the right wheel as an excitation that allows to decrease the number of degrees of freedom.

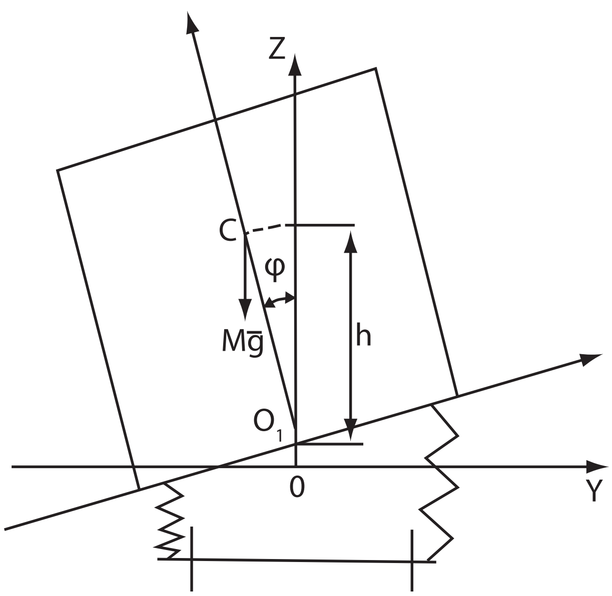


Fig. 2 Computational model of bouncing oscillations and side oscillation of the railcar

Let us assume that a vehicle body displaced by the value and made a turn by φ angle relatively O_1 point (Fig. 2).

At the exact considering the higher-order terms of vanishing in expanding of the expressions for kinetic and potential energy, and taking corresponding derivatives, we would obtain differential equations for bouncing oscillations of the vehicle gravity centre (z coordinate) and its side oscillation (φ coordinate):

$$\begin{cases} M\ddot{z} - Mh(\ddot{\varphi}\varphi+\dot{\varphi}^2)+2rz=rz_L+rz_n; \\ (I_x+Mh^2)\ddot{\varphi}+(2rb^2-Mgh-M\ddot{z}h)\varphi=-rbz_L+rbz_n \end{cases}$$

Here M and I_* are the body weight and its inertia moment relatively the longitudinal track axis correspondingly; 2b is the distance between the left and the right elements of the spring suspension with rigidity r; z_L and z_n is vertical displacement of the contact points between the left and the right wheel with rails correspondingly.

Analysis of equations shows the following. First of all, these equations are interconnected. We would like to emphasise that the component $Mh(\ddot{\varphi}\varphi+\dot{\varphi}^2)$ features a non-linear response action of the vehicle and reflects the influence of a side roll on bouncing oscillations and their increase with the gravity centre height increase. Secondly, it is ought to note that the second equation has both positive and negative solutions. This implies an important fact: strong interaction of constraining forces is possible in vertical and horizontal symmetry planes of the vehicle at certain correlation between the system structural parameters, which define its frequency of bouncing and side oscillations, and the track amplitude. This interaction may result in resonance phenomena and, correspondingly, in the considerable oscillations of the interaction force between a wheel and a rail, which decrease resistance against the wheel flange rolling over the rail head. This interaction of constraining forces in vertical and horizontal planes may have an especially strong impact on dynamic properties of the vehicles with a high gravity centre, first of all, for tank cars and open-box cars. As practice shows, the number of empty car derailments caused first of all by the lack of dissipation energy in the car spring suspension exceeds ten times the similar parameter for loaded railcars. Valid speed limitation for empty trains up to 60 km/h at the curved sections with low radius is a coercive measure that negatively influences the railway tonnage capacity.

Let us state one more significant instant. Side oscillations of the railcar body cause corresponding wheel pressure oscillations on rails and, hence, oscillations of the wheel traction with rail. In turn, decrease of the traction force moment during the train breaking increases the possibility that the friction force moment would exceed the above-mentioned one, especially in severe winter operation in Ural and Siberia and at insignificant air drying in the brake line. It is the reason that causes formation of numerous slid flats at the wheel tread area. Such slid flats in the wheels with increased hardness which become a more and more widespread result in considerable operation costs during their machining (machining time increases as well as consumption of excessive material and electric power). Material costs for the roundhouse servicing of open-box cars in the Kuzbass Region of the West Siberian Railway is about 70 – 100 (≈1,750-2,500 euros) thousand rubles that significantly exceeds the cost of the freight car life time.

During the body swaying oscillations, inertia force of the body and truck bolster make the work, which should be neutralized by the energy emitted at the expense of the friction of the wedge vertical surfaces with the solebar friction plates. It is known [12] that the force dispersion, which appears during the bridging of kinematical links, i.e. during selection of the gap between the truck bolster elements (end surfaces of friction wedges located in splayed apertures of the truck bolster) and stop members of the solebar, is in inverse quadratic dependence upon equivalent decay coefficient as well as upon the free travel of the vibration-protective system (this gap value). The lack of dissipative forces, which is caused by the above-mentioned reasons, as well as the existing insignificant transverse (relatively the track) free travel of a truck bolster result in the following consequence. Open-box cars which have deviations in the undercarriage design parameters from the rated ones make intensive hunting oscillations during their movement at the speed about 70 km/h; and these oscillations are accompanied by impacts of truck bolsters over solebars. These impacts are transferred to the end surfaces of axle boxes causing "herringbone"-like defects, loosening of end fastening and other defects resulting in the further roller jamming and increased heating of axle boxes. Significant normal components of rail reactions, which appear at this time in combination with high rigidity of a spring set, are the reasons of the intensive lateral oscillations of the car body, which decrease the stability margin against a wheel rolling on a rail. Tangential components (frictional forces of wheel flange on a rail) make an additional harm work of the motion resistance (apart from specific travelling resistance forces stated in the Rules for grade computations) causing the increased power consumption. Decrease of the rail gauge from 1524 up to 1520 mm like a pious hope, which is conceived to limit the hunting amplitude for freight cars. However, usage of domestic three-piece bogies, which do not correspond to modern requirements, results in increasing the frequency of contacts between wheel flanges and rails with all above-mentioned after-effects.

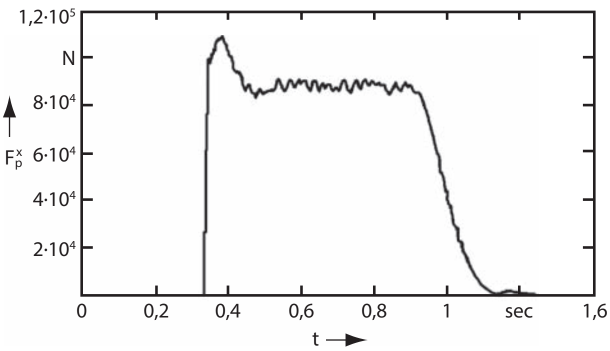


Fig. 3 Oscillograph record of the longitudinal force in the contact of a journal box and a solebar during braking the loaded car on a hump

Significant gaps (15 mm and more) between a journal-box and a bogie frame with further bridging kinematical links cause the impacts in the contact of a journal box and a solebar during a gravity classification yard and adjusting breaking in the train. Analysis of the mathematical model used to describe this process (Fig. 3) shows that longitudinal impact forces, which affect the vertical wall of the bogie side frame aperture of the first car, are about 115 kN while speed adjusting for the coupled three cars.

This predefines the highest concentration of crack formation in the area of the solebar journal-box aperture. It is interesting to note that the

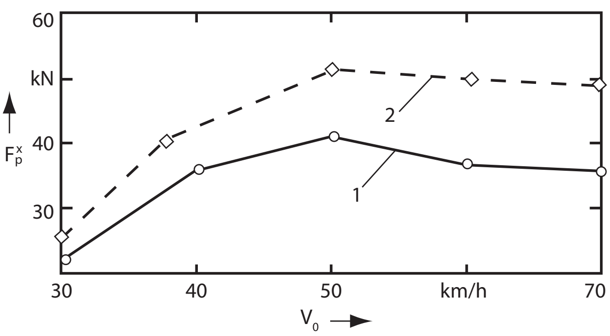


Fig. 4 Dependence of maximum impact load for the railcar journal aperture, which is located in the last third part of the train, upon initial speed during pneumatic breaking (gaps: 1 – 12 mm; 2 – 16 mm)

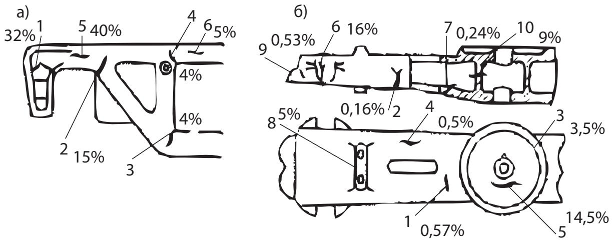


Fig.5 Crack distribution in the bogie 18-100

plot shape within 0.35-0.9 sec illustrates the effect of vibrating linearization of dry friction nonlinear force, which appears in the contact of a solebar support surface with a journal box.

Using the method of movement separation into fast and slow components, which is based on Acad. A. Tikhonov's theorem, the dependences are obtained for maximum impact load of the railcar journal aperture, which is located in the last third part of a train, upon initial speed during pneumatic breaking. They are shown on the Fig. 4.

The obtained data show the significant impact of the longitudinal gap in journal apertures on dynamic load of the solebar end parts (1.5 times on the speed 70 km/h). Such load predefines the appearance of cracks in them that makes a threat to train safety. The influence of railcar speed on the braking efficiency by composite brake blocks is also demonstrated – certain decrease of the sliding friction coefficient takes place at the train speed increase.

Fig. 5 shows the distribution of cracks in the units of the bogie 18-100 described in [13], which corresponds to the current condition almost completely.

According to the data of Carriage Facility Department of JSC Russian Rail-ways, 48 fractures in solebars occurred in the freight car bogies during the last 10 years at Russian railways. The biggest amount of fractures – 12 cases – took place in 2009. This negative trend maintained in 2011– the number of solebar fractures was 20 in the first quarter. There are following reasons for fracture appearance in solebars: the above-mentioned spatial impact loads, which are caused by the imperfection of dynamic processes in the system "car-track", significant unsprung weight as well as insufficient casting quality while manufacturing frames and truck bolsters for bogies.

There are following main reasons of fatigue cracks on the disk inner side near the wheel tread: combination of high thermal and mechanical loads appeared during braking at often imperfections of composite brake blocks, interaction forces within the system "wheel – rail" especially during the car motion along the track with concrete sleepers. Increased rigidity of such track as compared with wooden sleepers, large unsprung weight as well as significant hardness of volumetrically-quenched rails and wheels will result in an increase of dynamic forces during the rail contact with a wheel. It was found [14] that the unevenness on a tread surface 250 mm long and 1 mm deep results in an increase of the wheel pressure on a rail up to 215.6 kN for concrete sleepers and up to 192.1 kN for wooden ones at 70 km/h and the static wheel load 100.45 kN. Just due to these reasons, it was found two times more cracks in wheel sets at West Siberian railway in 2010 as compared with 2009 [2].

TREND IN DESIGNING MODERN BOGIES

The acute need to increase traffic safety, traffic and carrying capacity at the expense of the increased permitted axial loads, increase the time between repairs raises the problem to increase operation parameters of the freight car bogie. Many research groups are involved in solving of this problem.

One should note that three-part bogies, which have sufficiently simple design, are used in the USA, South Africa and in FSU countries in contrast to the basic modified Y 25 bogie, which are used in most countries of Western Europe, and some other models (LTF25), where the difference in the automatic coupling height is absent. For example, there is ZK6 bogie (with cross connections to prevent the bogie skew in a plane - China), 18-100 bogie and its modifications (18-194, 18-578, Russia) and 18-755, 18-781, 18-1711 (Ukraine) etc.

Most of the designers dealing with freight car bogies for Russian railways update 18-100 bogies (as an example, 18-9771 bogie may be mentioned, which was designed in Promtraktor-Vagon CJSC), or create the bogies based on the modified Barber bogie. The general trend of such bogies comprises a certain increase of static deflection of a spring suspension, use of the modern wear proof changeable elements and updating the bearer design.

This plant manufactures 18-9836 bogie (designed by «ASF-Keystone» (USA)) as an undercarriage for open-box cars with new design. This bogie fea-tures an increased rigidity in a plane as well as a decreased wear of friction couples, adapters in frame joints with journal boxes having cassette-type bearings.

Petersburg State Transport University, Moscow State University of Railway Engineering, VNIKTI, Ural State University of Railway Transport and other scientific bodies deal with bogie designing in close cooperation with Uralvagonzavod. Thus, Tikhvin Freight Car Building Plant CJSC has designed the innovative bogie of 18-9810 model, which is based on «BARBER S-2-R» bogie developed by Standard Car Truck. It does not have non-metallic elements that would keep its resistance to low temperatures. As it was announced, the overhaul life of the bogie is 500 thousand kilometres, and the static deflection under empty railcar is 25 mm; it is 3.5 times higher as compared with the bogie of 18-100 model and two times higher than 18-578 bogie.

The Strategy for Development of the Russian Railway in the Russian Federation till 2030, which was approved by Russian Government, foresees a fundamental modernization of the railway infrastructure and increase of container transportation. As a maximum, it is necessary to update almost 24 thousand locomotives and about 1 million freight cars. It means virtually complete renovation of the Russian railways stock. Taking into account the modern requirements to carrying equipment, the problem of designing a freight car bogie, which provides high dynamic properties, required speed and traffic safety, is especially topical today.

The need to decrease a railcar impact on a truck needs the decrease of the bogie unsprung weight. For this purpose, Uralvagonzavod designed the bogies with hollow axles and the spring suspension at axle stage in the 60s. However, that experience was unsuccessful due to high rigidity of the typical (traditional) spring suspension and considerable dynamic loads caused by it. Today, Izhorskie Zavody JSC has designed the bogie of P25.120 model with rubber and metallic springing elements at axle stage of a springing. Due to the strict limitation for the height difference of the railcar automatic coupling, the flexibility of the spring suspension for these bogies was insignificant and did not provide the necessary dynamic properties of railcars resulting in the increased stress and strain state of a bogie frame.

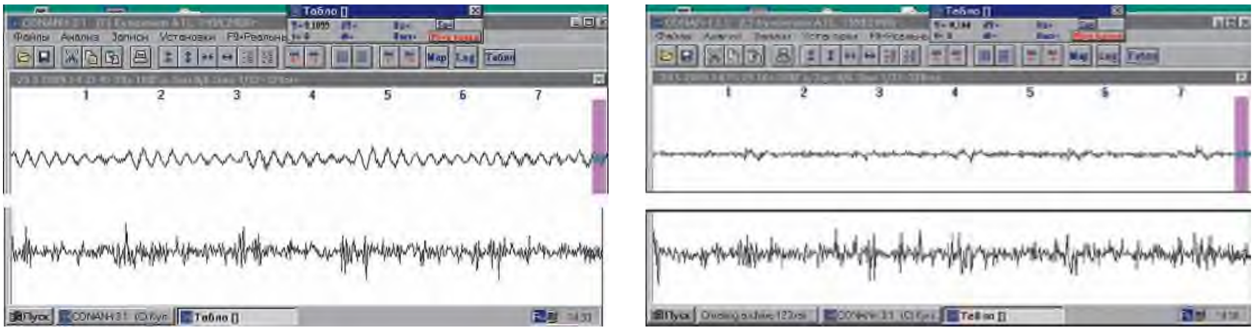
It is also necessary to note the important fact of the difference between the weather conditions in the USA and South Africa, where Barber bogies are used successfully enough, and in Siberia, Ural and the northern part of Russia, which are featured by low temperature of railroads six months and more. Track rigidity significantly increases at a low temperature; besides, a frost heave causes track irregularities. It is very important to note that an increase of the spring suspension flexibility is strictly governed by the above-mentioned limitation for the height difference of automatic car coupling. It could not be increased to the necessary value using typical spring suspension, which includes a set of springing element and a shock absorber. This limitation is virtually the main reason of many existing problems of railway operation (insignificant traffic and carrying capacity of track sections, which do not correspond to the modern traffic safety requirements, considerable operation cost for hauling operation and carrying equipment overhaul, insufficient operation life of freight cars).

In these conditions, increase of traffic and carrying capacity of Russian railways due to increase axle load and traffic speed of freight trains, which undercarriage is an off-market three-part design of the bogie and its modifications, is palliative in our opinion; it could not dramatically solve the problems of Russian railways due to the fundamental disadvantages of such bogies.

COMPENSATION OF EXTERNAL DISTURBANCES IS A WAY TO INCREASE THE RAILCAR DYNAMIC QUALITIES

As it is known, one should decrease vibration of a disturbance source and improve dynamic properties of the springing system of railway vehicles in order to achieve their smoothness of movement. This first direction is implemented as a continuous welded rail, which is made as heavy rails put on concrete sleepers and a stabilized broken stone underlayer; elimination of a wheel set imperfections (their eccentricity, ravelling, slid flats, etc.) and the tread surface of rail heads. The second direction is connected with an increase of vibration-protective properties of a spring suspension both in the vertical and horizontal plane via optimal rigidity and damping parameters for elastic suspension. Increase of relative travel of a truck bolster up to 40-50 mm will serve as an expedient measure in a horizontal plane with formation of non-linear (better as a tangent curve) spring and corresponding dissipative characteristics. It is necessary to take measures to prevent skews in bogie units in a plane by installing using diagonal rods, which efficiency was proven by H. Sheffel [15] and confirmed by the field experience of the railroads of China and South Africa.

The problem of an efficiency increase for dynamic qualities of a spring suspension and freight car as a whole may be solved using the principle of external disturbance compensation in the axle stage of the bogie springing [16], which is equivalent (in dynamics) to the decrease several times of the springing system rigidity of the object being protected. In turn, it facilitates a smoother travel of a vehicle, stabilization of the interaction between a wheel and a rail; decrease on an impact on a rail and decrease the possibility of flat slid formation. The



a) b)

Fig. 6. Oscillograph records of the vertical acceleration for the wheel (below) and body of an empty railcar: a – with typical spring suspension; b – with compensating device

essence of the principle is the parallel connection of spring element, which has a negative rigidity within the range of operation deflections, into the usual scheme of a spring suspender. This element forms the force directed opposite to the dynamic reaction of the main spring member. Alternate designs of the spring suspension, which use the proposed vibration protection, are developed based on the theory of analytical designing, which takes into account dimensional, strength and functional limitations imposed on the springing system parameters. Their novelty is protected by a number of patents.

Physical model of quasi-invariant spring suspension of a freight car was developed to estimate validity of theoretical studies based on similarity criteria. Disturbance action is the combination of track irregularities by N. Kudryavtsev and maximum operation wheel eccentricity 2 mm. Additionally, the disturbance corresponding to the rail defect No 14 was added. Maximum joint unevenness was 8 mm. CONAN hardware and software unit was used to analyze experimental results. Functional possibilities of the complex allow performing post-experimental data analysis, visualization of signals and experimental results. It was found that the vertical acceleration of the car body with proposed springing system is less by 60-80 % as compared with a car having typical bogie. This efficiency is almost impossible to attain for the railcars using the bogies with traditional spring suspension (Barber bogie, ZK6 etc.) due to the strict limitation per the height difference of an automatic coupling. It was found as a result of experimental study that the maximum acceleration of a track body equipped with a compensating device appears at lower frequencies as compared with the railcars with typical spring sus-pension. Maximum acceleration achieves for the railcar with compensating device at the disturbing frequency 3 Hz in an empty condition, at the disturbing frequency 2.5 Hz in a loaded state. We would like to note that static deflection of a railcar should attain 0.256 m at typical spring suspension in order to achieve its natural frequency of chattering oscillation 2.5 Hz in a loaded condition. It could not be implemented due to the strict limitation for the height difference of a car automatic coupling. We would like also to note that the natural frequency of chattering oscillations for a freight open-box car is 5.5 Hz in an empty condition and 3.2 Hz in a loaded condition for a freight open-box car equipped with 18-100 bogie.

Fig. 6 illustrates oscillograph records for vertical vibrating acceleration of the elements "car – track" at the motion speed 80 km/h (amplification coefficients for the devices are the same in both cases). Thus, due to the new spring suspension, considerable increase of dynamic properties will be able to provide:

- decrease of the force dispersion in the contact of a wheel with a rail, i.e. an increase of the resistance against the rolling a wheel flange on a rail head and, hence, increase of the traffic safety level;
- decrease of unsprung weight using the axle stage of springing with decreased dynamic rigidity and, hence, decrease of the impact on rail, decrease of repair costs;
- decrease of the probability for slid flat formation. Slid flats would de-crease the service life of wheel sets; increase an impact in track and rail structure dilapidation and increase of the machining costs for the wheels with increased hardness;
- wear decrease of the contact surfaces for damping device in the proposed spring suspension since the corresponding level of dissipative forces will be lower at the flexible springing as compared with the spring suspension of the typical bogie;
- decrease of dynamic loads on railcar units and decrease of overhaul costs;
- increase of movement smoothness and preservation of the cargoes being transported; increase of train speed and efficiency of the railway transport as a whole.

CONCLUSION

The presented paper confirm the relevance of the problem connected with increase of the competitive ability and operational efficiency of Russian railways; describe the disadvantages of the existing three-part freight car bogies and their development trend; show high dynamic qualities of the spring suspension based on compensation of external disturbances.

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Joint Stock Company Incorporated Electrotechnical Plants

JSC “The Incorporated Electrotechnical Plants” (JSC ELTEZA) is specialized in railway signaling equipment production for automation of technological processes management on rail, at underground systems and industrial enterprises. The Company accomplishes works at all life cycle phases of signaling equipment: design documentation development,equipment supply, construction, installation and start-up works with service backup at customer’s facilities.

The Company was established on the basis of electrical engineering plants, the branches of JSC Russian Railways. Business activities of the Company started on the 1st of June 2005, although history of rail signaling equipment manufacturing and development goes to 1916, when the first signaling and communication equipment department was established.

Vladimir KLYUZKO
Director General

JSC ELTEZA includes eight production branches:

- Armavir Electromechanical Plant;
- Volgograd Casting-mechanical plant;
- Yeletsky Electromechanical Plant;
- Kamyshlovsky Electrical Engineering Plant;
- Losinoostrovsky Electrical Engineering Plant;
- North-West Production Complex.

The Company is the largest producer of railway signaling equipment in Russia and CIS countries. The list of produced items includes more than 4,000 identities of serial production for railway signaling systems: relay, relay-processor and SCB (signalling, centralization and blocking) microprocessor systems devices, railway crossing equipment, control and monitoring systems. The equipment is delivered to the objects of new construction, reconstruction and modernization. Moreover, customer is supplied with backups for repair and maintenance purposes. The strategy of JSC ELTEZA is to provide of complex service package as an integrator in railway signaling projects: from equipment production and completing to testing and start-up works at turnkey objects. Policy of cooperation with international engineering company Bombardier Transportation supposes the employment of the up-to-date signaling equipment manufacturing based on JSC ELTEZA production capacities:

- a sleeper-integrated point machine EBI Switch 2000 designed for high-speed running;
- jointless track circuit equipment EBI Track 400;
- an automatic microchip-based level crossing system with a built-in electric power supply and remote monitoring system EBI Gate 2000;
- a high-power microchip-using computer-based interlocking system EBI Lock 950.

The priority of JSC ELTEZA work is the development of production capacities for modern signaling equipment systems manufacturing, improvement of production quality, implementing of turnkey works, organization of equipment service with full range of technical support at all stages of product life cycle.

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LEAN PRODUCTION TOOLS EFFECT ON EFFICIENCY OF NOVOCHERKASSK ELECTRIC LOCOMOTIVE PLANT LLC (NEVZ)

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The modern period of global economic development and globalization processes in the vehicles market and equipment rise new requirements to the national transport machinery. The saturation of the railway equipment producers market in developed countries is leading to the reorientation of marketing strategies of the world's engineering industry leaders towards the CIS countries, in order to fill free market niches that appeared in connection with the necessity to fully modernize the railways on the post-Soviet territory. In such circumstances, extensive established traditional approaches to manufacturing organization and a substantial backwardness of scientific and technological development of the national machine manufacturing from the foreign one may lead to the displacement of national railway equipment producers from the market in the future. The tendency to substitute the national manufacturer is progressing not only by the placement of orders for the equipment and its components abroad, but also by a partial reduction of process cycles and production capacity, especially at the primary and secondary production stage. This may ultimately lead to the development of assembly production alone. The development of the primary and secondary stages of the production chain is the most innovative, high-tech, knowledge-intensive and time consuming, which is of particular importance to the national industry and economy. Therefore, our companies need to introduce innovative and intensive methods of production management to successfully compete with foreign manufacturers. Innovations in our traditional industries, such as beginning-to-end raiway industry, will provide a tangible economic benefit. This is due to the real demand and practical possibility to implement innovations in classical industries, caused by the actual state of the national infrastructure and the current rate of development of the Russian economy.

The optimization using lean production tools was originally developed by Toyota factories in the 1950-s [1]. Nowadays, this kind of optimization is a widely known and popular organizational approach to improve the efficiency and intensification of a machine-building enterprise. The wide spreading of lean production began with a successful introduction in the American motor industry in the 1980-s and received its further development and implementation in major industrialized countries in the early 1990-s. The Russian manufacturers showed interest in lean production tools only in the 2000-s, which was naturally associated with specific economic development.

If we look at the country's history, rationalization, intensification and efficiency improvement issues were being researched long before the 1990-s. Integrated optimization of the production sector was considered within the scientific labor organization, which began to be promoted in our country in the 1920-s [2]. In the 1960-s and 1970-s, the approaches of the scientific labor organization were widespread at major national machine-building enterprises. If we compare the approaches of the scientific labor organization and the modern lean production tools, we will find a significant similarity, particularly in practical testing and implementation.

Regarding the implementation of innovative approaches in the organization of the production process, such as the scientific labor organization in the planned economy, and the lean production in today's market economy, Novocherkassk Electric Locomotive Plant has always occupied a leading position.

The company is the largest producer of trunk freight and passenger electric locomotives, industrial traction installations, electrical equipment and repair pieces for electric locomotives and electric trains. Since their invention, over 16,000 electric locomotives of more than 50 types were manufactured at NEVZ for various purposes. All of them are successfully employed on the railways of Finland, Poland, China, Russia and the CIS countries. Nowadays the company is successfully developing new capacities and new equipment.

The NEVZ always gives special attention to production and auxiliary processes rationalization, intensification and efficiency. Thus, A.S. Rodov, a production manager, introduced a system of operational production planning in the 1960-s [3], which allowed the realization of electric locomotives production on a single production rate, and the organization of information flows in the planning process was close to the Japanese system of Kanban. The material flow management in accordance with the common rate was carried out by means of the method that was close to the Hajunka principle, which is implemented within the Toyota production system. After the successful implementation at NEVZ, Rodov's system was spread to more than 1,500 enterprises of the former Soviet Union. Even foreign manufacturers showed interest to Rodov's system.

Active implementation of the lean production at NEVZ started in 2006. During the pilot project realization at the section of current collectors in 2007, they eliminated a "bottleneck" and the loss of 40% of the production cycle time, which allowed to use the section as a model and quickly transmit the positive experience to other units. The parallel large-scale introduction of the 5S system in the main production units has significantly improved the corporate production culture and has prepared the company for the introduction of more sophisticated lean manufacturing tools.

The crucial moment in the lean production implementation, which covers the basic production units, began in the middle of 2008. The realization of lean production projects, together with other organizational and technical measures, enabled the production of marketable output at the level of 104.6% from the indices of the business plan performance in the context of worn out and outdated equipment and lack of qualified personnel. Good results were obtained at 5 pilot main production shops: a steel, forge, body builder, bogie and electric machine shops. The projects at these shops involved the staff at all levels, they were aimed at the "undoing" of "bottlenecks" critical to the enterprise.

A number of measures to improve the quality of casting were realized at the steel shop. They were aimed at reducing the number of casting defects in the traction motor core, which enabled a 20% reduction of time during the draft core bore process during the section of mechanical operation at the electric machine shop. The level of steel casting defects has reduced by 38%.

Measures on forgings ensured the performance improvement of the thermal cutting section by more than 30%. The "bottleneck" on body and bogie frame blanks was removed, and the performance of the hardening furnace was improved by optimizing the thermal processing mode, which enabled a 20%-reduction of energy costs.

Measures implemented to optimize the production at the section of the breast beam of the body frame enabled a 46%-shortening of the production cycle. The general productivity increase of 20% was provided at the section where body frames were produced. This was the reason to abandon foreign cooperation plans for metal bodies that were in the business plan of the year 2008.

A full reorganization of the material flow and journal-boxes and axes production took place at the bogie shop. This led to the establishment of object-closed sections, focused on the continuous flow of single pieces. Technological solutions on gear wheels milling enabled a multiple performance improvements in the wheel production section.

Measures to improve the overall equipment efficiency were implemented at the electric machine shop. Conventional readjustment sheets were developed at the section of core mechanical operation. They enabled the efficient use of the working time of borers. Multi-machine servicing was introduced at the CNC equipment section. Taking into consideration the fact that they lacked highly-qualified operators, this innovation allowed making the switch to three working shifts, seven days a week, with the existing staff. Additional processing was transferred from the multipurpose equipment to CNC equipment, due to the increase of the working hours.

The total annual economic impact of the implementation of pilot projects of lean production at the 5 major production units reached 50 million rubles.

A practical analogy may be drawn if we carry out a detailed review of lean production tools and scientific labor organization approaches, which were introduced at our plant at different times (Fig. 1). The similarity of the lean production tools with organizational and technical measures to rationalize and optimize, which had been previously successfully implemented at NEVZ, and the positive experience of their implementation, enabled a significant acceleration in mastering new approaches of lean production. As you can see in Figure 1, complex approaches based on the lean production and the scientific labor organization basically consist in the systematic realization of improvements. It was the quick mastering of the lean production due to the positive experience in production efficiency optimization and improvement that enabled a significant strengthening of our positions in the market where conditions change daily.

The use of advanced approaches in the organization of the production, intensification and the efficient way of development in accordance with the lean manufacturing concept, have a significant impact on key performance indicators of the enterprise. The general trend of output growth was preserved in the period

Lean production tools	Analogy with the scientific organization of labor and system of work rationalization	Historical experience of the enterprise
	Production planning system	
Production Tact, Principle Pull: FIFO, Kanban (production using Tact, the "pull" system) One piece flow, Cell (continuous stream of single articles, production cells)	Operating production planning system for each material stream according to the needs of assembly workshops Organization of object-closed workshop sections and cells, flexible response of the production to changes in shift tasks	Implementation within the whole enterprise of the A. S. Rodov system (since 1962) The implementation of a continuous production stream of single articles, production cells in pilot divisions (since 2008)
	Methods of organizing working places	
5S, Standard Visual Management (System 5S) SMED (Optimization of the changeover time) Shop Floor Reengineering (Reorganization of production workshops)	Clean and tidy, ergonomics of workplaces. Measures to reduce the preparatory- concluded time during transition to another party Rational distribution of the working places and equipment in production workshops	Implementation of 5S throughout the entire enterprise (since 2006) Optimizing the changeover time at the pilot workshops (since 2007) Equipment transition, rearrangement and reorganization of working places, the combination of occupations, the implementation of many machine services to focus on a continuous production stream (since 2008)
	Technical maintenance and repair system	
TPM (System for universal service of equipment)	Creating integrated teams, the responsibility of team workers to maintain equipment in proper condition	Implementation of TPM on the scale of the entire enterprise (since 2006) Combination of mechanical and power engineer groups, in MRO workshop services, inclusion in the production teams of auxiliary workers (since 2010).
	Methods of analysis and problem solving techniques	
ABC – analysis (Method of analysis based on the 20:80 rule)	Selection of the most laborious part of the workshop nomenclature for rationalization	Appliance of ABC analysis in the workshops of the shop floor production to detect the product whose manufacturing process could be optimized (since 2008).
Diagram Ishikava, 5 why (problem-solving methods based on the cause-effect relationships) Value Stream Mapping (Mapping of the creation of the value stream)	System analysis	Application of Ishikava diagrams to solve problems of the foundry, to determine the causes of equipment downtime (since 2008). Application of the method of mapping in workshops of the shop floor production to identify the overhead losses (since 2008).
Diagram Spaghetti (Method of graphic representation of material streams)	Rationalization of planning, rational allocation of working places and equipment in production areas	Use of graphic analysis of material streams on the shop floor production workshops for rational permutations of equipment (since 2008).
OEE (Total efficiency of equipment)	Analysis of extensive and intensive usage of equipment at the working places	Application of OEE to analysis of the efficiency of equipment and working places at pilot sites with universal and CNC equipment (since 2008).
	System of control and quality assurance	
Statistical Process Control (statistic methods of quality control) Active Quality Control (Operating quality control system)	Analysis of the execution of quality plans in the workshop and in the enterprise, development of measures to improve quality Monitoring of quality control by workers of workshops, financial incentives for workforce to improve quality of production, formation of team forms of payment for labor	Implementation of statistical quality control at the enterprise (since 2008). Implementation of team forms of labor in the workshops with payment for the final quality product (since 2008). Implementation of self-control in the pilot divisions (since 2009).
	Organizational measures and practical training	
SWIP, Kaizen (formation of working groups to undertake practical training and short-term improvements)	Involvement of all personnel in the process of rationalization of the manufacturing site	Implementation of measures to improve by the working groups' efforts, formed from the labor of the employees of different divisions (since 2008)
	Rational approaches to design	
Standardize Components & Modularity, Poka Yoke (standardization of components and modular construction design)	Unification of assembling nodes and units	Implementation of the modular principle in designing of electric train EP20 (since 2010)

Fig. 1 The analogy of lean production tools with the approaches of scientific labor organization in the historical context of NEVZ

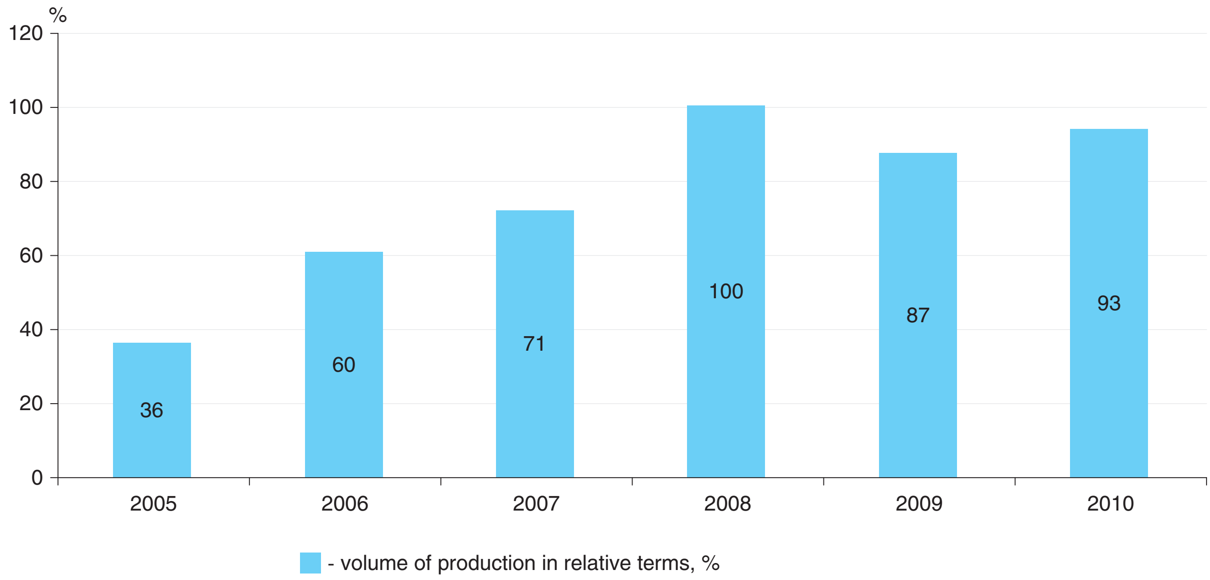

Fig. 2a Change of production plan

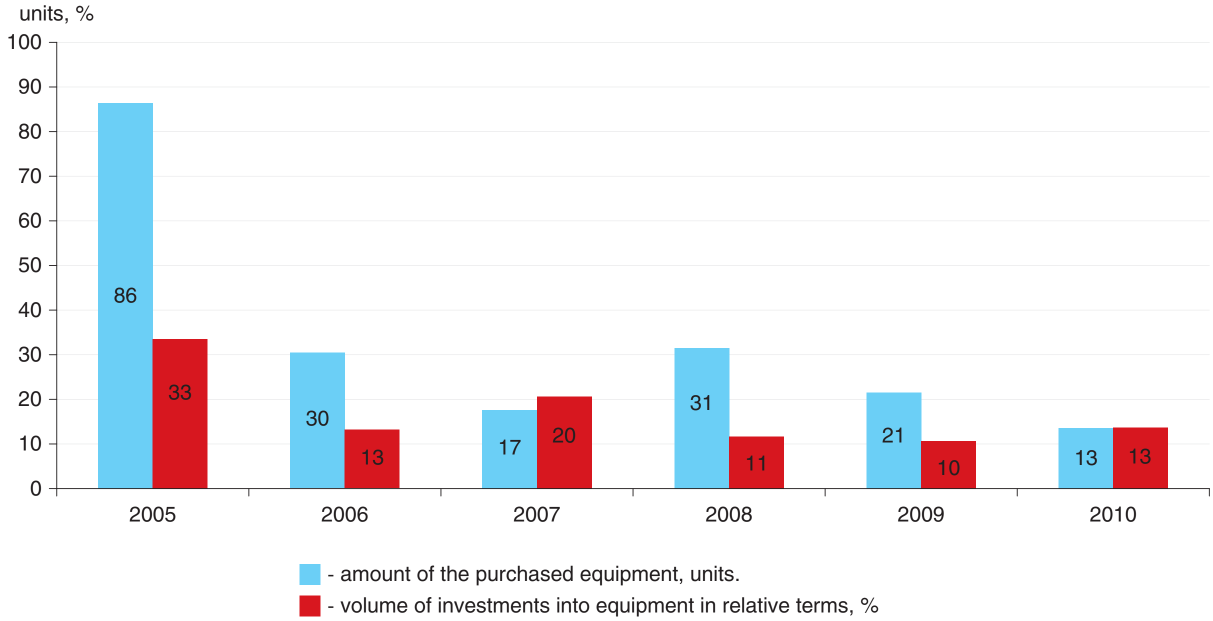

Fig. 2b Change of the amount of purchased equipment and investments in technical re-equipping

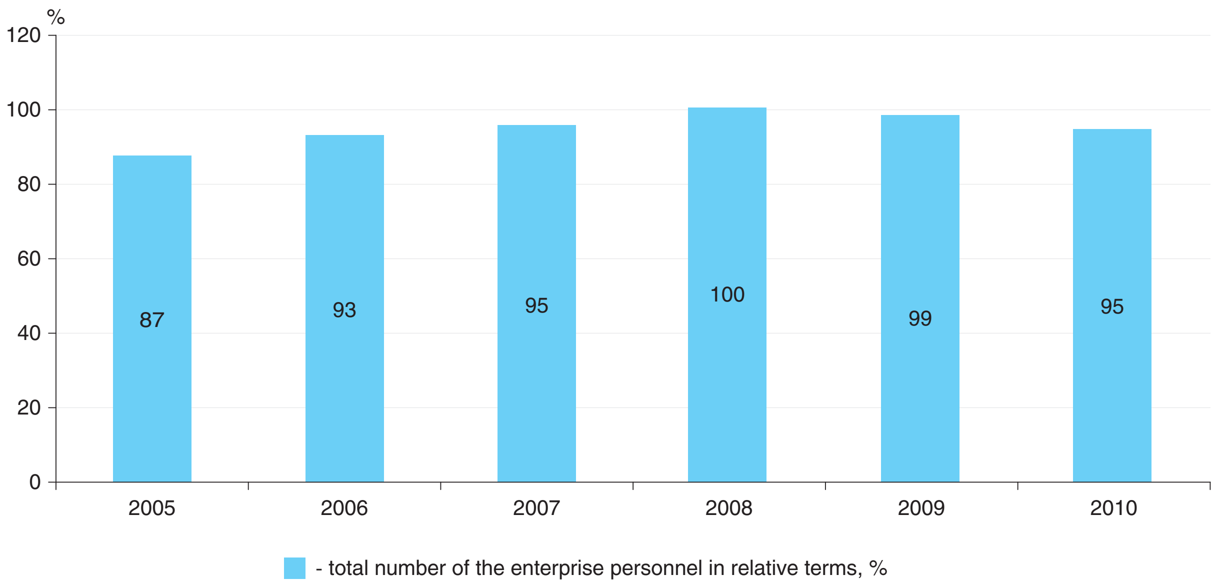

Fig. 2c Change of manning level on the plant

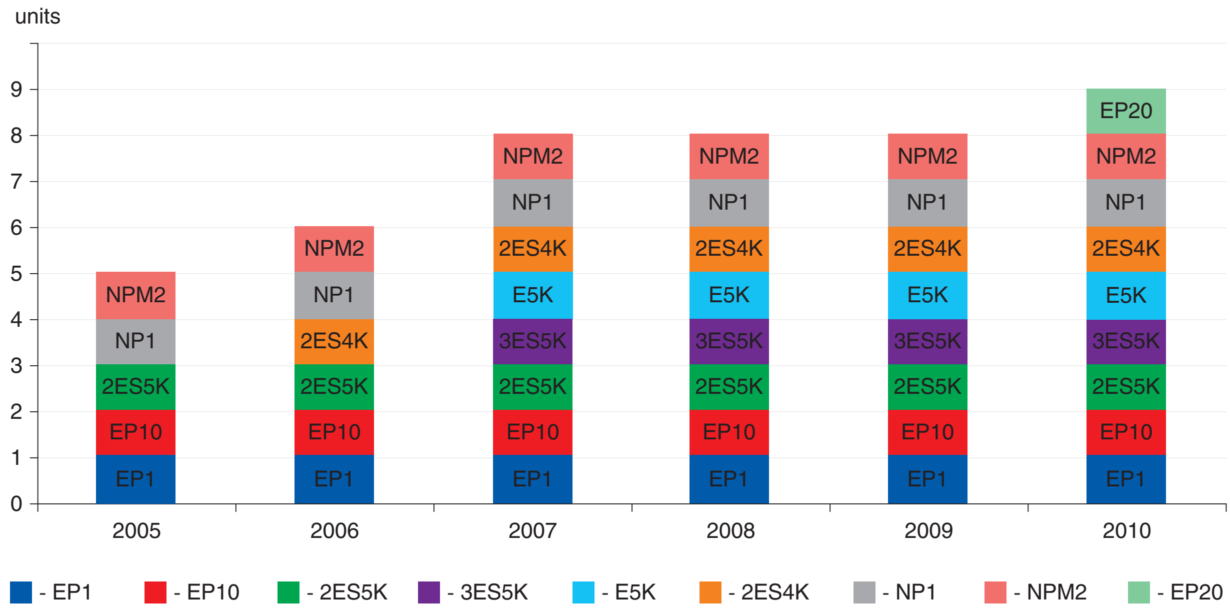

Fig. 3 Nomenclature of NEVZ products

of 2005-2010 (Fig. 2a). However, one may observe a significant decline of investments in technical renovation and the number of units of purchased processing equipment (Fig. 2b). The number of people working at the enterprise, has remained relatively constant, one may even observe a downward drift. (Fig. 2c).

When analyzing the dynamics of the key performance indicators, one may naturally observe a significant influence of the financial crisis that started in 2009. Still, a positive trend is preserved, which is indicative of the intense nature of the enterprise's development. If we consider the processes of new production output, the nature of the nomenclatorial line expansion (Fig. 3) shows the innovative way of development and the high speed new technical equipment mastering.

The fact that our enterprise has developed an innovative double-current electric passenger locomotive EP20 (Fig. 4) deserves particular attention. It has been designed as a result of a joint project of Transmashholding CJSC and the Alstom Transport Company. The EP20 locomotive is the leading model of a new Russian locomotives family, designed for speeds up to 200 km/h. The design of the EP20 electric locomotive implemented the principle of a modular assembly on a base platform. A wide range of passenger and

Fig. 4 The general shape of a new EP20 electric locomotive

freight electric locomotives of different configurations, kind of current and capacity are planned to be produced at its base. Labor costs for maintenance will be reduced by 20 times, due to the technical solutions implemented in the EP20 locomotive. They will also increase the run between repairs (for example, the average repair will be carried out after 1 million km vs 600,000 km at present) and ensure energy savings. Moreover, the service life of the new electric locomotive will be extended to 40 years (now it is 30 years).

The pre-production of the EP20 electric locomotive components was performed taking into account sound technical and organizational solutions for major industrial sections, which allowed the synchronization of serial and trial production in terms of the available output capacity. The introduction of a new experimental product in production was carried out using lean production tools.

Thus, the implementation of innovative methods of the production process, rationalization, optimization and ongoing intensification of industrial activities promote a successful development of our company even in an unstable economic situation. The role of lean production modern machine building is impossible to overestimate, as the innovative way for raiway industry development consists of the systematic approaches aimed to optimize business processes.■

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LIFE CYCLE COST (LLC) METHODOLOGY APPLICATION TO DETERMINE THE PROMISING DIRECTIONS OF INNOVATIVE PRODUCT DEVELOPMENT

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One of the key ways to improve the interaction of transport industry and rail transport is to change the pricing on their products. The transition from the "cost plus" pricing to the life cycle cost estimating methodology has to give a stimulus to the development of innovative products, since it would form a reasonable price for a more productive and improved rolling stock. In this case, the use of a uniform methodology by producers and consumers can obtain predictable calculation results, make economically sound solutions and more confidently plan their activities.

As part of the work of the main trade body, the non-profit partnership "Union of Industries of Railway Equipment" (UIRE), the development of pricing methodology is implemented by the Commission on improvement of the pricing methods for railroad engineering. The methodology called "Design procedures for calculating the cost-based prices for new rolling stock models and complex technical systems of rail transport" have been developed and approved. The standards and design procedures for calculating the life cycle cost for certain types of rolling stocks are being developed.

Life cycle cost estimating methodology was tested in calculations of new locomotives, passenger carriages, and freight wagons limit prices.

In the second half of 2010, a team of experts from the Institute of Natural Monopolies Research (IPEM) faced a number of tasks, related to the calculation of open wagons limit price. In contrast to the other studies that had been previously handled by the Institute, in this case, the task was to assess the impact of technical and economic indices of the new wagon and the operating conditions on the limit price of the wagon. That is, in the course of the study, to create a tool that would give the manufacturer of open wagons the answer to the question - "What is the size of the economically reasonable selling price of the created model of the wagon?", while the consumer would get the answer to the question - "At what price is it advantageous to buy a new wagon model, taking into account the peculiarities of the operation of the consumer's stock?" The scheme of interaction between the producer and the consumer within the application of a methodology for life cycle cost estimation is shown in Fig. 1.

The need for integration of these two perspectives into one model is due to the fact that the producers and consumers exist in different coordinate systems. Manufacturers are oriented in the system of technical and economic indicators of wagons: carrying capacity, empty weight to carrying capacity ratio, distance run between overhauls, and other indicators. While consumers are interested in the economy of a wagon's operations, such as loading loading, turnover, the size of revenue rates, the cost of repairs. Although these figures for the most part do not depend on the design of the wagon, the consumer takes them into account when deciding whether to purchase a particular model.

To solve the applied problem of calculating the limit price of a new open wagon with a number of differences from basic wagons the specialists of our Institute have built a model that takes into account - the increase in the life of the wagon, its carrying capacity, frequency and the expected cost of repairs, both planned and unplanned, losses from detention of wagons in all types of repairs. In order to most accurately simulate actual operating conditions, conditional routes and cargoes were chosen, the average annual run, tariffs and operating conditions of the wagon were calculated. After solving the basic problem, this parametric model was used to calculate the price elasticity to changes in each

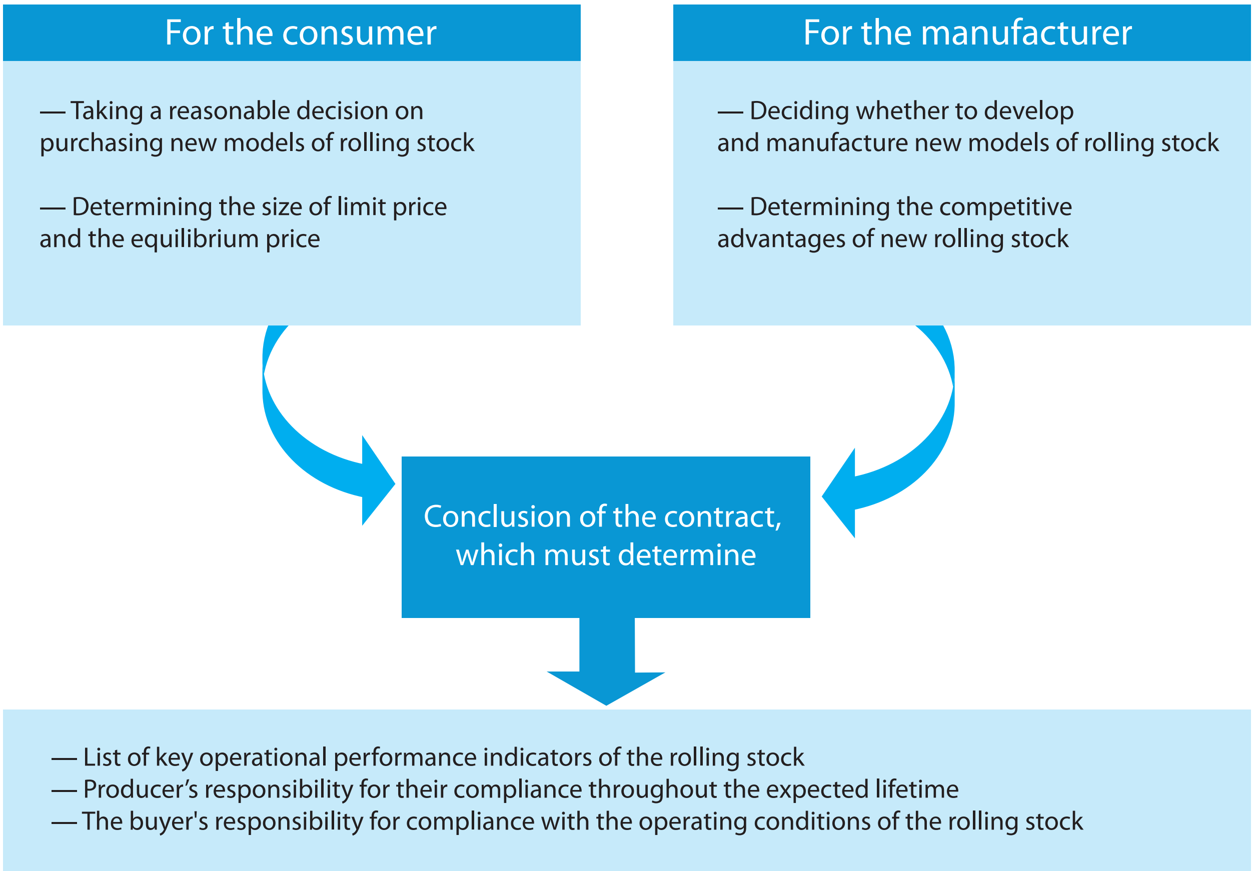


Fig. 1 The scheme of interaction between producer and consumer within the application of a methodology for life cycle cost estimation

of the selected risk factors (Fig. 2). In this case, the use of dimensionless parameters allows us to get rid of the "base effect" and obtain a qualitative assessment of the significance of each parameter in the formation of the price of the wagon.

The results are presented in Fig. 3. Even if they are predictable, they turned out to be rather interesting. The largest contribution to growth in prices was made by the rate of growth of carrying capacity of the wagon - an increase of 2.8% to the price for each percent of increase in the indicator. The indicator "run between depot repairs" is in the second place – 1.5%. Given the fact that the main trend in development of freight wagon building are now the multiple increases in the distances run between overhauls: up to 500,000 and eventually up to one million kilometres, the improvement of this indica-

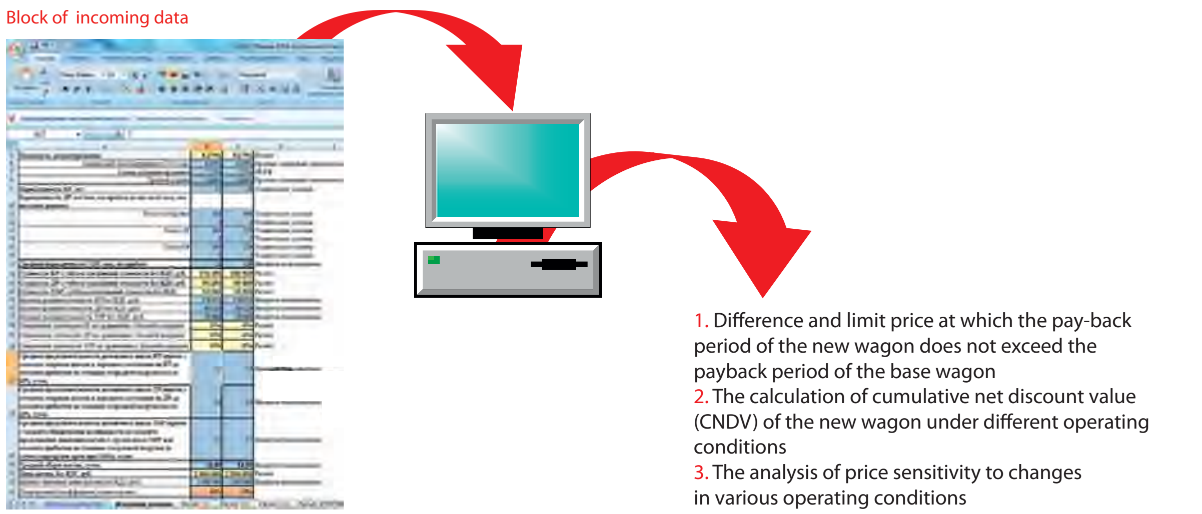


Fig. 2 General scheme of the mathematical model of life cycle cost estimates

tor will significantly improve the economic efficiency of wagons, and accordingly, the limit price. The inverse correlation with the index in the distance run between the overhauls, which rates third by importance: reducing the cost of depot repairs: 1.3% to the price of a 1% decline. Accordingly, when producers make decisions on further improvement of manufactured equipment, they have to be aware that the positive effect of the increase will be offset by in the distance run between the overhauls in the case of the rising cost of repairs. These two objectives – increasing the distance run between the overhauls and changing the cost of repairs need to be addressed comprehensively.

All the other factors that we have considered – the frequency and cost of other types of repairs, as it turns out, are not so important: according to them the growth of prices range from 0.1% to 0.5% to 1% change in the indicator. However, after the physical limits of the carrying capacity are reached, further increase in the reliability of wagons will require fundamentally new technologies and materials, it makes sense to make a regular analysis of the impact of changes in the technical and economic characteristics of the wagon to the limit price, starting from the indices of new models of wagons.

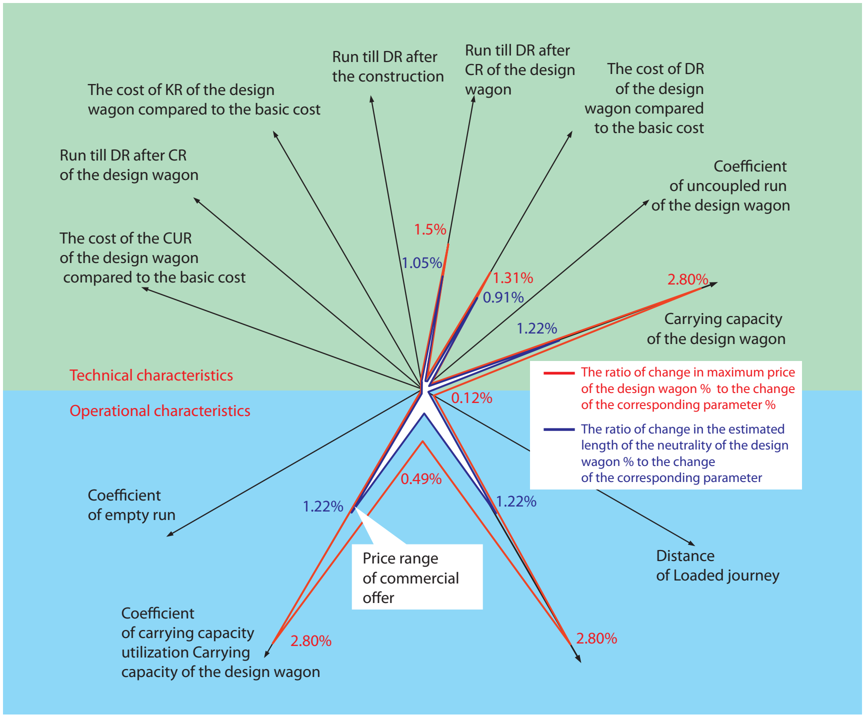
Indicators of operating conditions of the wagon were also analyzed: the coefficient of the empty run, capacity of utilization, turnout of the wagon, the income rate, the range of loaded journey, etc. The largest contribution to the limit price growth is made by the growth in the revenue rate and the growth of coefficient of utilization capacity. The values of both factors are 2.8% growth of the limit price by 1% increase in the value of each indicator. Since the size of the revenue rate does not depend on the design of the wagon, the obtained result can be used only by the consumer to assess its possibilities to operate cost-effectively the new wagon.

The importance of capacity utilization in determining the limit price of the wagon is correlated with the results, obtained for the producers, in terms of increasing capacity. Thus, we can assume, this direction is a priority for improving wagons up to the infrastructural limitations of the maximum axle load, which now amounts to 25 tons.

Summarizing the results of the study, the manufacturer can determine the main directions of its product development. In our case, this is increasing the capacity of the new open wagon up to the limits, defined by the infrastructure, increasing overhaul life and improving maintainability of wagons, which should lead to a decrease in the cost of repairs. The uses of trucks with 25-ton axle loads, improvement of wagon design are the main directions of development. After reaching the physical limit it is advisable to carry out the study again to determine other characteristics of the wagon, the improvement of which will offer the consumer a new product with even better performance.

For the consumer, such an analysis provides an answer to two questions – to what features of the new technology it is worth paying attention, taking into account the prevailing conditions of the stock operation, and what performance indicators of their work need to be improved in order to maximize profits from their operations.

Despite the fact that this study was carried out for abstract operating conditions of the stock, it allowed making a conclusion about another area of application of the methodology of assessing life cycle cost: the



Changing the technical characteristics of the design wagon:
- Carrying capacity
- Run from DR till DP
- Run up to DR after capital repairs
- Cost of CR, DR of the CUR in comparison with the base
- Coefficient of the run, etc.

Operational costs= const

Changing the operating performance of the design car:
- Coefficient of the empty run
- Coefficient of carrying capacity utilization
- Car turnover
- Profit rate
- Loaded journey, etc

Technical characteristics = const

Fig. 3 Results of the study focused on factors that shape the economically reasonable price of freight wagons possibility of its application to determine the main directions of product development and the main directions of improving the operation of rolling stocks.

In each case it is advisable to make such investigations when guidelines for the development of new models of rolling stock are chosen, which will force manufacturers to focus on key areas, taking into account technical and economic indicators of railway equipment operation under specific conditions.

Also, the use of common methodology by producers and consumers will allow them to communicate using one language and work jointly on improving railway technology.

The results of this study will be used to develop standards and methods for determining cost-based prices for new models of rolling stocks and complex technical systems of the railways in the framework of the UIRE Partnership Equipment to improve the methods of pricing for railway equipment. In the future, we plan to apply this model to develop a methodology for assessing life cycle cost of components and spare parts of rolling stocks and infrastructure.

The methodology of determining economically sound prices for new types of rolling stocks aims to replace the "cost plus" principle, applied for many years. RZD JSC decided that from 2012 all purchases of new rolling stocks and the complex technical systems in rail transport will be made only on the basis of economically sound prices, established with the help of the methodology of assessing life cycle cost. The principle of switching to this methodology is also set in the Charter on the Interaction of Russian Railways JSC, UIRE and the Russian transport industry enterprises, manufacturers of railway equipment, assemblies and components.

Andrey Shchepochkin,
Vice President, Chairman of the Board
of The Non-Commercial Partnership
"Association of outsourcing agents"

The Non-Commercial Partnership "Association of outsourcing agents" unites leading specialized companies working in the most varied fields where outsourcing is used. One of the most successful services provided by the partnership is the individual selection of companies for providing outsourcing in the transport sector. This includes services for underground transport companies, large and mid-sized automobile transport companies, transport machinery companies, branches and subsidiaries of RZD JSC. Partnership members provide technical servicing and repair of manufacturing equipment, power units and special-purpose machines. Services are provided to industrial companies in the sphere of maintenance and repair of water supply and sewage systems, repair of production and utility buildings, cleaning of rolling stock, and comprehensive servicing in the utility sector, cleaning of production buildings and territories. Services are provided for preparing the area before laying roads, gas pipelines, power lines, railroads, cleaning of rolling stock rights of way and storage yards. The Partnership has been actively promoting application of IRIS, the international railroad industry standard, on industrial enterprises. Within the framework of NP Union of Railway Equipment Manufacturers, the Partnership has been working on developing systems of pre-service and in-service training and retraining of staff, arranging for internships, migration programs, workforce adaptation programs. These systems are used to provide railroad companies with qualified machine operators, other workers, and to find new jobs for dismissed employees. Partial and comprehensive security programs and all kinds of security support of industrial enterprises and private business are also provided. The Partnership also provides consulting services and support of foreign companies in Russia.

Advertorial

PECULIARITIES OF PRICE FORMATION FOR INNOVATIVE PRODUCTS WITH ACCOUNT OF THE OWNERSHIP COST

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Every product, including innovative one, is an aggregate of tangible and intangible effects that companies create for consumer. Their goal is to compose such an aggregate of effects that would make target customers not only accept it in a positive way, but also make them willing to pay extra for receiving this particular product. Every product is accepted so far as it helps solve the customer's problem, and innovative products are no exception.

Depending on the current stage of a company's development, it may have various marketing goals. At the pre-design stage, a company provides activities related to consumer and market analysis, determines target segments of the market, forecasts potential sales volume, and develops a market entry strategy. A company's goals change by the design stage as it needs to develop its product strategy, pricing policy, communications policy, and realizes its marketing plan.

Success factors in the struggle for consumers' attention:

- overcoming the "gap" between new capacities of the innovative product and existing technical standards;
- forming a package proposal for the customer;
- development of infrastructure to promote the product, and building relationship with competent centers for implementation of innovations.

Sales of innovative products in B2B industrial sector are the most difficult thing to do. This happens for several reasons:

- in the recent years, there was little modernization in the industrial sector, many companies are not ready to accept new products, and often lack financial resources for purchasing them;
- sales managers do not have sufficient experience in realization of innovative products;
- the cycle of selling innovative product in the B2B sector is very long-drawn, and decisions have to go through multiple levels of approval in this sector. It is necessary to have a kind of specifically oriented advertising for professional audience in specialized publications, exhibitions, workshops and conferences.

Price is of great importance in promotion of an innovative product. In most cases, a higher asking price of an innovative product, in comparison with a standard product is determined by lower cost of ownership during all of its life cycle.

Speaking of total cost of expenses or the cost of ownership, we mean the discounted value equal to the contracted price of a product, to which we add the cost of operation, maintenance, repairs, utilization expenses, cost of staff retraining during the period of useful service, and from which we deduct the depreciated cost of products by the end of the abovementioned period, with such depreciated cost specified in bid documents or at an auction.

At the suggestion of research workers from the Institute of Natural Monopolies Research, the price for a new model of freight car for railway transportation system can be determined by a formula.

The limit price for a new model of freight wagon should be calculated as follows, in the general way:

$$P_{new\ lim} = P_{analog} + EE \times K_{EE} = P_{analog} + K_{EE} \times \sum_{t=1}^{T} \frac{\Delta R_t - \Delta F_t}{(1+E)^t}, \quad (1)$$

where

$P_{new\ lim}$ – limit price of a new model of freight car;

P_{analog} – price of one item of a similar commercial product;

EE – economic effect from using a new model of freight car as compared to a similar commercial product;

K_{EE} – economic effect partition ratio between the manufacturer and the customer. This is subject to agreement between the rolling stock manufacturer and the customer;

ΔR_t – difference in revenues from using a new model of freight car instead of a similar model for the period of t;

ΔF_t – difference in expenses when using a new model of freight wagon instead of a similar model for the period of t;

E – discount factor;

T – standard operation time.

The interval of calculation period t (a year, a quarter, or a month) shall be chosen as mutually agreed by the parties.

The suggested method of evaluating the cost of ownership coincides fundamentally with the method of evaluating the cost of a spring group package for wagons applied by NPC "Springs" LCC.

Below is an example of calculating the cost of a spring group package for wagon 18-100, manufactured by NPC "Springs" LCC, with account of the cost of ownership:

$$P_{new\ lim} =$$

$$= P_{\text{analog}} + \left(\left(\sum_{t=1}^{T} \frac{P_{analog} \times N + F}{(1+E)^t} \right) - P_{analog} \right) \times K_{EE}, \quad (2),$$

$P_{new\ lim}$ – limit price of a new model of freight car for the entire operating life of the freight car;

$\left(\sum_{t=1}^{T} \frac{P_{analog} \times N + F}{(1+E)^t} \right)$ – total cost of ownership for a similar model for the entire operating life of the freight car, with discounting;

N – number of replacement cases/instances for a similar model for the entire operating life of the freight car;

F – operation costs when using a similar model for the entire operating life of the freight car.

Let us study a specific example.

1. Description of the innovative product

NPC "Springs" LCC is a plant manufacturing heavy-duty springs with output of at least 2.4 million springs per year as of early 2012 (1.2 million spring group packages, which equals 20,000 freight car packages). This company is a joint project by RUSNANO JSC state corporation, Izhevsk Machinery Plant JSC (IZHMASH), and the Uralsib Financial Corporation.

The company owns a unique technology for manufacturing of springs with advanced durability, relaxation resistance and loading capacity.

Our analysis shows that there are no counterparts to such springs with considerably improved durability both in our country and abroad. The testing performed at the Urals division of VNIIZHT JSC detected a radical improvement in the quality of new springs in comparison to present-day’s mass-produced springs. The tests showed that inner springs could survive 10,000,000 stress cycles without destruction, while the stress applied exceeded the design requirements by 41.5%. Outer springs could survive 10,000,000 stress cycles (with the testing stress exceeding the design requirements by 30%), with almost no upsetting. The new technology allows ensuring stability of geometrical dimensions in an entire batch of springs within +1.5 mm, including by height. In addition, the technology applied at our enterprise allows using our springs even in the severe conditions of the Far North.

Every freight wagon bogie receives a repair package of 4 x 56 = 224 springs issued for the entire operating cycle of the bogie, in addition to the standard set of 56 built-in springs. When new quality springs are used, the need for repair packages of wagon bogies can be reduced more than fivefold. In fact, the set of springs installed in the course of a bogie construction will be used for almost the entire length of its life cycle. Therefore, maintenance and repair cost of freight railway transport will be reduced substantially. Moreover, the new quality springs may become an important

*Table 1. Prices for mass-produced springs for car truck (model 18-100), rubles**

Springs for car bogie model 18-100	Rival 1	Rival 2	Rival 3	Average market price
Inner 100.30.004-0	468.5	454.3	442.5	455.1
Outer 100.30.002-0	854.5	961.7	855.5	890,6
Total price for the package	1,323	1,416	1,298	1,345.7
Price for 1 kg	59.32	63.5	58.21	60.34

**The average rate for euro in 2011 is equal to 40.90 rubles*

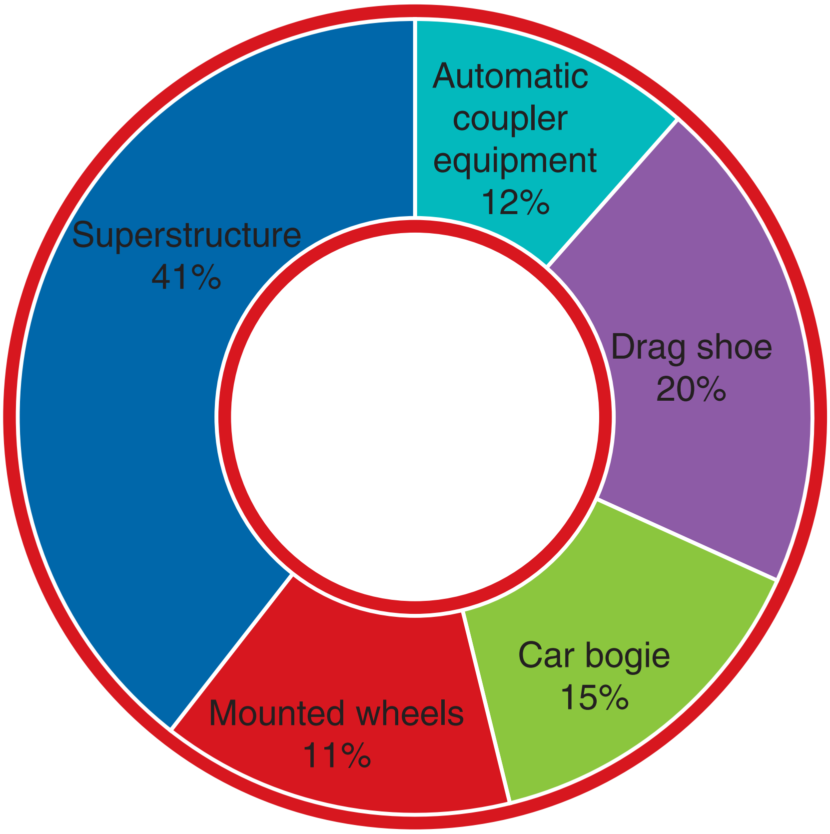


Fig. 1 The diagram showing percentage ratio of uncoupling instances by defective component (Source: Vagonniy Park Magazine, No. 6, 2010)

factor allowing an increase in the bearing power, and thus improve the speed of transportation or loading capacity of the rolling stock.

The existing models of mass-produced springs survive from 100,000 to 150,000 stress test cycles, and do not satisfy the design requirements of 500,000 cycles.

The cost of currently produced springs is approximately 1,298-1,416 rubles for a spring package.

2. Evaluation of expenses for uncoupling of cars due to spring failures.

In case of absence, displacement, or fracture of springs, the car is uncoupled and corresponding repair works are performed, with the minimal list of works including as follows:

- works in disassembly/assembly of the truck;
- replacement of outer spring;
- replacement of inner spring;
- locomotive work in delivering/pulling off the wagon to/from a repair facility.

The cost of uncoupling and replacement of springs only, will approximately reach 8,400 rubles, inclusive of VAT, if works are performed at a car-repair facility. The calculation does not include the cost of numbered components required for repair of freight wagons with uncoupling.

About 21% of all instances of uncoupling due to truck failure occur because of absence, displacement, or fracture of springs. Thus, 3% of uncoupling instances of freight wagons happen due to spring suspension failures. The average quarterly figure of uncoupling for freight wagons in Russia is 180,000. Therefore, 5,400 instances of uncoupling occur due to spring suspension failures.

For one quarter, the spending is 8,400 × 5,400 = 45,360 rubles for instances of uncoupling because of defective springs (excluding the cost of spare parts).

The average expenses for one pair of springs makes 8,400 ÷ 28 pairs = 300 rubles for one case of repairs involving car uncoupling.

Calculation of the effect from using an innovative product

Basic data:

- Durability of new springs covers the entire life cycle of the car truck;
- The price of existing springs (a pair) makes 1,298 rubles, the price of springs (a pair) of a new design is assumed to be 2,600 rubles according to the formula (2).

$$\text{Limit price} = 5{,}200 \text{ (ownership cost)} - (5{,}200 - 1{,}300) \times (1 - \tfrac{1}{3}) \text{ (economic effect)} = 5{,}200 - 3{,}900 \times \tfrac{2}{3} = 2{,}600 \text{ rubles.}$$

- It is assumed that the existing model of spring suspension package for freight wagon bogie is replaced four times during the wagon's life cycle (30 years);

- the cost of replacing one pair of springs for spring suspension of a wagon truck is 300 rubles;
- it is assumed that a spring suspension package of the new design will last for the entire life cycle of the freight wagon.

As a result, the current value of one pair of mass-produced springs for all operating life of the freight car makes 13,100 rubles (discounted value – 5,200 rubles). The operating effect from using springs produced by NPC "Springs" LCC will make 10,500 rubles for one pair of springs (discounted value – 2,600 rubles).

In accordance with the above-mentioned method by the Institute of Natural Monopolies Research, the limit price for a new model of spring is limited by/to the discounted cost of ownership and equals 5,200 rubles for a pair of springs.

The economic effect from using heavy-duty springs in a freight car will make 294,000 rubles (discounted effect – 72,800 rubles) per freight car. The annual effect for all rolling stock of the Russian Federation will achieve 9.8 billion rubles (discounted effect – 2.4 billion rubles).

In these calculations, we do not take into account the following collateral effects: terminal time, possibility of a defect in mating parts resulting from breakdown of mass-produced springs; possible accidents resulting from springs breakdown, selection and grouping of springs; we have also ignored missed profit from increasing the speed of transportation and weight of transported cargo. ■

STATISTICS

The statistic material was prepared by the Institute of Natural Monopolies Research (IPEM).
Source: Official data of Russian state authorities, Russian Railways JSC, rolling stock manufacturers.
For more actual and broaden data (including regular up-dating) contact the IPEM specialists: +7 (495) 690-14-26, ipem@ipem.ru, www.ipem.ru

RAILWAY INDUSTRY IN FIGURES

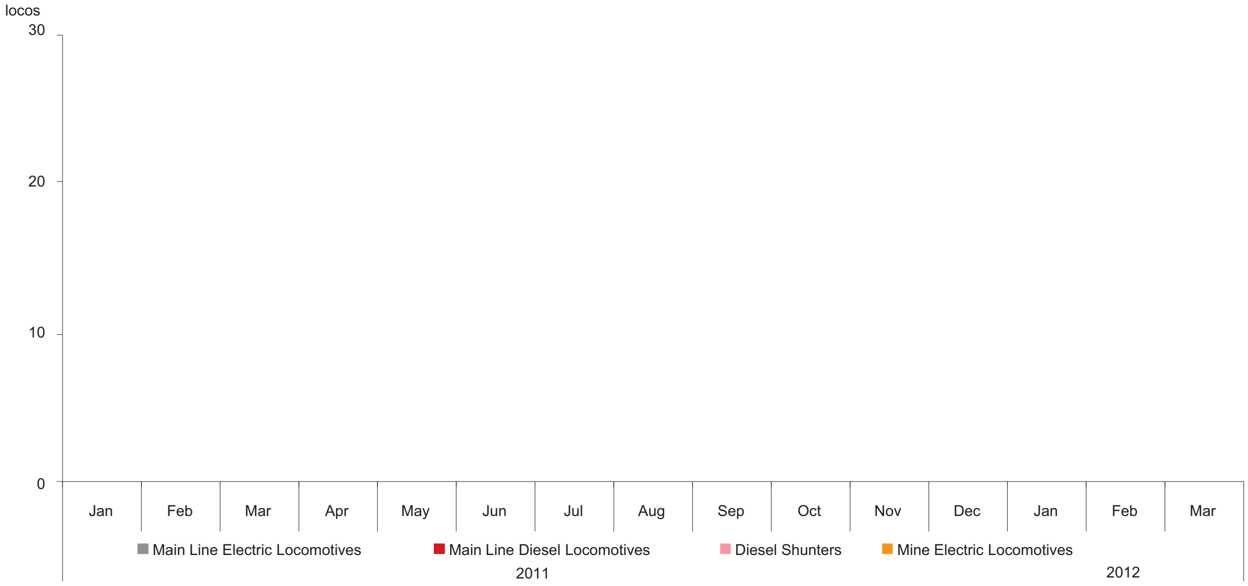
Production activities

Production of railway engineering, 2010 – Jan-Mar of 2012

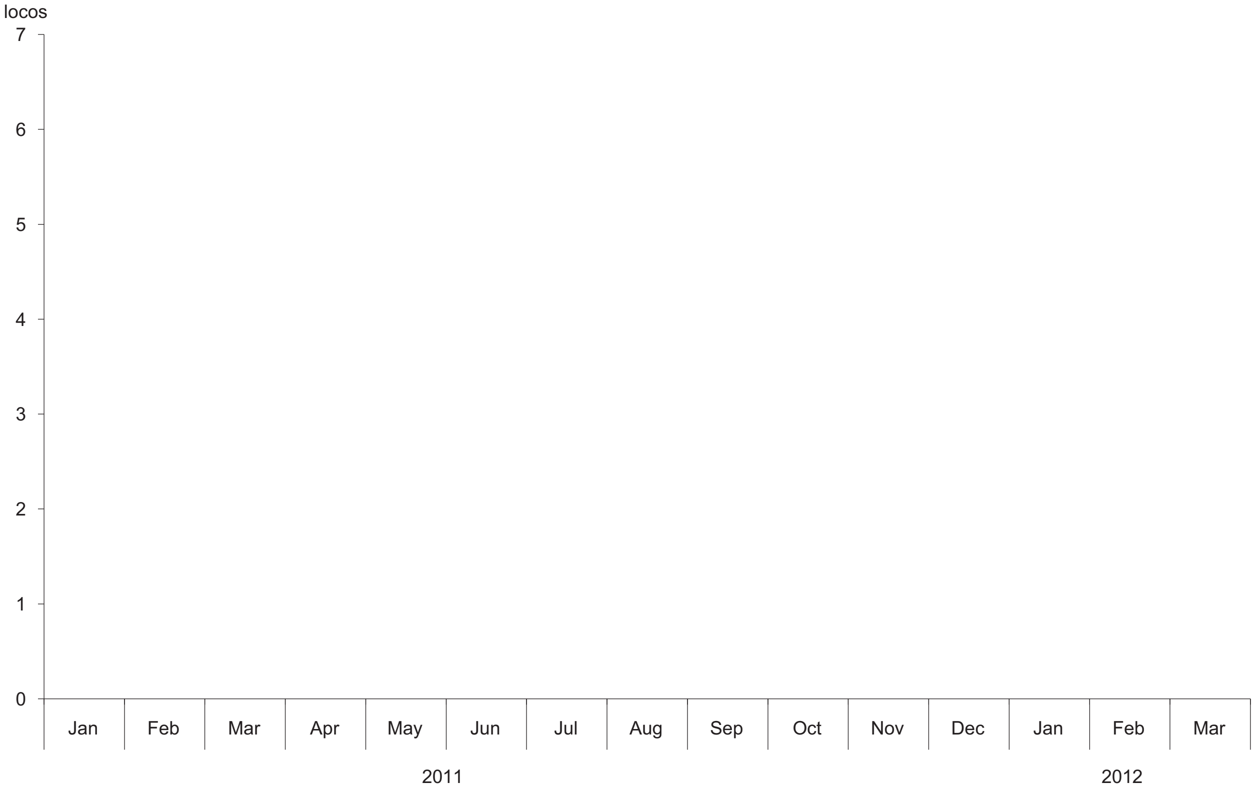
	2010	2011	Q1 2012
Locomotives			
Main Line Electric Locomotives			
Main Line Diesel Locomotives			
Diesel Shunters			
Mine Electric Locomotives			
Cars			
Freight Cars			
Passenger Coaches			
EMU & DMU Cars			
Metro Cars			
Tram Cars			

LOCOMOTIVES

Main Line Locomotive production, 2011 – 1st quarter 2012

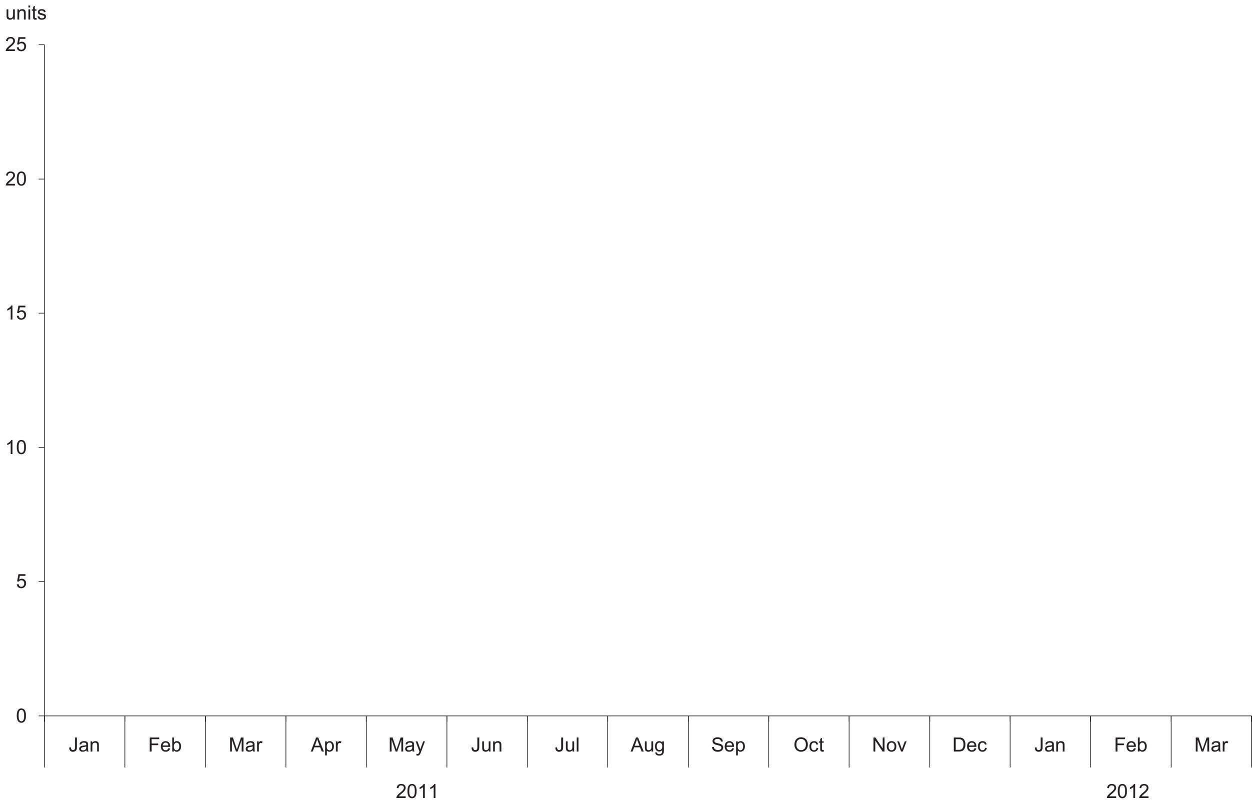


Main Line Diesel Locomotive production



Main Line Electric Locomotive production

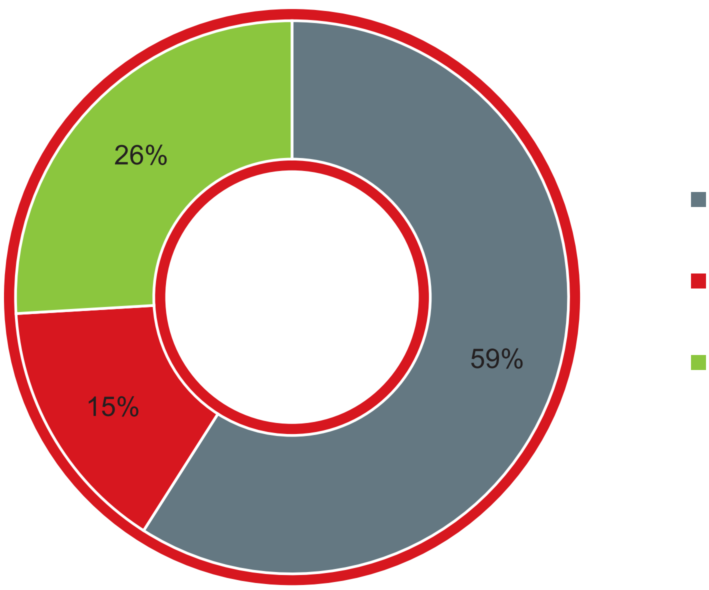
Diesel Shunters production



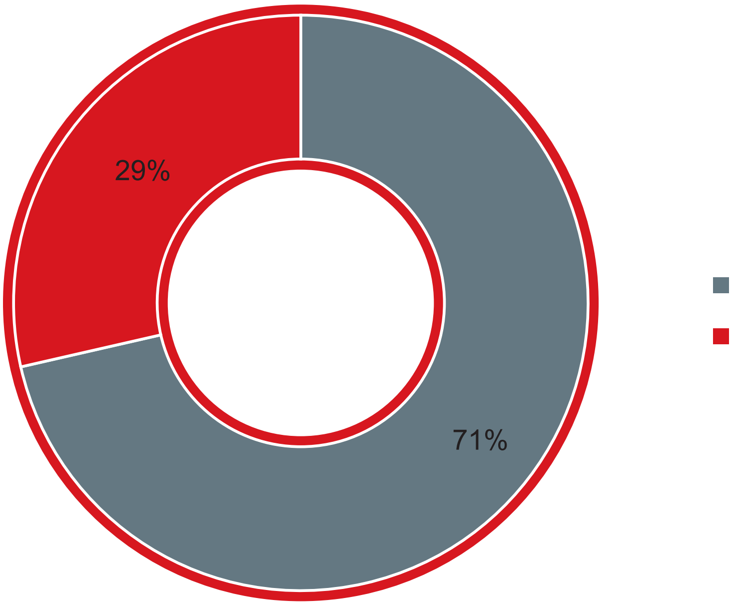
Locomotive production 2011 – 1st quarter 2012

Locomotive production	2011												Q1 2012		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Main Line Electric Locomotives															
Main Line Diesel Locomotives															
Diesel Shunters															
Mine Electric Locomotives															

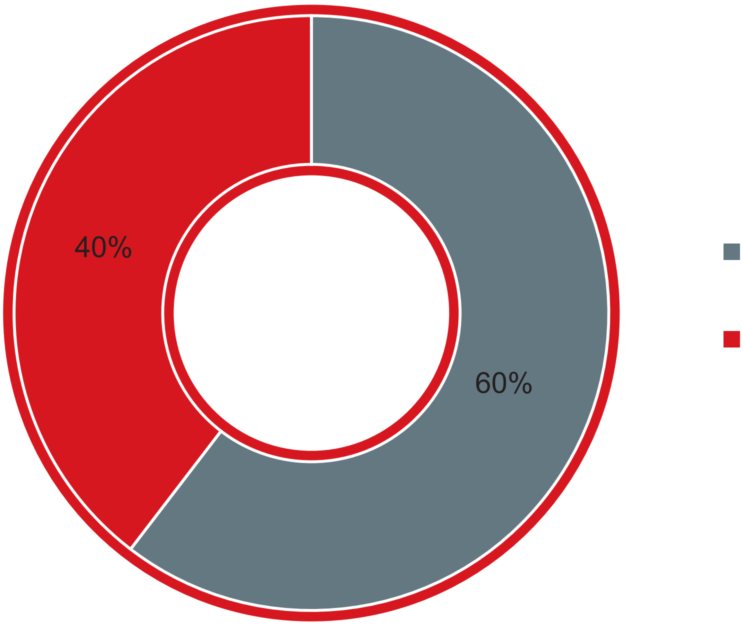
Main Line Electric Locomotive production by manufacturers, 2011



Main Line Diesel Locomotive production by manufacturers, 2011



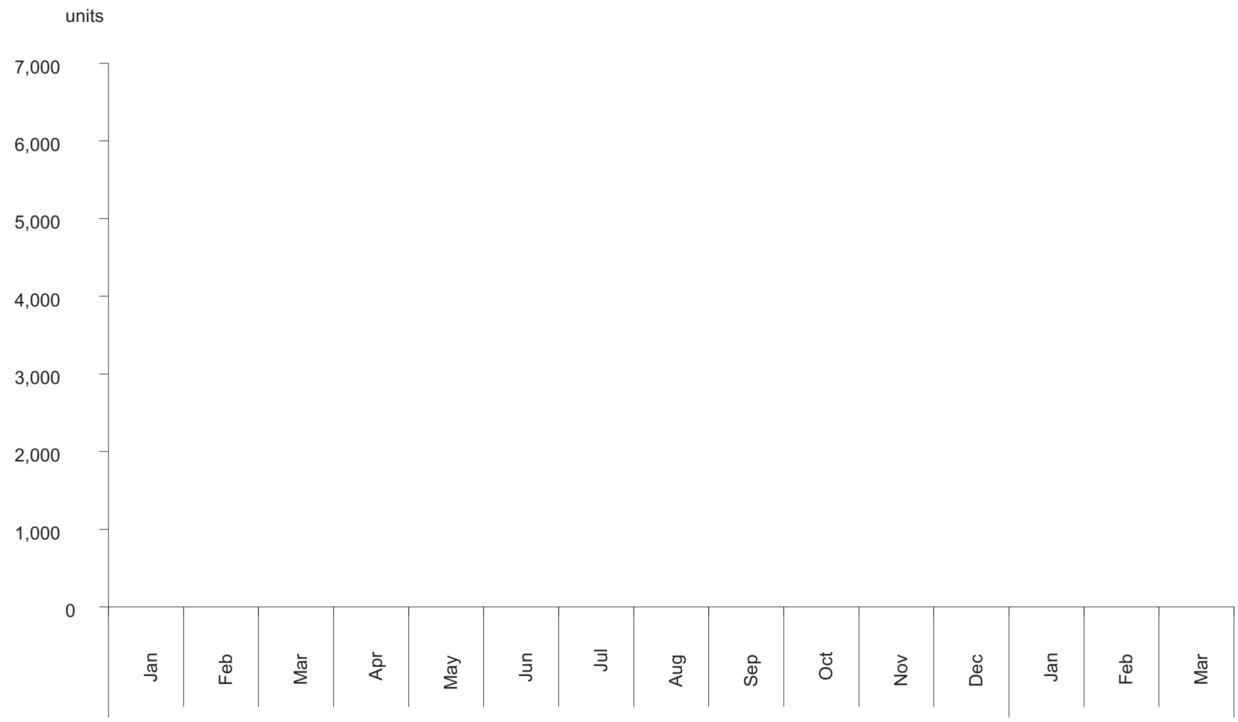
Diesel Shunters production by manufacturers, 2011



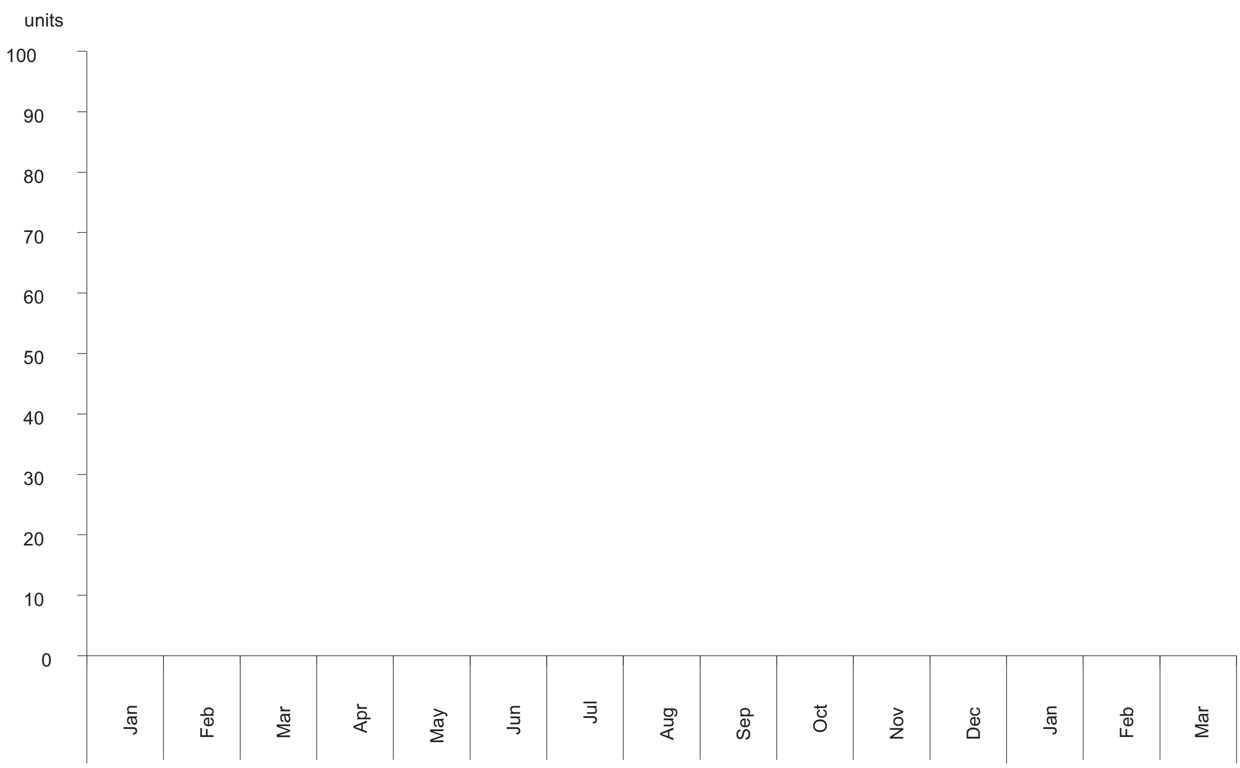
Cars production 2011–1st quarter 2012

Cars production	2011												Q1 2012		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Freight Cars															
Passenger Coaches															
EMU & DMU Cars															
Metro Cars															
Tram Cars															

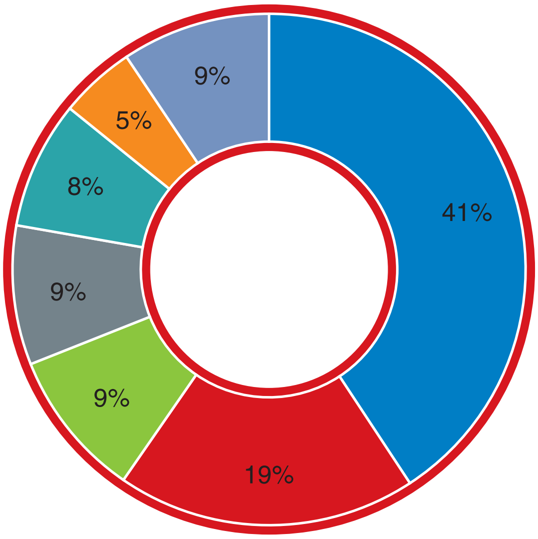
Freight Car production



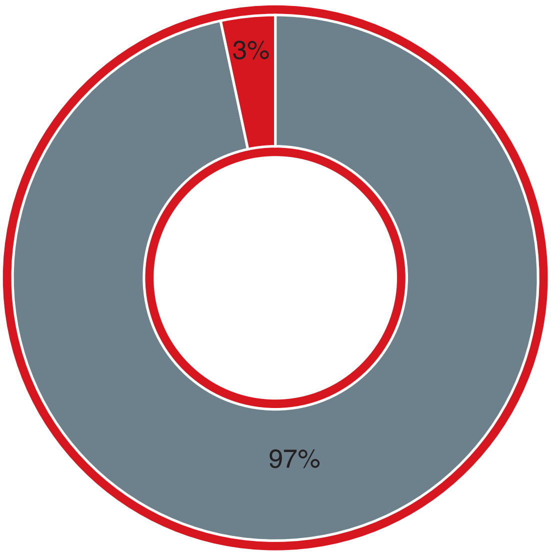
Passenger Coaches production



Freight Car production by manufacturers, 2011



Passenger Coaches production by manufacturers, 2011



Amount of railway industry production and services sold, exclusive of VAT, bln euro

	2010				2011				2012
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
Production of Rolling Stock									
Locomotives									
EMU Cars, DMU Cars, Metro Cars, Tram Cars, Locotractors									
Freight Cars									
Passenger Coaches									
Track Machines									
Production of Spare Parts of Rolling Stock and Track									
Repair and Maintenance of Rolling Stock									
Total industry									
Exchange rate									

Export-Industrial Firm
SUDOTECHNOLOGIYA

Solutions for motion

Special rolling stock on combined rail- pneumowheel run

Mechanization and automation of manufacturer and repair stock train processes

Robot welding system

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SURVEY OF RUSSIAN RAILWAY INDUSTRY PERFORMANCE IN 2011

INTRODUCTION

During the past year of 2011, the Russian economy continued to recover from the global financial crisis. Started in 2010, the growth of freight and passenger transportation continued and the business activity increased. In order to support the economic growth during this period, the Government of the Russian Federation pursued the containment policy of the tariff growth for rail transportation. As a result, the indexation of the tariffs for freight traffic lagged behind the growth of industrial, fuel and energy prices, affecting, first of all, the volume of the Russian Railways JSC investment program. Thus, the restoration of production volumes in the industrial sector took place in conditions of external constraints on the growth of effective demand for its products.

THE DYNAMICS OF PRODUCTION VOLUMES IN THE INDUSTRIAL SECTOR

The index of railway industry output physical volume in 2011 made 118.9%. The highest growth was observed in the production of freight wagons and motor car rolling stock (including the metro carriages) (132.4% and 129.4%, respectively). The locomotive production completed the year somewhat ahead of the overall growth (121.7%). The decline in output occurred in production of mainline passenger rail coaches (93%), track machines (97%) and rollling stock spare parts (97.2%). For comparison, according to the State Committee for Statistics, in general, the industry growth made 105.1%.

Thus, the rates of railway industry restoration from the effects of the global financial crisis[1] was higher than in the industry as a whole due to the low base effect.

It is worth mentioning that during the last few years, the market of transport industry production has undergone cardinal changes connected with the implementation of the structural reform programme in rail transport.

In 2011, the State refused completely from the regulation of profitability in the field of providing the rolling stock by having sold the controlling block of affiliated JSC Freight one shares owned by the Russian railways JSC to private investors. This led to a substantial increase of investment attractiveness of the companies, which operate the freight wagons, rush demand for wagons, and as a consequence, both the prices and the production volumes increased in 2011 in comparison with 2010.

In this connection it should be mentioned, that according to the dynamics of the last months of 2011 and the first quarter of 2012, another sharp increase of the production volume and the new rail car prices will not happen this year.

The long distance passenger carrier - the Federal Passenger Company JSC (the FPC JSC) - transports 2/3 of the passengers at the rates set by the Government and 1/3 of the passengers - according to the tariffs set by the carrier. The volume of subsidies allocated by the state does not cover the losses of the carrier caused by transport services rendered as per the state-regulated tariffs. As a result, the size of the profit received by the FPC JSC at the end of 2010 that amounts to 302 million roubles (7.51 million euros[2]), (profitability is 0.258%) is insufficient to finance its investment program in full for simple reproduction of the rolling stock. Despite some growth of orders in 2011 in comparison with the previous year, the order for 2012 is reduced to 1.5 times.

The trend of long-term orders volume decrease in the sector of motor car rolling stock is even more disturbing. The reasons for this situation are connected with the uncertainty of the sources of forming the investment programs on updating the rolling stock of the commuter rail companies and absence of the unified position between the federal and regional authorities on this issue. 2013 and subsequent years are of particular concern, as the investment program of the Russian Railways JSC will not contain the funds for the purchase of motor car rolling stock any more. The burden of financing

[1]The Railway Equipment, Sept., 2010.
[2] The average rate for euro in 2010 is equal to 40.21 roubles.

will lie fully on the carriers and regional bodies of executive power.

In the remaining segments of the transport industry production market, the Russian Railways JSC preserves its role of the major industry production consumer. In the segment of metro cars, the determining role is played by the orders of the city of Moscow as the main customer of this type of rolling stock.

VOLUMES OF THE INDUSTRY OUTPUT IN PHYSICAL TERMS

The manufacturers of freight wagons beat the historical record for the second year successively: in 2011, 62,600 wagons were produced, which is 24.8% more than in the previous year. In the sector of mainline diesel locomotive production, 42 units were produced following the results of 2011 (in 2010 – 36 units), the production of mainline electric locomotives made 266 units (in 2010 – 233 units), the production of diesel shunters made 197 units (in 2010 – 153 units).

In 2011, 689 units of mainline passenger rail coaches were produced (in 2010 – 629 units). In the production of electric carriers, 512 units were produced following the results of 2011 (in 2010 – 608 units), manufacturing of the metro cars made 241 units (in 2010 – 199 units).

THE DYNAMICS OF PRODUCT SHIPMENT

In 2011, the industry manufactured the products to the amount of 380.6 billion roubles (9.3 billion euros[3]), that is higher than in 2010 by 51.1%. Much of the growth of this result was due to the growth of production volumes and prices for freight wagons. In the other sectors of the industry, the growth of production volumes is largely achieved through the structural factor: cheaper but less productive equipment is being replaced by more expensive but, at the same time, more economically efficient units.

FINANCIAL CONDITION OF THE ENTERPRISES OF RAILWAY INDUSTRY

In the industry as a whole, the number of large and medium-sized enterprises, which are under regular statistical monitoring, remained at the level of 146 enterprises as in 2010. At the same time, the number of unprofitable enterprises has increased by one. The profit of the enterprises operating at a profit increased by 52.9% and reached 18.75 billion roubles (458.4 million euros). The loss of the enterprises operating at a loss was reduced by 42.4% and amounted to 1.96 billion roubles (47.9 million euros). The balanced financial result in the industry amounted to 16.79 billion roubles (410.5 million euros).

On the basis of the analysis of these aggregated results, it is possible to draw a conclusion that, in general, the industry is going through a post-crisis restoration, however, its condition is still far from safe.

CONCLUSION

Considering the main results of the industry activities, the following conclusions can be drawn:

- In general, the industry is in the state of post-crisis recovery.
- The key role in the passenger rolling stock segment will be determined by the availability of the steady investment resources so that the companies could update the passenger rolling stock.
- Some cooling should be expected in the freight wagons market.
- Preserving of the current trends (both positive and negative) should be expected in the remaining industry segments.

The survey was prepared by the Institute of Natural Monopolies Research (IPEM).
More actual and broaden information you can get by contacting the IPEM specialists: +7 (495) 690-14-26, ipem@ipem.ru, www.ipem.ru.

[3]The average rate for euro in 2011 is equal to 40.90 roubles.

INNOVATIVE-INDUSTRIAL CLUSTER OF TRANSPORT MACHINE-BUILDING "SUBWAY AND RAILWAY TECHNIQUE"

Innovative-Industrial Cluster of Transport Machine-Building "Subway and Railway Technique" (IIC TMB "SRT") was formed in Saint-Petersburg, Russia by combining the manufacturing, technological, research, infrastructural and other capabilities of geographically related manufacturing companies, research institutes, universities and other organizations of one sector for a more rapid and efficient development of new knowledge and production of innovative products in the field of guided transport systems.

Fig. 1. Interior of metro car designed by GLSK

Metro and urban railway transport is the most relevant and accessible (including from the standpoint of cost) type of passenger transport in Saint-Petersburg. And it defines the basic requirements for modern and high quality renovation of rolling stock and railway infrastructure.

Fig. 2. Metro car bogie manufactured by NPC SYSTEMA

The Cluster was created in 2011 on the basis of non-commercial partnership and its project was presented at the 15th International Forum 'Russian Industrialist' on the specialized stand of the exhibition area 'Cluster-Based Policy of St.Petersburg'.

The main purposes of the IIC TM "SRT" are the assistance to its members in production of equipment and services to metro and urban railway transport, the integration of resources for satisfaction of requirements in the process of innovative development, cooperation, localization and the sharing of know-how.

Cluster-members produce a big range of equipment and spare parts for rolling stocks and infrastructure to satisfy the requirements of metros and urban railway transport with:

- manufacturing, modernization and repair of metro cars bogies as well as manufacturing of spare parts to them;
- joint production and design of transport interiors;
- manufacturing of mechanical, electrical and pneumatic spare parts for metro cars;
- manufacturing of critical mechanical spare parts and component parts for escalators;
- full production cycle of semiconductor light sources - from initial heterostructures to complete light emitting diodes (LEDs).

The cluster is the member of International Association "METRO" (the only association of 16 subways of Russia and CIS countries) and Union of Industries of Railway Equipment. And has the support of the public transport authorities including:

- Petersburg State Transport University,
- St.Petersburg State Polytechnic University,
- Union of Industrialists and Entrepreneurs of St.Petersburg,
- Association of Industrial Enterprises of St.Petersburg,
- Russian Engineering Union,
- Chamber of Commerce and Industry of St.Petersburg.

IIC TMB "SRT" leads you to the correct and most competent russian partners.

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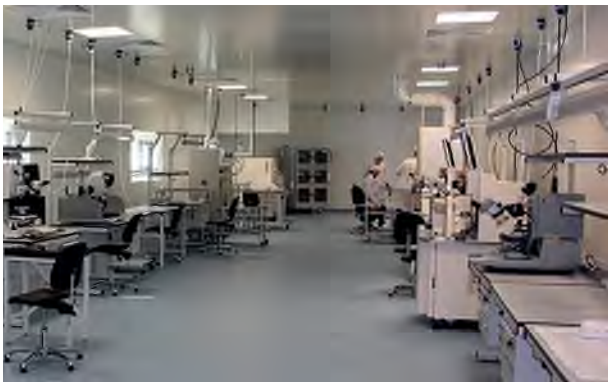

Fig. 3. LED lab of Svetlana Optoelectronics JSC

INTO THE FUTURE - IN THE NEW RUSSIAN ELECTRIC LOCOMOTIVES

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The situation on the railway transportation market requires innovative approaches in the design from the manufacturers of electric rolling stock (ERS), as well as for the manufacturing and service of manufactured products.

Contributing to the solution of this problem are the introduction of new technologies for ERS design and manufacturing, the use of modern technical solutions, devices, components and units that implement the functions of electric traction and traffic safety.

International co-operation between the world's leading manufacturers and developers of components for the ERS, division of labor, in-depth specialization in production, formation of segments of information technology in transport, open opportunities of production in the Russian Federation of the most modern railway technology, the creation of which in the recent past was possible only in theory.

Nowadays the current trends of locomotive construction are reflected in the use of traction drive with asynchronous traction motors and of the adjustable auxiliary drive on fully controlled power semiconductor devices, controlled by a microprocessor system with large functions of on-board (in-place) systems of diagnostics.

This very concept of building the structure of a modern ERS for the needs of Russian Railways JSC, in recent years has been used by Russia's leading developers of ERS, such as: Transmashholding CJSC: project of the EP20 (passenger electric locomotive using double-current), 2ES5 – (freight electric locomotive using alternating current) and Sinara Transport Vehicles JSC – project 2ES10 (freight electric locomotive using direct current).

With a view for the practical implementation of technical solutions on new generation locomotives with asynchronous traction motors, in 2010 an agreement on strategic partnership for the development and creation of the modern ERS has been concluded between Transmashholding CJSC and world's leading manufacturer of railway transport Alstom (France).

Within the framework of the cooperation program, on the initiative of Transmashholding CJSC a competence center for the development of the modern ERS (TRTrans LLC) was set up, whose task is to develop a fundamentally new range of locomotives. TRTrans LLC includes several engineering centers - the main one that specializes in the design of locomotives being formed on the basis of Novocherkassk Electric Locomotive Plant.

The practical implementation of these projects was made possible by the tangible support received from the various structures of Russian Railways JSC, both is technical and organizational aspects. Great contribution to the formation of technical requirements and approval of technical specifications for new electric locomotives was made by the department of technical policy, the management of traction, the management of repair, design office of locomotive facility (Locomotive project designing office of RZD JSC) and many other divisions and subsidiaries of Russian Railways JSC.

The policy conducted by Russian Railways JSC in recent years contributes to the improvement of technical and economic performance of the existing and developed fleet of electric locomotives.

As a general customer, Russian Railways JSC is interested in accelerating the period of creation of new locomotives and meeting the existing demand for locomotives.

PASSENGER ELECTRIC LOCOMOTIVE EP20

The first project of the engineering center was the design of EP20 passenger electric locomotive with double current employment. It became the basic platform for newly developed electric locomotives.

EP20 electric locomotive is intended for driving passenger trains on the electrified railways with 1520 mm wide tracks using alternating current 25 kV, 50 Hz and direct current of 3 kV. Electrical equipment is designed for continuous operation with the voltage changes on the current collector from 19 to 29 kV on alternating current and from 2.2 to 4 kV on direct current.

At the design stage, the management of TMH CJSC decided, that such key components as the traction and auxiliary transformers, traction transformers, high voltage safety equipment will be supplied by Alstom, and then the production of these components will be localized at Russian enterprises. The entire series of electric locomotives will be manufactured at Novocherkassk Electic Locomotive Plant LLC (NEVZ), with engineering support of TRTrans LLC.

Creation of EP20 was preceded by great work done by various agencies of TMH CJSC, TRTrans LLC, Alstom Transport, together with the responsible departments of Russian Railways JSC.

In the course of this work the operations site was analyzed: profile path, work of electricity supply systems, passenger flow of the operations site of railways, as well as many other factors that more or less influence the characteristics and parameters of an electric locomotive.

As a result of the analysis, extensive data that was obtained, after the careful consideration of which, the technical requirements for the future electric locomotive were formulated.

On technical requirements, the fundamentally new components and parts of electric locomotives, controls, protective and switching equipment, brake and mechanical equipment, power management systems, modular cab for the operator, safety systems, etc., have been ordered and produced.

Suppliers of equipment for the electric locomotives EP20 are hundreds of well-known Russian and foreign companies. Both Russian and foreign experts participate in the design of parts and technical support of the EP20.

In 2010, at the NEVZ, the assembly was completed of first electric EP20 locomotive, which is by far the world's most powerful one-unit passenger electric locomotive – one hour rating of 7,200 kW. Mechanical traction transmission has two versions: for speeds of 160 km/h and 200 km/h.

Table 1. Technical characteristics of electric locomotive EP20

Name of parameters	Normalized value	
Rated voltage, kV - alternating current 50 Hz - direct current	 23 5	
Wheel arrangement	2o-2o-2o	
Design speed not less than, km/h	160	200
Top speed, km/h	160	200
Power of hour mode on the shafts of the traction motors, kW, not less than	7,200	
Velocity of clock mode, km/h	78	100
Power of continuous operation on the shafts of the traction motors, kW, not less than	6,600	
Velocity of continuous mode, km/h	78	100
Tractive force in continuous operation, kN (ton-force), not less than	300 (30.6)	230(23.4)
Maximum tractive force at start, kN (ton-force), not less than	450 (45.8)	350 (35.6)
Tractive force at the maximum design speed, kN (ton-force), not less than	147 (15)	115 (11)
CAP in hour mode, not less than: - when operating on alternating current - when operating at direct current	 0.86 0.875	
Power factor (operating on alternating current), with loads ranging from 0.25 of continuous mode and higher, not less than	0.95	
Power of electric brakes on the traction motor shaft, kW, not less than: - regenerative - rheostatic: - when operating at constant current - when operating on alternating current	 6,000 4,500 3,200	
Length of electric locomotive along the axis of pulling faces, mm, not more than	22,550	

The mechanical part, traction motors, main electrical equipment are designed with the support of TRTrans LLC and manufactured at NEVZ.

Currently, adjustment of electric locomotives and preparation for tests is being carried out.

Structural features:

- as traction, three-phase squirrel-cage induction motor (TSM) are used;
- power of TSM is carried out by regulated static converters of voltage and frequency, included in the traction converter supplied by Alstom;
- auxiliary drive is implemented with the ability to control performance through the use of static converter of the Alstom Company;
- electric locomotive is equipped with regenerative, rheostat, pneumatic automatic, direct-acting pneumatic and parking brakes;
- electric locomotive construction provides for its service by a single person;
- modular cabin, modular electrical and pneumatic assembly;
- solid-rolled wheels with disc brakes;
- mechanical traction drive of the third class.

The advantages of electric locomotive

High traction properties. Electric locomotive provides driving of 24 passenger carriages on a straight horizontal section at a speed of 160 km/h and 17 carriages with up to 200 km/h.

Improving of working conditions of locomotive crew. In the design of the electric locomotive, current requirements for ergonomics and workplace climate were taken into account. Microclimate system in the cabin of the machinist ensures heating, ventilation and air conditioning in the cabin.

Safety of operation. The blocking system of high voltage equipment with a special set of keys has been applied. All electrical devices have reliable hardware and software protection.

Repairability. The high *repairability* is achieved through modular units and the presence of bilateral service equipment located on both sides of the central passage corridor of the electric locomotive.

Microprocessor control system with extensive diagnostic functions. On-board control system has a two-tier structure, in which the upper level controls the movement as a whole, the lower level uses local microprocessor controllers to control the traction and auxiliary drive, receiving tasks from the upper level.

The control system is characterized by a long list of operational and diagnostic information showed in a display for the machinist.

The mode “Advisor” is provided. In the event of a malfunction of electrical equipment, the display shows an image of a fragment of the circuit, and indicating the alleged reasons of the failure.

The use of a communication channel of CAN-open standard leads to a substantial simplification of the control circuits, increasing the rate of information exchange and significantly reducing the amount of wire mounting.

MICROPROCESSOR CONTROL SYSTEM has an open architecture that provides the ability to connect on an approved interface of additional systems (devices) such as safety systems, firefighting system, various parameters control and individual hardware control systems. MICROPROCESSOR CONTROL SYSTEM has 100% redundancy within each control unit.

The subsystem of diagnostics continuously monitors the work of the electric locomotive’s equipment, recording corresponding data and warning of the approach or the occurrence of limiting modes. It reveals the fault and informs the machinist about possible actions. The diagnostic system is designed with the ability to issue recommendations to service personnel, estimating the volume of upcoming and quality of performed works.

In the cabin of machinist there are two display units: working (technological) and the display unit for traffic safety. The latter displays information about any contingency that may occur along the train’s movement path. The equipment can work in interactive mode, has a vast array of memory, and when the engineer needs assistance, the unit, for any technical failure or refusal, provides the specific regulation of actions.

FREIGHT LOCOMOTIVE 2ES5

Today in Russia there is a shortage of rolling stock in the segment of the freight traffic on the sections electrified with alternating current. Only in recent years the lack of traction demand is partially satisfied by the supply of 2ES5K (Yermak) and 3ES5K, which are called “transitionelectric locomotives”.

For this reason, the next after EP20 project for TRTrans was 2ES5, freight electric locomotive of alternating current.

The design basis of the 2ES5 were technical solutions adopted in the base platform of electric locomotives, again developed by the Transmashholding Company (the head-project of which was the electric locomotive EP20). At the same time the concept of 2ES5 electric locomotive contains significant differences related to the freight type of the locomotive.

Main line freight electric locomotive using alternating current 2ES5 is designed to provide freight train traffic on railways with tracks of 1520 mm, electrified on alternating current with voltage of 25 kV of power frequency 50 Hz.

The 2ES5 Electric Locomotive far exceeds Yermak in tow-energy performance that will allow the use of 2ES5 Electric Locomotive (two sections) on many tracks, instead of the three-section 3ES5K Electric Locomotive.

Structural features

- as traction, three-phase squirrel-cage induction motor (TSM) are used;

- power of TSM is carried out by regulated static converters of voltage and frequency, included in the traction converter supplied by Alstom;
- auxiliary drive is implemented with the ability to control performance through the use of static converter of the Alstom Company;
- electric locomotive is equipped with automatic driving system, control of distributed traction and control system of the train of increased weight and length;
- Alstom bogie with a low disposition of inclined traction, motor-axial rotating bearings, brake blocks with composite pads, solid-rolled wheels, lubrication system with lubricant fed to each wheel, traction drive of the first class one-way transmission torque is provided;
- modular pneumatic and electrical installation;
- modular cabin.

Electric locomotive consists of two sections. Each section has control cabin and a set of equipment ensuring the operation of one electric locomotive as well as operation on a system of multiple units, consisting of two electric locomotives or three sections.

The chassis of electric locomotive meets modern requirements. The type of suspension of traction motors is axial support. The transfer of traction and braking from trucks to the bodywork is performed by solid inclined rods. Traction is located along the longitudinal axis of the electric locomotive and installed at one end beam of the cart frame.

The cart has a common structure with cart of electric locomotive "Prima 4200/6000", well proven during the extended period of operation on railways in China, Europe and North Africa.

One side of motor-gear unit rests on the wheel set, and another is fixed on the frame with suspension, at the ends of which there are elastic bushings for the relative movement between the wheel set and frame. Safety ledge protects the motor and gear box from a fall on a path in the event of the destruction of suspension.

Pneumatic assembly of the cart is made of stainless steel with anticorrosive treatment of the inner surface.

In the development of electric locomotives, since Project 2ES5, the list of modeling nodes on the design phase has been extended, which has not been done earlier in the projects of the previous series. In particular, the modeling of thermal processes of the cabin and the body at different ambient temperatures is carried out, the complex calculation of the strength of the body is performed.

Simulation of thermal processes has allowed, without transportation of the electric locomotive into the area of operation with extreme values of the ambient air, to perform an assessment of the equipment located in the body. At the same time, it provided gains in terms of design, and eliminated the possible structural flaws when designing.

Calculation of the strength of the body allowed the optimization of the design of load-bearing elements of the body, and avoiding an unreasonable consumption of materials, while maintaining the necessary reserves of strength.

2ES10 DIRECT CURRENT FREIGHT LOCOMOTIVE

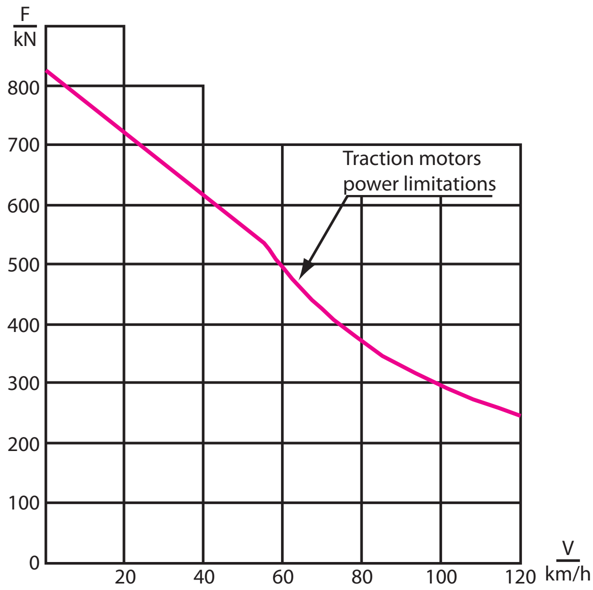

Fig. 1 Traction characteristics of the 2ES5 Electric Locomotive

Table 2. Technical characteristics of the 2ES5 Electric Locomotive

Name of parameters	Normalized value
Rated voltage of frequency 50 Hz, kV	25
Wheel arrangement	2x(2o - 2o)
Design speed not less than, km/h	120
Top speed, km/h	120
Power of continuous operation on the shafts of the traction motors, kW, not less than	8,400
Maximum tractive force at start, kN (ton-force), not less than	833 (85.0)
Tractive force at speed of 120 km/h, kN (ton-force), not less than	247 (25.2)
Efficiency factor in continuous mode, % not less than:	86
Power factor (operating on alternating current), with loads ranging from 0.25 of continuous mode and higher, not less than	0.95
Power of regenerative braking on traction motors shafts, kW, not less than:	7,600

The project to create a new generation main freight DC electric locomotive is being implemented by the second-largest player, in terms of production volumes, in the Russian market of transport engineering – Sinara-Transport machine JSC. Only a few years ago this company mastered the production of locomotives, by creating for the needs of Russian Railways JSC, the 2ES10 Direct Current Freight locomotive, belonging to the intermediate generation of locomotives. To date, a specialized company's affiliate Ural Locomotives LLC has been formed. At the plant in the city of Verhnyaya Pyshma the necessary industrial infrastructure has been created. In a certain sense, Sinara Group CJSC claims to occupy a niche, which during the Soviet period was occupied by the Tbilisi locomotive-building plant, formerly the largest manufacturer of direct current freight locomotives.

As a strategic partner for the project implementation to create the 2ES10 Sinara Group chose Siemens AG - a company with extensive experience of electric rolling stock designing. In the construction of the electric locomotive, several large units, developed by Siemens, primarily related to the electrical part are used. This is a unit of auxiliary transformers (high voltage part located in one of the boxes of traction converters (IGBT)), choke of input filter, a cooling unit, traction converter, traction motor and an integrated gear.

When designing a few solutions, somewhat unusual for the domestic tradition, were applied. In the two-section electric locomotive, four current collectors are used. They are used pairwise – 1-3 and 2-4, if scoring from cabin where the switch of the control circuit is on. The manufacturer indicates that this allow to reduce interference on the electric locomotive antenna, the number of voltage oscillations on the input of the converters and to prolong life of skid plates with reducing of the contact wire wear. Designers also suggest that the use of two current collectors allows for the installation on electric locomotive of current collectors at rated current of 2,100 A instead of 3,200 A. These current collectors have a considerably smaller mass of the moving part, which ultimately improves the quality of current collection.

In the design the all-metal cabin and modern lighting system using emitting diodes is applied. Emitting diodes are used not only in spotlights and buffer flashlights, but even in the lights in the engine room and cabins. To ensure normal working conditions of locomotive crew, electric locomotive is equipped with a system of microclimate, microwave and refrigerator.

The body of the locomotive section rests on the two-axle ball-joint carts. Links of the carts with body are ensured by means of springs of the "Fleksicoil" type, through the Limit Stops and oblique thrust. Vertical axle hydraulic dampers, as well as vertical and horizontal body hydraulic dampers are applied. Wheel sets with frame of carts are connected through axle springs and axle one-sided leashes.

The created locomotive is much more powerful than locomotives of the VL10 and VL11 series, which eventually need replacement. The one hour power of traction motors is 8,800 kW (against 5,200 of the VL10) so it will theoretically be able to drive trains weighing 40-50% more than the standard weight of the modern railway. The discussed possibility of creating three-section version, can increase the weight of the trains up to 9,000 tons. In fact, the limitation in this case becomes not the electric locomotive power, but infrastructure capabilities: there are opinions that the use of such powerful machines would require a substantial investment in the power supply system and the replacement of traction substations on many sections.

It is assumed that manufacturing of some of the equipment, which for the first electric locomotives now comes from Germany, will be localized in Russian enterprises. It has been reported, in particular, that the production of traction motors may be established on Electrosila factory in St. Petersburg.

Conclusion

In the Russian fifth-generation electric locomotives, which are being created by the largest Russian transport machine-building companies and their foreign partners, the latest global technological advances in part of construction, design, energy efficiency and information technologies in transport are implemented.

The new locomotives are able to meet the growing needs of Russian Railways JSC in a modern and reliable traction rolling stock. The massive use of modern, fast and powerful machines can change the face of Russian railways and make them much more efficient and competitive.■

Fig. 2 The appearance of 2ES5 Electric Locomotive

Fig. 3 The appearance of 2ES10 Electric Locmotive. Source: RIA Motor

TRIPLE-DIESEL ENGINE LOCOMOTIVE CME3 ECO: WITH CARE ABOUT FUTURE

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Zheldorremmash JSC the Development of the Railway Transport in the Russian Federation till 2030 ranges the innovative technologies implementation into Russian Railways JSC activity priorities. Upon that the company gives importance to new types of traction rolling stock construction, which includes multi-engine diesel locomotives.

The purpose of multi-engine diesel locomotives development is to increase the fuel efficiency, decrease hazardous atmospheric emission and to amend operators' conditions.

One of the tendencies in this area is the creation of diesel locomotive intense modernization projects, which include power, equipment, control systems, operating consoles replacement.

The first stage of multi-engine diesel locomotives development was the dual-engine shunters CME3. At the present time six dual-engine diesel locomotives are in operation on Moscow Railways.

The operation of modernized diesel locomotives confirmed their traction and operation performance and fuel consumption decrease.

The next stage of shunting diesel locomotives performance improvement was the development of triple-engine diesel shunting locomotive. The selection of triple-engine diesel scheme was determined with the fact that at shunting operation up to 60% of time the locomotive engine is idling with ineffective fuel consumption and diesel life management.

The main idea of triple-engine diesel shunting locomotive is that the auxiliary small-power (24 kW) diesel engine operates at idling and provides for traction diesel engines, operator cab warm-up and auxiliaries power supply.

The modernization includes activities on underframe life extension (TO-6) that allow to extend life cycle for 16 years.

The diesel locomotive modernization project was developed by the designers of Engineering centre - Zheldorremash JSC branch on the basis of the technical solutions of VNIKTI JSC. Microprocessor-based control system is developed by the VNIKTI JSC specialists.

Besides two 478 kW main diesel driven generating sets of Yaroslavl motor plant production the one 24 kW auxiliary set of Cummins production is mounted in CME3 triple-engine diesel locomotive.

The specifications of CME3 triple-engine diesel locomotive are represented in the Table 1.

The integrated joint cooling system for three diesel driven generators allows to warm-up the two main power plants in standby by means of operative auxiliary diesel driven generator.

The application of triple-engine diesel locomotive version design allows to reduce the hazardous emission rate and to provide for smoking at the exhaust decrease relative to that for one diesel engine.

Diesel locomotive environmental friendliness is achieved through the engine operation algorithm. At standby of shunting operation (up to 60% of time) only the one small-power (24 kW) diesel engine is currently in operation and provides for microprocessor-based control system operation, main diesel engines cooling system warm-up through the heat exchangers, compression plant operation, control cab heating and battery charging. At "easy" shunting operation (controller positions 1-4) only one of the main diesel engines is put into operation (automatically determined by the minimal spent life) to ensure diesel locomotive running over the range of speeds 3.5-25 km/h and with the tractive effort up to 23,700 kp. At two engine operation the locomotive speed up to 95 km/h and the tractive effort up to 31,000 kp are ensured. The principle of CME3 triple-engine diesel locomotive operation is represented in the Figure 1.

It was established by the calculations that the triple-engine diesel shunting locomotives operation allows to ensure the hazardous atmosphere emission reduction and the fuel saving up to 20%.

Intense modernization of CME3 series locomotives in dual and triple-engine diesel versions was performed in Yaroslavl electric locomotive repair plant - the Zheldorremmash JSC branch, which has well-fitted production and technical facilities.

Sufficiently hard development work on multi-engine diesel locomotive was carried out by the creative engineering team under the guidance of Yaroslavl plant director M.I. Prosvetov. The basic engineering-development tasks were implemented with the direct participation of principal engineer M.V. Volkov, deputy principal engineer A.N. Voronin, electric locomotives assembly workshop manager A.S. Vladimov, production engineer G.N. Bykov, Engineering center director A.V. Vasilev, IC deputy director D.A. Varfolomeev.

To promote the multi-engine diesel locomotives Zheldorremmash JSC sent two diesel locomotives of CME3 series to the III International Rail Salon EXPO 1520 in Scherbinka. The CME3-4423 diesel locomotive with dual-engine diesel took part in the railway

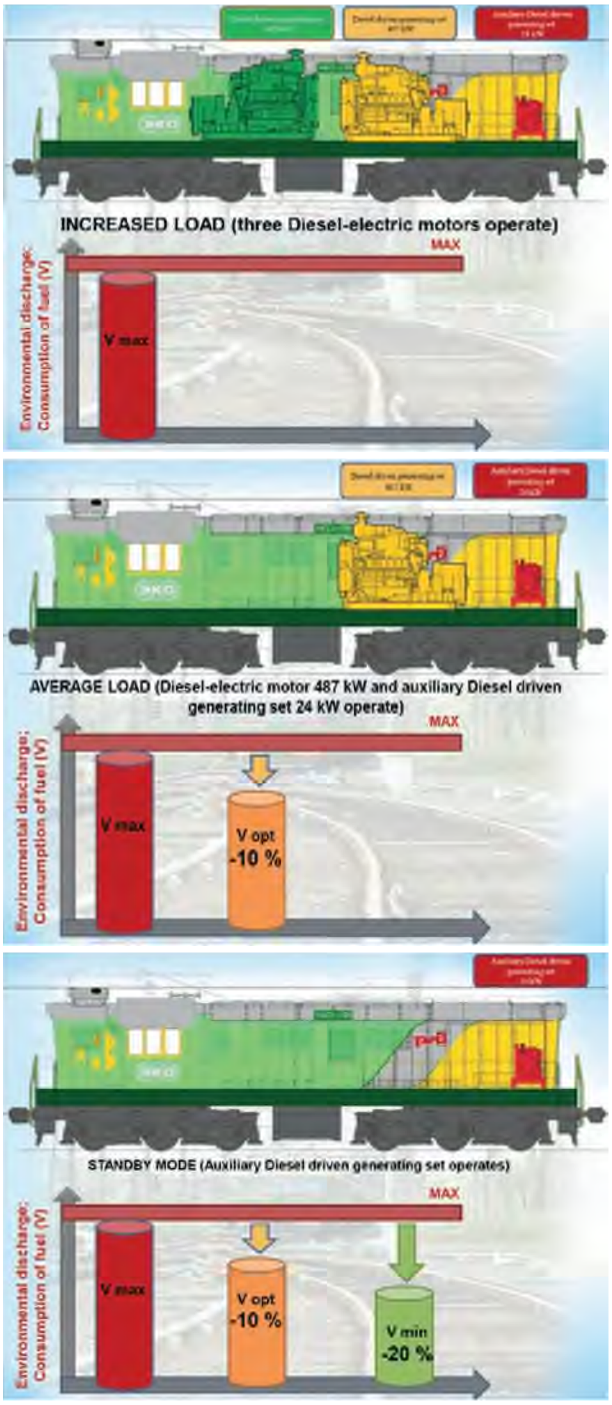

Fig. 1 Cycles of operation of CME3 triple-engine diesel shunting locomotive

Table 1. Basic specifications of CME3 triple-engine diesel locomotive

Class of service	shunting diesel locomotive (hauling)
Diesel locomotive apparent capacity kW (hp)	980 (1,333)
Transmission type	Electrical, alternating-direct current (AC-DC)
Design speed, km/h	95
Continuous rating speed, mps (km/h)	3.17 (11.4)
Continuous rating tractive effort, kN (kp)	225.6 (23.0)
Fuel consumption reduction relative to CME3, %	17.8÷21.3%
Annual costs saving relative to CME3, RUR000/year	1,864.8K

techniques parade. The second exponent - CME3-3323-ECO diesel locomotive with triple-engine diesel - occupied rightful place at the static exposition.

The focused attention in Salon exposition was given to ECO-conception implementation in railway service field. ECO-conception, which implicates efficiency and environmental friendliness of the new generation railway service, is the one of current technology tendencies in the transportation field.

The concept of locomotives with highly environmental friendly and energy-efficient features has been pictured in the design of the CME3 exponents with dual and triple-engine diesel.

The slogan "WITH CARE ABOUT FUTURE", which is placed on the CME3-ECO fuel tank underlined the environmental tendency of locomotive design (Fig. 2).

For diesel locomotive painting the environmental

Fig. 2 CME3 triple-engine diesel locomotive fuel tank with slogan "With care about the future. Equipment of XXI century"

compatible water-based materials of ECOCHEMICAL trademark, FIXAR and EPOCOR series were used. The "TEPLOCHIM" RPE specialists developed the technical schedule for materials application and

Fig. 3 Technical environmental performance demonstration of CME3-ECO locomotive

ensured the manufacturing engineering support during the application process. These materials are of fire-flame-proof type, offer outdoor weather and corrosion environment resistance, and good decorative properties.

The locomotive structure employs innovative environmental compatible finish materials, flameproof wear-resistant nanotechnology-enabled coatings, hydrophobic nano-coating for glass surfaces protection, LED lighting units.

The CME3 triple-engine diesel locomotive was of great interest of EXPO 1520 exhibition visitors from different countries, including Belorussia, Czech Republic, Germany.

Official exposition guests and visitors highly appreciated the environmental performance of CME3 triple-engine diesel shunting locomotive (Fig. 3)

Under the ECO-conception Zheldorremmash JSC apprises the main-line and shunting multi-engine diesel locomotives development as well as the hybrid ones as the upcoming trend, for environmental friendliness and energy-efficiency improvement of tractive rolling stock.■

THE SECOND FLOOR OF EFFICIENCY

Vladislav Mironov,
Deputy Chief Designer
Transmashholding CJSC

Recently, Russian railwaymen have been quite satisfied with single-deck carriages. Yet time passes. The Ministry of Railways of the Russian Federation has been reformed into Russian Railways JSC, from which the Federal Passenger Directorate was assigned, which in turn was recently transformed into "Federal Passenger Company" JSC. These reforms were aimed at improving the economic efficiency of the passenger transport and made Russian railwaymen consider the possibility to improve the economic efficiency of passenger long-distance traffic.

Two-story or double deck coaches are widely used abroad. The European "Stephenson" 1435 mm railways have a very limited size - the height of the rolling stock should be no more than 4.2 m from the railhead level. Such a "squeezed" size made European designers seek innovative solutions to increase passenger-carrying capacity.

The idea of a double-deck coach of three postulates:

1. The transportation in one carriage by almost doubling the number of passengers will reduce traction, as well as service and servicing operations costs.

2. The formation of the double-deck coaches will reduce the number of trains on busy routes such as Tuapse – Adler; the traffic is mixed on this route so it needs to ensure the way for both passenger long-distance trains and freight trains. The number of the latter has been constantly growing since they began constructing facilities for the Olympics-2014 in Sochi; Tuapse is the nearest port at which it is convenient to deliver construction materials by sea.

3. Storage yards for carriages are located in the central part of large cities, and the area occupied by them is limited; the use of two-storied carriages will alleviate this problem.

However, as long as these postulates were not formulated, railwaymen as well as scientists constantly argued about the feasibility and the right of existence of the idea of two-decker carriages. As you know, if two scientists meet, they will surely have three different views on the same subject. Practioner Valery Shatayev, the General Director of the Federal Passenger Directorate in 2007, is not a stranger to the operating principle of the passenger complex. He was the only man who could abolish all these discussions in 2007.

The double-deck carriage was an innovative product for Russia and could be born only in close cooperation with the railwaymen. The basic requirements for the carriage were as follows:

■ Since the distances in Russia are long, and service speed is not very high, passengers spend a lot of time in travel. Therefore, there should be sleeping carriages.

■ The carriage should be positioned at the lowest level of the passenger traffic segment, which is not regulated by the state. That is, it should be a compartment carriage with four-passenger compartments; the carriage must have a sufficient comfort level, but without superfluities. At the same time, as there will be most likely no possibility to include conventional single-deck carriages in double-deck trains, a small number of carriages should be of a higher comfort level - that is, there should be two-passenger compartments in these carriages.

■ The carriages should be equipped with all the possible up-to-date systems to reduce life cycle costs - centralized energy conservation, modern bogies and brakes, and, of course, all the systems made compulsory by law - air conditioning, eco-toilets, etc.

■ And most importantly – the passenger capacity of carriages should be maximum at a sufficient passenger comfort level that is comparable to the single-deck carriages.

Since the middle of 2007, the Tver Carriage Works JSC (TVZ), the leader of the Russian carriage building, incorporated to Transmashholding CJSC, had been undertaking a pre-design research on double-deck passenger cars. The experience gained in the design and launching into manufacture of single-deck new-generation carriages allowed creating all the preconditions for the successful implementation of the project of the domestic double-deck carriage. It should be noted that most of the double-deck carriages used in Europe are carriages with chairs, which is associated with the short distances and a short transit time on European passenger routes. Only a small number of double-deckers in Germany and Finland are equipped with sleepers. However market research of the situation in Russia showed that the Russian railways primarily need double-deck sleeping carriages.

The first concept of a double-deck carriage had been developed at the TVZ by the end of 2007; it was used to build a full-scale model of a carriage fragment. Both the designers and the railwaymen realized then that double-deck carriages have a right to exist. In May, 2008 the Chief Designer Department of TVZ started to design a double-deck sleeping carriage, the model 61-4465. The first prototype of this carriage was built on December 29, 2008, i.e., in less than eight months since the design work began.

In April 2008 TVZ was visited by Vladimir Yakunin, President of Russian Railways JSC and Vladimir Putin, Prime Minister of the Russian Federation, who praised the Tver residents' innovative design. In September 2009, the carriage was presented to the public at the II International Railway Salon EXPO 1520.

However, the exhibit activity was surely not the main purpose of the prototype. In 2009, the carriage was tested on the expanded program on the basis of the Tver Carriage-Building Institute. They conducted carriage wheel weighting, static resistance tests of the carriage body, thermo-technical, sanitary and electro-technical tests, as well as crash tests. Natural fire tests on the carriage fire safety were conducted on the modified prototype built in 2007. After considering the test results some changes were made in the design documentation, aimed at improving both technical and consumer parameters of the carriage.

In 2010, the project on the implementation in the Russian railways network shifted into the phase of final realization. The Federal Passenger Company decided that the Moscow–Adler direction would be the first route for double-deck carriages. They plan to start with a lot of 50 carriages, which will be grouped into three trains. Each train will have 15 carriages, 12 of them will be carriages with 4-passenger compartments, a carriage with 2-passenger compartments, a staff car with communication and train systems management equipment, as well as special equipment for disabled passengers and a double-deck restaurant car. Five different types of carriages will serve as substitutions during planned maintenance.

It is planned that the fare in double-deck compartment carriages will be lower than in comparable single-deck ones and just a little bit higher than in second class single-deck sleeping carriages, so it is assumed that the passengers who choose the second class sleeping carriages because of their low fares, will be able to "prefer" double-deck compartment carriages.

In the future we plan to implement a network of trains with double-deck carriages on routes with high passenger flow, such as Moscow–Kazan, Moscow–Mineralnye Vody, Moscow–Voronezh, Moscow–Novorossiysk, etc.

Taking into consideration that the Federal Passenger Company is experiencing sharp competitive pressure from bus and air transport, trains of double-deck coaches should significantly increase the economic efficiency of passenger transportation. The technical-economical specification of the project confirms that despite the higher cost of acquisition, the use of double-deck carriages in some directions will increase the economical efficiency of the transportation by 2.5 to 3 times, in comparison with single-deck carriages.

Let us dwell on the technical characteristics of the double-deck carriage design.

Like all the carriages built at TVZ, double-deck carriages are designed to operate at speeds up to 160 km/h. This speed is ensured by a well-proven in operation bolsterless bogies of the 68-4095 model with disc brakes and wheel slip/slide active protection system. The bogies are additionally equipped with a stabilizer bar, which serves to reduce the outstanding acceleration (rolling) at the upper level.

Double-deck carriages are designed to operate in trains of the permanent formation. This means that the train will move in the same composition throughout the route, a change in the train scheme will be possible at the place of the train formation and turnaround. The carriages are equipped with gapless drag bars and gas-tight inter-carriage passages that reduce noise and vibration levels. Standard SA-3 automatic couplings are fixed at the first and the last carriages in order to ensure the coupling with a locomotive. The carriages are equipped with centralized energy conservation by means of a high voltage static converter, installed in the under-roof space above the working enclosed platform. In this regard, the carriages may be only used on electrified railways, together with electric locomotives with DC or AC, providing a high voltage supply to the passenger train. Electric locomotives provide carriage heating by high-voltage air heaters, located at the output of the climate system.

The carriage body with smooth side walls is made of corrosion resistant (stainless) steel. The body frame of a complex spatial shape is made from high strength alloy-treated steel. The first floor level is lowered in the area between bogies allows fitting into the carriage, accepted at the railways of Russia, passing under the overhead system without any restriction and passing bridges, tunnels and other man-made structures.

Only the middle part of the carriage, located between the bogies, is it actually double-decked. The interior layout of the end parts of the carriage slightly differ from the modern single-deck carriages manufactured by TVZ. The floor level of the end parts is at the raised platform level. The operating end of the carriage includes an operating vestibule equipped with sliding plug entrance and automatic foldaway intercommunication doors – the same as in single-deck carriages. There is a private compartment that includes microprocessor-based facilities control console of the carriage that is already familiar to our conductors, fire alarm system, a microwave, a refrigerator, a sink, an electric kettle, and a cooler to have cold and hot water with

standard bottles. Since there is no boiler room or boiler in the carriage, the passengers will be provided with tea and coffee by means of an electric kettle and cooler. The guard's compartment is near the private compartment, it is equipped in the same way as in single-deck carriages – with a sleeper and lockers to store bedding. If the journey time of a route does not exceed 12 hours, the carriage will be serviced by one conductor, and the longer routes will be served by two conductors that work and rest in shifts.

There are three lavatories at the opposite end of the carriage. The way they are equipped does not differ from the ones in single-deck carriages. The service compartment is next to the lavatories, it contains a vertical collection tank of the vacuum eco-toilet complex; water tanks are located in the under-roof space. The volume of water tanks and the toilet collection tank is enough for the train to travel without servicing for 48 hours.

Due to the fact that the carriages are equipped with air-tight inter-carriage passages, the double-deck compartment carriages are not provided with a second, non-operating vestibule. The non-operating vestibule with a wide entrance door and hydraulic lift may be found only in the staff carriage, which provides a special compartment for wheelchair access and toilet accessible to handicapped persons. These rooms may be also found at the middle (intermediate) deck in the non-operating end of the carriage.

The passenger part of the carriage is double-decked. There are per two stairs at both ends of the carriage - down to the first floor and up to the second level. Both the first and the second floor contain 8 passenger compartments; to ensure proper weight distribution the passenger compartments of the first and the second decks are located on different sides of the carriage. The equipment of every passenger compartment does not differ from the one of a single-deck compartment carriage – every four-passenger compartment includes two lower and two upper bunks, a table, fluorescent and LED lights for public and individual use, a sliding door with a mirror and an electronic lock, and other things passengers are accustomed to. The lower ceiling level, as well as the absence of the luggage compartment over the door, make the difference between a double-deck and single-deck carriages. You may use all the space under the lower bunks to place your baggage; to increase the capacity of the luggage compartments, no lockers are installed in the compartments. Compartments on the first and the second deck are the same and they do not differ from one another by the equipment level, interior design or comfort elements.

There are two lower sleeper sofas in every 2-passenger compartment; they may be transformed into day and night positions. Each compartment has two LCD TV-sets to watch videos, the video sound is broadcasted through the headphones. A shower,

located in the last compartment of the lower deck is an additional comfort element in the carriages of this type. A similar shower unit for the train crew is installed in the staff carriage.

The passenger capacity of double-deck compartment carriages in the carriage with four-passenger compartments is 64 people, in two-passenger compartments–30 people and in the staff carriage–50 people, the staff carriage contains 2 seats that are specially equipped for disabled passenger and an accompanying person. These figures are 80% higher than those of single-deck carriages of similar classes.

Each carriage is equipped with two ventilation, air conditioning and heating units to provide a proper microclimate. In contrast to single-deck carriages, the heating system is of the air-type with high-voltage heaters installed at the outlet of the ventilation systems. Two air-control systems ensures the proper microclimate in all carriage rooms when the surrounding air temperature varies from -45 °C to +45 °C, as well as a redundant system, should one of the systems fail to work. Air decontaminating agents with ultraviolet lights are installed in the recycling channels.

One should note one more innovation - an aerosol fire-fighting system that is used in the Russian railway coach manufacturing for the first time.

As the number of passengers in a double-deck carriage is greater than in a usual carriage, the conductor will have to work harder. Therefore, Tver designers took care to at most free conductors from the duties associated with the carriage equipment control and handling. The train control and monitoring system (SKDU) transmits all the parameters of all operating systems of the train to the terminal located in the staff carriage. By means of this terminal the train master or train electrician can both control the operation of the equipment in all the carriages and take control and set the parameters for the systems of any carriage or all the carriages of the train. The information exchange and commands transfer between the train carriages is carried out with the help of a wireless communication, which is convenient when the train is being formed – as there is no need to connect additional wires; all the carriages are automatically connected to the train network and establish communication with the staff carriage when they are connected with one another.

And a few more features.

The empty weight of a carriage is a very important parameter in double-deck railway coach manufacturing. TVZ managed to keep the empty weight of a carriage, with all equipment, at no more than 65 tons (net) by means of innovative technical solutions and new materials. This means that the load per bogie on the axle does not exceed 18 tons with a full payload of the carriage (gross), which reduces maintenance and track repair costs.

The length of the carriage along the coupler pins is 26.2 m, which is 0.7 meters longer than the length of a single-deck carriage. The distance between bogie pivots is also increased – the length of a double-deck wheel base is 19 m vs 17 m on a single deck carriage. This is due to the need to maximize the length of the double-deck carriage zone, which is located between the bogies. However, the distance between support areas for jacks is preserved – 17 m, which means there is no need to rebuild lifting positions in railroad car sheds and maintenance depots.

The width of the carriage (3.15 m) is virtually identical to the width of a single-deck carriage (3.1 m). The most significant difference in overall dimensions is the height of the carriage 5.3 m vs 4.6 m by a single-deck carriage. The carriage designers used increased cab width (Tpr size), previously used only for freight carriages. This is a cross-country size proper for all trunk roads of Russia; however, entrance gate openings in some passenger depots may be lower than this size, and they need to be improved. By the way, the TVZ experienced a similar problem when they had to improve the gate of the paint-drying room in order to paint the double-decker prototype.

The design features of a double-deck restaurant carriage should be examined separately. The high service level, which is followed by Russian railwaymen in long-distance trains, implies the obligatory presence of a dining carriage. The double-deck trains will also have such a carriage.

The end (single-deck) parts of the dining carriage contains a vestibule and a service room with a remote control and two flanges for the restaurant staff (at the operating end) and a lavatory for the restaurant staff and a sink for the customers (at the non-operating end).

The lower deck of the dining carriage contains all the production facilities - pantries with refrigerators and freezers, a kitchen with electric stoves, convection steamers, microwave ovens and other kitchen equipment, a serving room and a dishwashing room. The production facilities are separated from the corridor by a baffle that prevents unauthorized access to this zone. The lower deck of the carriage also includes a bar with bar tables, intended for 6 visitors who have come to the dining carriage for a short time – to drink a cup of coffee, the bar contains a coffee machine to prepare it or chilled beverages, their storage is provided by a special showcase.

Because the lower deck level of the double-deck dining carriage is located below the raised platform level, special charging hatches in the pantry and in the corridor in front of the pantry are provided on both sides of the carriage to load the products, and their lower edge fits the raised platform level.

There is a room for up to 44-48 customers on the second floor of the double-deck dining carriage. The room is equipped with video and audio broadcast systems; there is a button to call the waiter at every table.

The double-deck restaurant carriage is equipped with the same stairs as the double-deck passenger carriage is. But the waiters will not carry hot dishes from the kitchen on the first floor into the dining room on the second floor–it is both inconvenient and dangerous. A special two-chamber lift will serve to transport food and drinks from the first to the second deck of the carriage. Cooked dishes are placed into the serving chamber and are taken up to the second floor, where a waiter takes them and brings them to a guest table. Dirty dishes are brought back through the second chamber of the same lift.

The innovation policy of Transmashholding CJSC has created all the prerequisites for the appearance of new high-performance vehicles – double-deck passenger carriages – in the network of Russian Railways JSC. TVZ, a national manufacturer, is responsible for their design and development. The developers of double-deck carriages hope that the latter will become a new quality stage of development for both national transport machinery, and passenger railway transport in Russia.■

AUTOMATED CONTROL SYSTEM OF SAFE RESOURCE-SAVING OPERATION AND MAINTENANCE OF ROLLING STOCK EQUIPMENT OF SUBURBAN PASSENGER TEAM (ACS SRSM MDRS)

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Increased incidents and emergencies on railway transport force us to become seriously aware of handling the problem of control and condition monitoring of equipment of all infrastructural assets in all life-cycle phases. It is no secret that the lack of objective quality control of manufacturing and repair of equipment at the stages of production and maintenance and the lack of observability of the real health (technical condition) degradation processes during the operation keep us from taking reasonable, both economically and technically effective actions for maintaining a high equipment reliability level promptly.

Availability of a big number of various monitoring and control tools at the disposal of manufacturing and service enterprises is no guarantee for high quality equipment condition assessment. These tools are not universalized in general, there is no consolidated base of monitored parameters and testing results, an announced metrological performance is not maintained, tools manufacturers frequently do not provide support service. The result is that only about one third of technical control means available in the enterprises' arsenal are on-stream. However there is another problem, because for monitoring and testing results to get the practical importance it must be open to all levels of management hierarchy at any time.

Solution of the denoted problems is achieved by condition monitoring and automated control systems creating [1].

Summarizing over 20 years experience of monitoring and diagnosing of critical equipment of continuous dangerous productions of petrochemical, iron and steel, and mining industries and the experience of rail transport equipment diagnosing SPC Dynamics now actively develops the innovative management engineering of rolling stock equipment health based on real-time monitoring – automated control system of safe resource-saving operation and maintenance of equipment ACS SRSM.

The purpose of ACS SRSM establishment and development is the increasing of railway transport safety and continuous operation by efficient health control of rolling stock equipment and infrastructural assets based on uninterrupted automatic real-time condition monitoring.

The primary tasks, solved by technical means of ACS SRSM, are [2]:

- prevention of emergencies, related to fast malfunction development during operation;
- data reporting on equipment health to different managerial levels in order to develop efficient administrative and technical impacts for equipment health management;
- outgoing qualitative inspection of carried out equipment and assemblies maintenance and repair;
- acceptance quality and condition test of supplied items, assemblies and equipment;
- inspection of staff executive discipline of manufacturing and operating enterprises;
- monitoring changes in technical condition during operation to increase the efficiency of maintenance and repair system;
- operating time registering for preventive maintenance planning and in-depth condition analysis using the stationary means of control and diagnosis.

The basic components of ACS SRSM developed in suburban passenger team, are the means of monitoring, diagnostics and integration:

- systems for the electric multiple unit's (EMU's) assemblies and units condition diagnosing at acceptance test, repair and examination areas (COMPACS®-EXPRESS, COMPACS®-AGREGAT, COMPACS®-RPP);
- system of EMU's sections comprehensive diagnostics at workshop test areas TP-2, TP-3 (COMPACS®-EXPRESS-TR3);
- on-board system for EMU's health monitoring (COMPACS®-EXPRESS-3);
- depot diagnostic network Compacs-Net® combines monitoring and diagnosing systems and provides data reporting to different decision levels.

Stationary System of wheel motor units (WMU) Vibration Analysis COMPACS®-EXPRESS aims at efficient assessment of current state, quality of WMU maintenance and repair during the operating maintenance TO-3 and the operating repair TR-1.

The system is placed at pit track in TO-3, TP-1 workshop and include: operator station; control cabinet with intelligent traction motor power drive providing smooth acceleration to the scheduled frequency and keeping wheelpair speed permanent during the testing process; joint device network apportioned over the pit track; compact remote unit with 6 vibration sensors and RPM sensor.

A full cycle of WMUs diagnosis for one car (4 units) including the set-up operations is less than 30 minutes. Outfitting testing areas with stationary wheelpair hanging devices assists a higher productivity. In that case testing time decreases by 40-50 percent.

The system became widespread in 2000-2005 years, is actively on-stream and show good results in detecting hidden bearing abnormalities of axle, reduc tion gear, traction motor, gear mesh defects, quality deterioration or lubrication lack, defects of element's balance, alignment and fastening, flexible coupling defects. Diagnosis validity is at least 97 percent [3].

Condition diagnostic system for assemblies and units at repair department COMPACS®-AGREGAT is meant for carrying out the acceptance test and repair quality diagnosis of traction electric motors, converters, compressors, collectors and wheelpairs axle equipment and wheel-reduction gear units directly at repair department and at acceptance test areas for certain equipment.

The rolling bearing acceptance test station COMPACS®-RPP is meant for carrying out acceptance test of bearings supplied to the enterprise, their washing, fault detection, demagnetizing, analysis and preservation.

Availability of that diagnostics tools group guarantees placing on rolling stock a properly functioning equipment of the maximum capacity.

System of EMU sections comprehensive diagnostics COMPACS®-EXPRESS-TR3 is meant for comprehensive automatic technical condition assessment of the most complex and most susceptible to service wear and malfunctions EMU sections equipment during large volume routine maintenance. Such equipment includes: WMUs, collectors, pneumatic and electro-pneumatic brake system equipment, electrical control circuits, high voltage power circuits, heating and booster circuits. According to specified equipment classes the system includes 7 diagnostic subsystems interacting in conjunction.

The system has a unique structure. That unicity is determined by particularly apportioned way network of effectively placed over the testing area connecting devices and by supplementing with portable measuring units operating by means of wireless network Compacs-Radio-Net®.

The system structure and composition in combination with established arrangement scheme allow to perform a comprehensive diagnostics of EMU sections of 15 different lines both DC and AC by the same firmware.

Generally, the examination area, where the diagnosis is carried out, in combination becomes the venue for debugging and tweaking of sections equipment, which is also carried out is carried out with the assistance and under the supervision of the system. After such calibration procedure of putting EMU in operation reduce itself to formality, labor of mechanical technicians greatly facilitates and working conditions improves.

The system is actively exploited in a number of depots and received good recommendations in detecting high number of various defects, including equipment assembly errors, misalignment, placing not standard elements, breach of wiring density in air supply and other. Validity of diagnosis, determined by the results of more than 5 year operating is 96 %, which is proved by the results of examination, dismantling, and also debugging, start-up and first period of in line operating of EMUs after repair [4].

On-board monitoring system COMPACS®-EXPRESS-3 is designed for continuous condition monitoring of running gear (wheelpairs, axle equipment, traction gear box, traction motor, assemblies suspension and fastening items), air brake system equipment, power circuit, and also auxiliary circuits of electrical equipment during operation and allows to detect the malfunction emergence and development in time, to display the information on them on the screen in the cab, to transmit data about EMU's health to the assigned depot.

The system automatically generates, archive and transmit technical readiness reports on every car and consolidated report on whole EMU to the health monitoring depot net Compacs-Net®. Automatic transfer of the results by means of wireless network Compacs-Radio-Net® require no operator intervention.

All system elements are highly vandalproof and reliably operate in various climate zones of Russia.

As of today on-board systems are placed at 45 DC EMUs, manufactured by Demikhovsky Engineering Plant and successfully exploited on Moscow, Oktyabrskaya and North-Caucasian Railways.

All ACS SRSM systems are build in compliance with the common principles. First of all it concerns:

- using the unified firmware;
- built-in self-diagnosis function of sensors, communication lines, measuring modules and software integrity;
- the stylistic look and feel of software interface;
- the way that equipment health information is represented (color icons, numerical characteristic values, expert reports, technical readiness reports);
- the unified metrology basis, including methods of measuring channels calibration/verification, which simplifies aftersales service and support of the systems.

Important attribute of the COMPACS® systems is the possibility of their integration into consolidated diagnostic network Compacs-Net® deployed in the enterprise. Integration of diagnostic systems from various workshops, diagnosing and testing systems for assemblies and units at repair department with all onboard monitoring system placed at EMUs into united automated condition monitoring complex for running and repairing in depot rolling stock is carried out by means of the network. Due to the diagnostic network Compacs-Net® objective data on equipment healh become available to enterprise head officers and executive officers on a real time basis. Now the available diagnostic information may be used for objectively justified management decision making to organize efficient safe resource-saving operation and maintenance of rolling stock.

In perspective monitoring and diagnostic facilities located in manufacturing facilities of parts and equipment for rolling stock and infrastructure can be connected to diagnostic networks Compacs-Net®. This will help to create common information space for efficient health management of the whole Railway sector of the country.■

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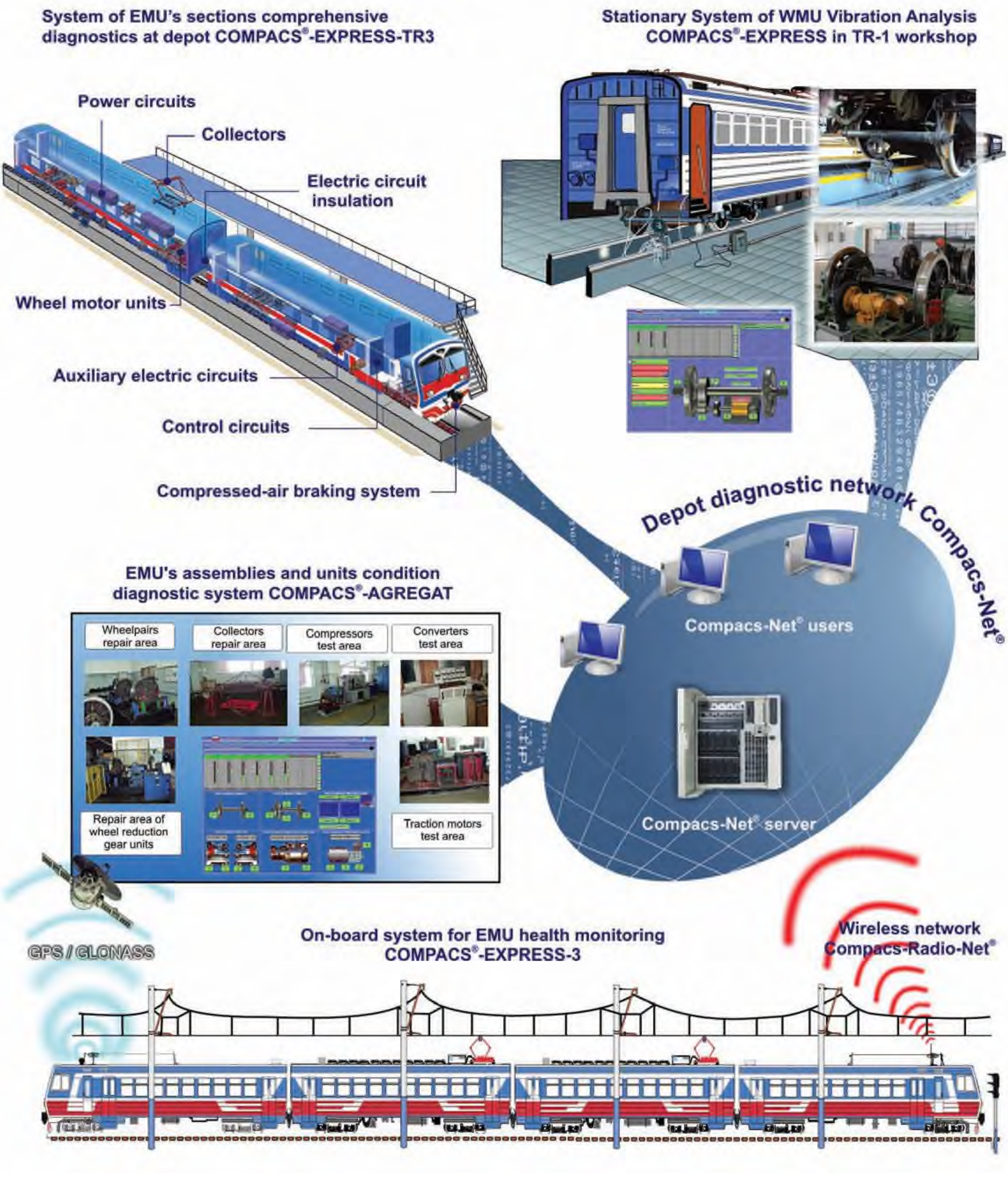
Advertorial

Structure of ACS SRSM in suburban passenger team of Joint Stock Company "Russian Railways" (JSC "RZD")



POSSIBLE WAYS FOR UNIFICATION OF FREIGHT CAR BOGIES, THEIR UNITS AND PARTS AT 1520 MM RAIL GAUGE

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DIRECTIONS FOR FREIGHT CAR BOGIE UNIFICATION

TSNII-KH3 railcar bogie started operating in USSR in 1956 after the long-term study and testing; later conditional number of 18-100 model was attributed to it. Any changes were implemented very severely in its design: in 1995 friction bearings were completely changed by rolling bearings; in 1996 the works were started upon equipping the rolling stock by wear-resistive elements; these works are not completed up to now. Since 1999, freight carrier manufacturers for the rail gage 1520 mm have been starting works upon launching of alternative bogies into manufacture.

Today the bogies offered at Russian market for the axle loading of 23.5 ton-force [1] may be divided into four groups by their design:

Group 1 – analogues of 18-100 model with its upgrading by M 1698 design (18-2128, 18-9801, 18-9845, 18-9841, 18-9770, 18-1750) – 80% of the whole bogie output within 2007-2009;

Group 2 – the bogies of 18-100 model upgraded by C 03.04 design, which provide improved car ride performance – they are produced for operation in Ukraine;

Group 3 – the bogies of 18-578 model and its analogues (18-9771, 18-7020), which are distinct in the increased run between repairs and improved car ride performance – 20% of the whole bogie output within 2007-2009;

Group 4 – the bogies of 18-9810 model, [2], which were designed by Barber S-2 technology. They differ by the design of main units, increased run between repairs and improved car ride performance – only pilot samples were manufactured.

For axle loading of 25 ton-force, four bogie models are offered at the Russian market (18-194-1, 18-9800, 18-9855, 18-9836), which significantly differ against each other by their design [1, 3].

The need of standardization becomes especially important for the bogies of 18-100 model, which virtually do not have the differences against each other. The following problems appear during their operation: variety of their types, maintaining the compliance of the bogies to design documents during overhaul per their configuration (for example, solebars of 18-100 model and truck bolster of 18-9770 model), inhering of the bogie parts within one model to different railway administrations, etc.

Other tasks are put for the bogies with improved characteristics:

1. Unification of the unit and part design for the 1520 mm rail gauge to be changed during operation (wheel sets, wheel boots, brake blocks, fasteners for brake blocks). At the same time, it is necessary to take into account the absence of exchangeability for wheel sets and bogies under the carriages with different axle loading in order to exclude errors made by operating and repair staff;

2. Unification of the bogies with the same axle loading upon their ability for interchange under cars, ability for inspections and maintenance;

3. Unit and part unification for the bogies with different axle loading produced by one manufacturer (friction wedges, friction plates and side bearers may be unified at technical capability) and simultaneous absence of unification with the units and

parts for the bogies fabricated by other manufacturers in order to maintain their competitive advantages.

UNIFICATION OF WHEEL SETS FOR THEIR USE IN THE BOGIES WITH DIFFERENT AXLE LOADING

Wheel sets for different axle loadings (GOST 4835) differ by the axle neck diameter: 130 mm for the axle loading of 23.5 ton-force; 150 mm for the axle loading of 25 ton-force; 160 mm for the potential axle loading of 30 ton-force.

Standard wheel set (for the bogies of the 18-100 model range) for the axle load 23.5 ton-force is equipped with journal boxes according to Industrial Standard (OST) 24.153.12 with two cylindrical single-row bearings 130x250 mm as well as the wheels with usual hardness and conical disc. Wheels with increased hardness and cassette-type double-row bearings are used for the bogies with the axle loading of 23.5 ton-force with improved performance characteristics (increased run between repairs).

SKF has certified cassette-type bearing with dimensions 130x250x160 mm for the wheel set with the axle loading of 23.5 ton-force; it may be installed into a journal box body. Brenco (Amsted Rail) has certified cassette-type bearings with dimensions 130x250x160 mm and 130x230x150 mm for the wheel set with the axle loading of 23.5 ton-force; these bearings are installed both into a journal box body and under an adapter.

Thus, there is no unification for the bearings used under an adapter as well as for wheel hardness for the axle loading of 23.5 ton-force.

In 2001 the Ministry of Railways of the Russian Federation developed and approved the "General Technical Provisions for Freight Cars of New Generation", in which the size of 150x250x175 mm was set for the bearing installed under an adapter. Later it was decided not to increase the bearing length and accept the dimension 150x250x160 mm in order to decrease the axle loading. Interchangeability of wheel sets of the bogies 18-194-1, 18-9800, 18-9836, 18-9855 for the axle loading of 25 ton-force during their operation is achieved by the unified cassette bearing of 150x250x160 mm installed under adapter. The wheels with increased hardness and S-shaped disc profile are used for all bogies.

Application of the cassette bearing having the same outer diameter (250 mm) and length (160 mm) under the bogie adapter for the loading 23.5 ton-force, which is used for the loading 25 ton-force, allows excluding usage of the wheel sets intended for the axle loading of 23.5 ton-force with the bogie intended for the axle loading of 25 ton-force.

The problem of unification of the wheel sets for freight car bogies may be solved by the development of their standard series (Table 1).

One should reject an installation of a cassette bearing into a journal box body since it may result in the inadmissible situation of using the wheel sets intended for the axle loading of 23.5 ton-forces in the bogies with the axle loading of 25...27 ton-force. Installation of the wheel sets for lower axle loading into the bogies intended for higher ones should be additionally limited by the configuration of adapters and axle box apertures. Within each axle loading, it is necessary to set standard requirements to the dimensions and mechanical properties of the mounting faces for a cassette-type bearing and an axle neck, the bearing surface of a cassette-type bearing and the adapter for a cassette bearing.

Such unification of wheel sets and bearings will allow to satisfy the interest of all participants of the railway vehicle market as per creation of the unified design for the main units and parts subjected to periodical changes during operation. It will also make impossible to install the parts, which decrease the run between repairs and make a threat to traffic safety, during current and scheduled repair.

18-100 BOGIES SERIES UNIFICATION

The possible accounting of the bogies, which are technically identical to 18-100 model, is the development of the following documents: new classifier with attributing a personal code to each model; reference book for bogie models with stating possible interchangeability for the particular bogie elements and assembled bogies; requirements to the part labels, which indicate their inhering to the bo-

Table 1. Standard series of wheel sets

Axle loading, ton-force	Axle neck diameter, mm	Bearing type	Bearing dimension, mm	Wheel type
23.5	130	two cylindrical one-row	130×250	usual hardness of wheel rim
23.5	130	cassette-type conical double-row	130×230×150	increased hardness of wheel rim, conical disc
25...27	150	cassette-type conical double-row	150×250×160	increased hardness of wheel rim, S-shaped disc
30	160	cassette-type conical double-row	160×280×180	increased hardness of wheel rim, S-shaped disc

gie model. This way has the following disadvantages: sophistication in distinguishing the technically identical parts during operation; appearance of the details with the same connecting dimensions and performance data but with different labelling.

The problem of the bogie unification in Europe was solved by issuing the unified set of drawings and transferring the maintenance function for this set to the independent body - International Union of Railways (UIC) [4], which also has the right to sale licenses for usage of the unified drawings. Normalized drawings contain such parts as bogies, separate drawings (including installation dimensions), bogie components; brake system parts for freight cars (including the parts of brake rigging installed on a bogie). Preset procedure for inclusion of new product into the list of unified parts provides their interchangeability.

Unification problem for bogies of 18-100 model may be solved at the 1520 mm rail gauge via development and implementation (for example, within UIRE) of the normalized drawing set for a unified bogie; setting the procedure of its supplement; the equal cost politics for all manufacturers. All parts included into the normalized drawing set should have the same labelling indicating their interchangeability.

There are following unification outcomes for manufacturers and repair bodies: acquisition of the bogie normalized drawing set; annual subscription cost into the holder of the normalized set on a flat-rate basis. Launching into manufacturing and certification of the bogies, which are manufactured according to the normalized drawing sets, becomes simple and includes shortened qualification tests. Thus, the cost of launching into manufacturing will decrease as compared with the new bogie designing.

It is necessary to establish the single procedure, which includes functional and operation tests, in order to include the drawings of the parts with new design into the normalized set.

UNIFICATION OF THE BOGIES WITH IMPROVED PARAMETERS FOR THE 23.5 TON-FORCE AXLE LOADING

Except the 18-100 model for the axle loading of 23.5 ton-force, different manufacturers have developed the bogies with improved parameters (for example, 18-578, 18-9771, 18-7020, 18-9810). Information per their performance characteristics is not sufficient today, it does not allow to assess their advantages as compared with other; that's why the task of their design unification is premature.

The approach to unification of the bogies with improved parameters may be in provision of their interchangeability under cars, ability to control and repair during their operation while maintaining improved parameters (first of all, upon the run between repairs).

While designing new railcars, it is necessary to foresee installation of wear-resistive and adjustment plates with unified fastening at the side supports of span bolsters. For the railcars with different wheel base, it is ought to design a size series of the wear-resistive and adjustment plates providing the contact of a bogie bearer and a car while passing curved track sections.

The following parameters need unification: the distance between the bearer support surface on a car body to the pivot block support surface; rated height of a centre bowl plane (795 mm as for the bogies of 18-100 model) while installing the car body with preset minimum weight (for example, minimum dead weight may be set as 21 tons). To improve the testing ability during operation, it is necessary to unify the fitting height for the fixed contact side bearers.

Interchangeability of bogies under railcars is also defined by a break rigging, in which it is necessary to standardize gear ratio and location of the levers, which provide the bogie connection with a railcar.

To provide repairability during operation, it is necessary to unify the following elements: the fastening of side bearers with fixed contacts; wheel boots preventing an exit of wheel sets from a journal set aperture, their fastening; break block, break block key, connecting dimensions of a break block to a fixed shoe.

In order to maintain the improved bogie parameters, exclude the possibility to install into a bogie the details, which decrease the run between repairs and make a threat to a traffic safety, it is necessary to make impossible an interchangeability of the bogie parts with the bogies of 18-100 model: wheel sets with bearings and adapters; solebars and truck bolsters, suspension springs and friction wedges, friction plates, wear-resistive elements, etc.

Such unification of the bogies with improved parameters will allow to satisfy the interest of all participants of the railway vehicle market at the expense of the unified design for the main units and parts subjected to periodical changes during operation. It will also make impossible to install the parts, which decrease the run between repairs and make a threat to traffic safety, during current and scheduled repair.

UNIFICATION OF THE BOGIES FOR THE AXLE LOADING OF 25 TON-FORCE

The situation connected with unification of the bogies for the 25 ton-force axle loading is similar to the bogies with improved parameters for the loading 23.5 ton-force; however, it is also necessary to take into account the requirement per avoiding interchangeability for the critical parts with lower axle loading.

GOST 9246 foresees an increase of the centre bowl diameter up to 350 mm thus making impossible to install the bogie for the axle loading of 23.5 ton-force (centre bowl diameter is 300 mm) under the railcar with higher lifting capacity.

Size range for wear-resistive and adjusting plates on the body side supports, installation height and fastening of the permanent-contact side bearers, rated height of the centre bowl plane under the empty car, wheel boots and break rigging for the axle loading of 25 ton-force may be harmonized with the axle loading of 23.5 ton-force. The distance from the bearer support surface on the car body up to the centre plate may be also harmonized, moreover, its value may differ from the bogies with the axle loading of 23.5 ton-force.

It is necessary to provide the absence of interchangeability for wheel sets with bearings and adapters with the bogies having the axle loading of 23.5 ton-force in order to maintain improved bogie parameters (including load capacity), to avoid installation of the parts, which decrease the run between repairs and make a threat to traffic safety, during running and scheduled repair. Solebars, suspension springs and friction wedges, springing inserts of adapters of the same manufacturer may be designed for the axle loading of 25 ton-force and used in the bogies with the axle loading of 23.5 ton-force.

Conclusion

Variety of the freight car bogies developed for the 1520 rail gauge causes the need of their unification in order to simplify operation and maintenance procedures, excluding of the staff errors resulting in the violation of traffic safety.■

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COMPUTER VISION TECHNOLOGIES FOR THE SUPERVISION OVER OBJECTS OF RAILWAY INFRASTRUCTURE

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All technical facilities used at the railways fulfill exclusive requirements for reliability. And through all exclusive requirements the modern technologies do not ensure the complete safety of traffic. Multiple factors such as location of settlements along the railway lines, high interference level for physical security techniques, high intensity and velocity of trains, have an effect on traffic environment and contribute to the occurrence of extraordinary circumstances [1]. A solution of the problem of safe movement on rail with increasing speed of the train is complicated by the presence of "human factors". It is very difficult for a man to react properly to the danger situation when the trip is extensive and performed at great speeds. The solution of such problems as modernization, duplexing, enhancement of functional capabilities of facilities, minimization of "human factors" impact on railway traffic can enhance the reliability of technical facilities providing traffic safety.

The development of hardware and software system of detection and identification of signaling light (PAK DISS) is conducted in order to enhance the functional capabilities of Integrated Train Protection System (KLUB-U). The usage of computer vision technologies in the surveillance module of PAK DISS provides the twenty-four-hour analysis of imagery information on the running of locomotive on the track on a real-time basis, as well as monitoring of railway infrastructure. If the hazard including non-conformity of traffic guide lights signals with automatic locomotive control signals was identified within train movement, PAK DISS generates audible warning signal for locomotive driver. At the same time the enlarged video image is transmitted to the KLUB-U display via CAN interface in order to provide the possibility for the locomotive driver to perform detailed analysis of the visible circumstances.

METHOD OF VERIFICATION OF INFRASTRUCTURE OBJECTS COORDINATES

It is required to use the computer vision technologies (CVT) jointly with technology of geo information support of objects [2] for the purpose of effective solution of problem related to the control over railway infrastructure objects. The algorithm of PAK DISS surveillance module will carry out the analysis of imagery information by means of CVT within locomotive movement. The space of detected objects where the detected objects of railway infrastructure are displayed in the form of points with dimensions of weight similarity coefficient at the image matrix is a result of video analysis carried out by means of the algorithm of PAK DISS surveillance module. The final identification of railway infrastructure objects is performed by the algorithm of verification of detected objects with geo information GPS/GLONASS map of railway infrastructure objects coordinates.

It is necessary to model rectification plane [3] and to determine a direction vector of characteristic lines at the space matrix of detected objects in order to perform the algorithm of verification. It will make it possible to determine the scene depth at the analyzed 2D image from a video camera, as well as carry out the analysis of perspective objects projection of detected objects space at the rectification plane.

It is essential to have two parallel or crossing lines [4] for the purpose of plane construction. Characteristic lines by means of which it is planned to construct the rectification plane are supposed to be obtained with the aid of algorithm of railway rail detection (ARRD). Rails are objects which meet the following requirements:

- rails are always present at the analyzed image;
- it is possible to draw two characteristic lines which are parallel;
- object has a known size of distance interval between two characteristic lines.

In order to solve the problem of rectification plane construction it is supposed that:

- characteristic lines appertain to the rectification plane;
- the ground surface is flat;
- the rectification plane is perpendicular to the vertical axis of earth referenced coordinate system;
- the space of detected objects is related to the locomotive system of coordinates.

The basic vectors of locomotive system of coordinates (LSC) where vector Z is directed along the locomotive movement and the vertical axis Y is perpendicular to the rectification plane are determined. LSC is left-handed (Fig.1).

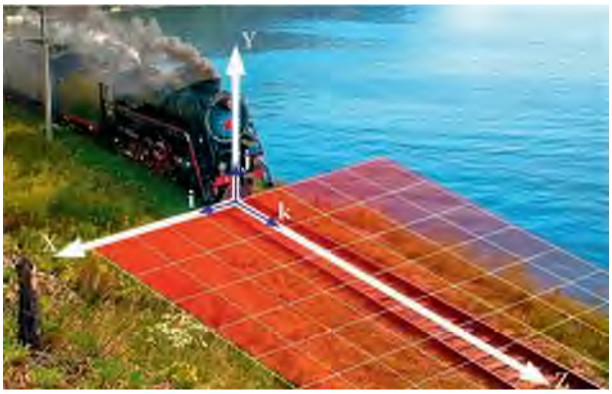

Fig. 1 Determination of rectification plane in LSC

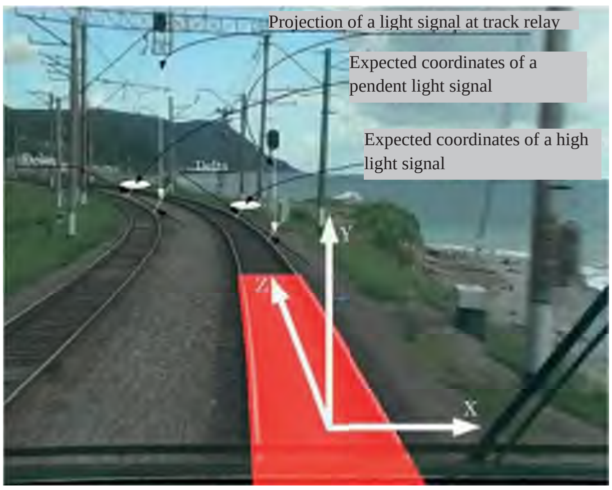

Fig. 2 Pattern of calculation of the object identification accuracy

When the coordinates of rectification plane are calculated by means of ARRD it is essential to perform transformations of geo information system of coordinates (GISC) to LSC. The result of transformation of GISC to LSC represents the underlying surface which coincides with the rectification plane at which coordinates of prospective objects of railway infrastructure are displayed. Within the analysis of *Delta* dimension it is possible to calculate object identification with relevant accuracy (Fig. 2) where *Delta* is the distance between expected coordinate of object and projection of coordinate of the object located in the space of detected objects at the rectification plane.

BOUNDARY DETECTION BY MEANS OF GRADIENT

Detection of lines such as railway rail can be performed by means of linear spatial filtering methods. The method of boundary detection by means of gradient is based on the calculation of first-order derivatives [5]. The general view of image gradient vector $f(x, y)$ at the point (x, y) is represented in (1).

$$\nabla f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix} \qquad (1)$$

The calculation of the gradient vector modulus for each point of image enables to emphasize characteristic features of the line (2).

$$\nabla f = |\nabla f| = \left|\frac{\partial f}{\partial x}\right| + \left|\frac{\partial f}{\partial y}\right| \qquad (2)$$

The calculation of the gradient vector modulus is produced by the following formula (3)

$$|\nabla f_{ij}| \approx |(f_{i+1,j-1}+f_{i+1,j}+f_{i+1,j+1}) - (f_{i-1,j-1}+f_{i-1,j}+f_{i-1,j+1})| + |(f_{i-1,j+1}+f_{i,j+1}+f_{i+1,j+1}) - (f_{i-1,j-1}+f_{i,j-1}+f_{i+1,j-1})| \qquad (3)$$

In order to solve this problem it is expedient to use the Prewitt operator mask within the calculation of gradient vector modulus (Fig. 3)

$$G_y = \begin{matrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{matrix} \qquad G_x = \begin{matrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{matrix}$$

Fig. 3. Prewitt operator masks

The calculation of gradient vector direction shall be carried out for the purpose of extraction of the railway rails characteristics. The angle between the direction ∇f at the point (x, y) and the axis x is a direction angle of gradient vector (4). The value of direction angle of gradient vector may be used for the purpose of determination of the angle of characteristic lines.

$$\alpha(x,y) = \alpha ctg\left(\frac{G_y}{G_x}\right), \text{ if } G_x \neq 0 \tag{4}$$

Figure 7 shows the results of image processing by means of the above method. The area of luminance difference which coincides with areas of railway rails location at the reference image is clearly distinguished at the processed image.

ALGORITHM OF RAILWAY RAILS DETECTION (ARRD)

The characteristic features of railway rails are proposed to be used for the purpose of rectification plane construction within the determination of characteristic lines. It is supposed that the object such as railway rail has:

- continuity at the small area;
- direction angle of gradient vector α(*x*, *y*) in the range of $\frac{\pi}{2}$±40 degrees;
- luminance distribution profile along the horizontal axis similar to Gaussian distribution.

It is proposed to use ARRD which enables to perform more qualitative segmentation of object such as railway rail than the segmentation by gradient calculation method in order to improve the stability of characteristic lines determination.

The general pattern of ARRD consists of several stages:

1. Preprocessing of reference image by the right and left Rails operator:

$$G_r = \begin{vmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 1 & 1 \end{vmatrix} * f, \quad G_l = \begin{vmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 1 & 0 \end{vmatrix} * f, \tag{5}$$

where f – reference image; sign * means folding of image with the operator; G_r, G_l – right and left Rails operator respectively;

2. The calculation of image preprocessing is performed by means of subtraction modulo of one matrix from another which was received after the processing by the right and left Rails operator.

$$\nabla E = \begin{cases} G_r - G_l, \text{ if } G_r - G_l > 0, \\ 0, \text{ if } G_r - G_l \leq 0. \end{cases} \tag{6}$$

The difficulty of rail determination arises on a sunny day. The presence of rail shadow at the image introduces an error of rail orientation relative to shadow into ARRD. It is essential to implement the algorithm for determining the shadow for the purpose of error elimination. If the shadow is on the left relative to the rails it is necessary to carry out the expression (6), otherwise (7).

$$\nabla E = \begin{cases} G_r - G_l, \text{ if } G_r - G_l < 0, \\ 0, \text{ if } G_r - G_l \geq 0. \end{cases} \tag{7}$$

Figure 8 shows the results of image processing by means of the above method. The area of luminance difference which coincides with areas of railway rails location at the reference image is clearly distinguished at the processed image.

THRESHOLD BINARIZATION OF PROCESSED IMAGE

It is necessary to perform the thresholding image filtering for the purpose of intensification of rail characteristic features at the image after preprocessing and false signature minimization.

It is proposed to use the Otsu's method for the calculation of optimal binarization threshold [6]. This method is the most effective of the global binarization methods. The main idea of the method consists in the following.

Suppose that the image is a two-dimensional array with dimensions of *n×m* and values of the array element lie in the range (0…255). In this case the histogram of this image will present one-dimensional array *H*[0...255] where each element *H(i)* contains the total number of pixel in the image with intensity equal to *i*.

The following expression is proposed for the calculation of threshold value indicator:

$$Ots(t) = 1 - \frac{D(0,t) + D(t+1,255)}{D(0,255)}, \text{ where } 0<t<255,$$

where *D(k,l)* is a variance estimate of the histogram fragment *H[k..l]*, where *0≤k,l≤255*.

All values of the array *Ots(t)* lie in the range [0..1]. The classification by brightness fractionation into two classes as regard to the threshold value is performed more effectively if this threshold is higher. The Otsu's algorithm calculates the threshold value for all luminance level of the reference image *t* = [0...255], however the optimal threshold is determined as follows:

$$T = \arg\max Ots(t), \ t \in [0...255].$$

Therefore, the computation of coefficient indicating the threshold value for the binary classification consists in detection of the luminance level at which the threshold value indicator takes the peak value.

The result of railway rail determination at the reference image Fig. 6 after the application of thresholding filtering by means of gradient (where G_x=0) and ARRD is shown at Fig. 5 and Fig. 6 respectively. Therefore the usage of ARRD method for the synthesizing of filtering which determines the object such as rail at the image is more effective than the usage of gradient method. The effectiveness of the algorithm of rectifcation plane construction depends completely on the quality of determination of the line such as rail.

ALGORITHM OF RECTIFICATION PLANE CONSTRUCTION

The rectification plane construction is performed in relation to the parameters of characteristic lines which in its turn are determined by means of the Hough method [7] at the processed image with the aid of ARRD (Fig. 7).

Fig. 4 Reference image

Fig. 5 Linear filtering

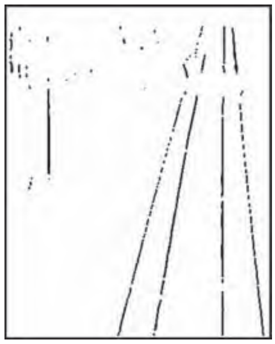

Fig. 6 ARRD

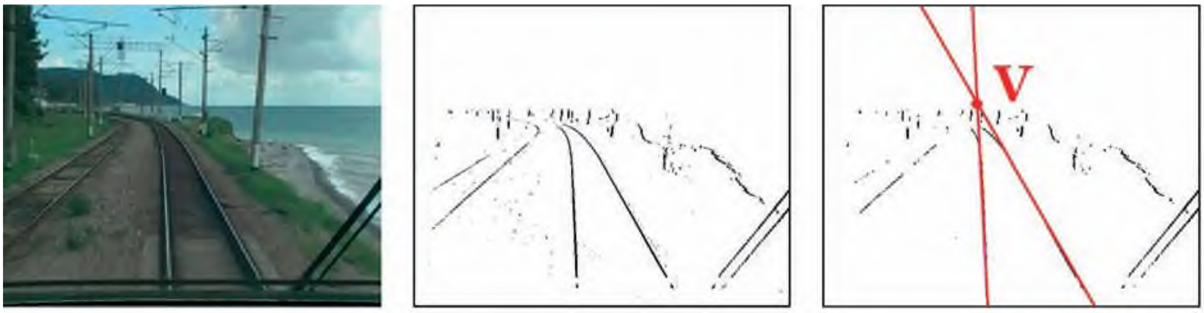

Fig. 7 Source image processed by ARRD, determined characteristic lines respectively

At Figure 7 the vanishing point V is a level with respect to which the lower plane of scene which coincides with the rectification plane can be modeled. The bearings of detected objects will be produced in the rectification plane for the verification algorithm (Fig. 8).

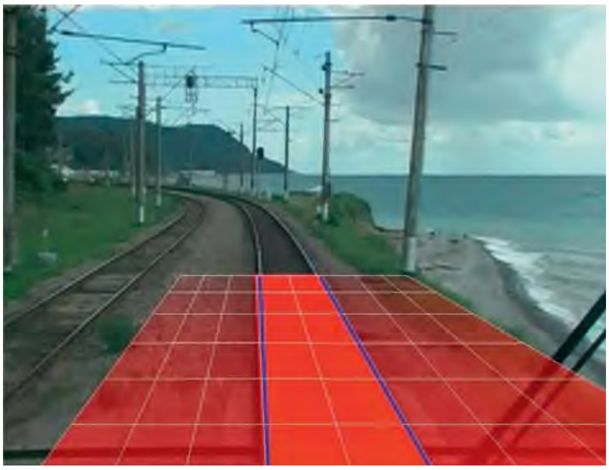

Fig. 8 Scene modeling

Conclusion

It was suggested to use the computer vision technologies jointly with technology of geo informational technologies in order to enhance the efficiency of non-contact detection methods for railway infrastructure objects. Rail detection algorithm which meets requirements for the rectification plane construction was formulated. A series of computational experiments providing the possibility to approve the validity of conclusions which were made within the work, as well as proving the effectiveness of suggested algorithm of railway detection, was conducted. ■

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RAILROAD DIAGNOSTICS WITH SIMPLE SYSTEMS

Current TVEMA Group' product range includes equipment for all types of railroad diagnostics: from manual removable equipment for local railway track section control to mobile high speed trunk line inspection systems.

Most popular manual systems manufactured by the Company are manual removable track geometry inspection bogies PT-10, geometry/NDT inspection bogies SPRUT and single-thread ultrasonic NDT analyzers SKAT.

They all feature light weight, compactness, ease of operation, simple design allowing their use in any environmental conditions, robustness, long-life battery and flexible software and hardware. These systems can be operated globally as they are designed for track gauge 1520, 1435 and 1067 mm wide.

When moved along the rails, **sensors of the track geometry inspection bogie PT-10** automatically measure track level, gauge and length, logging and saving data in the non-volatile memory of the microprocessor for further transmission to the track facility server via the communication adapter.

Apart from the above mentioned PT-10 capabilities, **SPRUT** detects defects in both rail threads along the entire length and rail section. One of the features of this device is monitoring of acoustic contact in each channel throughout the sounding cycle. Precise fixing of measurements is ensured by GLONASS/GPS receiver.

NDT analyzer acoustic measuring unit SKAT sounds the rail thread in several channels logging the signals (in the range from – 16 to + 12 dB) of defects along the length and rail section. Acoustic contact is monitored in each channel throughout the sounding cycle. Defect coordinates are displayed on microprocessor display in the on-line mode and recorded to the memory chip for further processing.

Mobile NDT inspection laboratory LDM is a unique product of TVEMA Group allowing diagnostics of short sections of the railway track at the speed of up to 40 km/h. LDM is a re-worked vehicle (UAZ, Land Rover, etc.) which can travel both on the highway and on railway tracks.

The system comprises unique equipment allowing fast mounting/removal of the laboratory on/from the railway track with any type of sleepers. Special design of the probe and skid ensures trouble-free operation of the laboratory even at low temperatures and in snow conditions.

In addition to defect detection in rails, LDM monitors parameters of the inspected railway track section (coordinates of the kilometer posts, crossings, switches, etc.). All data is logged and automatically processed by the local computer. On customer's request, LDM can be additionally equipped with geometry and georadar equipment.

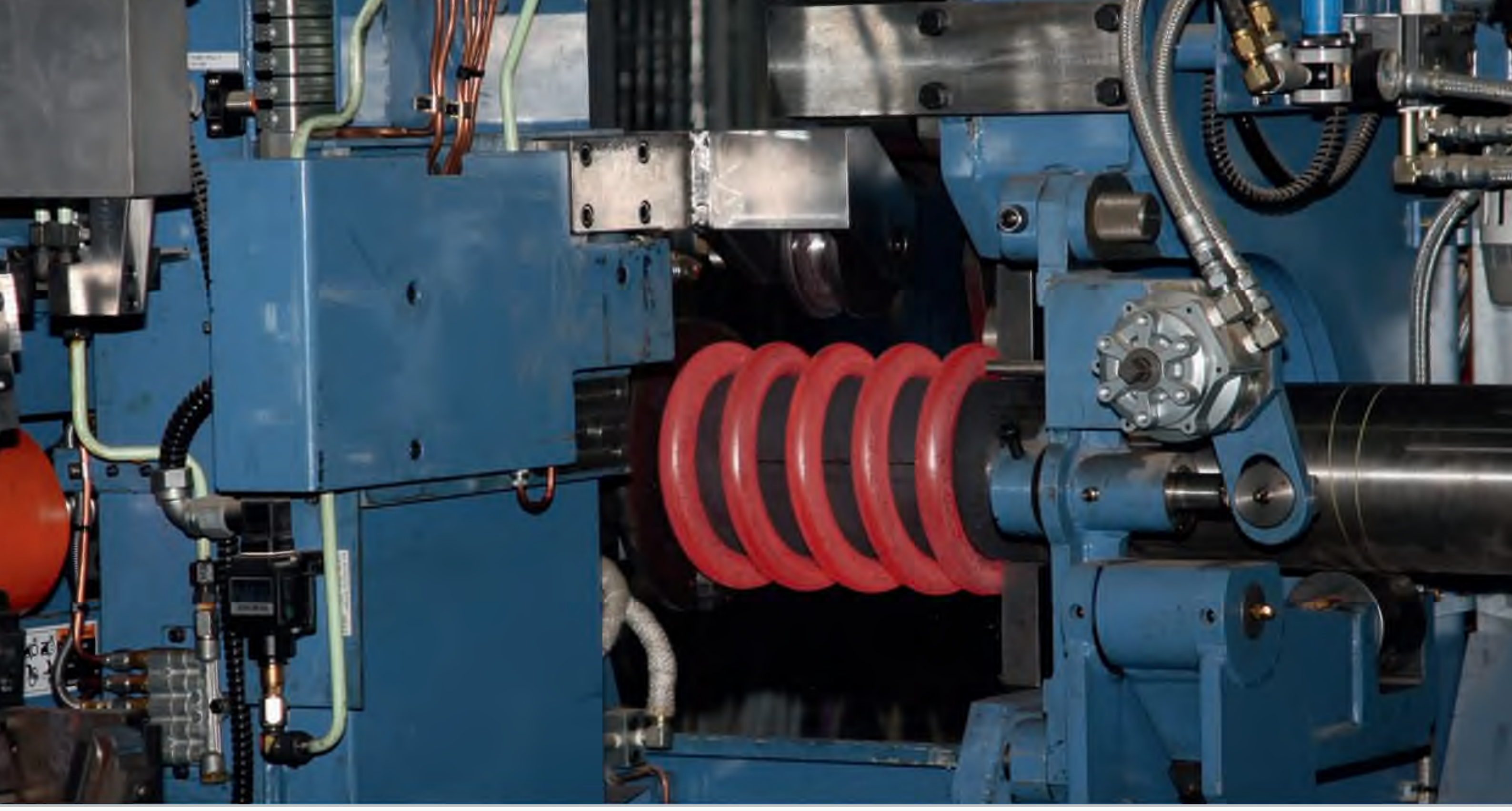
TVEMA' most demanded mobile diagnostics system is unparalleled **system of high-speed NDT inspection of tracks and automatic interpretation with non-contact sensors.** It makes possible previously unattainable inspection speed of up to 100 km/h, automatic location of defective areas and superposition of obtained video data and schematic mapping of defects and 'suspicious' point on the track model.

Non-contact automatic scanner and high-speed NDT analyzer are installed underframe. Such design excludes probe to track mechanical contact which can cause acoustic interference, and ensures precise alignment of sensors with rail centerline without reduction in speed during travel along straight and curved track sections and switches.

Recently developed TVEMA Group' visual defect detection system SVOD enables on-line detecting of track structure defects critical for traffic safety (damages of joints, cracks in rails and sleepers, etc.). It is installed on the undercarriage of any vehicle and allows continuous automated control of all elements of the track structure within the assembled rails and sleepers. This device logs and processes image from the high-resolution cameras located in the immediate vicinity of the monitored objects. To ensure effective operation in all environmental conditions, the system is fitted with fluid cooling, heating, dust removal systems and system of mechanical external wiper system.

All acquired video data are precisely referenced to the geographic and track coordinates. The system provides the possibility of comparing data from other diagnostics systems installed on the vehicle.■

Advertorial



THE "UNCONQUERABLE" HEIGHTS OF QUALITY

Vladimir Matiushin
Vice President
Union of Industries of Railway Equipment (UIRE)

A serious attention has been given to the subject of products quality in numerous research works, dissertation papers, articles, and many decisions concerning it have been taken at all levels.

Certainly, now every specialist knows that the socialist system, based on administrative management, had some advantages in the crisis periods of a society's development, but quickly deteriorated to standstill if things were in their normal way. It happened because the basic fault of the system was its resistance to innovative development, to creating new technical means and changing to modern technologies, and inability to focus on the task of improving product quality.

On the other hand, the market economy encourages activity in improving quality and technical level of products, enhancing labor efficiency, refining technology, and reducing the cost of production.

In the 1960s–1990s, all these things resulted in standstill and stagnation of one system, and in rapid technical development of the other system. In this case, everything is clear. We understand the reasons for low quality, and we realize that programs meant to improve were doomed. Yet Russia has already lived for 20 years without socialism; we have reformed its economy, changed it to a market-based pattern, but we still fail to see any noticeable improvements in product quality. Obviously, the first ten years were the time of crisis, the period of breaking the old economy, overcoming crisis conditions and adapting companies to work in the new market environment, creating market-based management mechanisms, including elaboration of corresponding laws.

Ten years is a long period, but there are still no fundamental changes in improving quality. Moreover, we are already losing certain segments of our domestic market and reducing exports of our products to other countries, including CIS countries, due to low quality, on the one hand, and rising product prices, on the other. Customers have to buy foreign-made products because there are no domestic products of equally high technical level, or because domestic products are of low quality. In this, not only do we give way to industrially developed countries, while still producing lower quality at prices becoming comparable with theirs, but we also give way to developing countries, products of which are cheaper, yet their quality is almost similar to ours. What is the reason for such situation with product quality?

This article does not attempt to analyze everything that has happened in the economy, but it only suggests studying problems of quality improvement of industrial products as exemplified by railway rolling stock. In our analysis of technical equipment supplied to railways, we will also abstain from consideration of experimental products or products manufactured in small amounts, because their quality indices in regular operation are still unknown.

Looking for positive examples of market development in the field of railway industry production, we should point out the following facts - the beginning of commercial production of goods that were never manufactured in Russia before that, emergence of new rolling stock manufacturers, beginning of commercial production of spare parts and components for imported equipment, and beginning of new equipment with improved performance characteristics.

There are also factors indicating the end of rolling stock manufacturing monopoly, with the most characteristic example being that of freight wagons.

In this field, competition between manufacturers arose, which now includes companies from Ukraine as well. It resulted in an abrupt fall of prices on the background of declining demand during the crisis period, but in the conditions of supply exceeding demand, in 2010, prices have grown more than in the pre-crisis period. Last year, new designs of car trucks were produced, their certification was accomplished, and manufacturing of a preproduction series began.

Yet no drastic changes have occurred in improving quality of freight wagons, which is indicated by a sharp increase in cases of car truck solebar fracture. It suggests that market mechanisms in this segment of production are still not so active to force all market players to work on improving the competitiveness of their products, determined by the price/quality ratio.

There have been notable changes for the better in the field of normative, methodological, and procedural support for the work in improving product quality, and these changes enable manufacturers to engage in this work actively even now.

Most manufacturers have signed the Charter of Cooperation between Russian Railways JSC, UIRE, Russian transport industry enterprises, railway industry manufacturers and railway equipment and components producers, undertaking to change to product evaluation by life cycle cost criteria, to organize permanent work in improving product quality, to introduce active innovation policy, updating production technologies and product designs, and to work on reducing cost of production.

At UIRE, we have developed standards regulating relationships between market players and determining ways to solve disputable technical issues, perform product quality evaluation tests, including tests by performance rating, and providing methods for performance of such tests [1]. We have formed an Expert Institute, the composition of which allows performing independent evaluation of any technical problems with a highest degree of competence [2]. See Fig. 1

We have prepared a package of standards at UIRE on a quality management system for railway industry manufacturers [3]. We have also completed the full cycle of preparatory work that allow member companies of the Partnership to begin implementation of the European business management systems, ensuring successful solution of product quality improvement problems in accordance with IRIS.

Still, very little is being done in this field, and there are examples to suggest lack of concentration on ensuring safety and product quality even in the segment of car production which is experiencing tough competition now:

- application of automatic double-speed welders in welding works on the car main frame by the order of the company management, while knowing that strength of such seam is sub-standard;
- employment of welders without proper on-site training and proficiency testing as well as without appropriate documents, and entrusting them to perform welding works in production of car underframes;
- almost double reduction of internal rejection rate in production of molded pieces of car trucks against the background of maximum utilization of foundry facilities without any improvements implemented into the corresponding technologies, which suggests massive commissioning of faulty units.

The above-mentioned facts have been registered in four enterprises during the last six years.

The most important and the most dangerous thing about these examples is that they do not result from operating errors, but appear as conscious actions in producing faulty products.

Therefore, this problem does not originate from backward technologies or lack of market relations; it is rooted in factors preventing works on improving product quality, or in complete lack of motivation for such works.

Most likely, the present-day situation in majority of enterprises will require investments to solve the problem of improving product quality.

Any investment program can be realized only if it yields results allowing us to recoup all expenses within a specified period of time, and finally brings improved profitability and competitiveness. As we know from experience of market-economy countries, investing into quality refinement must result in reduction of costs related to faulty items. Such cost can be “external” – recovery of customers’ expenses, including warranty liabilities, and “internal”, determined by how much is spent on quality control, recovery of rejection, and losses from irrecoverable rejection. In addition, these expenses are interconnected in such a way that it makes companies spend more on “internal” issues in order to cut spending for the “external” costs.

However, in the present-day Russian economy, “external” expenses are virtually reduced to guarantee costs, which are not high, and therefore Russian companies do not feel the need to improve quality control and increase corresponding expenses.

To find out the reasons for such situation, we need to examine the whole system of economic relationships, beginning with the customer.

The simplified idea of the market for laymen is that of two parties, the seller and the buyer. The buyer determines demand, therefore he shapes the market, and his role is of greater importance. The buyer’s goal is to purchase an item of better quality with minimal expenses.

The seller’s goal is to sell the item he has at a highest price possible. If the buyer is not satisfied with what the seller has, he refuses this purchase or starts looking for another item. It makes the seller think of improving his product or reducing its production cost.

In the railway industry market, the situation is somewhat different. For example, in the sector of rolling stock there is an operator on the one side, and the manufacturer on the other side. It is interesting to know, that they have similar goals – to receive profit. In addition, we have analyzed

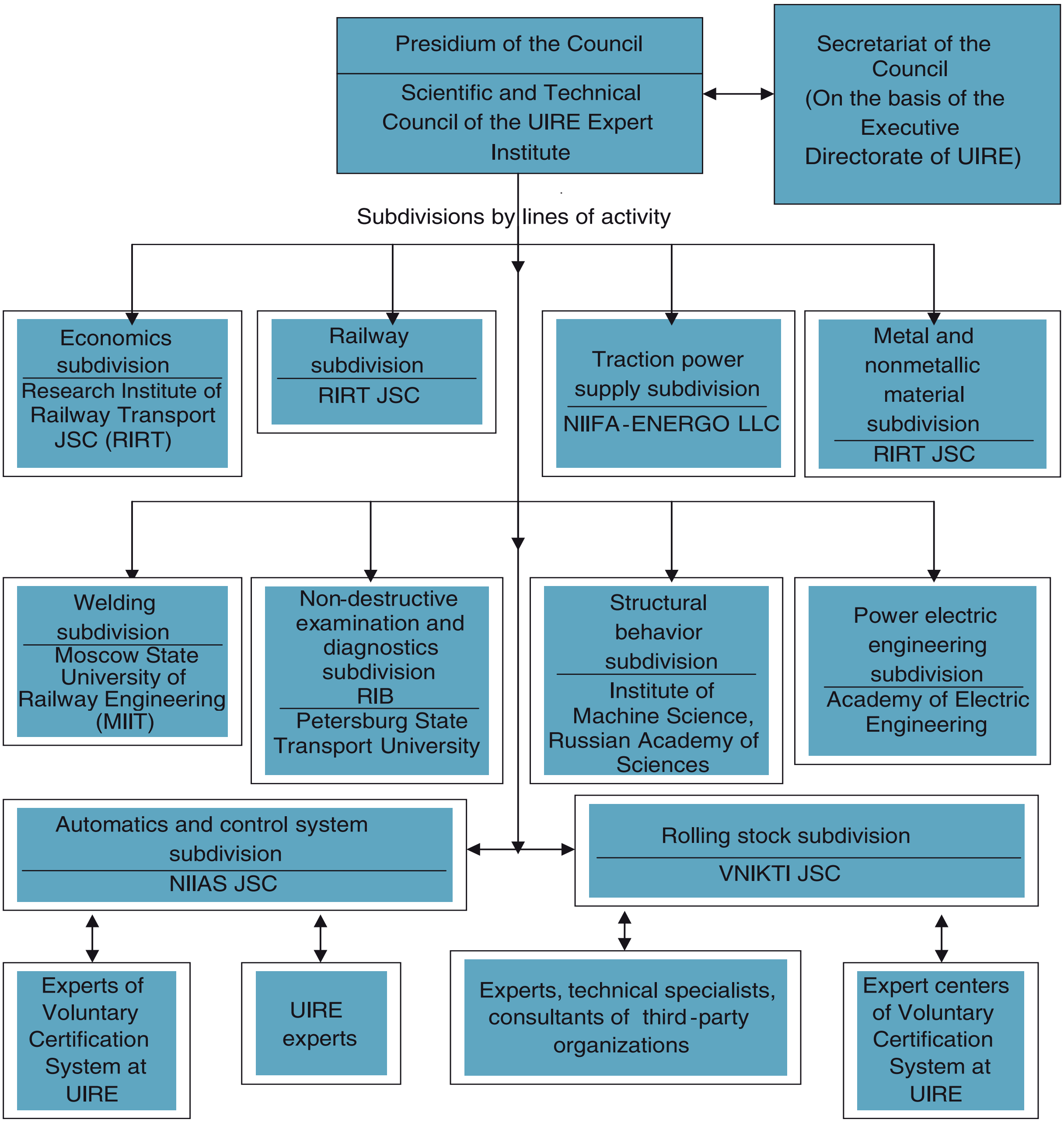


Fig. 1 Structure of UIRE Expert Institute

the manufacturer's position repeatedly and we will consider it later, but the position of the operator as both customer and purchaser requires a more careful examination.

To receive more profit, the operator must try to increase his income and reduce maintenance costs. One of the ways to increase income may be expanding his market of services or freight and passenger transportation, or improving performance of his rolling stock.

Reducing costs is possible through lowering energy consumption of the rolling stock, simplifying its handling operations, and reducing maintenance and repair expenses; minimizing costs of violating cargo safety and emergency maintenance, and reducing damage compensation costs in case of accidents.

Essentially, all of these can be determined by product quality ratings, and in certain cases the need for application of new kinds and types of rolling stock with improved performance indexes may arise in order to achieve the customer's goal.

Therefore, based on the assumption that he strives to increase his profit (reduce loss ratio) the operator must state general requirements to the rolling stock being purchased. The next step should be to evaluate the technical feasibility of realizing these requirements. At this stage, one should employ highly competent experts with sufficient experience in elaboration of similar documents and product definitions. This work should result in drawing up a document containing necessary product quality requirements, and this is where the first stage ends.

At the second stage, one should calculate income and expenses for operation of rolling stock with such quality ratings. In a number of cases, it may be reasonable to perform it with account of peculiarities of actual operating conditions, for example, in changing the depot over to new rolling stock, or in doing the same to a certain shipment line, for which the new rolling stock is meant.

However, it is also necessary to determine the acceptable price of the new rolling stock before evaluating the entire investment project for implementation of such stock. At the next stage, European railways and operating companies calculate the price limit. For this purpose, they determine the minimal profitability level for operation of new rolling stock, and with account of already calculated data on income and operating expenses, they find the highest price at which such degree of profitability can be achieved.

Having this basic data, one may analyze the market for products offered and begin negotiating for supply. Yet negotiations may end at a price still higher than the set price limit, and one may have to give up the purchase. Another option is that the market may have no product of the required performance ratings.

In this case, one may arrange an order for development of new rolling stock, and provide the designer with the maximum life-cycle cost figure calculated on the basis of a certain price limit. The life-cycle cost may also be preplanned from the level already achieved, determining the real life-cycle cost of serial products and reducing that by the desired figure.

Today, technical parameters are mostly determined based on the current needs and with account of the technical level achieved by leading companies in this field, with the subsequent technical and economic assessment. Formally, these actions correspond with the first and second stages of the suggested scheme, but in the present-day economic conditions, it is more reasonable to state one's requirements with the goal of receiving the maximal profit.

Currently, they do not calculate the acceptable price limit at all; on the other hand, there is no method for such calculation. It is necessary to introduce calculation of price limit and required life-cycle cost into the practice of works on ordering new equipment, as they are the parameters that should determine the decision to purchase a certain product.

Yet, this is also only a preparatory stage in the policy of purchasing new equipments, as all quality ratings at this stage exist only on paper – in the documents prepared by the manufacturer when accepting the customer's requirements. At this stage of the ordering process, it is expedient to conclude a letter of intent only.

According to the existing procedure, the manufacturer shall receive the order and construct experimental items of rolling stock, which then have to pass acceptance trials and certification testing. Unfortunately, there is a recent tendency for reduction of acceptance trials, which test the product for compliance with engineering specifications down to the scope of certification testing. Meanwhile, certification testing examines only safety ratings, and it is forbidden to add quality-rating evaluation into such testing. It is hard to understand why customers still put up with such approaches.

Even if full-scale acceptance trials have been performed, reliability ratings will not be examined, while they are the main factor to determine maintenance and repair costs.

Designated purpose ratings can be controlled during acceptance trials, but in the case of rolling stock there may be problems with their realization under actual operating conditions. Therefore the decision on making a purchase must be made while complete evaluation results are not available as well as the confirmation for quality ratings of the product. To find the answer on how to act in such a situation, let us analyze the experience of EU railways, which is economically feasible, justified legally and confirmed by long-term practice.

For innovative products based on conceptually new technical solutions and having a high degree of technological novelty, a preproduction series of items with a certificate of safety should be purchased. This preproduction series should be tested under actual operating conditions in the course of its intended mode of operation.

These tests enable us to evaluate the realization of designated purpose ratings (performance, energy consumption etc.), and register all expenses on maintenance, repair and defect elimination works. Tests provide a combined evaluation of reliability rating, and help to calculate operation cost and life-cycle cost. If results are positive, the certificate of serviceability is issued, and the decision on bulk purchasing of this item by the customer and other EU operators is made.

If a variant of purchasing products without any conceptually new solutions is considered, a procurement contract for a large batch can be concluded. However, the contract stipulates liability for performance of quality ratings, including life-cycle cost. In case of default, certain penalties are applied, to compensate economic losses of the operator incurred because of the product's non-compliance with quality standards specified in the contract. In addition, the law provides for compensation of all losses in case of an accident that arose through a product's failure that took place because of its non-compliance with the quality requirements.

If such system of order and purchase is implemented, the operator shapes not only technical parameters of quality, but also economic figures of that. It introduces a system for their control and economic accountability of the manufacturer for product non-compliance.

All that allows the operator to forecast with a high degree of certainty, and receive the pre-planned profit from putting new rolling stock into operation, which shapes his active innovation policy – a policy that is needed by manufacturers.

As a result of implementation of such a system, refusal of purchase if the minimal price limit is exceeded (even if the price is not inflated) makes the manufacturer work on reducing production costs; introduction of requirements based on quality ratings and their control leads to the need for actual coordination of product quality improvement programs; manufacturing faulty products results in huge expenses for external defective items, which forces the manufacturer to impose tighter quality control measures for his products.

Further on, let us examine the ways to realize the manufacturer's goal of receiving maximal profits. The easiest way is to raise the price. However, this method is checked by mechanisms of competition that limit its opportunities. In case of a monopolistic manufacturer or an abrupt increase in demand, the availability of a price limit results in customer's reconsideration of his innovative policy. He may end up refusing this purchase, reducing its volumes, looking for similar products abroad, or purchasing an obsolete product, which however does not make him suffer losses.

Penalties meant to compensate losses of the operator may lead to a sharp decrease in profits, and even to losses from selling products which do not comply with quality standards. To avoid it, the manufacturer will have to impose strict quality control measures, which reduces "external" expenses for low quality, but increases "internal" expenses, and finally results in increasing production costs. Both variants of increasing expenses for low quality lead to reduction of manufacturer's profitability. Therefore, when the operator wants to achieve a required profitability level for his investment projects and realizes a policy of receiving high-quality product through setting correct requirements, including requirements for life-cycle cost, introducing a quality control system, developing procurement contracts which reflect the requirement for compensation of losses resulting from poor quality of equipment supplied, it may reduce considerably the profitability of production, if low-quality items are manufactured.

The attempt to preserve profitability of production through simplifying technology, reducing the number of check-out operations, saving on design and technology departments, and using cheaper low-quality materials will inevitably result in deteriorating product quality and the corresponding increase in expenses because of the low quality.

Therefore, a situation emerges when it is wasteful to manufacture low-quality products, and the manufacturer will find it expedient to invest in improving all quality characteristics of his product. On the other hand, manufacturing a higher-quality product with lower life-cycle cost will promote its competitive advantage considerably, despite its price being higher!

The manufacturer, who succeeded in this field of activity, need not to fear the opening of the Russian market upon joining the WTO.

So what should a manufacturer do to preserve his profitability while he introduces the abovementioned principles in his relations with customers?

He should begin with implementation of real and efficient quality and resource management systems, and the introduction of the so-called "lean manufacturing," and in such situation the cost of their realization will soon be compensated. This is the main reason for such systems to become so widely popular in European countries, while in our country their implementation sometimes fails to produce any economic effect.

Simultaneous promotion of these two projects will help to identify processes of critical importance for quality, and determine their effects on production costs, with account of the need for stronger control and increase in internal rejection rate, respectively, and help to minimize such costs. In the long run, implementation of the "lean manufacturing" system and cost saving may compensate for expenses on ensuring quality.

Having determined all processes within the manufacturing cycle and their effects on quality, we may effectively formulate the program for improvement product quality. Our first steps in this process regardless of the kind of product we manufacture will be more active work with suppliers and increased labor efficiency of the design department and production department. As the rolling stock manufacturer is a customer in his relation to suppliers of raw materials and components, he needs to implement the same model as described in this article, including obligatory control of quality ratings by specimen test data, to introduce a required degree of incoming inspection, and to stipulate penalties for supply of faulty items in all of his procurement contracts.

From the very beginning, designers should work on the design of new equipments, as well as when they modify it to improve its quality, and have perfect knowledge of its in-service environment and operation system. At every stage of a product development, reliability ratings should be evaluated, operation cost and life-cycle cost should be calculated. For this purpose, systems of product maintenance and repair must be developed in the scope required for the task, making provisions for the necessary equipment needed for control, diagnostics, adjustment and setup of the product, as well as for its repair.

It is possible that realization of such program provides an acceptable degree of product quality and product cost, which is going to ensure competitiveness and acceptable profitability.

Yet it is probable that the work in realization of a quality management system may detect a process or processes that cannot be adjusted at the necessary level. Then there is a need to implement new technologies, i.e. the need for the realization of an investment project. Usually, realization of such project does not only allow improving product quality, but also reduces expenses and increases labor efficiency, thus improving profitability. Besides, there are usually new and considerable opportunities for design improvements. As an example of realization of this approach, we may examine a company from the southeast of Germany, producing car trucks for traction of rolling stock.

In 2001, a group of specialists from Russia studied the experience of implementing ISO 9000 quality standards in German companies specialized in rolling stock manufacturing and repairing. The program included both modern enterprises with most advanced technologies, and enterprises with equipment and technologies similar to those used in Russia.

In terms of technology, the plant producing car trucks did not differ much from Russian companies, but it manufactured high-quality products supplied to leading European companies. A distinctive feature of this plant was availability of a roller rig imitating dynamic effects of the superstructure and presence of quality control gates after almost every operation. It helped to solve two tasks at once. In the first place, it prevented faulty product from being sent into operation, because detection of a faulty car truck in operation will bring on immense penalties, resulting in loss of orders and customers. In the second place, such system allowed detecting faults right after they appeared, which minimized "internal" expenses for low quality, because the cost of faulty product increases in many times as it goes down the processing chain from where the fault appeared initially.

In recapitulation, we were informed that marketing research was underway, and according to the results of that study, if there were a good sales forecast, total reconstruction of production facilities would begin; in case of an unfavorable sales forecast, the plant would be closed. Stockholders were dissatisfied by low profitability, which resulted from huge expenses for quality control and elimination of detected faults.

In realization of the system described above, the principle already provided in technical regulations should also become the principle to determine and regulate relations between the customer and the manufacturer.

The manufacturer must develop and provide the operator with manuals for operation, maintenance and repair, the observance of which ensures realization of quality ratings in everyday operation. In compliance with these documents, the life-cycle cost should be calculated. The next step to take is testing which should confirm quality ratings specified in the contract. Therefore, in further application of the product, claims of the operator for penalties should only be accepted if requirements for operation and repair documents are fulfilled, and it affects the post-warranty period as well, if corresponding requirements have been stipulated in the procurement contract.

Conclusions.

1. Presently, the manufacturer lacks economic incentive to finance implementation of programs for improving product quality, due to absence of any real competition in a number of market sectors, and absence of a system to compensate for operator's costs incurred by a defective product.

2. Implementation of the suggested system for administration of investment projects will allow operators to achieve the planned profitability level as a result of introducing the purchased rolling stock into operation.

3. For the manufacturer, implementation of the suggested system will ensure quick payback on product quality improvement programs, stimulate changing to product evaluation by life-cycle cost ratings, allow increasing prices along with improving product quality and reducing operating costs, and will improve competitiveness considerably.

4. It is necessary to put into practice service tests for rolling stock and soundness tests for components in order to achieve a balance between interests of the parties and make relations between customers and manufacturers more transparent and predictable, including when any claims arise.

Reference:

1. Standard Evaluation Requirements UIRE 6-2009 Comparing trials. Procedure.

Standard Evaluation Requirements UIRE 7-2009 Recommendations for organizing work with suppliers. Choice of supplier, organizing incoming inspection with observance of recommendations on forming requirements to evaluation of supplied products for inclusion into the procurement contract.

Standard Evaluation Requirements UIRE 11-2009 Rules for certification of rolling stock for serviceability

2. www.opzt.ru.

3. Standard Evaluation Requirements UIRE 15.0-2011 Quality management system for enterprises-manufacturers of railway engineering equipment. Basic provisions.

Standard Evaluation Requirements UIRE 15.1-2011 Quality management system for enterprises-manufacturers of railway engineering equipment. Requirements.

Standard Evaluation Requirements UIRE 15.2-2011 Quality management system for enterprises-manufacturers of railway engineering equipment. Recommendations to ensure quality of the purchasing process.

Standard Evaluation Requirements UIRE 15.3-2011 Quality management system for enterprises-manufacturers of railway engineering equipment. Recommendations to ensure quality at the stage of production.

Standard Evaluation Requirements UIRE 15.4-2011 Quality management system for enterprises-manufacturers of railway engineering equipment. Recommendations to ensure quality at the stage of design and development.

Standard Evaluation Requirements UIRE 15.5-2011 Quality management system for enterprises-manufacturers of railway engineering equipment. Recommendations to ensure quality at the stage of operation.

IRIS STANDARD IS THE MOST IMPORTANT COMPONENT OF TRANSFORMATION OF RUSSIAN RAILWAY INDUSTRY

Sergey Gapeev
The Head of the Technical Audit Center – structural subdivision of the Russian Railways JSC

Russian Railways JSC Board of Directors has set a strategic task to improve the quality of technical equipment that is used in the infrastructure of the Russian Railways JSC.

Within this instruction on the 17th of September 2009 the main directions of the Policy of the Russian Railways JSC in the sphere of strategic management of production quality, used by the Russian Railways JSC, were confirmed.

Nowadays the Policy is posted on the websites of the Russian Railways JSC and the UIRE and provides the certification of business management systems (BMS) of the railway engineering enterprises to comply with the specifications of IRIS standard.

The policy encourages the achievement of the next main goals in the sphere of strategic management of production quality utilized by the Russian Railways JSC:

- the upgrade of transport service by means of implementation of new rolling stock types and complex engineering systems that are relevant to the best world analogues;
- the raise of productive-economic efficiency of the company on the basis of the acceleration of innovative development and realization of the tasks of technological modernization and technical re-equipping of the rail transport;
- the harmonization of machinery complex development strategy with long-term programs of the Russian Railways JSC.

Here with, orienting the producers of rolling stock and complex technical systems to meet the requirements of ISO 9001 standard and IRIS international standard, there takes place the meeting of 10 main challenges.

1) Forming of the efficient cooperative connections for production manufacturing for the Russian Railways JSC and reduction of operating costs.

2) Create the base of modern requirements to the quality of the production, using the latest achievements of international practice.

3) Forming and renovation of the data base of the production manufacturers and its main components.

4) Production monitoring in exploitation and realization of the correcting and preventive actions on the found discrepancies to the standards of quality by the manufacturers of the production.

5) Undertaking agreements with the manufacturers of the production about the terms of preparations to the implementation of the international railway industry standard IRIS and instruments of quality FMEA (failure mode and effect analysis), RAMS (reliability, availability, maintainability and supportability) and others in the enterprises.

6) Adoption to the formation of the product price considering the system life cycle cost and performance measurements in maintenance.

7) Optimization of the system of subcontracted supplies and a development of the competition among the manufacturers of component items.

8) Regular assessment and conformation with requirements of the IRIS standard of engineering and manufacturing systems and quality management systems of production manufacturers.

9) Phased transition from the system of inspection and acceptance control to the product quality management on the basis of a regular and planned technical audit of the second party and, as the result, increase of the Quality Management System (QMS) effectiveness of production manufacturers.

10) Implementation of the flexible system of motivation to improve the quality of the production.

The president of the Russian Railways JSC Vladimir Yakunin has settled the next terms of the Policy realization:

- 2010-2011 – in association with manufacturers there was made a preparation of plans of implementation of the requirements of IRIS standard in the machine-building enterprises campaigns;
- 2012-2014 – switch to the requirements of IRIS standard and main instruments of quality;
- starting from 2015 – finishing forming the system of strategic quality management of production and acquisition, by the Russian Railways JSC, of the railroad equipment and components mainly from the enterprises, certified according to the requirements of IRIS.

The implementation of IRIS standard in Russia started from signing the Memorandum about the collaboration between UIRE, the Association of the European Rail Industry (UNIFE) and IRIS Management Center in November 2007. The Memorandum was prolonged and complemented on the 31th of March 2011.

The main aim of the Memorandum is to raise the competitiveness of Russian railway industry by means of absorption of the IRIS standards request. IRIS management center together with UIRE provides training of specialists of Russian railway industry enterprises to learn the IRIS standards, to hold conferences and seminars devoted to the problems of implementation of the standard in Russian enterprises.

In addition, to increase the effectiveness of the collaboration in February 2008 there was a reciprocal Contract about strategic partnership, directed on the dynamic development of both associations and intensification of their influence in European and Russian market of railway equipment, signed by UIRE and UNIFE.

Also, on the 1st of June 2012 as a part of the VII International railway business-forum "Strategic partnership 1520", the Memorandum about mutual understanding was signed. It is aimed at: unification of the efforts of railway transport development, harmonization of Russian and European legislation in the sphere of technical regulation, organization of joint activity in the sphere of standardization and development the of quality and business management systems.

Besides, the Licence agreement, that provides granting UIRE exclusive rights for the translation and distribution in Russian Federation and CIS countries of the European IRIS standard of railway industry, was signed. The authenticity of the translation of the standard into Russian language is confirmed by the experts of IRIS group.

THE IMPLEMENTATION PROCESS OF IRIS STANDARD AT RUSSIAN RAILWAY INDUSTRY ENTERPRISES.

Nowadays the task to gain a new level of railway rolling stock quality on the basis of innovative, disruptive technologies is stated in front of Russian railway industry enterprises. The development and launching into manufacture of rolling stock with refined exploi-

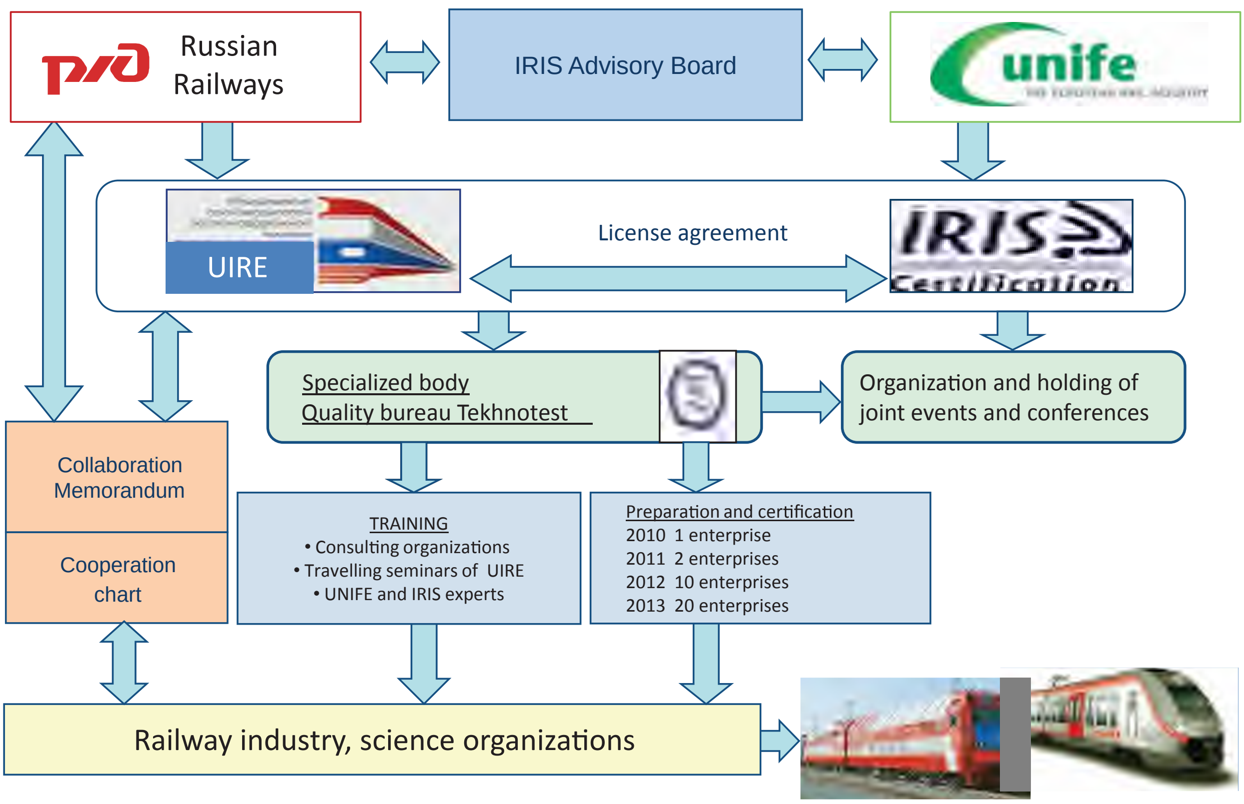


Fig. 1 The cooperation between the Russian Railways JSC, UIRE, UNIFE and IRIS

tation characteristics is being made by the leading Russian railway equipment producers. This approach will allow getting the high-effective rolling stock with refined characteristics of energy consumption, ecological compatibility, interrepair exploitation and other indicators in the nearest future. On the other hand, the backup for production of completely new items of railway equipment, that had no analogues in the world practice, is being made. Naturally, the solution of such ambitious targets is impossible without the implementation of the most progressive international standards and, first of all, IRIS standard. UIRE and the Russian Railways JSC, being the members of IRIS consultative committee, actively participated in the supplement of the 2nd version of the standard. At the present moment the second version of IRIS standard is translated and being distributed among the enterprises-manufacturers of the railway production.

The first Russian enterprise that received the certificate of compliance to the IRIS standard of the railway industry in April 2010 was Izhevsky Radiozavod JSC. About ¼ of the production, produced by the factory, is made for the railway transport. Particularly, these are safety devices and communication tools for the Russian Railways JSC. During the implementation on the enterprise 18 pilot functional projects aimed to raise the work effectiveness were established. More than 3,800 factory workers had a three directions of trainings: technology-engineering, manufacturing and economic. In April 2010 the international agency Bureau Veritas Certification has provided a certification audit in Izhevsky Radiozavod JSC, which results gave the factory a right to get the IRIS compliance certificate. In 2011 two more Russian enterprises were certified to get the IRIS compliance certificate: MTZ TRANSMASH JSC and Bombardier Transportation (Signal) LLC (joint venture of Bombardier Transportation and the Russian Railways JSC).

Fig. 2. IRIS certificates

In 2012 the Russian Railways company made the assessment of readiness of Russian enterprises of railway industry for the certification of compliance to the standard requirements. At the present time efforts to implement it are constantly made on more than 70 enterprises. There are 15 enterprises in the high readiness degree of certification in 2012. In 2013 20 enterprises and in 2014 – 30 are planning to pass the certification procedure, and also numerous sub-contractors. The average level of enterprises' readiness for the certification is 85% in 2012, 70% – in 2013 and 50% – in 2014.

At the present time according to the estimates made by the majority of experts, in the range of national iron and steel plants Vyksa Steel Works JSC (is a member of United Metallurgical Company (OMK) is ready to implement new European standard in its production to the fullest extent. Currently the enterprise has already sent an application to the certifying authority.

Other major machine manufacturing companies are also declaring about their readiness to implement the new standard. Kamensk-Uralsky Metallurgical Works JSC, Novokuznetsky carriage works JSC, Novokuznetsk Car-Building Plant JSC (NKVZ), Novocherkassk Electric Locomotive Plant LLC (NEVZ), Ludinovo diesel locomotive building plant JSC (LTZ), Tvema CJCS, Factoria LS LLC and others are planning to get the certificate in 2012.

UIRE under the auspices of the Russian Railways JSC and UNIFE accepted an important task to adapt the European standard IRIS for Russian enterprises of railway industry. In 2009-2012 there were six training seminars with the assistance of IRIS Management center experts given, 122 specialists trained, they received qualification of training specialists for a further cascade implementation of the IRIS standard requirements in national enterprises.

Executive directors of Russian railway industry enterprises, who took part in the seminars, highly appraised the informativeness, competence and philosophical loading of the IRIS Center lecturers. During such seminars people are able not only to learn the requirements of the standard, but also to see the practical aspects of implementation and interpretation of the standard from the first hand. The instructions

about the IRIS standard requirements are continued to be given in the enterprises using the cascade method, about 14,000 workers have already been instructed and the instructions continue being lectured.

Except trainings with experts of IRIS group in 2010-2012 a range of events was organized, aimed to prepare national enterprises to the implementation of IRIS standard: these are international conferences, practical seminars in Russian and leading international railway industry enterprises, constant discussions of difficulties of implementation in the quality committees of UIRE.

One of the last seminars "The practical usage of the IRIS standard was given on the 16-21th of April 2012 in France in the Alstom transport enterprise in La Roshel with the participation of the managers and specialists of the railway engineering enterprises, certification bodies and consulting organizations. The seminar was organized by UIRE Tekhnotest quality bureau under the auspices of the Russian Railways JSC and Transmashholding CJSC companies.

METHODOLOGICAL SUPPORT AND CERTIFICATION

At the current moment the estimation of the correspondence in IRIS system is provided by 14 international certifying bodies approved by IRIS group, including one Russian state authority – Russian Register. IRIS makes the equally high certification demands of the existence of internationally-recognized accreditation, qualified auditors, the experience of certification of the railway industry enterprises, the professional responsibility to all of the approved bodies.

UIRE provides methodological help to implement the standard, the organization standard of UIRE "Methodological recommendations about the IRIS standard implementation in the railway industry enterprises", the assistance in registration in the Portal and acquisition of Audit Tool methodology is provided, the procedure of approval of consulting organizations that help to implement systems of business management in the enterprises is formulated. At the present moment 5 consulting organization are already approved: Center Priority CJSC, FINEX Quality CJSC, IRICONS LLC, Ural interregional certification center, Kuzbass SSC LLC.

On the General meeting of UIRE members Tekhnotest quality bureau LLC was entrusted a function of branch coordinator of IRIS standard implementation in Russia. Tekhnotest quality bureau was created in

order to assist the railway industry enterprises in the sphere of effectiveness improvement of quality and business management system functioning, to provide the constant quality improvement of the production produced.

To accomplish the goals set by the General meeting of the Partnership Tekhnotest quality bureau:

- implements the policy of UIRE in the sphere of quality assurance of the supplied production by holding the complex of system activities on strategic interaction of enterprises and organizations of railroad industry that realize the production and capital repairs of the rolling stock, its components, technical devices and components of railway infrastructure;
- organizes and conducts audits of QMS (Quality Management System) enterprises that are oriented on perfection of methods of production quality management, increase of compliance to technical requirements, implementation of progressive instruments of quality assurance;
- coordinates the conduction of long-term quality agreements between the Russian Railways JSC and enterprises, with determination of main indexes and agreed objectives;
- takes part in the process of standards and technical conditions harmonization of the enterprises with UIRE standards;
- implements measures of systematization of enterprises' work with suppliers, conduction of sample quality inspections of the production supplied by the subsuppliers, that are the components of complicated systems of special importance;
- develops methods of assessment of enterprises' achievements in the quality sphere using indexes determined in UIRE;
- provides methodological assistance to the enterprises that hold activities of quality management systems certification of correspondence to the international standards requirements and UIRE standards;
- conducts the procedures of production acceptance and production supervisory control at the request of interested organizations;
- organizes and conducts training and preparation concerning advanced methods of quality management system organization and requirements of international standards in this sphere for managers and specialists of transport engineering enterprises.

The work conducted by the Teknotest quality bureau encourages the active development of national machine manufacturing, the improvement of quality and reliability of the manufactured production. At that a wide implementation of IRIS standard requirements all over the machinery complex will allow national enterprises to become the owners of the most modern management system based on the requirement of constant improvement. This approach fully conforms the objects of modern stage of economic development and will provide a long-term motivation for innovative development of machine manufacturing complex for the enterprises. ■

INFLUENCE OF RELIABILITY AND UTILIZATION INDEXES VALUES ON LOCOMOTIVES TECHNICAL READINESS

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In general the analytic formula for locomotives technical readiness coefficients was obtained. It indicates the relation of this coefficient to the reliability and the utilization indexes, as well as to the planned maintenance system parameters. On the basis of the calculations results the conditions of required readiness and reliability indexes values performance for freight locomotives were established. The physically and statically adequate regression three-index model of additive type for technical readiness coefficients was deduced.

The system approach to the locomotives readiness assessment is based on theirs conditions types relation hold – the Up State and the Down State. At that the locomotive readiness is understood to be its ability to perform required function at required conditions and given instant or during the specified time interval at its provision with external resources [1].

The «Up State» characteristic is the locomotives MUT (Mean Up State) for the considered time period, the «Down State» characteristic is the locomotives MDT (Mean Down State) for the same time period. The locomotives can be in the MDT in conjunction with the planned (preventive) maintenance MDT_{PM} (Preventive Maintenance) or in conjunction with the unplanned (corrective) maintenance MDT_{CM} (Corrective Maintenance), as well as due to the logistic and administrative delays MDT_{LAD} (Logistic and Administrative Delay).

In accordance with the type of locomotives state, characterized with MUT, relation to the state, characterized with the one or another MDT, three categories of their readiness are recognized - intrinsic (i), technical (t), operational (o), which are estimated by the values of relative readiness indexes according to the formula

$$A_{i,t,o} = \frac{MUT}{MUT + MDT} \qquad (1)$$

The locomotives technical readiness is characterized with the technical readiness index value, which is calculated according to the formula

$$\hat{A}_t = \frac{MUT}{MUT + MDT_{PM} + MDT_{CM}} \qquad (2)$$

where $MUT+MDT_{PM}+MDT_{CM}=MUDT$ – locomotives time budget for the considered calendar time period of their operation (reference designation).

The MUDT expression,can be used to modify (2) to

$$\hat{A}_t = 1 - \frac{MDT_{PM}}{MUDT} - \frac{MDT_{CM}}{MUDT} \qquad (3)$$

For the further analysis (3) let's agree to that $\hat{A}_t$ is determined by the sampling of N locomotives for the certain time period of their operation, which consists of M months. With provision for these designations the locomotives time budget can be conceived of as

$$MUDT = MUDT_1 \times N \times M \qquad (4)$$

where $MUDT_1$ – is the monthly time budget for the one locomotive.

The value of the one locomotive MDT due to MDT_{PM} depends on the interrepair time values and planned maintenance delay time values.

Let's also agree to that for the certain calendar time period of operation for the N locomotives sample there are two types of MDT_{PM} – maintenance (MT) and routine repairs (RR). In this case the locomotives MDT due to the MDT_{PM} can be conceived of as

$$MDT_{PM} = \left(\frac{L_M \times N \times M}{\Delta L_{MT}} - \frac{L_M \times N \times M}{\Delta L_{RR}}\right) \times T_{MT} + \frac{L_M \times N \times M}{\Delta L_{RR}} \times T_{RR} \qquad (5)$$

where L_M – is the locomotive monthly average running;

ΔL_{MT} , ΔL_{RR} – interrepair running for MT and RR, correspondingly;

T_{MT}, T_{RR} – is the locomotive delay time for MT and RR, correspondingly.

The value of locomotives MDT due to the MDT_{CM} depends on the average failure rate ω, which are result in unplanned locomotives repairs and on the locomotives delay time for these repairs. By this means the locomotives MDT due to the MDT_{CM} can be conceived of as

$$MDT_{CM} = L_M \times N \times M \times \omega \times T_{UR} \tag{6}$$

where T_{UR} – is the locomotive delay time for unplanned repair.

By substituting (4), (5), (6) in (3) and taking into account that $\omega = \Delta L^{-1}_{UR}$ (ΔL_{UR}), and having fulfilled corresponding transformations we obtained

$$\hat{A}_t = 1 - \frac{\left(\frac{L_M \cdot N \cdot M}{\Delta L_{MT}} - \frac{\Delta L_M \cdot N \cdot M}{\Delta L_{RR}}\right) \cdot T_{MT} + \frac{L_M \cdot N \cdot M}{\Delta L_{RR}} \cdot T_{RR}}{MUDT_1 \cdot N \cdot M} - \frac{L_M \cdot N \cdot M \cdot \omega \cdot T_{UR}}{MUDT_1 \cdot N \cdot M} = 1 - \frac{L_M \cdot N \cdot M \cdot T_{MT}}{\Delta L_{MT} \cdot MUDT_1 \cdot N \cdot M} + \frac{L_M \cdot N \cdot M \cdot T_{MT}}{\Delta L_{RR} \cdot MUDT_1 \cdot N \cdot M} - \frac{L_M \cdot N \cdot M \cdot T_{RR}}{\Delta L_{RR} \cdot MUDT_1 \cdot N \cdot M} - \frac{L_M \cdot N \cdot M \cdot T_{UR}}{\Delta L_{UR} \cdot MUDT_1 \cdot N \cdot M} = 1 - \frac{L_M}{MUDT_1} \cdot \left(\frac{T_{MT}}{\Delta L_{MT}} - \frac{T_{MT}}{\Delta L_{RR}} + \frac{T_{RR}}{\Delta L_{RR}} + \frac{T_{UR}}{\Delta L_{UR}}\right) \tag{7}$$

The important conclusion follows (7) from the analysis – the locomotives readiness coefficient value, in general, does not depend on the locomotives sample number but it depends on planned maintenance system (PMS) parameters. Its dependence on planned maintenance and repairs coefficients, delay time for the unplanned repairs is compelling by convention, as exemplified by the assumption formula (2).

On the assumption of the previously denoted and by applying in (7) the conditional constant coefficients C_i, we obtain the following general expression for $\hat{A}_t$ for PMS as a function of reliability factor ω ($\omega = \Delta L^{-1}_{UR}$) and utilization factor L_M

$$\hat{A}_t = 1 - (C_1 + T_{UR} \times \omega) \times C_2 \times L_M, \tag{8}$$

The following calculation results A_t are represented for the locomotive, included in the PMS with the repair cycle, which consists of the RRs with the 50,000 km frequency. At that the locomotive delay time for RR with order numbers 1, 2, 3, 5, 6 and 7 is accepted to be equal to the standard value of mainline diesel locomotives delay time for RR-1 by Russian Railways JSC direction, dated 17.01.2005 №3r, with number 4 for RR-2, and with number 8 – for RR-3, according to this direction. Two variants of $\hat{A}_t$ calculations were provided: the first one was for locomotive running for 200,000 km; the second one was for calendar period of 2 years. For both variants calculated at T_{UR}=24, 48, 72, 96, 120, 240 hours, the following values of ω and L_M were used: ω=11, 22, 33 1/10⁶ km; L_M=10, 15, 20 ths. km. The results of $\hat{A}_t$ calculation for minimum and maximum coefficient values combination are represented in the Table 1, the complete results are represented in the Figure 1, 2.

The data of the Table 1 show that at L_M=10,000 km the value of $\hat{A}_t$, calculated for the 2 years period slightly differs from this factor value, calculated for the 200 ths. km running. The similar situation is observed at the same L_M value and at different ω and T_{UR} adopted values, as well as for L_M=15,000 km However, the discrepancy of the mentioned $\hat{A}_t$ values do not exceed 0.3%. At L_M=20,000 km. the $\hat{A}_t$ estimated values fully coincide.

Prior to the total data analysis which are represented in the Fig. 1, 2, we should mention that the values of freight locomotives technical readiness and reliability coefficients values required by the Russian Railways JSC are as follows: $\hat{A}_t$=0.95 (at least), ω=11 1/10⁶ km (at most) [2]. We should also mention that the adopted locomotive delay time for unplanned repair T_{UR}=120 hours corresponds to the maximum time, which is allotted for the defect elimination by the Manufacturer during the locomotives warranty maintenance in the Moscow, Gorky, North-Caucasus and South-Eastern railways, T_{UR}=240 hours – the same for the locomotives, which operate in the Oktyabrsk, Northern, Sverdlovsk, Kuybyshevsk, Volga and South Urals railways. We also underline that the following calculations results are fair only for the above mentioned locomotive PMS parameters values.

The following arises from the data of the Fig. 1:

- for the simultaneous approaching the A_t=0,95 and ω=11 1/10⁶ km in the L_M from 10 to 20 ths. km range the T_{UR} stipulates the limit value;
- with locomotive utilization intensity increase, which is characterized by the L_M, the required values of A_t and ω are provided by the smaller values of T_{UR} (point 1 on the Fig.1 a, b, c);
- the approach of the A_t required value is possible at the values of ω>11 1/10⁶ km. with the constraint on the T_{UR} value (point 2 in the Fig.1 a, b, c);
- the approach of the A_t required value is possible at any locomotive utilization intensity and at any value of the ω, but with the constraint on the T_{UR} value (point 3 in the Fig.1 a, b, c);
- at locomotive intensive utilization (L_M>15 ths. km.) the ω required value approach is more possible. A_t that, however, it is possible that the locomotive will be uncomfortable with the A_t required value, although the T_{UR} value at that can be less than the maximum value of the time, allotted for the defect elimination by the Manufacturer in accordance with the Supply agreement for the locomotives (point 4 in the Fig. 1 b, c). At the direct adoption in A_t calculation of the T_{UR} (10 and more days) maximum admissible value, it can be predicated with a high probability that the logistic-administrative item will be accounted for in the locomotive technical readiness assessment. Let's also mention that the time consumptions for such delays should always be excluded from the T_{UR};
- at light utilization of the locomotive (L_M<15 ths. km) the A_t required value can be approached in the bigger range of ω at lower «response» of $\hat{A}_t$ for T_{UR} value.

Table 1. The estimated values of locomotive technical readiness coefficient $\hat{A}_t$ at limiting values of ω, L_M and T_{UR}

ω, 1/10⁶ km	L_M, ths. km	T_{UR}, hour	Value of $\hat{A}_t$	
			for the 200 ths. km running	for the 2 years period
11	10	24	0.982	0.985
33	20	240	0.752	0.752

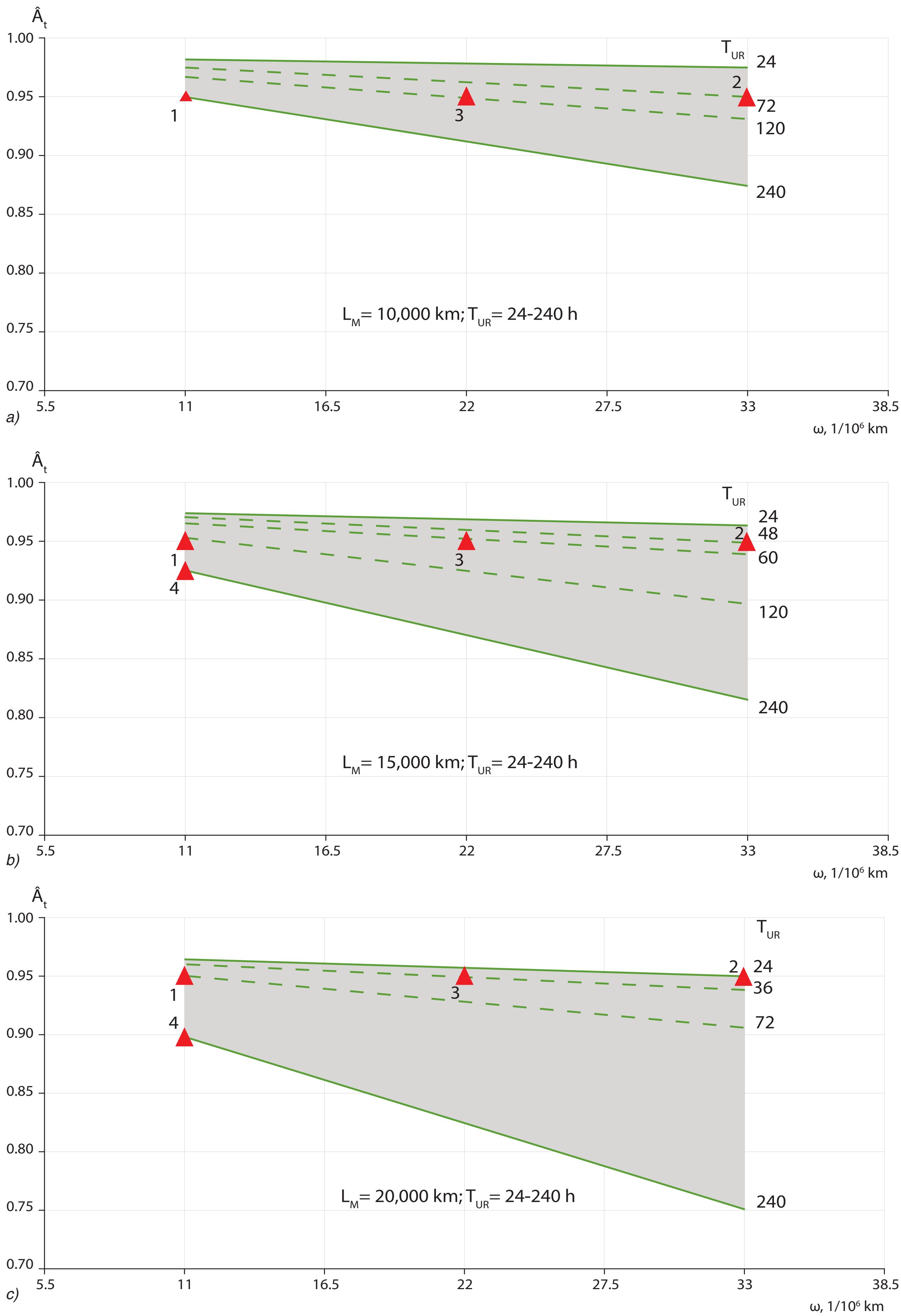

Fig. 1 The behaviour fields of the locomotive technical readiness coefficient A_t for the average failure rate ω at the different average monthly running L_M and the delay time for the unplanned repair T_{UR}

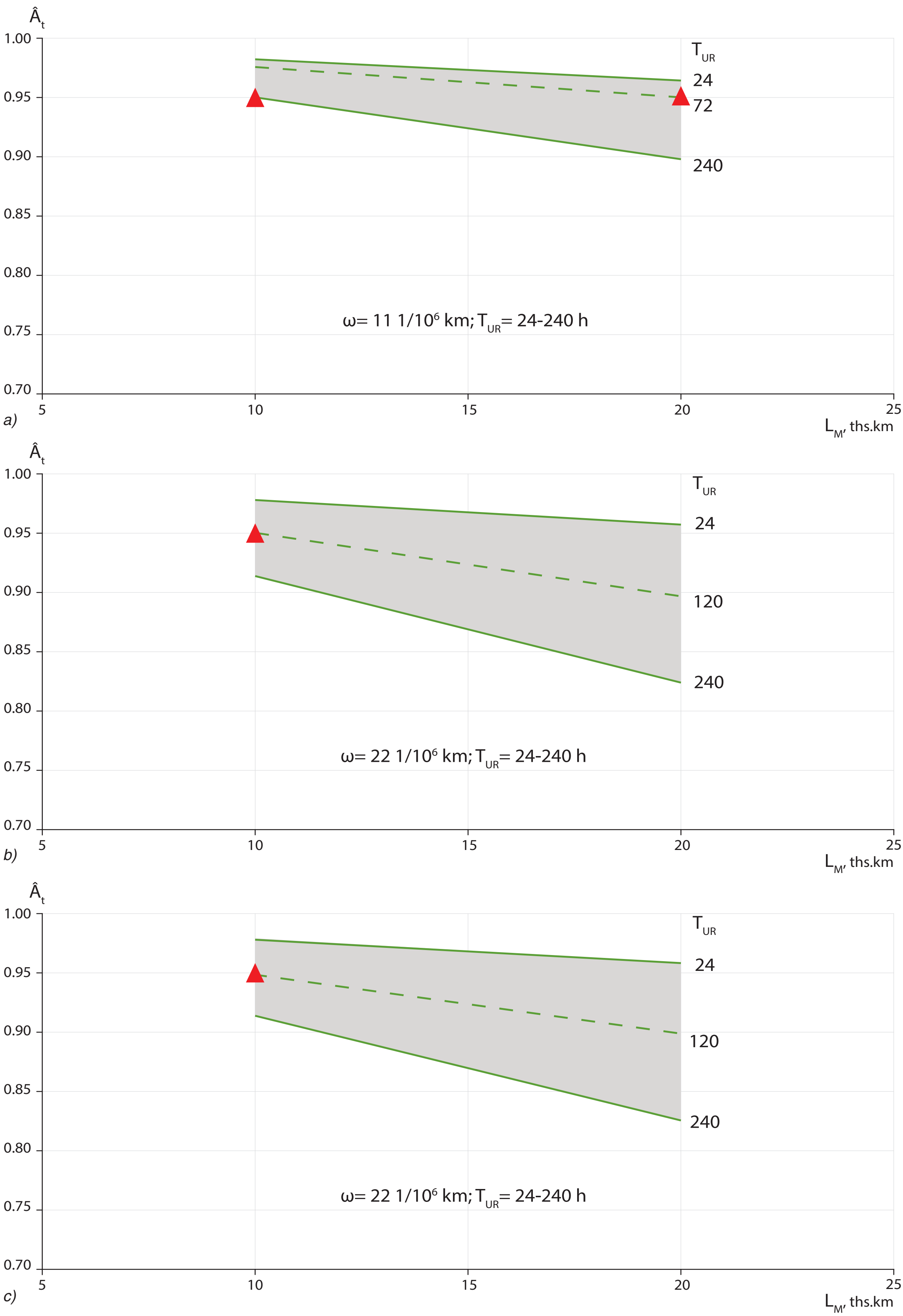

Fig. 2 The behaviour fields of the locomotive technical readiness coefficient A_t for the average monthly running L_M at different average failure rate values ω and delay time at unplanned repair T_{UR}

The behaviour of the A_t estimated values as a function of L_M at the different ω and T_{UR} values are represented in the Fig. 2. Essentially this behaviour follows from the data of the Fig. 1 and requires little comments.

On the obtained by calculations massive of the A_t values (successful attribute) at different combinations of the adopted values of ω, L_M, T_{UR} (component attributes) the 14 regression models for A_t were constructed, they are represented in general in the [3]. The one from this functions set is specified below – it is of linear (additive) type, consists of additive factors, each of them has an individual effect on the resulting attribute.

$$\hat{A}_t = 1{,}0658 - 0{,}0015 \times \omega - 0{,}0036 \times L_M - 0{,}0005 \times T_{UR}, \quad (9)$$

$$(\eta=0{,}94;\ \varepsilon=0{,}78\%)$$

where the η - is the correlation ratio, ε - the ratio error.

The formula (9) is fair for the factor values range: ω=11–33 1/10^6 km, L_M=10–20 ths. km, T_{UR}=24–120 hours. The most precise results of the A_t calculation in the (9) are achieved at T_{UR}=48-96 hours. The physical adequacy of the model is evident, the static adequacy is proved by the high value of the η and the low value of the ε. Let's also mention that the intercept term in the formula (9), which reflects the influence of uncounted in the model factors in a way, is not interpreted meaningfully in regression equations [4].

Generally the represented results correlate on the influence of their reliability and utilization indexes values on the locomotives technical readiness and are the continuation of the previously started work in this direction [5]. The represented results also prove the reliability and readiness prioritization in the general assessment of the locomotives reliability requirements conformation. The locomotives conformation with the specified reliability requirement is the necessary condition, and the conformation with the specified readiness requirement is the sufficient condition for total assessment of the locomotive reliability requirements conformation. ■

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