

RAILWAY®

EQUIPMENT

September 2014

SPECIAL ISSUE
INNOTRANS
2014



UNION OF INDUSTRIES OF



UIRE Members

- Russian Railways JSC
- Transmashholding CJSC
- Russian Corporation of Transport Engineering LLC
- Machinery and Industrial Group N.V. LLC
- Power Machines - Reostat Plant LLC
- Transport Equipment Plant Production Company CJSC
- Electro SI CJSC
- Titran-Express - Tikhvin Assembly Plant CJSC
- Saransk Car-Repair Plant (SVRZ) JSC
- Express Production & Research Center LLC
- SAUT Scientific & Production Corporation LLC
- United Metallurgical Company JSC
- Electromashina Scientific & Production Corporation JSC
- NII-EFA-ENERGO LLC
- RZD Trading Company JSC
- ZVEZDA JSC
- Sinara Transport Machines (STM) JSC
- Siemens LLC
- Elektrotiyazhmash-Privod LLC
- Special Design Turbochargers Bureau (SKBT) JSC
- Electromechanika JSC
- Chirchik Booster Plant JSC
- EPK Managing Company JSC
- Transpnevmatika JSC
- Electrovipryamitel JSC
- TransEnego CJSC
- UralVagonZavod Research & Production Corporation (UVZ) JSC
- MTZ TRANSMASH JSC
- Milorem Michurinsk Locomotive Repair Plant JSC
- Tver Carriage Works (TVZ) JSC
- Nev'yansk Brake Equipment Plant (NEZTOR) CJSC
- Otyabr Production Corporation FSUE
- Volgodizelapparat JSC
- Institute of Natural Monopolies Research (IPEM) ANO
- Vykxa Steel Works JSC
- Radioavionika JSC
- ASI Engineering Center LLC
- Izhevskiy Radiozavod (IRZ) JSC
- Tikhoretsk Machine Construction Plant (TMCP V.V. Vorovsky) JSC
- Electrotyazhmash Plant SOE
- Association of railway braking equipment manufacturers and consumers (ASTO)
- Transas CJSC
- Zheldorremash JSC
- RIF Research & Production Corporation JSC
- ELARA JSC
- Kirovsky Mashzavod 1 Maya JSC
- Kalugaputmash JSC
- Murom Railway Switch Works KSC
- Nalchik High-voltage Equipment Plant JSC
- Baltic Conditioners JSC
- Kriukov Car Building Works JSC
- Ukrrosmetall Group of Companies - OrelKompressorMash LLC
- Roslavl Car Repair Plant JSC
- Ostrov SKV LLC
- Start Production Corporation FSUE
- Agregat Experimental Design Bureau CJSC
- INTERCITY Production & Commerce Company LLC
- FINEX Quality CJSC
- Cable Technologies Scientific Investment Center CJSC
- Rail Commission NP
- VNI IKP JSC
- TPF RAUT LLC
- Barnaul Car-Repair Plant JSC
- Caterpillar CIS LLC
- RPM Group JSC
- Freight One JSC
- Association of outsourcing agents NP
- Russian Automatics and Telematics Systems Research Research & Production Corporation (RoSAT) CJSC
- Academician N.A. Semikhatov Automatics Research & Production Corporation (NPOA) FSUE
- Center Priority JSC
- LenStroyCom-Service LLC
- Tikhvin Car Building Plant (TVSZ) CJSC
- Car-Building R&D Institute JSC
- Bridge R&D Institute FSUE
- VNIIZHT JSC
- VNIKTI JSC
- Transenerkom CJSC

RAILWAY EQUIPMENT (UIRE)

- TVEMA CJSC
- Ritm Tver Brake Instrument Production JSC
- Svetlana-Optoelectronika CJSC
- Faktoriya LS LLC
- Dolomant Research & Productin Company CJSC
- SKF Tver LLC
- Kremenchug Steel Foundry PJSC
- Kambarsk Machinery Plant Trade House LLC
- SDS-MASH Holding Company JSC
- EVRAZ Holding LLC
- VNIIR JSC
- Sespel Enterprise of Cheboksary CJSC
- EPK-Brenco Bearing Company LLC
- Transolutions CIS LLC
- Novokuznetsk Car-Building Plant (NKVZ) KSC
- Tomskcable CJSC
- AVP Technology LLC
- HARTING CJSC
- Alstom Transport Rus LLC
- Smelyansky Electromechanical Plant LLC
- Dynamics SPC LLC
- Barnaul plant of asbestos technical products (BzATI) JSC
- NEE Ural Interregional Certification Center LLC
- Siberian Certification Center – Kuzbass LLC
- NIIAS JSC
- RDM-contact LLC
- FRITEX JSC
- Faiveley Group
- Sudotechnologiya Industrial Export Company CJSC
- Metrodeta NP
- Vagonmash Production Corporation LLC
- INFOTRANS CJSC
- POLIVID LLC
- HARP Oskol Bearing plant JSC
- NPC Springs LLC
- Federal Freight JSC
- ELTEZA JSC
- Ural Locomotives LLC
- Balakovo Carbon Production LLC
- “Wagons” R&D Center, JSC
- Helmos LLC
- Car-Repair Company One JSC
- State Rail R&D Center of Ukraine SOE
- Timken-Rus Service Company LLC
- V.M. Bubnov Head Specialized Design Bureau of Car Building (GSKBV) LLC
- Dolgoprudny Research & Production Enterprise JSC
- Armavir Heavy Industries Plant JSC
- Car-Repair Company Two JSC
- Car-Repair Company Three JSC
- Stakhanov Car-Building Plant (SVZ) JSC
- Car & Wheel Workshop LLC
- PRIVOD-N R&D Center CJSC
- Zavod Metallokonstruktsy JSC
- TRANSWAGONMASH LLC
- Togliatti State University TFSBEI HPO
- Cable Alliance Holding LLC
- Moscow State University of Railway Engineering TFSBEI HPO
- Technotrade LLC
- Electro-Petersburg CJSC
- Energoservise LLC
- Ural Car-Repair Company CJSC
- ABB LLC
- Scientific Instruments CJSC
- Kav-Trans CJSC
- Azovmash PJSC
- Azovelectrostal Private JSC
- Uralgorshakhtkomplekt (UGShK) CJSC
- SSAB Swedish Steel CIS LLC
- Dielektrik CJSC
- New Car-Repair Company LLC
- RailTransHolding Group LLC
- Certification and Licensing Expert Center LLC
- Russian Register Certification Association
- Schaeffler Russland LLC
- TATRAVAGONKA JSC
- Knorr-Bremse Systeme für Schienenfahrzeuge GmbH
- Knorr-Bremse Railway Transport Systems LLC
- Kupino Car-Repair Company LLC
- Samara State University of Railway Engineering TFSBEI HPO
- Belarusian Railways NU
- Kazakhstan Temir Zholy (KTZ) JSC
- MYS CJSC
- SG-Trans JSC
- TTM LLC
- S.S.Monyatovsky LUGCENTROKUZ Private JSC
- Profit Center Plus Managing Company LLC
- Pokorovka Finance LLC
- Teploservice LLC

Published by



Institute of Natural Monopolies Research
2/7 bldg. 1, Malaya Bronnaya Str.,
Moscow, Russia, 123104
Tel.: +7 495 690 1426
Fax: +7 495 697 6111
vestnik@ipem.ru
www.ipem.ru

Supported by



Union of Industries of Railway Equipment
3, Rizhskaya sq., Moscow, Russia, 107996
Tel.: +7 499 262 2773
Fax: +7 499 262 9540
opzt@opzt.ru
www.opzt.ru



Committee on Railway Engineering of Russian Engineering Union

The magazine is registered by the Federal Service on Mass Media and Cultural Heritage Protection Control, license PI № FS77-31578 of 25.03.2008.

According to the Resolution №6/6 of 19 February 2010 of the Higher Attestation Commission Presidium of The Ministry of education and science of the Russian Federation, the Railway Equipment Magazine was included in the List of leading scientific magazines and editions under review.

The magazine is included in the Russian Science Citation Index database.

To effect subscriptions for Russian-language issue is necessary to address to MK-Periodica JSC or one of its partners in your region.

Tel.: +7 495 672 7012
Fax: +7 495 306 3757
info@periodicals.ru
www.periodicals.ru

Printed by City Print Typography LLC
10 bldg. 41, Dokukina st., Moscow, Russia, 129226
Circulation: 1000 copies
Periodicity: Quarterly

Passed for printing: 25.08.2014

All rights reserved. Reproduction and transmission of the Railway Equipment magazine materials is allowed only with reference to the issue.

Not for sale.

Editorial board

Editor-in-Chief

Valentin Gapanovich,
Senior Vice President, Chief Engineer, Russian Railways President, UIRE

Deputy Editor-in-Chief

Yuri Saakyan,
Dr., Director General, Institute of Natural Monopolies Research, Vice President, UIRE

Deputy Editor-in-Chief

Sergey Palkin,
PhD, Prof., Vice President, UIRE

Rushan Alyaudinov,
*Dr., President, Ankor Bank,
Corresponding member of AENPD Russia,
Member of IIA*

David Kirzhner,
*Dr., Deputy Head of Technical Policy
Department, Russian Railways*

Viktor Kureichik,
*PhD, Prof., Member of RANS,
Chairholder, SFedU,
Honoured Science Worker of Russia*

Nikolay Lysenko,
Executive Director, Vice President, UIRE

Anton Zubikhin,
*Dr., Deputy Director General, Sinara Transport
Machines
Vice President, UIRE*

Vladimir Matyushin,
Dr., Prof., Vice President, UIRE

Anatoly Mescheryakov,
Vice President, State Secretary, Russian Railways

Bulat Nigmatulin,
*PhD, Prof., Chairman of Board of Directors,
Progress-Ecologia*

Yuri Plakitkin,
*PhD, Prof., Member of RANS,
Deputy Director of the RAS Energy Research
Institute*

Elmar Pozamantir,
*PhD, Prof., Chief Researcher of the RAS System
Analysis Institute*

Oleg Senkovskiy,
*First Deputy Chief of the Technical Audit Center,
Russian Railways*

Igor Tomberg,
*Dr., Prof., Head of Energy and Transport
Research Center of the RAS Oriental Studies
Institute*

Oleg Trudov,
*Head of division in Technical Policy
Department, Russian Railways*

Publishing Team

Publishing Editor:

Sergey Belov

Translator:

Margarita Stupina

Editor:

Kevin Smith

Designer:

Danila Rozhkovets



80 | Application of Composite Materials in Wagon Manufacturing



72 | DP-M: A New-Generation Russian DMU



8 | Developing Olympic-standard transport infrastructure facilities for Sochi

Contents

| RAIL FOR SOCHI-2014 |

<i>E. Yanchenko, D. Kobelkova.</i> Developing Olympic-standard transport infrastructure facilities for Sochi	8
<i>A. Stepanov, I. Gurgenidze, A. Cherevan.</i> Managing and implementing the Sochi Winter Olympics railway timetable	14

| EVENTS |

EXPO 1520 – at the heart of Eastern Europe’s Railway Industry	20
<i>N. Lysenko.</i> UIRE develops its international reputation	25
<i>B. Kaufmann.</i> IRIS develops globally	28
<i>S. Gapeev.</i> Business Management System: Results of Five-Year Deployment	29
Railtransholding – A serious partner for your successful business	32

| TRENDS |

<i>M. Nigmatulin, E. Rudakov.</i> Using IPPEM indices to monitor Russian industry development in the second quarter of 2014.	33
--	----

| ANALYTICS |

<i>A. Polikarpov, A. Slobodyanik.</i> Russia’s railway services market reacts to significant challenges.	40
<i>V. Savchuk, I. Skok.</i> The future of Russian Railway Industry	44

<i>V. Matyushin.</i> About new railway technical regulation system in the Custom Union	51
<i>O. Nazarov, D. Kiryushin, B. Khomyakov.</i> The Sapsan high-speed train development and acceptance tests procedures	53

| STATISTICS | 59

| ENGINEERING DEVELOPMENT |

<i>A. Nazarov.</i> The Experience of Launching Sapsan and Allegro high-speed trains in Russia	64
<i>I. Mikhalkin, O. Simakov.</i> The philosophy of diagnostics as a tool of intelligent control of the railway infrastructure	70
<i>N. Polukhov.</i> DP-M: A New-Generation Russian DMU	72
<i>M. Lobov.</i> Applying composite materials in locomotive components.	76
New Messenger Wire – as Strong as Bronze, as Conductive as Cuprum	79
<i>A. Dorozhkin, S. Ozerov, M. Aginskikh, A. Ushakov, A. Izotov.</i> Application of Composite Materials in Wagon Manufacturing	80
<i>M. Tarabrin.</i> TVEMA – Safeguarding track safety	85
<i>O. Kravchenko.</i> Innovative Hybrid Shunting Locomotive	89
<i>D. Tikhonov.</i> Automatic Driving Systems for Locomotives	94



Dear colleagues,
Welcome to the 10th anniversary of the InnoTrans exhibition!

Since it began 18 years ago, InnoTrans has grown into the largest railway equipment exhibition in the world. The industry has also changed during this time: thousands of kilometers of new railways have been built, while line speeds have increased, and more and more automated technologies have been adopted that are improving the efficiency of railway transport.

Russian railway transport is also celebrating a number of landmarks this year. Most notably it has been 180 years since a father-and-son team of inventors – the Cherepanovs – designed and built Russia's first steam locomotive. Their workshop in Nizhniy Tagil in the Ural mountains was a long way from Europe's Industrial Revolution, and while unique, the Russian engineers' invention was in no way inferior to those conceived by the great British engineer George Stephenson. I believe this development marked the start of railway transport in Russia, and the beginning of its great history, which is awaiting its next big achievement over the next few years.

Our country covers a vast area between Europe and Asia and offers significant opportunities to establish strategic transport arteries between continents and oceans. I believe that securing the Trans-Eurasia transport connection is not only an opportunity for Russia, but something that will benefit people around the world, and I feel that it is our duty to deliver on this objective.

The Russian government's decision to commit to delivering enhancements to the Baikal-Amur Mainline and Trans-Siberia Railway is a very important step towards achieving this goal. The increase in traffic capacity that will result from introducing the latest innovative technologies will be a significant achievement, and, most importantly, will bring the markets of Europe and Asia closer together. The future prospects of the Trans-Eurasia connection only affirms the key role that rail will play in the global economy's development in the 21st century.

Increasing speeds and enhancements to loading capacity, while introducing sustainable technologies and improving safety are the decisive factors driving the future of this industry. Railway engineers and scientists are facing the significant challenge of developing the technological solutions that will deliver these objectives, which is essential if railway transport is going to fulfill its potential.

I am sure that InnoTrans 2014, as it has in previous years, will attract all of the industry's leading specialists and will offer a fantastic platform for discussion and to exchange views, which will undoubtedly prove beneficial in the future development of railway technologies.

I sincerely wish you an eventful and productive show, where I hope you will gain new perspectives, make new acquaintances, and benefit from exposure to new and bold ideas!

*Vladimir Yakunin,
President of Russian Railways JSC,
Chairman of International Union of Railways*



Dear readers and guests of InnoTrans,

I am very happy to present the latest issue of RAILWAY EQUIPMENT magazine, which has been published especially for InnoTrans 2014. This issue comprises news stories and in-depth feature articles on state-of-the-art engineering solutions from Russia's railway transport sector as well as updates on the current status of rolling stock manufacturing and railway services in Russia. I am positive that in the context of a growing market and increasing demand from passengers for railway services in Russia that you will find this information useful and it will spark your interest.

Now in its fourth edition, the English-language issue was originally released to coincide with InnoTrans 2008, and has been issued at each subsequent edition of the world's largest railway equipment exhibition. RAILWAY EQUIPMENT magazine's international edition once again looks at the major highlights and key developments for Russia's railway industry over the last two years. The issues addressed include standardisation, LCC estimation, product localisation, and the introduction of innovative rolling stock products. In addition, this issue features a special chapter on recent Russian rolling stock products, including those developed in conjunction with foreign partners. Among the highlights are articles on the new DP-M Diesel Multiple Unit, composite hopper-car, and the TEM35 shunting locomotive. Moreover, officials from Russian Railways (RZD) and VNIIZhT present insights into the successful

homologation and operation of Sapsan and Allegro high-speed trains, which are symbols of the gradual modernisation of Russia's passenger railway services.

I would also like to take this opportunity to underline the significance of the now well-established productive relationships between Russian and European rolling stock manufacturers. Likewise, the Union of Industries of Railway Equipment (UIRE), which has now been active for seven years, is successfully providing a platform for discussions on the technical and economic issues facing railway manufacturers in Russia while developing proposals to improve Russian railway operations. UIRE members will be at the forefront of upcoming large-scale projects to develop the Trans-Siberian and Baikal-Amur Mainline railways as well as construct high-speed lines and upgrade railway infrastructure in the greater Moscow area.

The experience gained from the preparation works for the Sochi-2014 Winter Olympic Games, in which the railway industry was one of the key stakeholders, once again showed the importance of effective teamwork and team-oriented efforts that utilise expertise from both domestic and international partners. I am confident that the railway community will continue to follow "fair play" principles when developing and deploying innovative technologies as well as in improvements to manufacturing processes that will facilitate enhanced mobility for people all over the world in the coming years.

*Sincerely,
Valentin Gapanovich
Editor-in-Chief of Railway Equipment Magazine
President of NP UIRE
Senior Vice-President, Chief Engineer
of Russian Railways JSC*

Russian railway industry market perspectives



Dietrich Moeller,
Director
of Siemens'
Russian office


Railway industry is currently one of the Russian economy's most dynamic markets and remains attractive for many companies. Siemens is currently implementing a number of major projects in the Russian railway sector and localising manufacturing is critical to the success of our business here.

At present there are several areas of demand. Firstly with a major renewal of its locomotive fleet underway – Russian Railways (RZD) plans to purchase 450 locomotives per year up to 2016 - there is a significant need for locomotive manufacturing.

Another key growth area is the supply of high-speed rolling stock. The proposed Moscow – Kazan high-speed line will pass through seven regions, and offer a minimum travel time from Moscow to Tatarstan of 3h 30mins at a maximum speed of 400km/h. The Russian-German Chamber of Commerce has launched an initiative for German companies to participate in the development of high-speed infrastructure in Russia with

the aim of successfully integrating German companies' experience of global high-speed projects with Russian railway construction and operation know-how. Siemens intends to participate in this project and is prepared to not only offer modern rolling stock, but also electrification and power supply, monitoring and automation systems, communication networks, as well as servicing for rolling stock and depot equipment.

Other major infrastructure projects include new construction and upgrades of rail automation and electrification systems on the Trans-Siberian and Baikal-Amur Mainline railways, while urban transit projects are also set for major investment.

The City of Moscow recently announced development programmes for the Moscow Metro, including the procurement of more than 2500 new metro cars up to 2020, and the redevelopment of Tram depots. Both present significant potential opportunities for manufacturers. 




Philippe Pegorier,
President
of Alstom Russia

Alstom recognises that the Russian and 1520mm-gauge market is currently passing through a phase of modernisation and is extremely attracted by the potential opportunities that exist. For example there is strong need to replace Russia's huge but largely obsolete rolling stock fleet. However, rather than simply purchasing new modern locomotives, trains, and light rail vehicles from abroad, Russia is approaching this problem in an innovative way.

A programme of co-operation between local and foreign manufacturers that localises production is now in place, which is allowing Russia to not only replace its outdated rolling stock with tailor-made solutions, but enhance its domestic industry by allowing a technology transfer and knowledge sharing process to take place. As a result international best practices are being adopted, which will benefit Russian industry in the long-term.

Sufficient demand exists in the 1520mm-gauge market for all manufacturers to gain if they are willing to invest. For example upcoming projects to develop the Trans-Siberian and Baikal-Amur Mainline railways, as well as infrastructure investments relating to the 2018 World Cup, will intensify demand for new main line and urban rolling stock as well as infrastructure and signalling, as was recently experienced with the Sochi Winter Olympics.

With locomotives crucial to Russian extensive railfreight sector, growth this market segment seems assured. In addition with growing urbanisation and related problems with traffic congestion, the population's desire for mobility will stimulate demand for new main line and urban rolling stock as well as state of the art signalling solutions. This demand will also excite the component market and local supply chain to provide products such as transformers and parts for traction systems. 

7th International Railway Technology Exhibition

exporail 2014

28 – 30 October 2014

Expocentr, Moscow, Russia

Supporting Organisations:



Everything for railways :

- Rolling stock manufacturers and suppliers of vehicle subsystems and components
- Track and infrastructure companies
- Signalling, train control and communications specialists
- Electrification contractors and equipment manufacturers
- Information Technology specialists

General Information partner:



Official journal of the exhibition:

RAILWAY[®]
EQUIPMENT

www.exporailrussia.com

Organiser:

RESTECBROOKS

Romeland House, Romeland Hill,
St Albans, AL3 4ET, UK
Tel.: +44 (0) 1727 814 400
Fax: +44 (0) 1727 814 401
Email: exporailrussia@mackbrooks.com



exporail.ru

Developing Olympic-standard transport infrastructure facilities for Sochi



Eugene Yanchenko,
Head of the Technical Policy
Department, RZD, JSC



Dinara Kobelkova,
Senior Engineer, Design Office
for Locomotive Fleet RZD, JSC

Preparations for the 2014 Sochi Winter Olympic Games began five years before the athletes arrived in the south-western Russian city for the sporting extravaganza. The almost complete absence of the necessary infrastructure to host such a huge event was a real challenge for Russian Railways (RZD), and required intensive engineering and construction efforts in order to meet strict deadlines. New rail links and tunnels were subsequently constructed, while existing stations, terminals and transport hubs were renovated. Lastochka (Russian for Swallow) EMUs were also introduced and became one of the major attributes of the Olympic transport strategy.

Ambitious targets

In its blueprint for the XXII Winter Olympic Games and XI Winter Paralympic Games, Russia's National Olympic Committee placed suburban rail as the basis of its transport strategy.

In late December, 2007 the Russian government issued an act entitled the Programme of Olympic Venues Construction and Sochi Town Development in the Capacity of an Alpine Resort. Under the programme, RZD was selected as the contractor responsible for the following four Olympic venues:

- development of rail infrastructure between Tuapse and Adler,
- operation of the new rail service on Sochi – Adler – Sochi International Airport link including the construction of new Adler – Sochi Airport line,
- arrangement of freight terminals for Olympic construction purposes, and
- construction of a 46-room building at RZD's four-star 'Mys Vidniy' health resort in Sochi's Khosta District.

RZD's construction division proceeded to commence design and carry out survey and preparation work for the Olympic venues immediately after the act was published.

However, the programme was updated and amended many times over the course of construction, with contractors allocated additional projects as the work progressed. This situation was primar-

ily due to the aggressive games preparation schedule. The Ministry of Transport, jointly with the National Olympic Committee and IOC Experts, was developing the transport and logistics concept for the Olympic Games in parallel with the execution of the Olympic projects, meaning that amendments were almost inevitable.

As a result, RZD's list of responsibilities was extended to seven projects by October, 2012, after the addition of the following three undertakings:

- a combined railway and road between Adler and the alpine resort Alpika-Service including the construction of second track between Sochi, Adler and Vesolyoye,
- passenger stations on the line between Tuapse and Adler, which required upgrades to allow access for disabled passengers, and
- hub stations in Sochi, Khosta, and Matsesta.

Development of the stations in Sochi, Matsesta and Khosta was assigned to RZD just a year before the scheduled completion date of Olympic construction activities. Construction of the hub facilities would take place adjacent to the existing local railway stations.

Such amendments increased the scope of the construction projects' engineering and construction task packages, inevitably requiring RZD to allocate additional capital, as well as human and material resources and equipment in order to meet its deadlines.

Key rail infrastructure facilities

Transport of construction materials and structures, machinery and equipment to the construction sites was the first step in the development of the Olympic facilities. To achieve this, it was necessary to construct railfreight terminals in the Imereti Lowland.

With Sochi lacking a seafreight terminal, and road connections limited to only a two-lane road from Dzhubga, rail was essential to carry the millions of tonnes of building materials for the projects in both the coastal and mountain clusters.

In order to manage this demand, RZD built and equipped at its own expense two freight terminals with total capacity of up to 15 million tonnes. The terminals were the first construction projects that were built for the Olympics, opening at the end of 2009.

The combined highway and rail link between Adler and Alpika-Service (see Figure 1) was RZD's largest project for the Sochi Olympics. The line is 48.2km long and includes more than 27km of tunnels.

Several routes for the road and rail line were considered during the development phase. And following an exploratory study, the optimal route was identified on the left bank of the Mzymta Riv-

er. The line has an estimated 40‰ longitudinal slope and was the shortest route considered for the link between the Olympic Park in the Imereti Lowland and the mountain stadiums in Krasnaya Polyana. The road crosses rivers and mountain gorges, and for around two-thirds of its length it runs on numerous bridges, overpasses, and through tunnels, which were all constructed for the project in record-breaking time.

RZD built tunnels totalling 26km over five years for the new road and railway. Specifically it built six railway tunnels totalling 11km, three highway tunnels totalling 7km, and three service and escape galleries totalling 8km.

To construct the tunnels on the combined Adler – Alpika resort road, innovative tunneling processes were used. Tunnel system No 3 is the longest and most complex from an engineering and geological perspective. It includes a 3.2km motorway tunnel with a diameter of 13m, a 4.57km, 10m-diameter railway tunnel, and two service and escape galleries, which are nearly 6km long, and 6m in diameter.

During construction, engineers faced issues with stabilising the sliding hillside located at the northern tunnel portal. Engaging Swiss en-



Fig. 1. The combined highway and rail links between Adler and Alpika-Service

gineers from Amberg Engineering, the taskforce overcame this issue by altering the planned route and tunnel excavation method in this area. The expert committee accepted the mitigation plan and agreed to the taskforce's request to increase the length of the railway tunnel by 500m to 4.6km, and shortening the motorway tunnel by 830m to 3.2km.

Progress was also held back by Karst fracture zones, which mean that various methods of excavation were required, ranging from drilling-and-blasting to rock tunnelling, the shield method and the deployment of the latest tunnel boring and driving machines.

On December 1, 2011 the combined road and tunnel construction project was nominated as one of the best projects of the year at the annual International Tunnelling Association awards.

Innovative engineering solutions were also evident in the successful project to erect a bridge over the Mzymta River. Due to the river's circuitous course, the project required building the bridge along the bed of the river instead of a traditional cross structure.

A large central cable span (see Figure 2) helped to preserve the Mzymta River's natural state, with the cable structure of the orthotropic-deck bridge consisting of three spans: 121.5m, 312m,

and 121.5m for 555m in total. The bridge weighs 5.2 tonnes, and stands at 82m in height. The total length of the crossing is 810m.

A further example of the use of innovative technology is the Low Vibration Track (LVT) solution used in the tunnels on the Tuapse – Adler link.

The LVT-system consists of a concrete block, a resilient pad and a rubber boot, surrounded by unreinforced concrete. The resilient pad under the block provides for the load distribution analogous to the ballasted track and reduces the influence of low frequency vibrations. The rail pad in turn protects against the effects of high frequencies.

The LVT-system has been proven as the ideal solution for a track used by very high-speed traffic where highly accurate track geometry is required, on inner city lines due to its lower noise levels, and in tunnel construction where it restricts vibration attenuation.

For the purpose of construction and upgrades of Olympic rail projects, each of these factors was important. However, another advantage of the LVT-system was that without a ballast section, tunnel systems No 6 and 7 could accommodate Tpr-gauge required for EP20 electric locomotives hauling double-deck passenger coaches.



Fig. 2. Cable bridge span on the Mzymta River

Olympic Swallows

“Lastochka” (Desiro Rus) high-speed EMUs (see Figure 3) were built specifically by Siemens for RZD for the Sochi Winter Olympic Games. They were used for passenger services from Sochi Airport to Adler and from Sochi to Adler, Krasnaya Polyana and the Olympic Park.

The first completely assembled train was presented to Russian experts in early 2012 before they passed climate tests at the Rail Tech Arsenal facility in Vienna during the spring of that year. Trains were exposed to realistic weather conditions during the tests, which confirmed that the EMU is suitable for operation in the varying climatic conditions experienced across Russia.

To comply with the Sochi Olympic’s ‘Barrier-free Environment’ concept, the manufacturer incorporated a designated section designed especially for disabled passengers. The vehicle has a wheelchair lift to provide access from both high and low platforms, while the internal gangway is designed to allow easy passage of a wheelchair. The compartment is also wider than the standard model and includes special safety belts as well as an audio passenger information device, along with low-lying light switches, sockets, and an attendant call button all of which feature Braille labels. A toilet cubicle suitable for wheelchair users is included in the section, which is larger than the conventional one, and has additional handrails to improve convenience along with a sound-and-light indicator board.

“Lastochkas” can operate at up to 160km/h and are fitted with state-of-the-art energy-efficient equipment, reducing energy consumption by up to 30% compared with existing EMUs. Each train consists of five cars and can accommodate over 800 passengers. Lastochka trains were gradually introduced into service during 2013, with the first trip with passengers taking place on January 23, 2013 from Moskovsky station in Saint Petersburg. The following month passengers began using the train on the Moscow – Nizhniy Novgorod route and they entered service on the Sochi – Adler – Sochi Airport line on May 1, 2013.

The journey time on the Sochi – Sochi Airport line is just over 30 minutes. One objective of the Sochi Airport service was to relieve pressure on the highways. Developers took into consideration the features of Sochi’s infrastructure, and the needs of local community as well as Olympic guests to develop an efficient and effective service.



Fig. 3. Lastochka trains

Specialist maintenance facilities were built to maintain Lastochka trains at a new depot located adjacent to the North Caucasian Railway and on the site of the existing passenger coach depot at Adler station (see Figure 4). The 24,282m² development, which includes a 200,353m³ building, cost Roubles 5.6bn to complete and is one of the most sophisticated railway maintenance facilities in Russia. Among the improvements carried out to existing facilities on the site were renovations to freight wagon maintenance and repair stations, while a new building for breakdown and firefighting trains was built.

To accommodate maintenance and repair activities at the facility new equipment was installed, including Furrer&Frey’s HV feeder sys-



Fig. 4. Lastochka maintenance depot

tem, Stemmman-Technik's external supply system, AHA crane installations, wheelsets changers and Neuro's automated maintenance process equipment. In total more than 30 foreign compa-

nies participated in the depot construction project, which offers convenient access to the new suburban platforms at Adler station by avoiding a crossing of the main line.

New passenger stations



Fig. 5. Bird's eye panorama of Olympic Park station

New multimodal passenger stations in the Sochi area were designed to effectively handle large volumes of passengers. Adler station is the largest on the Black Sea coast and was designed by Sibgiprotrans, with its architectural concept developed by Mostovik. With the area exceeding 23,000m², and the station having a maximum capacity of 15,000 passengers per hour, the facility can handle up to 56 pairs of trains per day.

As a part of the station project, three platforms were modernised and two newly built. In addition several technological innovations have been incorporated, including the use of solar energy from panels located on the roof of the car park to provide energy for 70% of the facility's hot water. Solar panels installed on lamp posts and platform roofs are also supplying powering for the station's lighting.

Adler station's microclimate is maintained automatically within preset parameters, with each room monitored by a dispatch system which also takes into account the affect of outside conditions. The air ventilation system is similarly equipped with air recycling and recovery units which provide a constant flow of fresh air into the facility.

During Sochi's hot summers, transparent doors, windows and facades with multi-purpose glass offer shade from the sun, and minimise its impact even during the hottest period of the day. A hydraulic power system is also in place to supply water for the fire protection, including a water mist system which offers four times greater efficiency than traditional systems, and lawn watering systems.

Similar technologies are also in use at two new stations: Olympic Park and Alpika-Service.

Olympic Park is the grand entrance to the Olympic Games site and is the final station on the coastal line with capacity for up to 12,500 passengers per hour (see Figure 5). The seven-storey 17,000 m² station building is located on the edge of the park, 1.5km from the seafront, and offers an easy walk to and from the park's Olympic venues which hosted the majority of the events, as well as the opening and closing ceremonies.

The building, which is designed to resemble a seagull, was designed by Sibgiprotrans with Studia 44 tasked with bringing the vision to life. The structure's shape is intended to maximise the use of daylight, while offering shelter from direct



Fig. 6. Alpika-Service station

sunlight and rain. The large roof is fitted with solar panels and low-emissivity glass, with the building designed, constructed and certified according to BREEAM Bespoke Green Standards.

Alpika-Service station in Krasnaya Polyana (see Figure 6) is a mountain terminal station from where Olympics visitors could access the Rosa Khutor Ski Resort, Laura Biathlon & Ski Complex, the Sanki Olympic Sliding Center, the Zima Freestyle Skiing and Snowboarding Center, as well as the Olympic village and other Olympic venues. Sibgiprotrans was again responsible for design with Mosgiprotrans providing the architectural concept.

The three-storey, 14,500 m² terminal has capacity for 8,500 passengers per hour. The station has three tracks with 290m-long passenger platforms. The platforms are situated above the station building level with access provided by two underground walkways. Lifts for wheelchair passengers, stairs and escalators have also been installed.

A shortage of available space in the area meant that the terminal was constructed on a hillside and had to incorporate landslide control measures in its design. The building is supported by a metal pipe structure which is capable of withstanding an intensity nine earthquake. Furthermore, a 357m-long, 3.2m-wide, and 20m-high retaining wall made from 553, 1.2m-diameter piles was required. The platforms also incorporate a pile-based foundation with 559 piles with similar diameter installed on the hillside.

Esto-Sadok station is situated in close proximity to the Russki Gorki Jumping Center, 43km

from lower Adler on the Adler – Alpika-Service line. Due to only a 10,000m² area being available for the station, its concourse, waiting room, ticket hall, coffee-room, sleeping quarters and other amenities are located 6m below the railway tracks. Sibgiprotrans provided design and with Mosgiprotrans again developing these plans. The station features two tracks with capacity for up to 7,500 passengers per hour.

In addition to new construction, stations at Sochi, Dagomys, Matsesta and Khosta were renovated as part of the Olympic projects. New modern ticket gates were installed and platforms upgraded, while the stations' layout were altered to improve navigation for passengers. To boost accessibility, lifts were installed on overpasses and underground walkways, while disabled passengers are benefiting from new wheelchair ramps, sensory cues on sidewalks, platforms, handrails and lift buttons, special route identifiers, information boards that use redundant audio and light signals, special ticket offices, sleeping quarters, and toilets.

Throughout the Olympic Games from February 6 to 24 and the Paralympic Games from March 7 to 19, passenger journeys on the railway network in and around Sochi were free. In total, 4,764,018 passengers used the suburban trains during the Olympic and Paralympic Games, with 413 trains operating every day at a minimum headway of six minutes on the Sochi – Adler line. 50 EMUs were used for the services, including 40 class ES1 Lastochka trains and 10 ED4M vehicles. (S)

Managing and implementing the Sochi Winter Olympics railway timetable

Anatoly Stepanov, Chief of Traffic Management Process Department, Research and Development Institute for IT, Automation and Communication for Railway Transport (NIIAS JSC)

Inna Gurgenidze, Senior Research Associate in the Traffic Management Process Department, NIIAS JSC

Anna Cherevan, Senior Specialist in the Traffic Management Process Department, NIIAS JSC

NIIAS utilised microsimulation to build a passenger flow to forecast passenger use of rail services during the Winter Olympic Games in Sochi. The rail timetable subsequently adopted during the Olympics is based on this model and contributed to the successful organisation of safe and efficient passenger services between the various Olympic venues.

Analysis Subject and Boundaries using Microsimulation Approach

The microsimulation model is built from data showing the expected volume of passengers and the type transport they are using at a specific station or hub at particular times of the day (see Figure 1). To simulate passenger flow during the Olympic Games in Sochi, passenger activities at the following hub stations were considered: Sochi, Adler, Krasnaya Polyana, Olympic Park, Esto-Sadok, Khosta and Matsesta. The size of the passenger flow used in the simulation is based on the competition schedules at the mountain

and coastal clusters, the arrival and departure schedules for road and railway transport, along with the usual daily rush hour peaks. During peak times, the hub stations are simulated to operate at capacity, which helps to identify potential bottlenecks and prevent issues with transport in the event of changes to the competition schedule.

To prepare the simulation, operations at each hub were analysed in-depth. This included functional elements such as stairs, escalators, platforms, bridges and tunnels, walking and

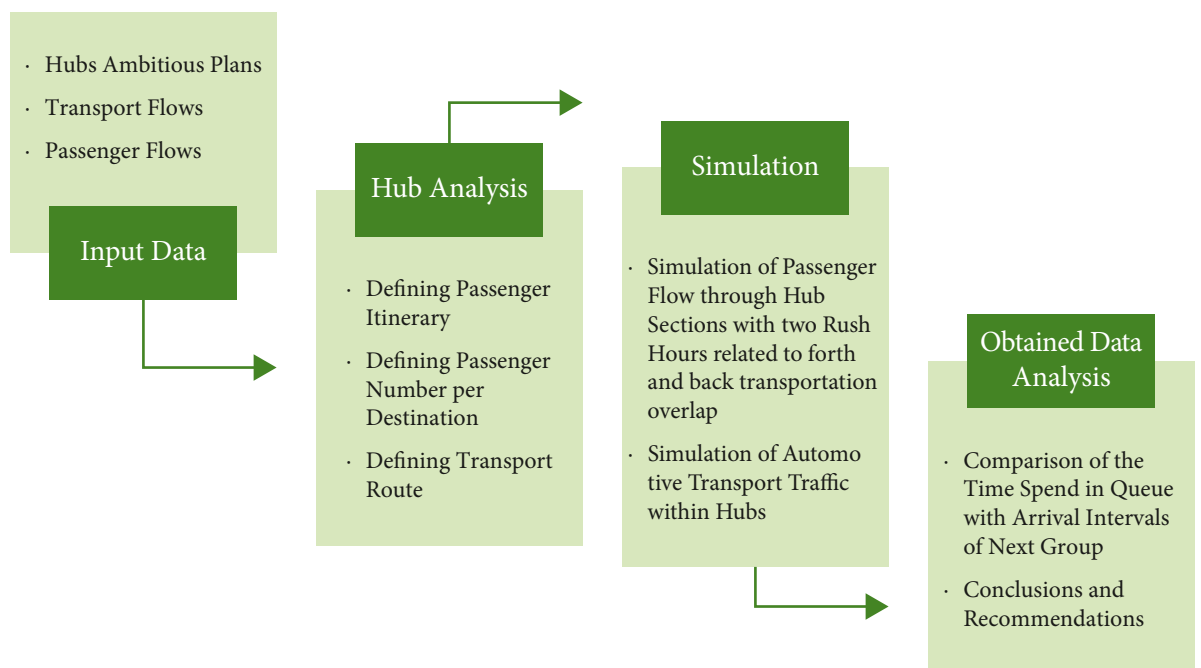


Fig. 1. Progress of the Study

security check zones, while transport, including secondary bus services, and passenger flow routes were defined.

A specific transport hub's capability to sustain a steady flow of passengers for an hour, or reduce a passenger queue at an interval not exceeding the headway of the transport mode in question were identified as the criteria for a positive assessment of a station's operational performance.

The data retrieved from the simulations was subsequently used when planning specific engineering improvements to maximise the efficiency of Sochi's Olympic transport system. NIIAS

identified the optimal level of hourly passenger flows at hubs for every day of the Olympic Games taking into consideration a specific day's competition schedule as provided by the Olympic Games Transport Directorate. As a result hourly loads at transport hubs and their related requirements for vehicles including various bus types, and EMUs were estimated on the basis of this information.

Experts from the International Olympic Committee offered high praise for the NIIAS report and the results of the microsimulation of passenger flows during the Sochi 2014 Olympics.

Train Schedule for the Olympic Games

To establish a train schedule capable of supporting the high passenger flows expected during the Olympics, the traction performance of Lastochka (Desiro RUS) and ED4M trains were considered, with a maximum speed of 120km/h identified for the Adler - Krasnaya Polyana mountain cluster, and 60km/h for Sochi - Olympic Park coastal cluster.

The following special assumptions were taken into consideration throughout the scheduling process, which were deemed crucial to delivering a timetable capable of meeting the high passenger demand expected during the Olympic Games:

- consist and highly available traffic in the Olympic operating domain,
- the single-track Adler - Krasnaya Polyana line section with passing loops is a major potential bottleneck and its effect must be minimised (this section was under construction at the time of preparing the schedule),
- the existence of 'clean' and 'not-clean' zones required by the police at Adler, Sochi and Olympic Park stations, which results in significantly reduced flexibility of passenger flows during train arrivals and departures,
- limited traffic capacity at Adler station, and
- the requirement to offer an hourly repeated train schedule.

Moreover, for the purpose of preparing a train schedule to meet these demands, Sochi was identified as the terminal station for all Olympic suburban routes, thus limiting the territorial impact from certain external factors such as weather conditions or possible passenger trains delays on the schedule's stability.

The original concept for the Olympic train schedule was based on dynamic-loop operation on the Adler - Krasnaya Polyana single-track line section where suburban trains would operate without stopping on the double-track passing loop sections to pass the Olympic services operating on the main line. However, this proposal was rejected because of its high risk factor. Yet without adopting something close to this strategy, the carrying capacity rate on the Adler - Krasnaya Polyana line section increased to close to 1.0. Thus an alternative method was required to achieve the desired flows of traffic.

As a result, an intermediary dynamic-loop method was used for the Adler - Krasnaya Polyana section in order to effectively handle the high levels of traffic and passengers. This strategy required sufficient flexibility to switch to dynamic-loop operation when required, and for the purposes of this strategy, locations suitable for trains to stop in the event of delays were identified (see Figure 2).

The National Olympic Committee's requirement for RZD to operate 12 trains per hour on the Sochi - Adler section meant that trains would operate at five-minute headways. We have found that a schedule with this traffic load contained no redundancy meaning that in the event of a delay of more than five minutes, the time would not be recovered within 24 hours.

In light of this understanding, we developed a train traffic schedule which offered different service patterns with respect to the time of the day. Under this schedule the operating day is divided into the following three time periods:

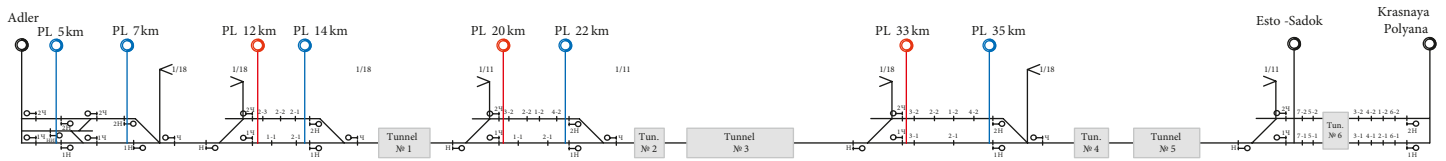


Fig. 2. The new Adler - Krasnaya Polyana line is a single-track line with double-track passenger loops (PL - passing loop)

- 08.00 - 21.00 passengers are expected to arrive in the Olympic zone (Sochi International Airport - Sochi) while guests will arrive at the Olympic venues,
- 21.00 - 01.00 mass departures from the Olympic Park and Krasnaya Polyana hubs will occur following the conclusion of competitions, and
- 01.00 - 08.00 passenger flow will decrease.

From 8.00 - 21.00 passengers will arrive at the Olympic zone located on the R31 route between the airport and Sochi to attend the competitions. Data retrieved from Vancouver about the passenger flows it witnessed during the 2010 Winter Olympic Games showed that this should increase evenly. In this context, the following transfer paths were identified for the train schedule:

- R1 Route (Sochi - Olympic Park) - five trains per hour. Stops: Matsesta, Khosta, Adler, Olympic Village,
- R2 Route (Sochi - Krasnaya Polyana) - two trains per hour. Stops: Matsesta, Khosta, Adler, Esto-Sadok,
- R2* Route (Adler - Krasnaya Polyana) - one train per hour. Stops: Esto-Sadok,
- R31 Route (Sochi - Sochi International Airport) - 1.5 trains per hour. Stops: Adler,
- R4 Route (Krasnaya Polyana - Olympic Park) - one train per hour. Stops: Esto-Sadok, Verkhne-Imeretinsky Kurort, and
- LD Route (long-distance trains which terminate at Adler) - 1.5 trains per hour.

From 21.00 - 01.00, the period in which competitions held in the mountain and coastal clusters reached their conclusion, transport had to be organized in such a way that all of the guests could leave all of the venues in the minimum possible time. The 21.00 - 01.00 train schedule was as follows:

- R1 Route (Sochi - Olympic Park) - six trains per hour. Stops: Matsesta, Khosta, Adler, Olympic Village,
- R2 Route (Sochi - Krasnaya Polyana) - two trains per hour. Stops: Matsesta, Khosta, Adler, Esto-Sadok,

- R2* Route (Adler - Krasnaya Polyana) - one train per hour. Stops: Esto-Sadok,
- R31 Route (Sochi - Sochi International Airport) - 1.5 trains per hour. Stops: Adler,
- R4 Route (Krasnaya Polyana - Olympic Park) - one train per hour. Stops: Esto-Sadok, Verkhne-Imeretinsky Kurort,
- LD Route (long-distance trains which terminate at Adler) - 0.5 train/hr.

From 01.00 - 08.00, the flow of passengers in the Olympic operating domain decreases. From 02.00 - 05.00, R1, R2, R2*, and R4 trains undergo servicing and routine maintenance inspection at the Olympic Park station, while R31 trains are maintained at Adler station. The train flows for the different times of day are shown in Figure 3.

This schedule provides sufficient flexibility to allow the operation of services on the Adler - Sochi section at six-minute headways, while allowing flexibility for immediate adjustments and recovery in the event of delay. However, conflicting routes in the southern section of Adler station significantly reduce traffic flow.

In order to meet security requirements, each transport hub was given a specific security classification:

- “clean” zones in which trains arrive from and depart to locations adjacent to the Olympic venues, with passengers required to pass through a security area, and
- “not-clean” zones, where these security checks are absent.

The “clean” and “not-clean” zones at Adler station are located the following areas:

- Park K - a “clean” zone where trains connecting Sochi and the Olympic Park, and Sochi and Krasnaya Polyana arrive and depart, and
- Park A - “not-clean” zone, where Aeroexpress trains between Sochi and Sochi International Airport, Adler and Sochi International Airport, as well as long-distance passenger trains arrive and depart.

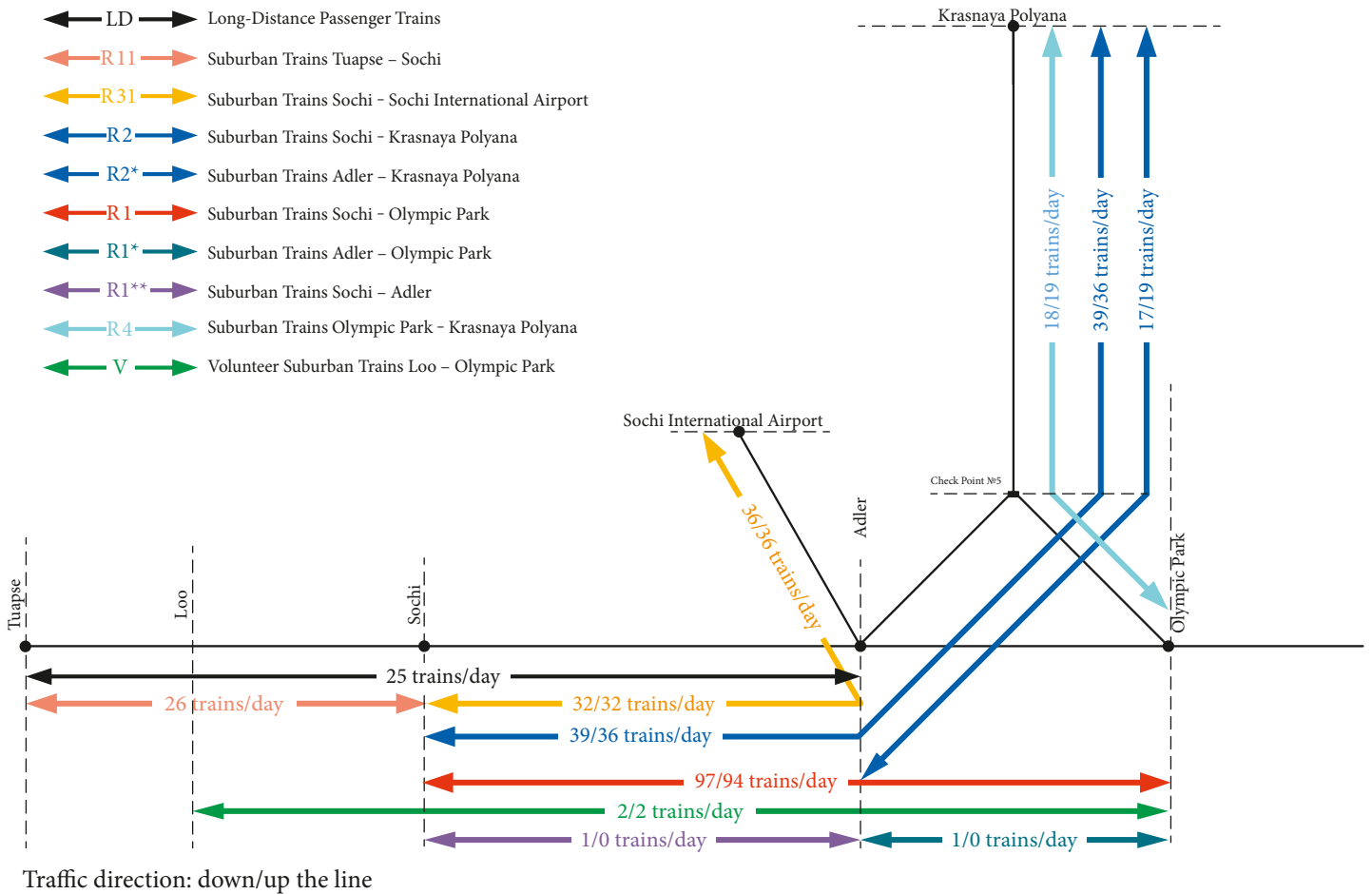


Fig. 3. 24-hour train flows in the 100% Olympic schedule

Results from pilot operations showed that due to the 20‰ track gradient on the line south from Adler station towards Sochi International Airport, headways between trains should be extended. As a result the time between successive arrivals at Adler on Sochi International Airport – Adler and Olympic Park – Adler services, which all pass through the station’s southern section, should be at least eight minutes.

However, in light of this restriction and the existing station track capacity, the utilisation factor for Adler station reaches 1.2 when three train pairs per hour operate on the Sochi International Airport – Adler line section, and 0.97 when two train pairs per hour are operated. Thus, without establishing new entrance and exit routes between Adler and Sochi International Airport, Adler and Olympic Park, and Adler and Krasnaya Polyana, the Olympic train schedule was impossible.

To eliminate train crossings and to improve the reliability of railway services during the Olympic Games, NIIAS recommended renovating the southern entrance to Adler station, specifically through

an extension to the existing 8A siding and the laying of a cross-over between track 8A and track IIA.

With the use of parallel routes rather crossing routes in the southern section potentially reducing the section’s utilisation factor to 0.53, RZD decided to alter the track development strategy for Adler station. Under the new strategy entrance and exits routes for electric trains linking Sochi and Olympic Park, Sochi and Krasnaya Polyana, Adler and Sochi International Airport, and Sochi and Sochi International Airport are not required to cross in Adler station’s southern section.

The following train schedules were introduced in the Olympic operating domain in order to gradually increase train service frequency on the new lines from Adler to Olympic Park and Adler to Krasnaya Polyana:

- 30% Olympic schedule from 01.11.2013 to 06.01.2014,
- 50% Olympic schedule from 07.01.2013 to 23.01.2014 and 24.02.2014 to 06.03.2014, and
- 100% Olympic schedule from 24.01.2014 to 23.02.2014.

30% Olympic schedule

From 01.11.2013 to 06.01.2014, the priority was to start operating suburban trains on Olympic routes in line with the working hours of Sochi's existing public transport of-

ferings in order to serve the transport needs of Sochi's population. The daily railway traffic flows approved for this schedule are shown in Figure 4.

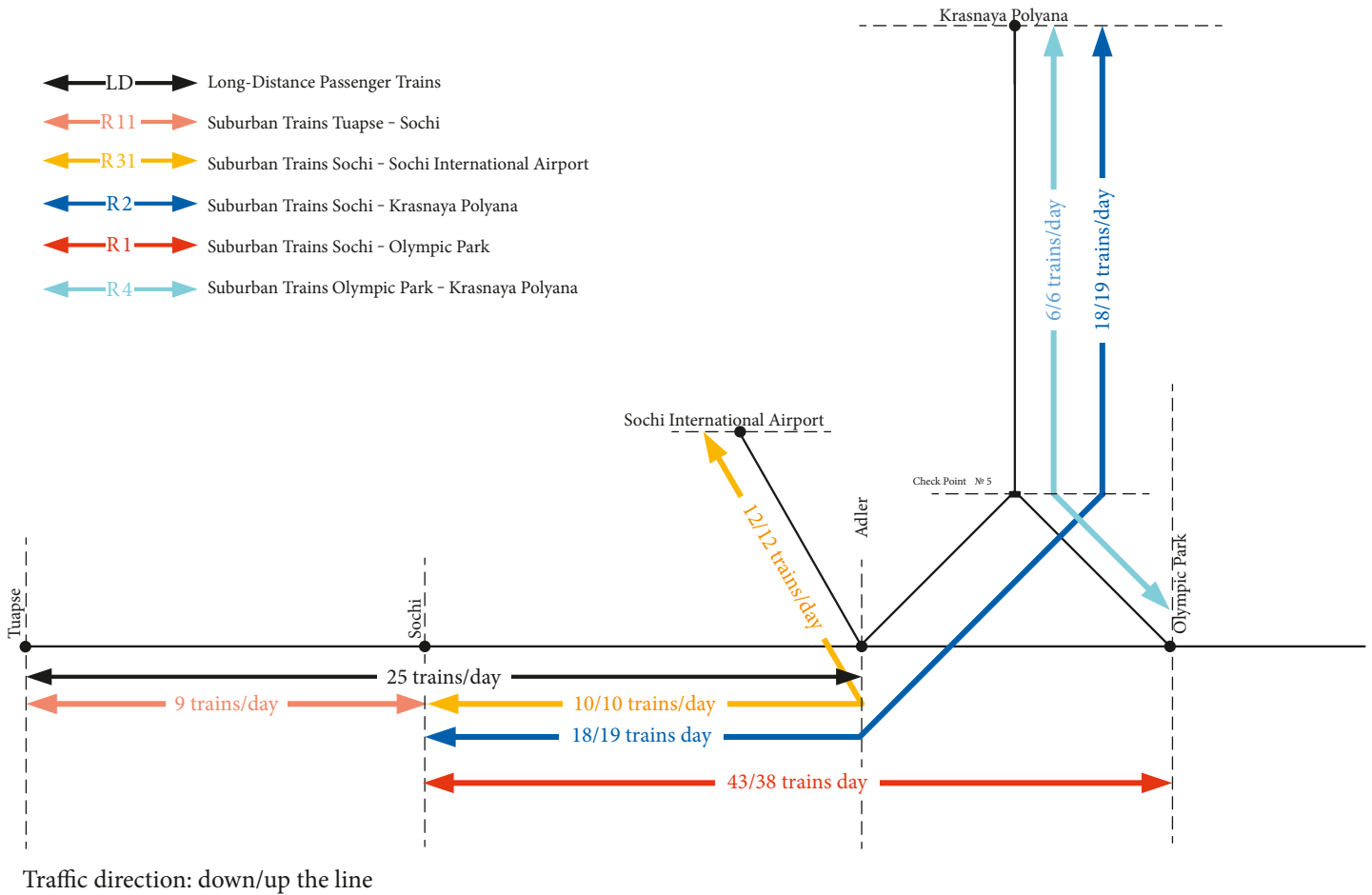


Fig. 4. Daily railway traffic for 30% of the optimal Olympic schedule

50% Olympic schedule

A schedule with a 50% load was introduced during the following periods:

- from 07.01.2014 to 23.01.2014, the pre-Olympic phase. During this period, mass media representatives began to arrive, athlete training activities occurred, while maintenance staff and participants in the opening ceremony were transported to the Olympic venues for rehearsals.
- from 24.02.2014 to 06.03.2014, the interim phase between the Olympic and Paralympic competitions. During this period, the majority

of the Olympic guests were expected to depart, and Paralympic athletes arrive.

The daily railway traffic flows approved for the 50% schedule are presented in Figure 5.

In addition, NIIAS developed alternative train schedules for the Olympic Games which took into account the use of extra trains and their location:

- for services on the days of the opening and closing ceremonies, which were both defined by mass passenger arrivals and departures to and from the Olympic Park, and

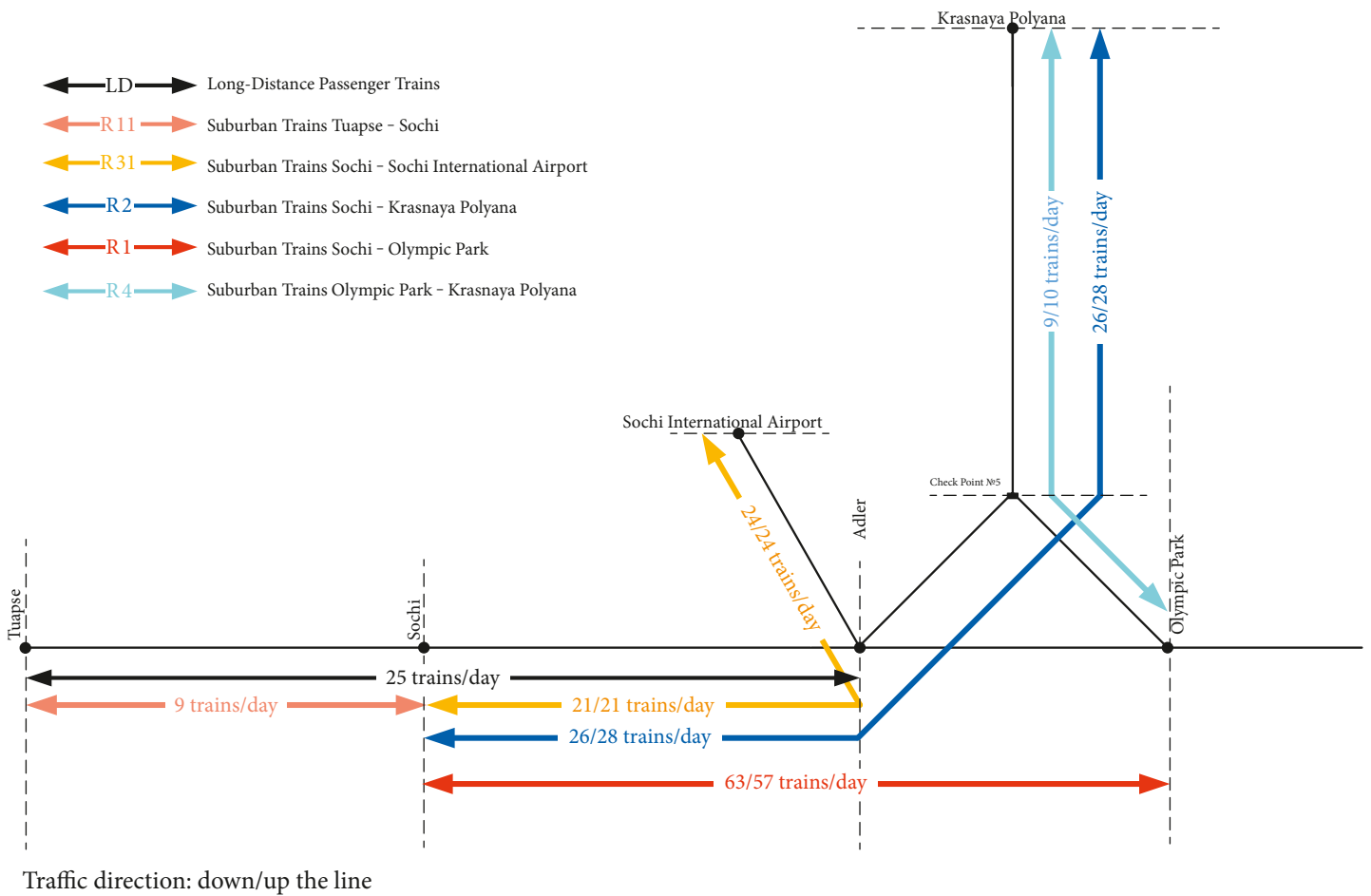


Fig. 5. Daily train traffic for 50% of the optimal Olympic Schedule

- for various emergency scenarios such as in the event of closures to passing loops on the single track lines.

On the busiest days of the Olympics, when events took place at the Olympic Park, passenger flows exceeded 35,000 passengers from 23.30 - 01.10. As a result operators at Adler’s Railway Traffic Control Centre (DTsUP) decided to redirect an additional six double-unit trains from the Adler - Krasnaya Polyana line to boost services on the Adler - Olympic Park route. These measures helped to manage the high levels of passengers in the shortest possible time.

A dedicated traffic management system was the answer to the challenges posed by the unique railway traffic conditions experienced during the Olympic Games. The requirement to operate a dynamic-loop service pattern on the single-track Adler - Krasnaya Polyana line, along with a highly intensive schedule and improved railway transport safety requirements were all met by



Lastochka EMU on the route

the system. And with an uninterrupted service successfully offered throughout the course of the Olympics, the challenge of serving such a high number of passengers was met. (S)

EXPO 1520 – at the heart of Eastern Europe’s Railway Industry



The International Rail Salon EXPO 1520 held every odd year in the city of Shcherbinka, near Moscow, is the largest railway exhibition and forum in Eastern Europe and the CIS. The first event was held in 2007 and it has grown with each subsequent edition: in 2007 delegates from 12 countries attended the event, while in 2013 representatives from 25 countries, including exhibitors from Germany, Switzerland, France, China, Poland, and Slovakia took part. Indeed the 2013 show set a world record for the quantity of railway products and vehicles on display in Eastern Europe and the

CIS at any one time – 127 vehicle units in total. And with substantial infrastructure and rolling stock investments expected in Russia and the CIS over the next few years, more international rolling stock and component manufacturers are expected to attend the event in the future.

Most of the 330 firms which attended the 2013 exhibition have already confirmed their presence in 2015. While it is not a simple task to exceed the above figures, if they do succeed, EXPO 1520 will be firmly established as a global railway community event.

Conference

A major feature of the event is a high-level conference dedicated to the latest issues in rolling-stock manufacturing. Representatives from industry and public authorities take the opportunity to summarise their performance over the past two years and outline their objectives for the future. The manufacturers receive an opportunity

to get first-hand information on their prospective customers’ needs as well as outlining how future agreements might be structured. In addition discussions during plenary sessions enable market players, scientists and regulatory authorities to come to a shared understanding of transport engineering problems in Russia.



The 4th EXPO 1520 in figures

For example, in 2009, the impact of the economic recession on rolling stock manufacturing was understandably one of the conference's core talking points with delegates discussing various changes to the Strategy of Transport Engineering Development of Russia. The updated version of the latter integrating the outcomes of past years panel discussions has been developed by Institute of Natural Monopolies Research (IPEM), and presented to the Ministry of Industry and Trade of the Russian Federation in 2013.

The future prospects of domestic rolling stock manufacturing was the primary subject of the third EXPO 1520 Salon held in 2011. Modernisation and localisation of production facilities are considered crucial to the future development and competitiveness of Russia's rolling stock manufacturing industry. A three-party delivery and maintenance contract signed in Shcherbinika between Russian Railways (RZD), Siemens and Sinara Group for Lastochka trains (Desiro RUS) was the major highlight of the event. The contract required 35% localisation of the trains with a view to increasing this to 80% in the future. In 2013 Ural Locomotives, a joint venture between Sinara Group and Siemens, launched the mass production of Lastochka, which have since demonstrated excellence in service, including during the Winter Olympic Games in Sochi.

Russian railway industry experts are generally of the opinion that the increasing globalisation of rolling stock manufacturing requires domestic manufacturers to enhance their competitiveness. In many cases, existing Russian rail vehicles do not currently meet strict international standards, whereas the development of new products that do is hindered by a lack of low-cost production facilities. In addition an insufficient debt capital market to provide consistent demand for rolling stock products, and government policy that supports domestic manufacturers over their foreign competitors, is considered to have held back local industry. To overcome these issues, market players argue that by encouraging foreign companies to transfer technologies and expertise, and localise production in exchange for access to the Russian market, the future of the domestic railway manufacturing sector will be assured.

Utilising lean manufacturing practices and adopting International Railway Industry Standard (IRIS) is a major issue for the success of these relationships and is recurring topic of the conference. Compliance with European standard is in-



2ES7 freight electric locomotive

creasingly important for companies attempting to secure business from RZD, Russia's primary rolling stock customer. The acceptance of Russian as one of IRIS' official languages alongside English, French, German and Italian, was as a result considered a major milestone for the Russian railway industry. According to Mr Valentin Gapanovich, president of UIRE and senior vice president of RZD, this has established Russian manufacturers as "equal players in the global rolling stock market." Mr Bernard Kaufmann, general manager of IRIS Group, commented at the 2013 edition of EXPO 1520, that 11 local audit firms are now offering IRIS certification services in the 1520 region, with 31 certificates now issued, and 76 sites engaging in the certification process.



EP20 passenger electric locomotive

Most Significant Deals at EXPO 1520

2007:

- Manufacturing and delivery contract for 212 E5K and EP2K passenger and freight electric locomotives between RZD and Transmashholding
- Delivery contract for 40,000 freight wagons up to 2010 between RZD and Uralvagonzavod

2011:

- Three-party agreement for the delivery of 1,200 Lastochka EMU cars and maintenance of 54 trains between RZD, Siemens and Sinara Group
- Preliminary Contract for the delivery of 40,000 Cars between Uralvagonzavod and Second Freight Company (renamed into Federal Freight in 2012 (FGK))

2013:

- Memorandum of cooperation between RZD International and DB International for the promotion of Russian-German railway business relationships
- Delivery contract for 6,000 freight wagons with Barber S-2-R Bogies between Tikhvin Car Building Plant (TVSZ) and Siberian Coal Energy Company (SUEK)
- Delivery contract for 1,500 composite hopper wagons between Uralvagonzavod and Rusagrotans

Exhibition

Displays of the latest rolling stock for the 1520 region in both the exhibition grounds and during track demonstrations on the Railway Research Institute of Russian Railways (VNIIZhT) test track, is perhaps the highlight of EXPO 1520 for industry experts and railway enthusiasts alike. The test track, which was built in 1932 and is now a historic Russian railway site, hosts a parade of the achievements of domestic and foreign rolling stock manufacturers.

As the show has developed, many of the products presented as ideas and prototypes in earlier editions have been rolled out at subsequent shows. For example, in 2009 Tver Carriage Works presented a prototype double-deck passenger coach, which was on display at the 2013 edition ahead of its entry into revenue service between

Moscow and Adler in November 2013. Visitors to the 2009 event were similarly treated to a preview of the Sapsan high-speed train built by Siemens before it carried its first passengers from Moscow to Saint Petersburg at the end of that year.

The major attraction of 2011's EXPO 1520 was the GT1H-001 gas-turbine locomotive built by Lyudinovo Locomotive Building Plant. During the event the locomotive hauled a 2km-long train consisting of 170 wagons with an aggregate weight of 16,000 tonnes on the test track, a record listed in the Guinness Book of World Records. The dual voltage EP20 locomotive, which represents the fifth generation of Russian locomotives and was developed jointly by Novochoerkassk Locomotive Building Plant and Alstom, also demonstrated its capabilities.



Three-party agreement between RZD, Sinara Group and Siemens for the Lastochka EMUs delivery (at EXPO 1520 in 2011)



Conference at Expo 1520 in 2014



Stadler FLIRT EMU for Estonia railway



GT1h freight gas-turbine locomotive



P36 steam locomotive at heritage parade



O* (W for Walschaerts valve gear) steam locomotive at heritage parade

Visitors to the 2013 exhibition were treated to displays of the latest DMU models for the Russian market - a Stadler FLIRT and Transmashholding's DP-M. Uralvagonzavod, Russia's leading manufacturer of freight wagons, also presented an innovative hopper-wagon prototype which was built using composite materials. Visitors to the next edition of the show are likely to see the mass produced version.

A parade of heritage Russian steam locomotives and railway vehicles dating from the early 20th century up to the present day is a hallmark of EXPO 1520, and a major attraction for visitors, who can experience the evolution of Russian transport history firsthand. This mix of state-of-the-art vehicles and railway icons is intended to underline the continuing pursuit of best practices in Russian transport engineering.



SO18 steam locomotive at heritage parade

Major Unveilings of EXPO 1520

2009:

- Double-deck sleeper coaches, Tver Carriage Works (Russia)
- Sggmrss 90 wagon, Tatravagónka (Slovakia)
- TEM-TMH-001 diesel locomotive, a joint project of Bryansk Engineering Plant (Russia), Vilnius Locomotive Maintenance Depot (Lithuania) and CZ Loko (Czech Republic)
- TEM9 shunting locomotive, Sinara Group (Russia)

2011:

- EP20 electric locomotive, a joint project of Novocherkassk Locomotive Building Plant (NEVZ) (Russia) and Alstom Transport (France)
- ChME-3 Eco shunting locomotive, Yaroslavl Locomotive Repair Plant (Russia)
- ED4M EMU, Demikhovo Engineering Plant (DMZ) (Russia)
- GT1H gas-turbine locomotive, Lyudinovo Locomotive Building Plant (Russia)


2013:

- TEM18G gas-fuelled Locomotive, Bryansk Engineering Plant (Russia)
- DP-M DMU, Metrowagonmash (Russia)
- FLIRT DMU, Stadler (Switzerland)
- Prototype composite hopper-wagon, Uralvagonzavod (Russia)
- 2ES7 freight AC locomotive, Ural Locomotives (Russia)
- Metro car mockup for Moscow Metro, Siemens (Germany)

What to expect at EXPO 1520 in 2015

While the programme for the 2015 edition of EXPO 1520 has not yet been finalised, the exhibition and conference is expected to focus on high-speed infrastructure construction, mainte-

nance and equipment support, the deployment of innovative rolling stock products, the localisation of production, and engineering development. Manufacturers of metro and light rail vehicles are also expected to display their latest solutions at the event in light of upcoming opportunities in urban areas in Russia, particularly Moscow.

With no current major competitors in eastern Europe, EXPO 1520 is expected to grow further as new participants from more countries recognise its importance to region's industry and as a platform from which to display their offerings. EXPO 2015, like previous editions, will promote an inclusive environment and a belief in sharing ideas and experiences between people committed to railways and their development. The Shcherbinka exhibition is not just the 1520 region's must-see event, but an occasion that railway suppliers as well as members of the research and engineering community hoping to expand their presence in the region can no longer afford to miss. 



The driver of P36 steam locomotive and the young visitor of EXPO 1520

UIRE develops its international reputation



Nikolay Lysenko,
CEO and Vice President of NP UIRE

Established in 2007, the mission of the Union of Industries of Railway Equipment (UIRE) non-profit partnership is to build international relationships among rail vehicle manufacturers active in Russia to exchange best manufacturing practices and technologies for rolling stock and components.

UIRE's international reputation is clearly growing. But what factors are stimulating its development?

Firstly, over the last seven years UIRE membership has grown, with new members accepted from Germany, Ukraine, Belarus, Kazakhstan, Uzbekistan, and Slovakia as well as the Russian subsidiaries of the world-leading railway equipment manufacturers, Siemens, Alstom and Bombardier.

Secondly, since 2008, UIRE has become a permanent participant in international railway exhibitions and conferences such as the 1520 Strategic Partnership held in Sochi, EXPO 1520 in Shcherbinka, InnoTrans in Berlin, Hannover Messe, and the MSV Trade Fair in Brno. At these events, UIRE organises conferences and round-table discussions involving its international partners to discuss the issues facing the Russian railway manufacturing sector.

Thirdly, the Union has promoted its image on the international stage by signing cooperation agreements with:

- the Association of the European Rail Industry (UNIFE),
- the German Railway Industry Association (VDB),
- the Czech Railway Industry Association (ACRI),
- SwissRail Industry Association (SWISSRAIL),
- the French Railway Industries Association (FIF), and
- the Austrian Railway Industry Association.

In addition, provisional agreements are now in place with representatives from the railway



UIRE and FIF cooperation agreement signing in Paris on April 23, 2014

industry associations and unions of Britain, Italy and Spain, while in 2014 UIRE representatives held a meeting with the USA Commercial Mission in Russia where the process to establish a cooperative agreement with the Association of American Railroads (AAR) was initiated.

To deliver on these agreements each partner has developed a specific action plan.

For example following the joint meeting between the heads of UIRE and VDB on October 28, 2013 in Berlin, the parties agreed the 2014 Interaction Plan.

The above efforts allowed the Union to expand its international relationships and become a recognizable brand, in Europe and around the world.

The Working Group 8 (WG8) of the Industrial Round Table of Russia and the European Union regularly discuss cooperation with agencies responsible for the development of regulatory documents, as well as review regulations and standards to improve harmonization with EU



Russian delegation with American colleagues from Amsted Rail

standards, which is essential to develop effective relationships with European manufacturers.

Fourthly, UIRE supports an active communication process with its members in order to meet IRIS requirements at their facilities.

As a result, 51 Russian railway manufacturing companies have already fully aligned their business management systems with international best practice, while 40 companies received their IRIS compliance certificates in 2013.

These companies receive strong support from the Russian Engineering Workers Guild. Specifically, any problems encountered during the deployment of IRIS standards are discussed with certifying and consulting agencies at the Rolling Stock Manufacturing Committee, which again will be held in 2014.



Alstom Transport HQ in Saint-Ouen, venue of IRIS workshop on October 14-18, 2013

Experts from UIRE and Russian Railways (RZD) are permanent panellists of IRIS advisory boards. Training workshops for Russian IRIS deployment officers are organised regularly, with Mr Bernard Kaufmann, IRIS General Manager, participating in these events.

And finally, four travelling workshops were arranged at European and American rolling stock manufacturing sites in 2013 which exposed Russian experts to modern international railway transport practices and quality improvement solutions.

April, Bombardier (Italy)

On April 15-19, 2013 Bombardier Italy's Rome Engineering Center hosted a workshop on IRIS requirements for officials from plants that manufacture rolling stock products and components.

Attendees were presented with the details of how to apply quality enhancement tools used in IRIS standards like Failure Modes and Effects Analysis (FMEA), Reliability, Availability, Maintainability and Safety (RAMS), and Life Cycle Cost Management (LCC).

July, Amsted Rail and Caterpillar (USA)

On July 7-13, 2013 a Russian team was involved in a training workshop arranged by UIRE and Amsted Rail at several American railway companies' facilities in Chicago, Memphis, Paragould and Muncie.

As part of the trip, the attendees visited Amsted's axle manufacturing and wheelset fitting plant, and freight car assembly facilities, as well as Progress Rail's locomotive plant.

During the visit to the Belt Railway and BNSF Railway regional railways, participants toured diesel locomotive, freight wagon and flat wagon maintenance and repair facilities, and railway and freight container yards. Russian specialists also visited Caterpillar subsidiary Electro-Motive Diesel's (EMD) locomotive assembly facilities in Muncie, Indiana, where they followed the complete production process for a locomotive. An SD70Ace locomotive adapted to operate in Russian climatic conditions, and which could potentially use liquefied natural gas (LNG) as a fuel, was presented during the tour. This specific project involves the establishment of an Engineering

Center in Russia, so was of particular interest to participants.

Other significant projects to draw interest were: an automatic wheelset formation production line; a computer-based system that provides live data on rolling stock repair operations, components replacements, as well as feedback from operation; articulated flat wagons for the transport of automobile containers and trailers; a robotic welding station for locomotive underframe production; 110-tonne mineral wagons with a 32-tonne axle loads; and a wagon design which does not use a backframe.

October, Alstom (France)

Alstom Transport hosted an IRIS workshop on October 14-18, 2013 with the workshop's opening sessions taking place at the company's headquarters in Paris. During these sessions, Alstom executives explained how the company uses and deploys the various stages of a quality management system, and the current application of quality tools that meet IRIS standards for rolling stock engineering and design.

After the meetings, the attendees travelled using the TGV to Belfort where one of Alstom's largest electric locomotive and EMU assembling facilities is located.

This was followed by a visit to Alstom's Ornans facility, which produces traction motors for high-speed trains and electric locomotives.

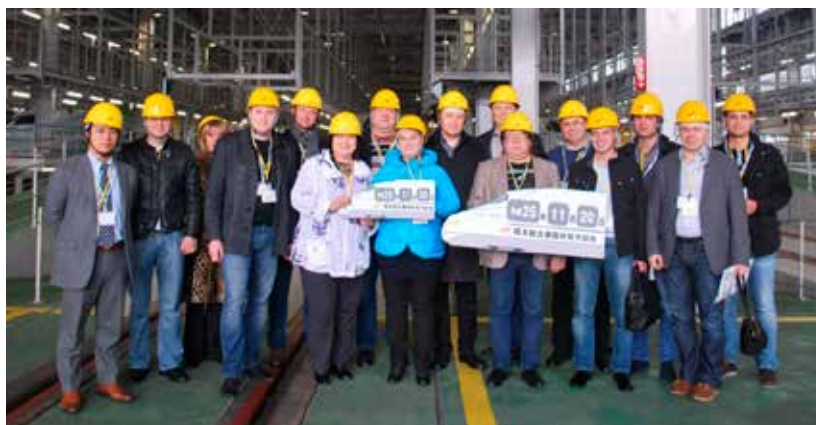
At the end of the workshop all the attendees were awarded personal certificates.

November, Mitsui (Japan)

A team of 87 Russian rolling stock company officials and specialists took part in a training workshop arranged by UIRE and Mitsui at several Japanese railway companies' facilities from November 17-23, 2013.

The first stop was the Kyushu Tetsudo Kiki Seisakusho plant which produces track infrastructure. The plant has developed the production of point systems for 1435mm tracks. Among the highlights was the presentation of the company's point frog system which allows trains to operate at up to 300km/h over points.

During a subsequent visit to Kyushu regional railroad, maintenance techniques for the N700



UIRE delegation at Kyushu Tetsudo Kiki Seisakusho plant

and N899 series Shinkansen bullet trains, as well as high-speed track maintenance techniques were presented.

In addition the team visited the Railway Research Institute where testing of all rolling stock components and equipment, track components, as well as signalling, communication and power supply devices takes place.

In addition to building awareness of the latest technologies and developments in the international railway industry, these international workshops, held under the auspices of UIRE and its foreign partners, facilitate the establishment of new contacts and potential business opportunities.

On September 11, 2013 the following agreements were signed at the IV International Fair EXPO 1520 in Shcherbinka:

- the cooperation agreement between UIRE and UNIFE,
- the contract between UNIFE and Standartinform, Russia to distribute a Russian-language version of IRIS in the Russian Federation.

This was followed on September 12 with an IRIS Advisory Board meeting to present an official Russian version of the standards, review the requirements for IRIS deployment in Russia, as well as consider proposals to enhance and improve the standards.

The above efforts are only opening steps of what will become a major international programme to deliver new rolling stock products for the Russian market that meet the requirements of IRIS and feature improved competitiveness, performance and safety levels. With the success of this programme dependent on cooperation with international partners, we will continue to pursue these efforts to the benefit of all involved. ☺

IRIS develops globally



Bernard Kaufmann,
IRIS General Manager

In early May 2014, 8 years after its creation, IRIS awarded its 1000th certificate! This is a significant milestone for the IRIS certification which has become an international seal of quality that is increasingly recognised by rail operators and producers alike.

Currently, the scheme's implementation is progressing very quickly in Russia. Due to several Memoranda of Understanding signed with NP UIRE based on enhancing knowledge, cooperation, better understanding of requirements and the strong involvement of RZD JSC, companies must accelerate the reliability of their organisations in order to deliver the expected Quality through their products and systems.

Moreover, the IRIS Management Centre is monitoring the assessments in order to ensure a common high level of both audit results and certificate accuracy.

IRIS helps to change the Quality mindset and approach within certified companies for two main reasons:

- Customers will only recognise improvements when they are visible;
- It's the industry's responsibility to guarantee the ability of its suppliers to deliver according to its needs.

Taking those elements into account, we are continually developing and promoting IRIS to push the rail sector to reach its potential. This is being accomplished through:

- The two commitments deployed within UNIFE members regarding audit types and supply chain management,
- The IRIS Advisory Board's validated strategy for the next five years (which is summarised below),
- The next technical evolution of the IRIS Standard in which takes into consideration the upcoming new ISO 9001: 2015 version. IRIS will implement this in a two phase approach:

1. Short-term approach with an IRIS Addendum in 2015: including all elements to further develop IRIS in line with internal strategy, (e.g. considering correction received from the field (user, stakeholders, state of the art)),
2. Mid-term approach with a new IRIS Rev.03 in 2017: including ISO 9001:2015 and further improvements.

We are convinced that all these elements will give the necessary impulse for the rail sector in the near future. All stakeholders will have to play their role in order to ensure the success and recognition of IRIS. 📞

VISION – Our ambition for the future

Quality is AN ABSOLUTE prerequisite for a reliable and safe rail product.

- ❖ IRIS enables companies conducting business in the rail sector to **sustainably ensure quality and satisfy their customers' needs in terms of quality.**
- ❖ IRIS instills a **culture of quality** in the rail sector by promoting methods and behaviours that focus on quality improvement.
- ❖ IRIS is **recognised and used worldwide.**

MISSION – Our purpose

Sustainable and consistent high quality can only be achieved with clearly defined processes and procedures which are implemented and regularly maintained.

The **International Railway Industry Standard (IRIS)** was developed and is promoted by the European Rail Industry Association (UNIFE) in order to define requirements, tools and means to improve the quality of rail products.

Our goal is to increase **customer satisfaction through** continuous and tangible improvement of **product performance** and **quality** within our sector worldwide

Business Management System: Results of Five-Year Deployment



Sergey Gapeev,

Director, Technical Audit Centre, a Business Unit of RZD JSC

Five years ago, Russian Railways (RZD) prioritised the adoption of International Railway Industry Standard (IRIS) at Russian rolling stock manufacturing companies.

As part of its efforts to secure quality management for purchasing, RZD's Management Board adopted several measures to ensure that rail vehicle manufacturers respect the IRIS' international requirements during the development of new products. These policies support the following key objectives:

- efficient cooperation between the parties involved in the development of products for RZD with the aim of reducing operating costs,
- establishing a list of requirements for products which include world-best practices to guarantee quality,
- development of a database of product and component manufacturers which is continuously updated,
- monitor the performance of products in operation,
- follow-up manufacturers' corrective and preventative maintenance activities,
- evaluate product costing, including life cycle costs and operational KPIs,
- regular evaluations of production, industrial, and quality management systems at manufacturers' plants and to carry out updates of these facilities to meet IRIS requirements, and
- boost manufacturers motivation to improve the quality of their products.

Implementation of IRIS in Russia began in November 2007 when the Russian Union of Industries of Railway Equipment (UIRE), the European Rail Industry Association (UNIFE) and IRIS Management Centre signed a joint Memorandum of Cooperation on Licensing Agreements. The principal objective of this agreement was to help Russia's rolling stock manufacturing sector grow competitively through the adoption of IRIS

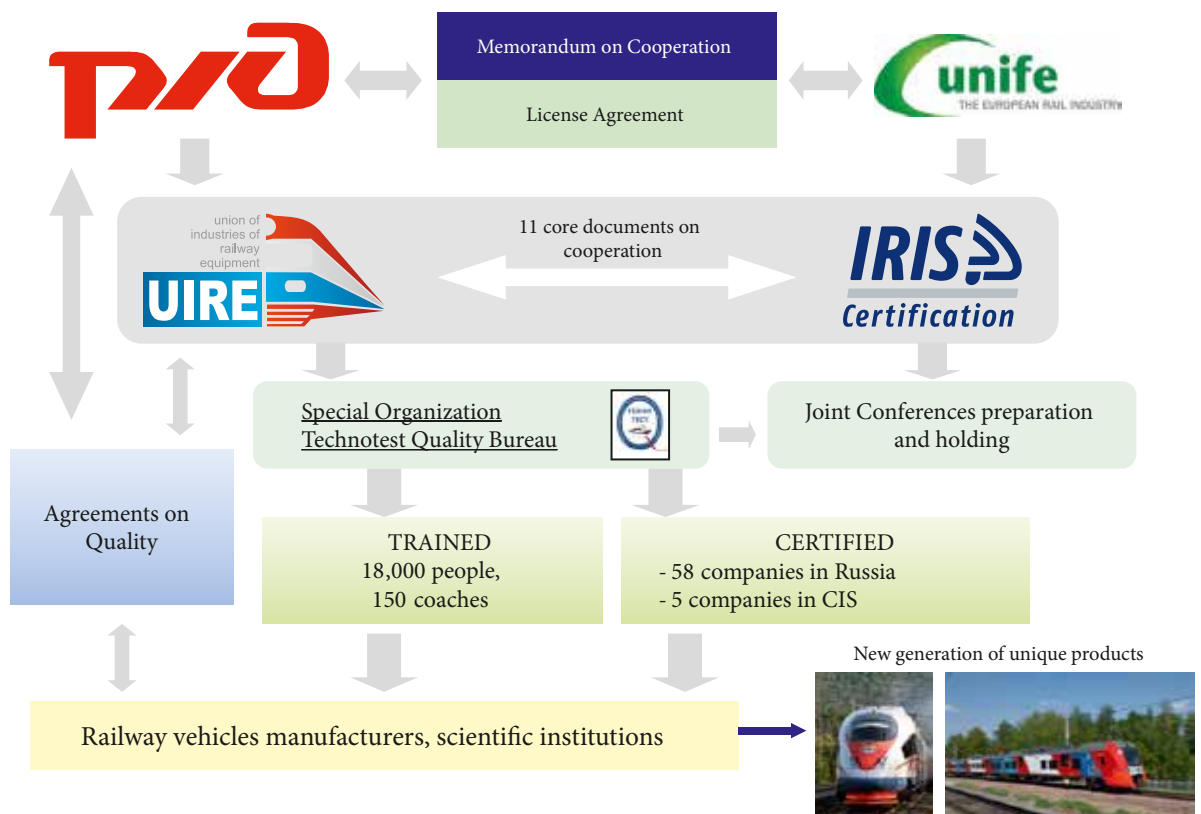
requirements, and the staging of joint workshops and conferences which would help each party achieve this goal.

The relationships between UIRE and UNIFE are governed by 11 core documents, which are updated annually. One of the most important steps in IRIS development in Russia was the official recognition of the Russian language in the IRIS system. On September 11, 2013 an IRIS Booklet in Russian was presented at the Fourth International Railway Salon EXPO 1520, in Scherbinka, near Moscow. The Russian version of the standards is now available from Standartinform, the official standards distributor authorised to work in Russia.

The IRIS Management Centre (IMC), jointly with the UIRE, provides training for the staff of Russian rolling stock manufacturing companies, and organises conferences and workshops dedicated to the issues faced during the introduction the standards in Russian companies. So far, 150 IRIS officials have been certified to assess deployment in Russia, while more than 18,000 employees have been trained in the IRIS requirements, and 105 plants are now registered with the IRIS portal and have purchased the audit tool.

On May 16, 2008 in order to effectively implement IRIS standards in Russia, during a joint meeting, the members of UIRE decided to establish a special institutional body, the Quality Bureau Technotest, to operate as an industrial coordinator for IRIS implementation.

Quality Bureau Technotest has subsequently been very active in supporting Russian companies' efforts to adopt the IRIS standards by developing related guidelines and standards. The bureau also organises hands-on workshops on IRIS



A model of cooperation between RZD and UNIFE

best practices and lean production. Beginning in 2010, travelling workshops have been organised at the industrial facilities of leading manufacturers in Russia, Europe, the United States, and Japan, including Izhevskiy radiozavod, Ansaldo-Breda, Knorr-Bremse, Alstom, Siemens, Bombardier, AAR, Nippon Steel, Voestalpine and Plasser & Theurer.

Seven companies were certified to perform training and consultancy services relating to IRIS implementation at UIRE member companies: Quality Bureau Technotest, Center Prioritet, Finex Quality, IRICONS, Ural Inter-regional Certification Centre, Siberian Certification Centre - Kuzbass, and Pokrovka Finance.

UNIFE has 14 authorised certification companies operating worldwide, with five represented and active in the Russian market: DQS, Bureau Veritas, TÜV Rheinland, Afnor, and Russian Register, the sole Russian company.

To date 58 Russian suppliers have been certified as complying with IRIS standards. Of these, 34 companies (59%) are major system integrators which manufacture rolling stock products and components and each employ more than 1,000

people. The companies include Uralvagonzavod Research & Production Corporation, Vyksa Steel Works, Production Complex Novocherkassk Electric Locomotive Building Plant, Tikhvin Wagon Building Plant, ELARA, Izhevskiy radiozavod, and Evraz Nizhniy Tagil Iron and Steel Works (NTMK). In total these companies employ more than 132,000 people, with individual head-count of the 15 IRIS-certified companies, equal to 26% of the total, ranging from 100 to 1,000 people, while the nine small plants in the list (15%) each employ less than 100 people.

RZD conducted a poll among the certified companies to better understand their experiences with IRIS. Overall feedback was positive, with the following benefits worth emphasising:

- an improvement in products and service quality,
- more new projects and products entering new markets, including those suitable for export,
- personnel skills development,
- an 8% average growth in sales,
- a 10% average rise in labour performance,
- the award of 30% more tenders,
- reduction of defects in the supply chain, and

- economic benefits relating to the optimisation of the business process as well as improved identification and utilisation of in-house resources.

Over 80% of Russia's rolling stock manufacturers are expected to secure IRIS certification by the end of 2014. The next important step in the process is to expand certification to the entire production chain, with RZD set to increasingly emphasise this objective during its audits.

The progress made towards securing universal certification of Russian rolling stock manufacturers is significant, but for RZD as the infrastructure owner, the first priority is to guarantee quality of infrastructure components and maintenance equipment. Even though RPM Group, the manufacturer of track machines for track laying, overhauling and maintenance, has certified its manufacturing divisions in Kaluga, Orenburg, Yaroslavl, and Perm, its sites producing rails and track superstructures fall outside the certification process. As a result, RZD believes it is critical to extend certification to include these elements in the third version of IRIS.

RZD initiated the adoption of IRIS in the Eurasian Economic Union area in 2009. The company's management continues to support the adoption process and is actively engaged in monitoring the quality of IRIS deployment at Russian companies. The companies which have certified their business management systems are now benefitting from improved performance of their business processes, consistently higher product quality, and can now offer adequate prices based on the lifecycle cost of a specific product.

The current system of technical audits comprising assessments of manufacturing processes, products and quality management systems carried out by RZD in its capacity as the product user is proving to be effective and successful. The system permits quality control of the products supplied for rail infrastructure developments and is providing a comprehensive analysis of a specific product's reliability and safety. In instances when non-conformity is identified, RZD's Technical Audit Centre instructs the certification authority and the IRIS Management Centre to launch a certificate cancellation procedure. The audits that RZD conducts will eventually cover more than 100 suppliers and are a key tool in monitoring adherence to IRIS protocol as well as motivating suppliers to maintain and improve the quality of their rail products.




IRIS Advisory Board, Scherbinka, Russia, September 12, 2013

On June 11, 2014 RZD, Kazakhstan Temir Zholy (KTZ) and Belarusian Railways (BC) held a joint meeting where it was proposed to utilise RZD's experience of technical audits to introduce these processes throughout the Eurasian Economic Union.

In light of complex nature of the integration process required to build a new technical audit system, and the current difficult economic environment in the member countries of the Eurasian Economic Community Customs Union, the countries agreed to adopt a programme for the development of a technical audit system for manufacturers supplying railway-related products in the union. An action plan facilitating the integration processes was also identified during the meeting.

The first steps in this integration process involve establishing a common regulatory framework, and as a pilot project, constructing a schedule to conduct comprehensive technical audits of rail vehicles producers for 2015. A training workshop entitled "The technical audit of manufacturing processes, products, QMS (BMS) at rolling stock manufacturing plants" is also proposed.

In parallel, UIRE is currently working to establish an independent entity to conduct technical audits of wagon maintenance and repair facilities, and to develop universal rules and regulations for rolling stock maintenance and repair activities. The new organisation's work will result in wagon repair companies taking greater responsibility for scheduled freight wagon maintenance, and ultimately improvements in the quality of this process. These steps will mitigate the risk of using products on RZD's railway infrastructure that deviate from norms and regulations. 

Railtransholding – A serious partner for your successful business

Railtransholding Group first emerged in the Russian market in 2011 and since then has grown into a leading player. The group offers a wide range of transport, logistics and manufacturing services in Russia, the CIS and the Baltic countries, covering each phase of the railway transport life cycle starting with the development of new railway products, to manufacturing, maintenance and repair and fleet operation

The group possesses a modern industrial complex in Novozybkov, Bryansk Region which produces freight wagons, electric thermal and electric welding equipment. Its manufacturing facility has the capacity to produce more than 10,000 cars per year in a variety of designs. In 2003 the factory developed, homologated and entered into series production in FBU RS FZhT* its class 12-132 hatch-type gondola wagon, class 18-100 freight wagon bogie and the class 11-9962 closed wagon. Moreover, for its international customers the company is manufacturing class 31-1556 class rear tipper wagons and 1435mm-gauge class 19-9936 ballast hopper wagons. This year the company launched production of class 13-9975 long wheelbase flat wagons for transport of large-capacity containers. Railtransholding is also planning to produce prototype class 13-9990, a standardized 40 foot-long flat wagon as well as special-purpose tank wagons to transport molten sulfur, sulfuric acid, fuming sulfuric acid, liquefied gasses, petroleum and gasoline products, methanol and sodium hydrate. It also plans to certify and launch into production the class 12-196-01 and 12-196-02 gondola wagons, which feature increased capacity, and a 25-tonne axleload freight bogie, as well as start in-house wheelset production in 2014.

In addition to its manufacturing activities, Railtransholding has set up an Engineering Research Centre which is developing both its own new rolling stock products and is liaising with some of Russia's leading engineering companies and rolling stock manufacturers to develop new solutions.

Railtransholding Group currently owns around 25,000 standardised and special-purpose freight wagons and the group is also very active in the after-sales services market with an extensive clientele. Maintenance and repair services


are provided by the wagon repair depot, which is affiliated with the Holding Company. A Railtransholding-affiliated company specialising in full package services for rolling stock operation and repair is carrying out work on both wagons owned by the group's various divisions as well as third parties.

While regularly implementing new efficient methods for managing railfreight transport, the company also delivers freight by rail and road for customers without a railway siding. The road transport activity is undertaken by the entity offering freight transport services and automotive truck leasing. The company has over 100 trucks which are equipped with radios and the GLONASS global navigation satellite system. Its dispatch centre is responsible for carrying out full time condition monitoring of the fleet as well as safety checks.



15-9544 tank wagon

Railtransholding has a history of cooperating successfully with the leading rolling stock manufacturers, developers and operators and is a member of well-known and recognised non-profit organisations including the Union of Industries of Railway Equipment, the Council of Participants of the Railway Rolling Stock Operators Market, and the Association of Railway Cars Builders.

As a company demonstrating dynamic and sustainable growth, Railtransholding Group is a reliable partner that will aid your pursuit of success. 

* FBU RS FZhT – Federal State-Financed Institution ‘Certification Register on Federal Railway Transport’



For more details about our services and products please address:

18, bld. 1, Newton Business-Center, Andropova Ave., Moscow, 115432, Russia

Tel./Fax: +7 (495) 921-05-70/ 921-05-71

E-mail: info@railtransholding.com

Using IPEM indices to monitor Russian industry development in the second quarter of 2014



Mansur Nigmatulin,
Analyst of Energy Sector Research
Division, Institute of Natural
Monopolies Research (IPEM)



Evgeny Rudakov,
Deputy Head of Energy Sector
Research Division, IPEM

In 2008, in an effort to improve measurements and to offer a greater understanding of the impact of economic recessions on Russian industry, the Institute of Natural Monopolies Research (IPEM), inspired by the Russian Ministry of Industry and Trade, developed two indices to act as an alternative to the Industrial Production Index (IPI) provided by the Federal Service for National Statistics (Rosstat). IPEM-Production and IPEM-Demand are based on analyses of electrical energy consumption and railfreight volume data. These up-to-date and highly reliable indices do not have many of the drawbacks of IPI and are proven to offer significant value even during economically stable times. In addition, by comparing the dynamics of the production and demand indices, it is possible to accurately assess the probability of an economic and/or industrial downturn occurring.

Introduction to IPEM Indices

In the event of an emerging economic crisis, relevant, reliable and complete information about current trends plays a critical role in effective crisis management decisions by state authorities and the business community. There are two methodological approaches to securing baseline macroeconomic estimates, such as the IPI, a traditional, bottom-up method which relies on observations of primary data; and an alternative top down approach which emphasises analytical calculations based on reliable baseline data.

Rosstat's IPI index relies primarily on statistical aggregation. In our publications we have repeatedly underlined the drawbacks of IPI computations that rely on this method [1]. The major disadvantages are linked to the complex and laborious process of collecting and processing data, which requires substantial resources, and is a slow process. The method is also limited by only including data from large-scale and mid-size businesses and relying only on statistical aggregation and not factors such as state fiscal policy. Moreover, the adjusted indices based on the complete data often differ significantly from the initial results, particularly in some categories outlined in the Russian Classification of Economic Activities. Furthermore, long lead items are taken into consideration for

the purposes of IPI calculation within a month of their completion, in spite of the production process normally continuing for several months. During periods of sustainable economic growth, there is not a significant distortion in the data retrieved. However, in a more volatile economic environment, alterations in this data indicate potential changes in overall economic trends.

An alternative analytical calculation of industrial production dynamics is possible due to the interrelated national economic system, which relies on rigid correlation between basic macro aggregates. A correct estimation of these correlations provides an up-to-date and reliable indicator of industrial development. The IPEM's indices are based on indirect integral measures such as electrical energy consumption (IPEM-Production) and railfreight volumes (IPEM-Demand). This data is tracked in real-time, and may be characterised as highly reliable and current, thus avoiding many of the drawbacks of the classical IPI calculation.

IPEM-Production Index

The Industrial Production Index (IPEM-Production) is based on the fact that electrical energy

serves as the means of production for any industrial process.

The Index model is centred on three parameters that define short-term electrical energy consumption: industrial production, weather and seasonal factors, with all of this data readily available, up-to-date and reliable.

IPEM-Demand Index

The Index of Demand for industrial products relies on the assumption that industrial product consumption corresponds with levels of transport. The IPEM-Demand Index therefore utilises online data of railfreight loadings carrying industrial products. This data does not take into

account transit and import volumes, but does include goods for export. Rail transport carries up to 80% of Russia's industrial goods (pipeline transport not included), which means that railway performance can provide an accurate reflection of the aggregate demand for industrial output in the economy. The calculation is substantiated through rigid correlations between the output of various industrial goods and rail transport volumes.

The IPEM-Demand Index model repeats Rosstat's IPI calculation, in which the index is calculated by aggregating physical data showing changes in the value of industry production. As a result the IPEM-Demand calculation model utilises more operational loading than production data.

Key Results of Q2/2014 Indices

At the end of Q2/2014, both the IPEM-Production and IPEM-Demand indices were showing respective 1.3% and 1.4% falls compared with the same period the previous year (see Figure 1).

The IPEM-Production Index fell by 1.7% in H1/2014 compared with 2013, while the IPEM-Demand Index has also declined by 1.6%

since the start of 2014. For the first time since the crisis of 2009, the biannual IPEM-Production Index went into the red, following a 0.6% gain in 2013 compared with 2012, 2.8% growth in 2012 compared with the previous year, 4.3% in 2011 compared with 2010, and 7.8% in 2010 compared with 2009.

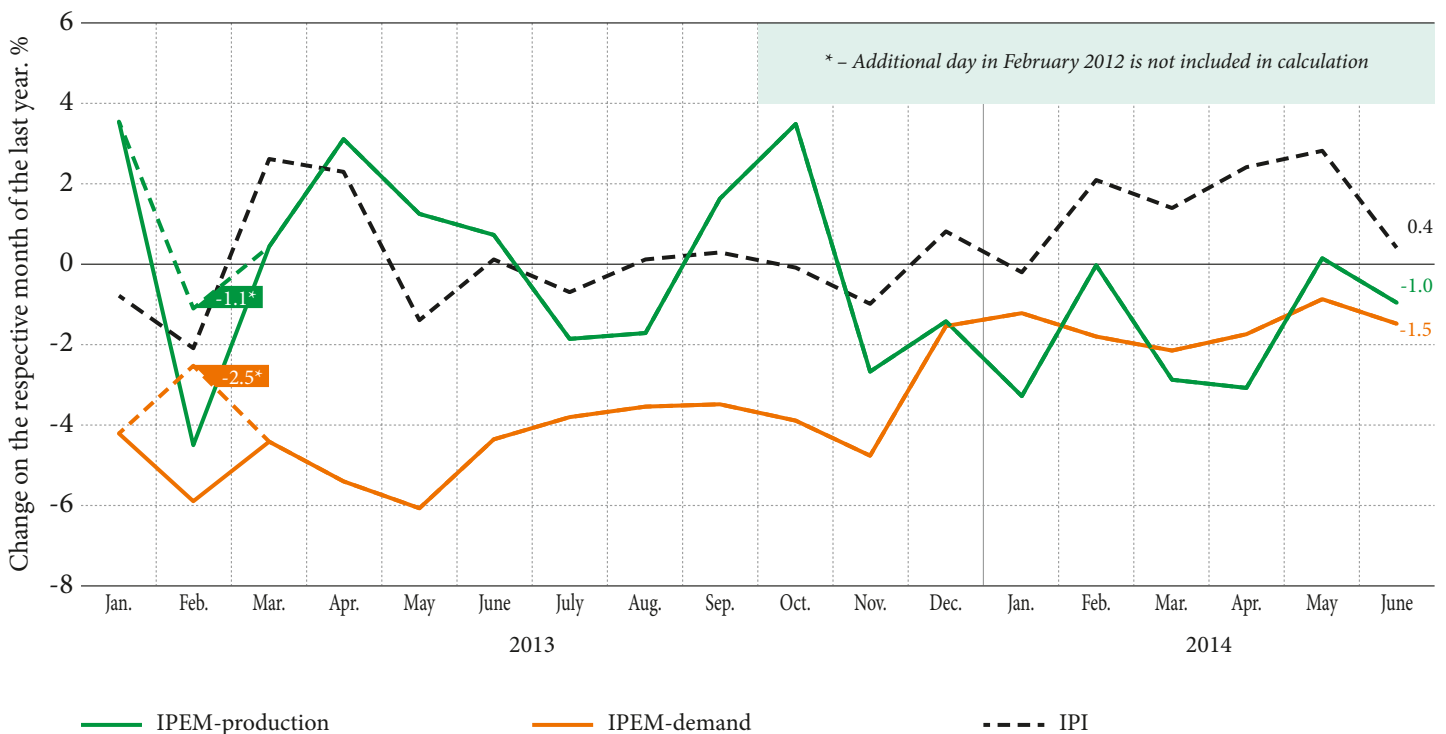


Fig. 1. IPEM indices dynamics monthly year-on-year comparisons 2013 to 2014

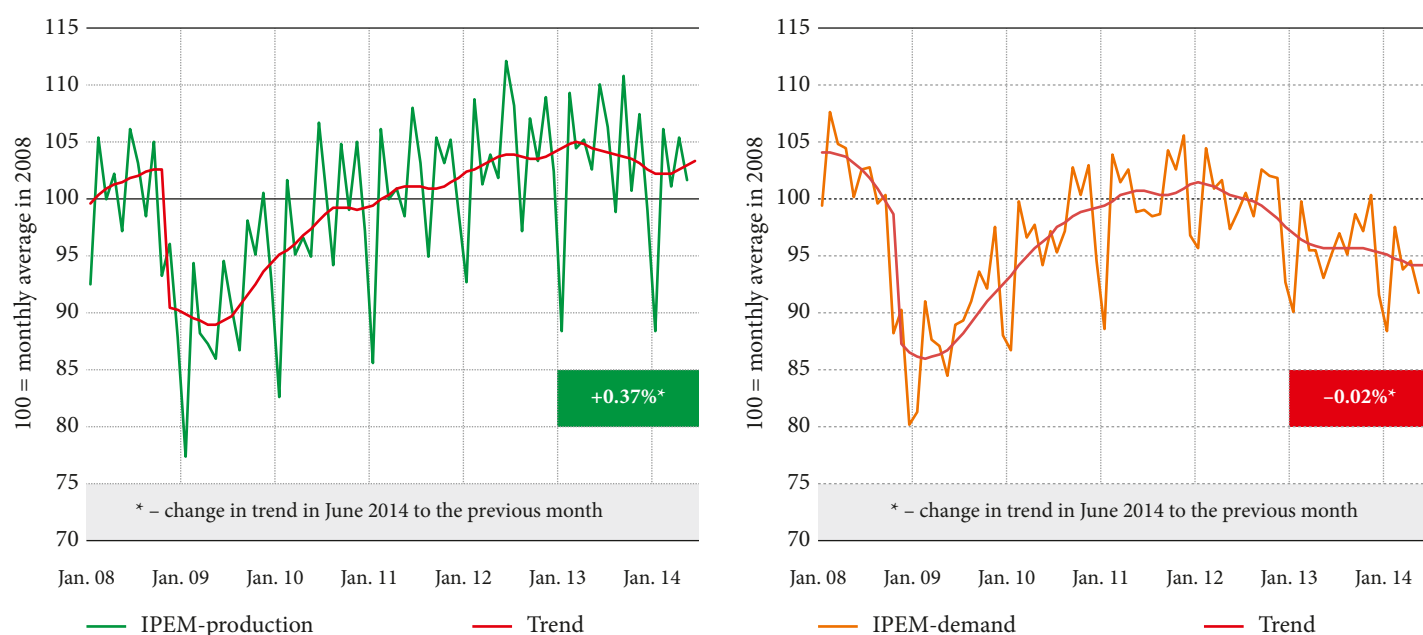


Fig. 2. IPEM Indices Dynamics over 2008 to 2014 (with seasonal adjustment)

Comparisons of seasonal trends in the data show that the indices pattern changed in mid-2014. The IPEM-Production Index continued to show signs of recovery which first emerged in early spring, while the IPEM-Demand ended its long-lasting decline (see Figure 2). Indeed since the beginning of 2014, the demand recession has shown a gradual slowdown, with February 2014 losing 0.31% compared with January 2014, and no loss reported by the end of June. However,

while these trends indicate that a recovery might be underway, the demand-production balance remains unstable.

A significant slowdown in the growth of demand after slight pullbacks first became apparent in mid-2012, led to a decline in production activities during 2013. The IPEM-Production Index varied widely mainly due to the volatile performance of some industries within the fuel and power sector. Long-term unstable produc-

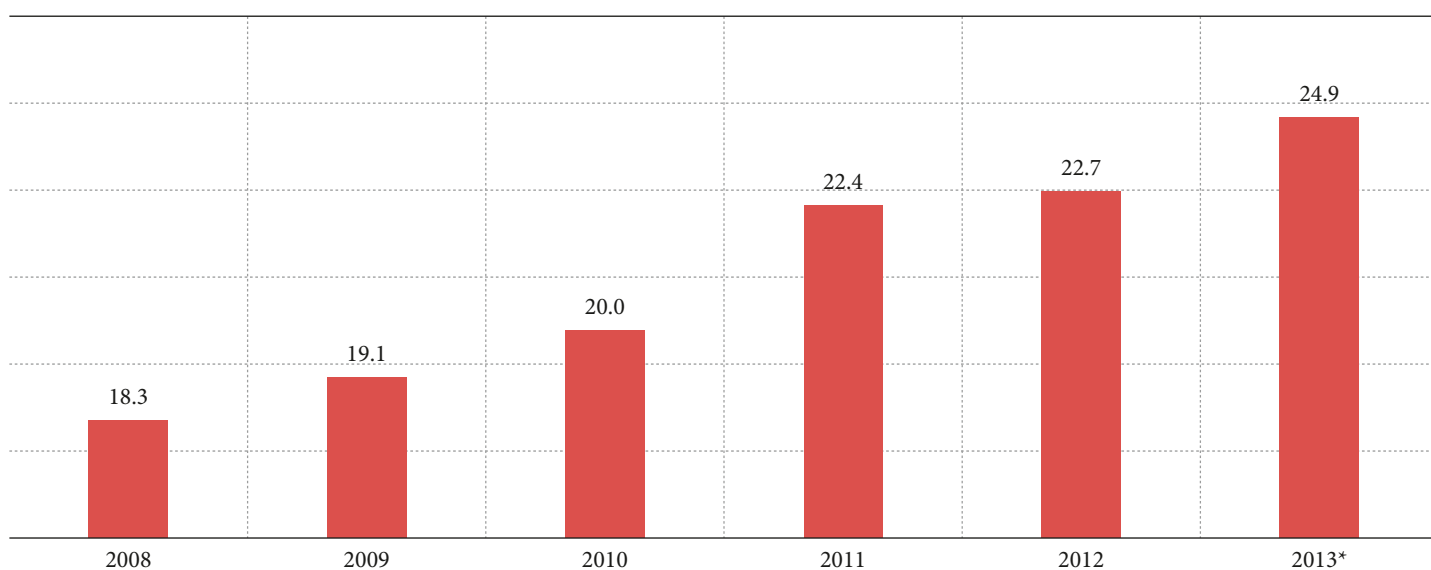


Fig. 3. Average monthly stock balance in consignors' warehouses 2008–2014

* – H1 2014

tion output coupled with weak demand resulted in an increase of stockpiled goods in consignors' warehouses (see Figure 3), a logical outcome in such a scenario.

The industrial sector's pre-crisis situation, which emerged at the end of 2013, gave way to a period of stability in the first half of 2014. This change in the indices may reflect the search for equilibrium as a result of an economic slowdown. Indeed sluggish demand in early 2014 forced manufacturers to adjust their production targets. The resulting deceleration in the industrial index to a negative value in June 2014 thus took place within the context of a slowdown in the demand index, which resulted in the end of warehouse

stock growth, with the monthly average stock balance amounting to 24.1 million tonnes in both H1/2013 and H1/2014.

A high balance of stock balance has largely been maintained in 2014 due to a growth in construction material shipment stockpiling following a slowdown in this specific market, with its share in the overall stock balance growing from 24.7% in 2012 and 28.7% in 2013 to 32.5%, or 7.5 million tonnes, year-on-year in Q2/2014.

Current trends show that the balance of warehouse stock will decrease in the coming months as it will be given priority in sales. These decreases will be accompanied by adjustments in factory output targets and falls in production activities.

Indices by industry

The IPEM-Demand Index by industries in H1/2014 compared with H1/2013 reports the following trends:

- extractive industry output fell by 0.2% (minus 0.1% in Q1/2014, minus 0.3% in Q2/2014),
- low-tech industries reported increased output by 4.8% (6.9% in Q1/2014, and 2.8% in Q2/2014),
- medium-tech industries output fell by 1.3% (1.6% in Q1/2014, and 0.9% in Q2/2014),
- high-tech industries output declined by 16.3% (20.7% in Q1/2014, and 12.3% in Q2/2014).

Industrial trend data, which takes seasonal balancing into account (see Figure 4), offers several conclusions:

- demand in medium-tech industries experienced a modest rally by mid-2014 following two years of decline in 2012 and 2013. The key growth driver is consistently high demand for minerals and chemical fertiliser (a rise of 5.6% in Q2/2014, and 8.4% over H1/2014), which is supported by strong export figures (+7.3% Q2/2014, +11.8% H1/2014)¹, and increased domestic demand (+2.4% Q2/2014, +2.6% H1/2014). Consistently high prices in international food markets and associated increases in demand, as well as changes in potassium fertiliser man-

ufacturers' selling strategy to emphasise supplying higher quantities over price in order to secure their market position, also contributed to this improvement. The domestic non-ferrous metals market similarly reported two quarters of sustained growth (a rise of 10.2% in Q2/2014 and 14.0% in H1/2014) and is an important driver, with equipment manufacturing for grids such as cables and transformers, aircraft and instrument manufacturing sectors the key generators of non-ferrous demand.

- high-tech industries have reported negative growth trends since the H2/2011, following declines in investment activities. The sector experienced a slight revival at the end of Q2/2014. However, further declines are likely with the industry reporting only limited prospects for growth. This is underpinned by the ease in which parts and component suppliers can adjust their contracts.
- growth in demand from low-tech industries reported in H2/2012 was steadily decreasing in Q2/2014. Poor performance in food and consumer goods industries, which were heavily affected by increasing import duties, was the primary cause of this poor performance.

¹ Domestic export and supply data is based on the volume in tonnes of the related commodities carried by rail

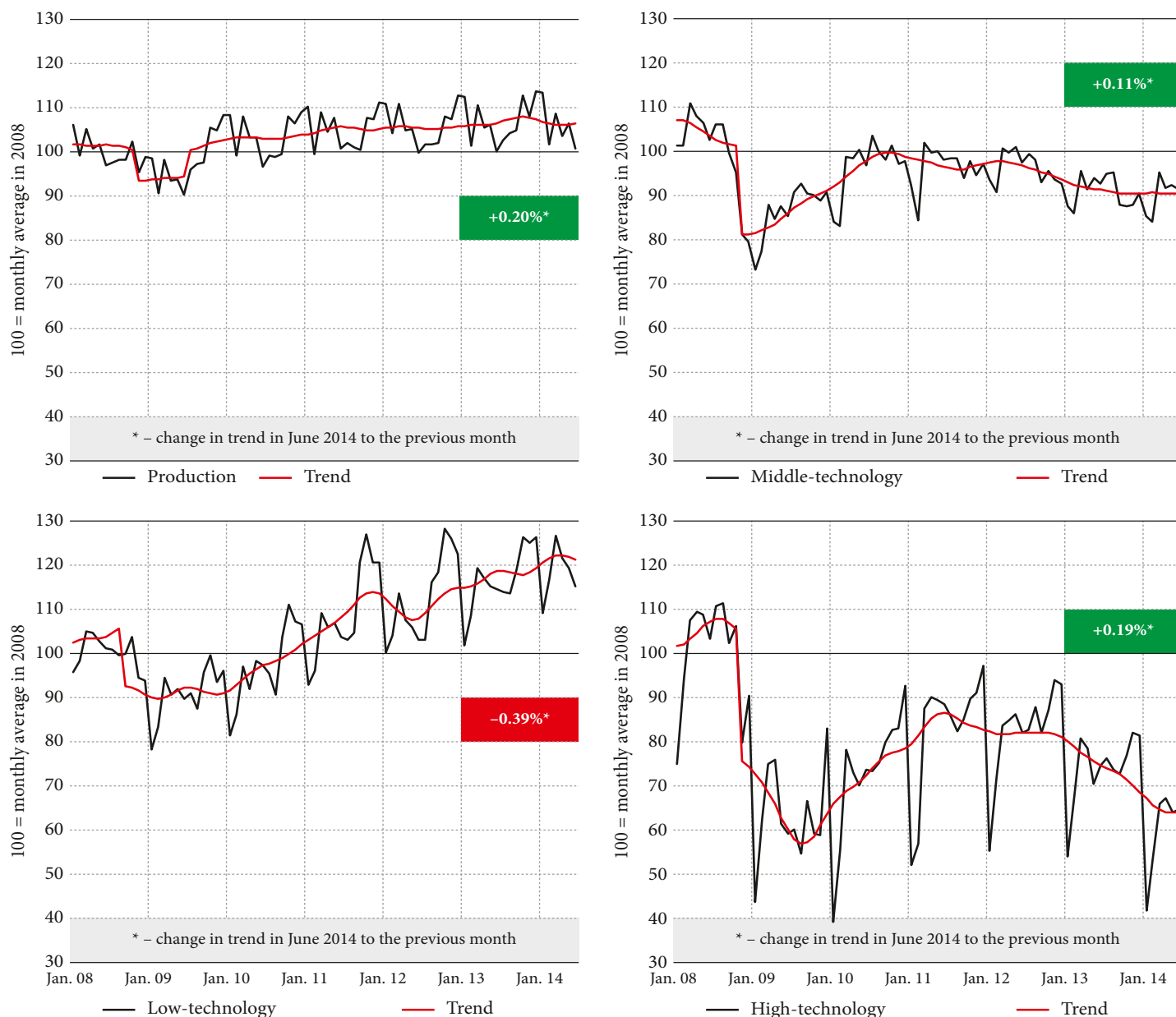


Fig. 4. IPEM-Demand dynamics by industries 2008 to 2014 (seasonally adjusted)

Developments in fuel and power industries

The fuel and power sector has close links with state industrial production and is traditionally a key factor in estimations offered by the industrial indices (see Figure 5).

Data trends from the extracting industries were mixed during H1/2014. For example growth in the oil sector continued to slow, with 0.7% growth reported in April down to 0.5% in May and reducing to 0.1% in June. In contrast natural gas production had climbed out of recession by the end of the first half of the year. In April production was down by

6.9% compared with the previous year, while in May extraction had grown by 0.7% year-on-year, the same value as the previous year, with growth continuing at 2.9% in June. However, coal production fell throughout Q2/2014, although this rate of decline had slowed to 0.6% by the end of June following falls of 9.4% in April, 6.9% in May.

It is too early to make any long-term assessments of these trends. However, it is clear that the basic macroeconomic factors underpinning the weak trends in the extracting industries are

closely connected with the geopolitical crisis in Ukraine.

Overall oil production increased by 0.9% in the first half of 2014. However, for sustained growth to occur it is clear that the future of the Russian oil sector is reliant on increasing supplies to the east and through potential shipments to the Republic of Crimea, although consumption here accounts for only 0.5% of Russia's total production volumes.

Natural gas production fell 1.1% in the first half of 2014, with domestic gas consumption declining by 2.1%. Russia's largest gas producer, Gazprom, reduced its production by 3.4% during the first six months, while its share in gross gas production fell from 71.8% in H1/2013 to 70.4% in H1/2014. At the same time, the export of natural gas from Russia increased by 8.7% in H1/2014. This increase may be explained by growth in demand from European consumers for storage in order to secure stable short-term supplies, as well as a new long-term natural gas delivery contract with China. The average German border price of Russian gas fell 4.2% from €290.03/thousand m³ in Q2/2013 to €277.88/thousand m³ in Q2/2014.

Gazprom, reduced its production by 3.4% during the first six months, while its share in gross gas production fell from 71.8% in H1/2013 to 70.4% in H1/2014. At the same time, the export of natural gas from Russia increased by 8.7% in H1/2014. This increase may be explained by growth in demand from European consumers for storage in order to secure stable short-term supplies, as well as a new long-term natural gas delivery contract with China. The average German border price of Russian gas fell 4.2% from €290.03/thousand m³ in Q2/2013 to €277.88/thousand m³ in Q2/2014.

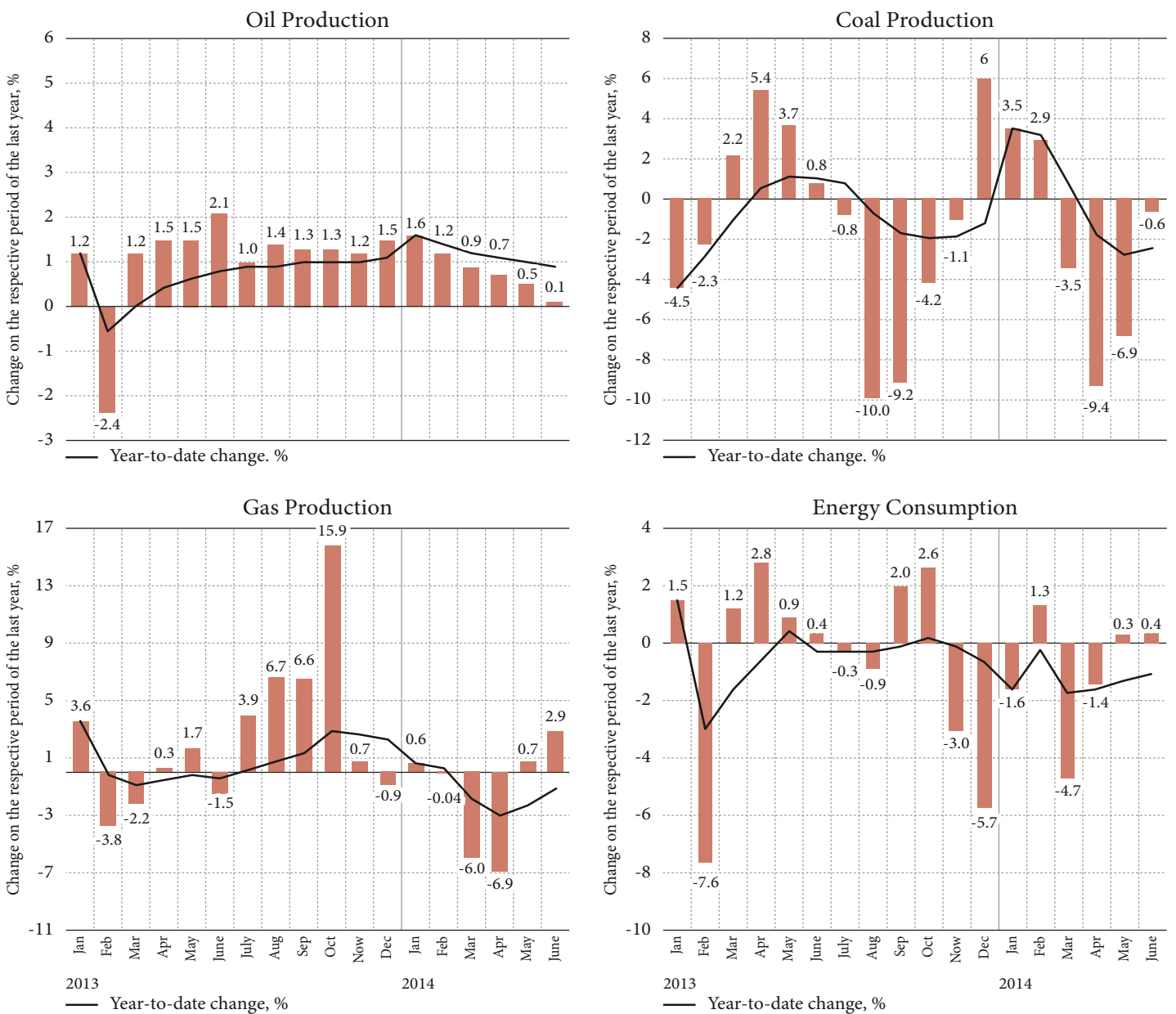


Fig. 5. Performance of Russia's fuel and power sector 2013–2014
 Source: Russian Ministry of Energy, System Operator of the Unified Power System

Flagging domestic demand for coal, which decreased by 10.4% in H1/2014, led Russian companies to decrease their coal mining output by 2.5% compared with the same period in 2013. However, a 10.6% increase in external demand, primarily from Asian and Pacific markets, insulated the producers from declines in the average price of power-station coal, which fell by 16.3% compared with H1/2013 (FOB Newcastle/Port Kembla). Data from sea ports also shows an increase in coal exports, with coal handling at Russian ports growing by 15.3% to 56.6 million tonnes in the six months up to June 30, 2014.

Electric power consumption has declined by 1.1% since the start of 2014 compared with the same period in 2013, although daily maximum values have been exceeded every month, with an increase of 0.2% in June 2013 compared with the previous year, and 2.3% in May. As a result daily power consumption schedules have become more irregular, indicating changes in the activities and roles of various industrial electricity consumers, which are experiencing declines in their overall share of the power consumed in favour of non-industrial consumers such as households, the service industry, trade, and electrified transport.

Future development

Russia's domestic market recession has persisted for a year. Fixed capital expenditure shrank by 0.2% last year compared with 2012, the decrease from January to May 2014 amounted to 3.8% compared with the same period in 2013. This measure reflects current domestic demand for industrial goods.

Year-on-year figures from June 2014 show that railfreight volumes fell by 2.8%, while in the first half of 2014, the loading index fell by 1.0% compared with the same period of the previous year. These declines were underpinned by a 4.6% fall in domestic volumes since the beginning of the year. However, freight turnover actually grew by 5.6%, indicating an increase in the average distance of railfreight journeys which were driven by the 6.6% increase of export-related loadings since the start of the year. Falls in domestic volumes are reported across the primary commodities transported by rail, which indicates a deterioration in domestic sales as external demand has grown.


For example, coal loading for the domestic market fell by 10.5% in the first half of 2014, while the export-related loading went up by 10.6%. Ferrous material loadings for export increased by 1.3%, however, domestic loadings dropped by 1.2%. And while overall mineral and chemical fertiliser loadings increased by 8.4%, loadings for export went up by 11.8%, with the domestic market only increasing by 2.6%. These developments indicate that the domestic market currently offers only very limited opportunities for growth

in a climate that favours export, particularly with Russia currently benefiting from favourable international exchange rates.

The decline in transporting construction materials by rail following the completion of Sochi Olympic facilities is also worth noting, with construction materials volumes falling by 2% in Q2/2014 and 2.6% in the first half of 2014.

One of the few positive recent developments for domestic Russian industrial production is the growing likelihood of substituting imported goods with domestic products, particularly in response to recent political events. Shipments of Ukrainian goods to the Russian market have fallen substantially in the last few months, which could result in domestic producers stepping up to fill this void. Moreover, the need to localise fuel and power equipment manufacturing facilities was recently highlighted during a top level meeting of the Russian Commission on the Strategic Development of the Fuel and Power Sector and Environmental Safety. As a result this sector may become a strong driver of Russian industry and the Russian economy in the near future.

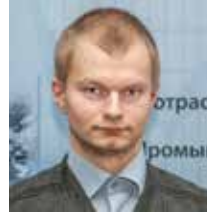
Sources:

1. N. Porokhova, E. Rudakov, Y. Saakyan. Alternative methods to estimate the dynamics of industrial production // Studies on Russian Economic Development. - 2012. - T. 23. - № 4. - 350-362 p. 

Russia's railway services market reacts to significant challenges



Alexander Polikarpov,
Head of Freight Transportation
Research Department, Institute
of Natural Monopolies Research (IPEM)



Alexander Slobodyanik,
Analyst of Freight Transportation
Research Department, IPEM

2013 was not an easy year for Russian railway transport. Russian Railways (RZD) carried 1.237 billion tonnes of freight in 2013, a 2.8% decline on the previous year. Freight turnover also fell by 1.2% compared with 2012 amounting to 2195.8 billion tonne-km, although freight turnover including empty running actually increased by 1.1% year-on-year to 2,812.8 billion tonne-km. The average distance of a loaded run also increased by 2% compared with 2012 to 1574.9 km. The figures were similarly mixed for passenger traffic. RZD carried a total of 1.081 billion passengers in 2013, a 2.1% increase over 2012. However, despite suburban services reporting a 3% increase in passengers to 970.1 million, long-distance passenger traffic fell by 5% year-on-year to 110.7 million passengers, meaning that overall passenger traffic decreased by 4% compared with 2012 to 138.4 billion passenger-km.

Freight Traffic

Russian railfreight services carried 1.39 billion tonnes in 2013, which while exceeding 2000 levels by 30.7%, was 3% less than the volumes reported during 2012. The peak for Russian railfreight was recorded in 2007 when the network handled 1.49 billion tonnes, 7.3% higher than in 2013. Domestic freight shipments accounted for 838.5 million tonnes in 2013, which is 0.3% less than 2000.

It is worth noting that a steep decline in the transport of construction materials was avoided due to strong demand from construction sites for the 2014 Winter Olympic Games in Sochi. Indeed, more than 70 million tonnes of building materials for Olympic construction projects were transported via the railway between 2009 and 2013.

Despite falls in traffic since the 2008 global economic crisis, over the past few years RZD's railway network has experienced unprecedented freight wagon fleet growth. Tariff Schedule 10-01 was one of the major changes adopted as part of Russia's railway structural reform in 2003, which was followed by further fundamental changes to the freight transport tariff system. These changes established favourable economic conditions for investments in railfreight rolling stock. Indeed the new rules set forth in Tariff Schedule 10-01 made it possible for operators to secure a payback

period of less than five years on new freight wagon purchases.

Demand has also been stimulated by a decline in RZD-owned freight wagon fleet, and the entry of more private operators into the market. For example in 2006, private freight wagons accounted for 33.2% of total freight fleet, yet this had increased to 78.5% by 2012. In 2012 RZD wagons carried only 3.9% of total railfreight compared with 60.7% in 2006, and in 2013 RZD-owned wagons were almost absent from revenue service.

As a result of these fleet renewals, the fall in RZD's marketshare, and the global financial crisis which has stifled demand for freight services, there is currently a surplus of freight cars in Russia. RZD estimates that approximately 300,000 wagons, including nearly 200,000 gondola wagons that were purchased in great quantities over the past few years, are currently surplus to requirements.

Furthermore, the growth of private operators, and subsequent increase in privately-owned wagons operating in Russia, has contributed to a deterioration of the network's operating performance.

For instance, average double-run operations rate has fallen to 1.05 in 2013 from 1.2 in 2007, while car turnover increased from 9 days to 16.9 days during the same period. Shunting operations have grown eight-to-tenfold, while

service speeds have decreased by 6.6 km/h, or a 54 km/day, compared with 2007.

As a result, the railway sector facing increasing competition from other modes of transport, in particular road, which is gaining in the transport of high added-value products, forcing railfreight operators to focus on cheaper bulk freight.

This fall in higher-paying freight transport was noticed initially on services covering small distances, or those transporting small batches, where truck operators have the advantage of being able to deliver directly to their clients. However, from the mid-1990s onward, competition has intensified at increasingly greater distances, with the ceiling for competition between rail and automotive transport now reaching 3,000km.

Revisions to the tariff system, which promote long-distance shipments over short distance traffic, are the primary cause of this shift. In the case of transporting goods by long-distance truck, a consignor pays only for carrier services, which are comparable with the wagon and locomotive usage components of a rail tariff. Yet with highway infrastructure maintenance and development supported through public financing, and with significant competition among a greater number of road-freight carriers, costs are falling. In addition, with poor state control of their actions, some operators are identifying loopholes, which are not always legal, to further reduce their prices.

In an effort to recapture and increase rail's share of the freight market, RZD is offering en-

hanced access and services to railfreight carriers. This includes allowing more trains to depart in firm-time slots in an effort to increase reliability.¹ The policy has already had an effect with 2,590 trains taking advantage of the service on the Oktyabrskaya Railway in 2013.

Another major policy is the introduction of fast container trains² that operate for just seven days on the Trans-Siberian Railway. This has also been met with strong demand, with 10 trains of this type now operating simultaneously covering around 1,200km daily, which is expected to increase to 1,500km/day by 2015.

However, perhaps the most significant factor that will instigate to a shift back to rail is granting RZD the right to change freight transport tariff rates. Under an order from the Federal Tariff Service (FST), a federal executive body responsible for statutory regulation of goods and services rates and tariffs, from January 27, 2013 RZD was allowed to alter tariffs on infrastructure and locomotive components, with the bottom rate specified by FST standing at -12.8%, with a ceiling of 13.4%.

RZD immediately invoked this right, with natural gas producer Novatek and Novolipetsk Steel among the first clients to receive the discount.

Yet in the approximately 18 months since this change was implemented RZD has not yet reported the improvement in overall freight volumes that it was hoping for, with the complex tariff change validation process impeding the efficient adoption of the "price corridor."

Passenger Transport

Results from Russia's passenger sector show a similar fall in competitiveness in recent years, particularly in long-distance operations. Approximately 110.7 million passengers used long-distance trains in 2013, a 5% decline compared with 2012.

The current situation is partly the result of federal and regional level authorities providing subsidies on the price of airline tickets for flights from the far east of Russia to the west of the country. Rail transportation volumes are thereby falling, whereas air passenger transportation is growing (see Figure 1).

In response to this, Federal Passenger Company (FPC) has developed various marketing programmes intended to increase the attractiveness of railway transport. For example, on July 1, 2012, FPC launched the "RZD Bonus," passenger loyalty program which offers reward points for train journeys that can be exchanged for fare reductions on future journeys.

In addition, beginning on March 1, 2013, a dynamic pricing method for fares on journeys in closed compartment sleepers, first-class and

¹ Firm-time slots mean a train service under a firm timetable that is not subject to change.

² Fast container trains run under a tight time schedule, and are made up of special-purpose or all-purpose wagons and flat wagons loaded with containers. These trains leave at certain intervals and travel to their destination with no re-formation and marshalling required.

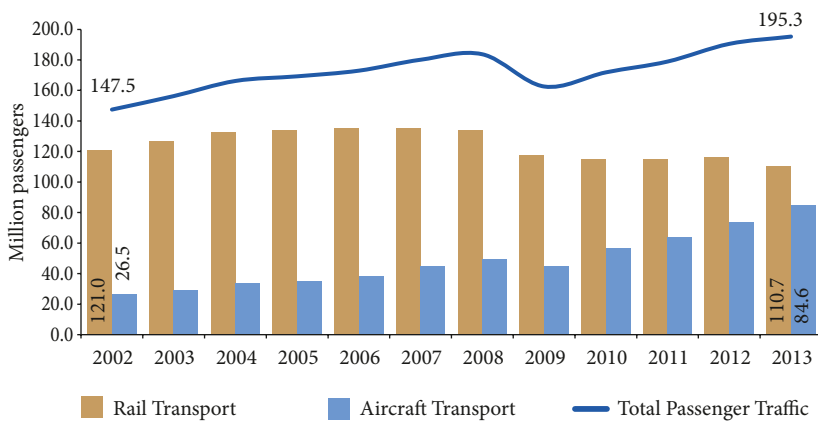


Fig. 1. Long Distance Traffic, Comparison between Rail and Aircraft Service

lounge cars on some routes was initiated in order to offer attractive deals to passengers. Under this system, rather than offering a flat rate, the price of a ticket is calculated based on multiple factors. These include the level of train occupancy, seasonal demand, time of departure and arrival, level of competition with other means of transport for a given route, and the time of ticket purchase.

FPC is also undertaking a programme of rolling stock renewal, including on its Moscow - Adler services, where double-deck sleeper coaches

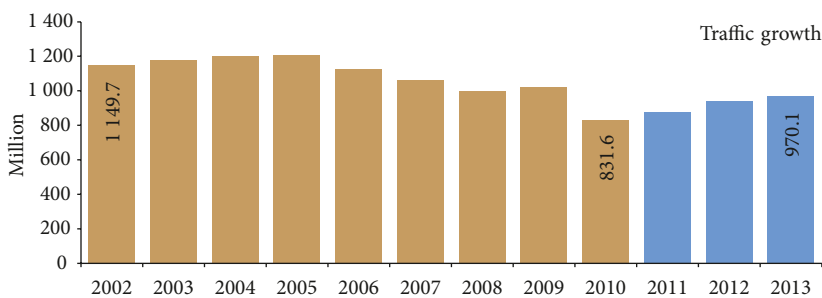


Fig. 2. Evolution of Suburban Passenger Service

Infrastructure

With over 86,000km of lines, Russia currently has the world's third largest railway network, behind only the United States with around 194,000km and China with more than 100,000km.

designed to increase comfort for passengers, entered service on October 30 2013.

New modern rolling stock is also in use on Russia's Sapsan and Allegro high-speed services, while a new Lastochka (Swallow) EMU entered service in 2013. Lastochka trains were used for passenger service during the Sochi Olympics in 2014 and the Summer University Games held in Kazan in 2013, and since January 2013 have been operating on the following routes: Saint Petersburg - Chudovo - Novgorod and Saint Petersburg - Chudovo - Bologoye.

While long-distance services have suffered in the past few years, suburban traffic is increasing with these services carrying 970.1 million passengers in 2013, a 3% increase over 2012 (see Figure 2).

This overall growth is underpinned by dramatic increases in the Moscow region, with traffic elsewhere actually in decline. A number of projects are now underway to improve the level of service in and around Moscow to meet this demand. Specifically, upgrades to Moscow's Small Ring railway will allow the adoption of five minute headways on services as well as improve connections with the metro network and land transport. In addition, enhanced passenger services to Yaroslavl, Gorky station in Nizhny Novgorod, Kursk, Pavelets and Kazan will soon be offered with new stations and bridges included as part of the renovation process.

However, in all other regions of the country the level of available suburban and regional electric services is falling considerably due to the impact of a debt crisis on these operations. In January 2014, 144 suburban services were cut back in 26 regions, forcing many passengers to identify alternative means of transport. This has consequently boosted road transport, the primary competitor to rail, as well as aviation for long-distance journeys.

Russia's main line track³ amounts to 124,000km, with almost half of lines electrified, and the length of the so called "velvet tracks"⁴ exceeding 74,000km. Double-tracked and multiple-tracked lines account for 37,000km, or 43% of the total.

³ Main line mileage is estimated as a sum of all main line tracks (first, second, third tracks, etc.)

⁴ 'Velvet track' describes rails with a distance between the rail joints which is far in excess of the manufactured length of a rail (25 meters).

In the first half of 2013, 5,018km of track was repaired as part of an annual maintenance plan comprising more than 10,000km of track and the rehabilitation of over 3,500 points.

RZD's network currently suffers from bottlenecks at several locations where the load exceeds the maximum traffic capacity⁵. The primary factors in the emergence of these bottlenecks are:

- significant growth of traffic on some lines as a consequence of increases in production and consumption, and because of the changing geography of freight routes,
- under-maintained and under-developed infrastructure as a result of funding shortfalls,
- poor management of empty and loaded private freight wagons, and
- uncontrolled wagon fleet expansion.

Furthermore, a lack of sufficient financing for infrastructure development and maintenance means that RZD's infrastructure is failing to keep pace with the desired rate of freight volume and

wagon fleet growth, which is placing greater strain on the network.

At the start of 2013 Russia had approximately 8,100km of restricted capacity lines, or 9.5% of the total length of its network. In addition "bottlenecks" have increased by more than 40% since 2010. Limited capacity lines are primarily located in the east of RZD's network, specifically on the Baikal-Amur Mainline.

As a result of these issues, in April 2013 the government released Roubles 60bn RUR to RZD from the Federal Treasury to implement railway infrastructure development projects in its Eastern region.

RZD is planning to build 640km of additional main line track, as well as rehabilitate and add new point systems, and restore 48 stations and other facilities.

It is estimated that the total project, which is expected to cost Roubles 562bn, will increase freight traffic by 55 million tonnes per year compared with 2012.

Conclusions


Over the past few years the competitiveness of freight and passenger railway transport in Russia has declined.

With RZD lacking the financial capacity to develop the required railway infrastructure, a misalignment between infrastructure development rate and growth of freight volumes has emerged. This financing shortfall has also had an effect on rail's competitiveness resulting in a shift of freight and passengers to other modes.

In order to retain existing and attract clients and passengers back to its services, RZD needs to continue to pursue efforts to optimise its working practices in order to enhance its competitiveness.

Some efforts have been already launched, including the development of new logistic services, increasing firm-time slots available for railfreight traffic that increase reliability, as well as the intro-

duction of high-speed and improved passenger services on some routes. Moreover, the eastern region of RZD's network is set to benefit from a Roubles 562bn development programme, with Roubles 260bn of this funding provided by central government. These projects will significantly improve traffic capacity which in turn should correlate to additional freight traffic volumes.

Moreover, work to increase the attractiveness of the Trans-Siberian Railway to the extent that it becomes the route of choice for freight traffic between Asia and Europe will also attract additional freight volumes, and revenue, to the network. However, these efforts need to be sustained because without the balanced and continuing development of rail transport through adequate development programmes, freight and passenger traffic will continue to leave Russia's railway network. 

⁵ This is defined as having traffic utilisation of 85% for single-track lines, 87% for lines with sections of double track, 91% for double-track lines, and 100% for receiving-and-departure tracks and at stations.

The future of Russian Railway Industry



Vladimir Savchuk,
Head of Rail Research Division,
Institute of Natural Monopolies
Research (IPEM)



Igor Skok,
Senior Analyst of Railway Industry
Research Department, IPEM

As the Russian and global economies continue to recover from the 2008 global economic crisis, Russia's railway industry has similarly entered a phase of rehabilitation and renewal. Various measures are now underway to refurbish and renew the country's rolling stock fleet with the latest state-of-the-art solutions, while a need to answer the increasing demands of service users, as well as the desire to develop competitive domestic products, are all spurring the growth of a revitalised domestic railway sector. However, while the measures taken have enabled some sectors and company's to return to pre-crisis output levels, many companies are struggling to match previous levels of growth.

The railway industry sector currently accounts for 0.22% of GDP and 0.64% of industrial output. The industry's leading sectors are freight wagon production, which accounts for 25%, rolling stock maintenance and repair services

(27%), and locomotive manufacturing (16%) (see Figure 1).

From 2013 to 2020, and in the long-term up to 2030, the development of the various railway industry subsectors will clearly depend on the Russian government's policies to support the industry and the investment and development plans of the industry's major customers. Order variations among the different sectors are already apparent.

For example, Russian Railways' (RZD) rolling stock and locomotive renewal plans are spurring an increase in main line and shunting locomotive production, while the need to replace various industrial companies' (PPZhT¹) life-expired locomotive fleets, which include shunting and short-distance locomotives, a significant proportion of which are 40-50-years-old, is expected to stimulate further demand.

However, developments in the passenger coach sector are less certain. Again manufactur-

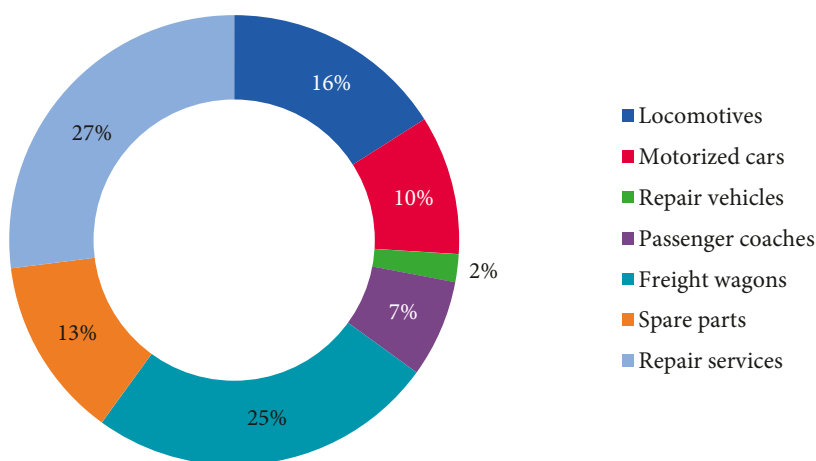


Fig. 1. Railway Industry Breakdown in 2014, on shipped value basis

¹ PPZhT – means a standalone transportation unit, or a transportation department of a plant, mine, factory, power station or other industrial site, the purpose of which is to transport industrial goods (products, materials, wastes, etc) from between industrial sites, or, more typically, from industrial facilities to an RZD station RZD .

ers here are reliant on the procurement policies of the major customers, RZD, and its long-distance main line passenger subsidiary Federal Passenger Company (FPC). It remains uncertain at this stage whether the current period of stagnation will ensue in the next few years, or an increase in orders will allow a return to pre-crisis levels of production.

The short-term outlook for freight wagon production is no more optimistic. With an overstocked market, a significant fall in demand for freight wagons is expected in 2013 and 2014. And while a revival is expected in general from 2015 to 2030, this depends again on state policies regarding freight wagon fleet renewal and the desire to switch to a new generation of rolling stock.

Locomotive Production

RZD remains Russia's primary main line locomotive customer. Russia currently has the world's third largest locomotive fleet behind only the United States² and China. As of January 1 2012, RZD's rolling stock fleet amounted to 20,500 locomotives of which 10,200 are electric and 10,300 diesel locomotives. The fleet comprises 11,500 freight locomotives, 6,000 shunters, 3,000 passenger locomotives, and 50 dual passenger and freight locomotives.

The average age of a Russian locomotive is 27.6 years, with electric locomotive now on average 28.6-years-old of a standard service life of 35 years, and diesel locomotives 26.5 years of a 32-year service life. Locomotives in operation for more than 40 years represent approximately 10.1% of the overall fleet.

With many local railways still using old Soviet locomotives such as VL80, VL10, 2TE10, there

is a critical shortage of up-to-date main line DC locomotives, main line freight diesel locomotives, dual voltage locomotives and asynchronous locomotives.

As a result RZD is expected to purchase 700-800 new locomotives per year to bridge this gap, and has announced plans to purchase 4684 new locomotives between 2012 and 2020 as part of a major investment programme. It also plans to refurbish 6600 existing units.

The freight and passenger transport requirements for RZD's locomotive fleet from today up to 2030 are shown in Table 1.

In 2013 RZD's new rolling stock financing policy underwent a major turn-around. Investment exceeded Roubles 90bn, almost 1.5 times the investment in 2012. In total RZD purchased 803 locomotives compared with 532 in 2012 and from

Table 1. Requisite Locomotive Fleet until 2030, in units

Locomotive type	Conservative scenario			Innovative scenario		
	2015	2020	2030	2015	2020	2030
Electric freight locomotives	7,245	7,618	7,799	7,706	8,613	8,806
DC	3,333	3,428	3,471	3,545	3,876	3,919
AC	3,912	4,190	4,328	4,161	4,737	4,887
Electric passenger locomotives	2,212	1,998	1,630	2,263	2,341	2,681
DC	911	785	629	932	916	1,035
AC	1,155	1,041	857	1,180	1,219	1,410
Dual voltage	146	172	144	151	206	236
Diesel freight locomotives	2,824	2,934	2,975	3,122	3,423	3,446
Diesel passenger locomotives	568	512	416	582	606	689
Diesel shunting locomotives	5,371	5,590	5,830	5,732	6,088	6,335

Source: Strategy of Transport Industry Development of Russia until 2030, as per information of The Institute of Natural Monopolies Research (IPEM)

² Class 1 Railroads

³ Innovative means advanced rolling stock product, which design integrates new never used before in Russia parts and engineering solutions.

2014 through 2016 the company is planning to buy an additional 1,529 units.

At the same time, RZD is focusing on introducing innovative³ high-power locomotives as a means to introduce heavier freight trains on its network.

Among the other innovative solutions that RZD is exploring is the use of gas-powered units. Sinara Transport Machines will begin production of a natural gas locomotive at its plant in Lyudinovsky in 2014 and RZD is expected to introduce

up to 40 new gas-powered units up to 2020. These will be primarily used in areas with active natural gas production where gas liquefaction units are readily available.

In November 2011, Ural Locomotives began development of 2ES7, a new AC freight locomotive, the prototype of which was exhibited during the EXPO 1520 International Trade Fair in September 2013. The new locomotive, which is Ural Locomotives' first AC product, has an 8.4MW output and can operate at 120km/h.

Freight Car Production

As of January 1, 2014 Russia's complete rolling stock fleet comprises 1,206,500 freight wagons. The primary freight wagon type is gondola wagons, which represent 45.8% of the total wagon fleet (see Figure 2).

The rapid expansion of Russia's overall freight wagon fleet was instigated by the adoption of Schedule 10-01 "Rates for Cargo Transportations and Infrastructure Services Performed by Russian Railroads" in 2003, which attracted private investment in Russia's railfreight sector. The Federal Tariff Service of Russia's subsequent decision to introduce a distance-based tariff indexation for private owned freight vehicles in 2007 resulted in rapid growth in competition among rail freight wagon operators to attract business, particularly for the transport of bulk goods using gondola wagons.

As a result the network's overall fleet size has increased substantially, while its average age has fallen gradually since 2003 and reached 15.3

service years in 2012 (see Figure 3). However, some wagon types, particularly gondola and tank wagons have been replaced at a faster rate, while less demand has existed to replace the special-purpose freight wagon fleet and refrigerated wagons.

Innovative freight wagons, manufactured by Uralvagonzavod, Tikhvin and Promtraktor-Vagon, which offer advanced performance, began to enter the Russian market in 2008. The wagons adopted thus far include class 19-9870 and 19-9838-01 hopper cars, class 15-195, 15-565 and 15-566 tank cars and class 12-196-01, 12-9869, 15-9853 and 12-9788-01 gondola cars.

The advantages of these rolling stock over conventional solutions include:

- enhanced carrying capacity and lower empty weight,
- increased repair intervals,
- higher top speeds for loaded and empty wagons,
- decreased impact on railway infrastructure.

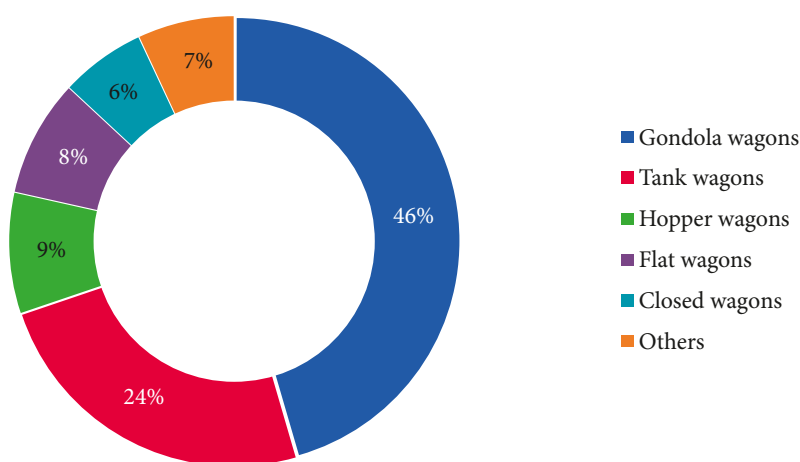


Fig. 2. Russian Freight Wagon Fleet Breakdown, as of January 1, 2014

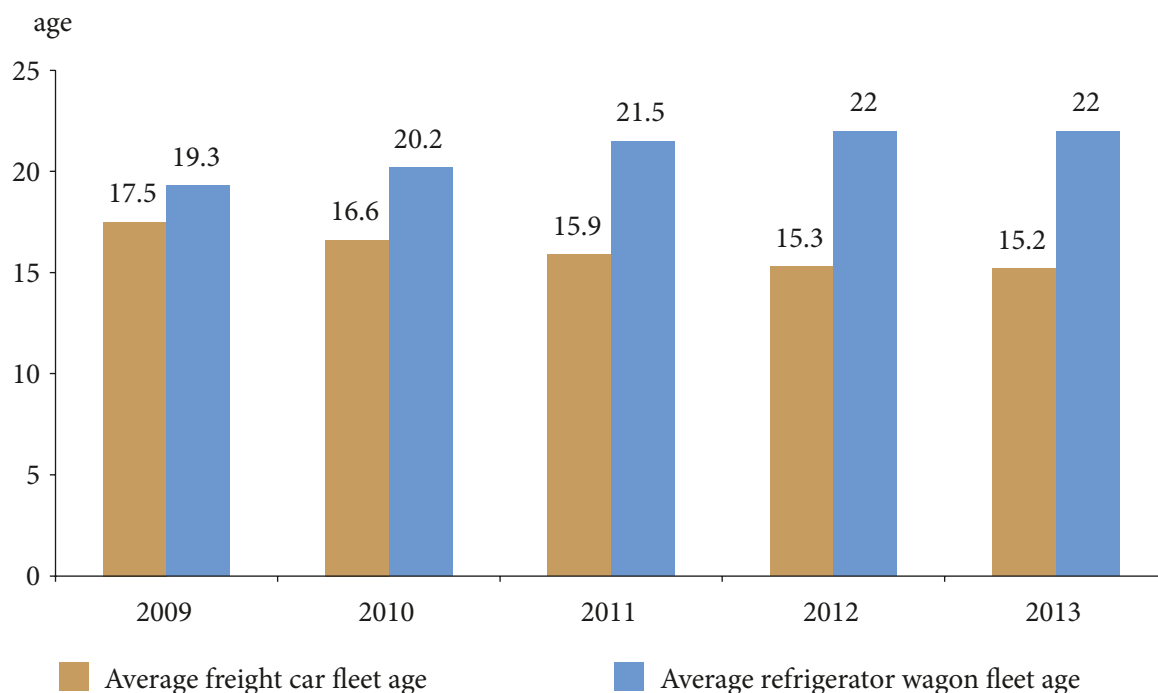


Fig. 3. Average service life of Russia's freight wagon fleet in 2009–2013

To meet demand for these and conventional wagon types, Russian wagon manufacturers have ramped up production levels. In 2012 71,700 wagons were manufactured in Russia compared with 62,700 wagons in 2011, representing 14.4% output increase. Moreover, production in 2011 through the first half of 2012 was actually restricted by the limited capacity in the manufacturing process to cast wagons rather than demand from customers.

However, due to a current surplus of freight rolling stock, the industry experienced a downturn in demand for freight wagons in 2013. Total output amounted to 60,500 wagons, a 15.5% drop versus 2012 levels, and this downward trend is expected to continue in 2014.

It is worth noting that the freight wagon market's future prospects are tied to several key factors. The proposed introduction of a ban on extending the service life of freight wagons could potentially reverse the downward trend by requiring fleet owners to purchase new rolling stock sooner than they might have done so. There are currently more than 260,000 wagons in service that have exceeded the factory-specified service life. These wagons have lower operational performance, are more likely to cause track damage which increases costs to RZD, and require special care during maintenance and repair. Writing-off around 50,000 of these wagons annually would encourage the purchase of a sufficient quantity of new freight wagons to rejuvenate the overall fleet and market.

Passenger Cars Production

EMU Cars

Russia is currently experiencing a decline in timetabled suburban and regional railway services. As a result, passenger vehicle manufacturers are reducing their output accordingly, in particular the production of EMUs. While some operators are replacing outdated EMUs as required, most notably in Moscow which is expected to receive 39 new EMUs in 2014, the overall market is declining at an

alarming rate. The Figure 4 shows recent Russian EMU market trends, with overall EMU production in decline since 2008 with 275 cars produced in 2013, which is just 33% of 2008 output.

The current overall suburban EMU fleet consists of 13,690 cars. However, with 1000 EMU cars set to be written off in 2013–2015, followed by 4000 more between 2016 and 2020, at current purchase volumes, suburban passenger operating companies (PPC⁴) could soon be in a position

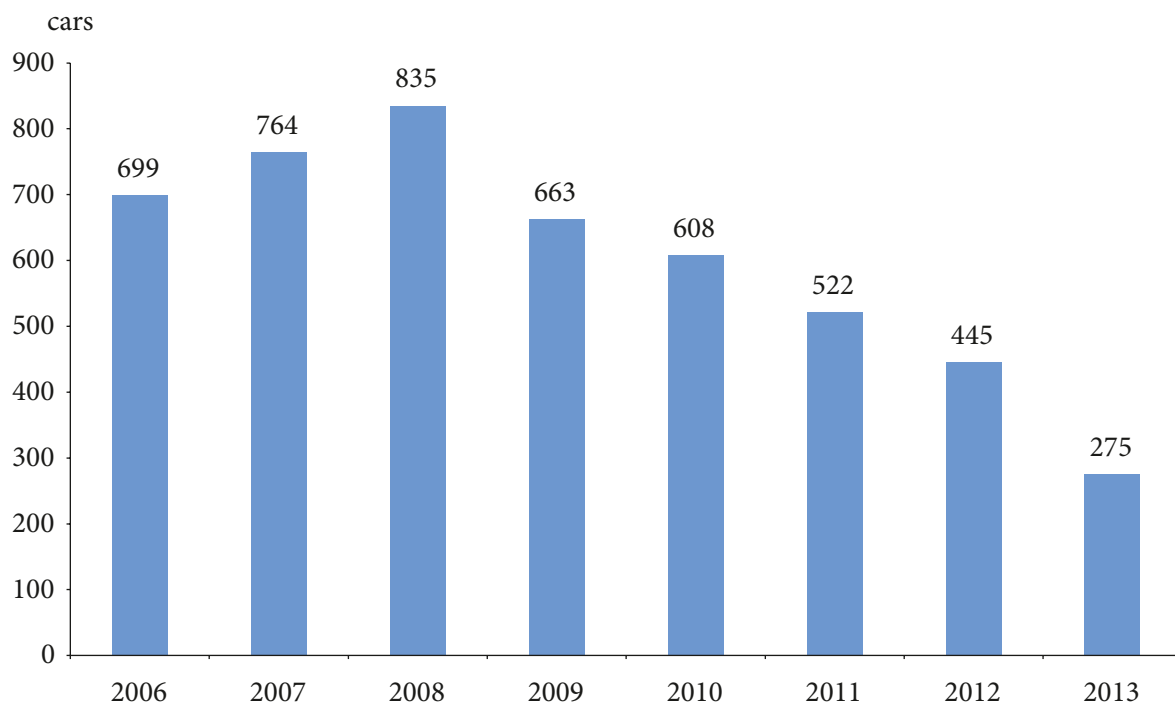


Fig. 4. Historical Movement of EMU output in 2006–2013

where they are unable to cover regional passenger services due to a severe fleet shortage. In addition, if this trend continues, local EMU manufacturers could face bankruptcy which would lead to the de-industrialization of this sector in Russia.

To reverse this trend, PPCs and regional governments should establish a long-term vision for orders to substitute the recently-cancelled centralised order system that was led by RZD. This new system would guarantee orders for the manufacturers of around 800-900 EMU cars per year, helping to sustain this critical manufacturing sector.

HS and VHS Rolling Stock

RZD and Siemens signed an initial contract for the delivery of eight Sapsan high-speed trains that would be manufactured at Siemens' plant in Krefeld, Germany in 2006. This was followed by an order for another eight 10-car trains which were delivered in time for the launch of Moscow - Nizhny Novgorod services.

Locomotive-Hauled Passenger Coaches

Like suburban services, long distance passenger transport is currently experiencing a decline

in Russia which is affecting passenger coach purchases and production volumes. In 2008, passenger coach production accounted for 13.1% of the total rail vehicle manufacturing industry, but this has fallen to 7% in 2013. While Tver Carriage Works (TVZ), a major manufacturer of long-distance passenger coaches, delivered 50 new double-deck coaches to Russian customers in 2013, only 507 coaches were produced in total during the year across the sector, which represents a decline of more than 150% since a record 1282 coaches were manufactured in 2008.

This decline can be attributed to the current difficult financial situation of FPC, Russia's primary customer for unpowered passenger coaches with a 90% market share. The company is currently reporting substantial operational losses and is relying on government subsidies to scrape by. However, these subsidies are far from sufficient to maintain its desired level of operation. As a result, FPC has cut back its operating fleet, which has resulted in reduced purchases and a consequential decline in passenger coach production.

The impact on the industry is substantial. In 2014 Tver Carriage Works will produce only 213 coaches compared with 400 in 2013 at facilities

⁴ PPC is defined as a company providing passenger suburban transportation services for distances up to 200 km using both own and leased trains.

with capacity to produce 1,200 vehicles. These orders do not even cover the plant's production expenses. As a result Tver will partially cease operations during the year which will equate to four months of downtime for employees. Moreover, between February and June the plant is switching to a four-day working week, and is expected to cut a significant number of jobs by the end of the year, with 630, or 8% of total staff, expected to be made redundant.

Light rail vehicles (LRVs)

The situation for LRV manufacturers is no more optimistic, with no manufacturer yet returning to pre-crisis output levels. However, some upward trends in production were observed in 2013 (see Figure 5) as local manufacturers invested in the production of high-capacity low floor trams. Nevertheless, existing manufacturing capacity is not sufficient to meet similar rises in demand in the next few years.

Whether this increase is a new trend remains to be seen, particularly given the fact that in recent years the number of trams operating on urban railway networks in Russia has fallen significantly: 8,600 trams were in operation at the end of 2011 compared with 12,100 in 2000, a fall

of 29%. In this context, annual ridership on urban tram services in Russia has declined by more than 3.5 times from 25.1 to 6.4 billion passenger-km since 2000.

The fall in overall tram fleet size is accompanied by an increase in average vehicle age. More than 60% of the trams in service at the end of 2011 have been operational for 20 years or more compared with 13% in 2000.

With orders for tram products scarce, as is the case for EMU and coach production, the result is a fall in manufacturing capacity, and a corresponding failure by companies to invest in new innovations and developments. Jobs have consequently been cut and some facilities shut down. And without a turnaround, it is likely that local players will exit this market segment completely in the coming years.

Metro Cars

Metro cars are the only type of motorized multiple unit train that is currently experiencing an increase in production. This is primarily the result of Moscow Metro's 2012–2020 Development Programme which encompasses the construction of over 150km of new metro lines, at least 70 metro stations, and the purchase of more than

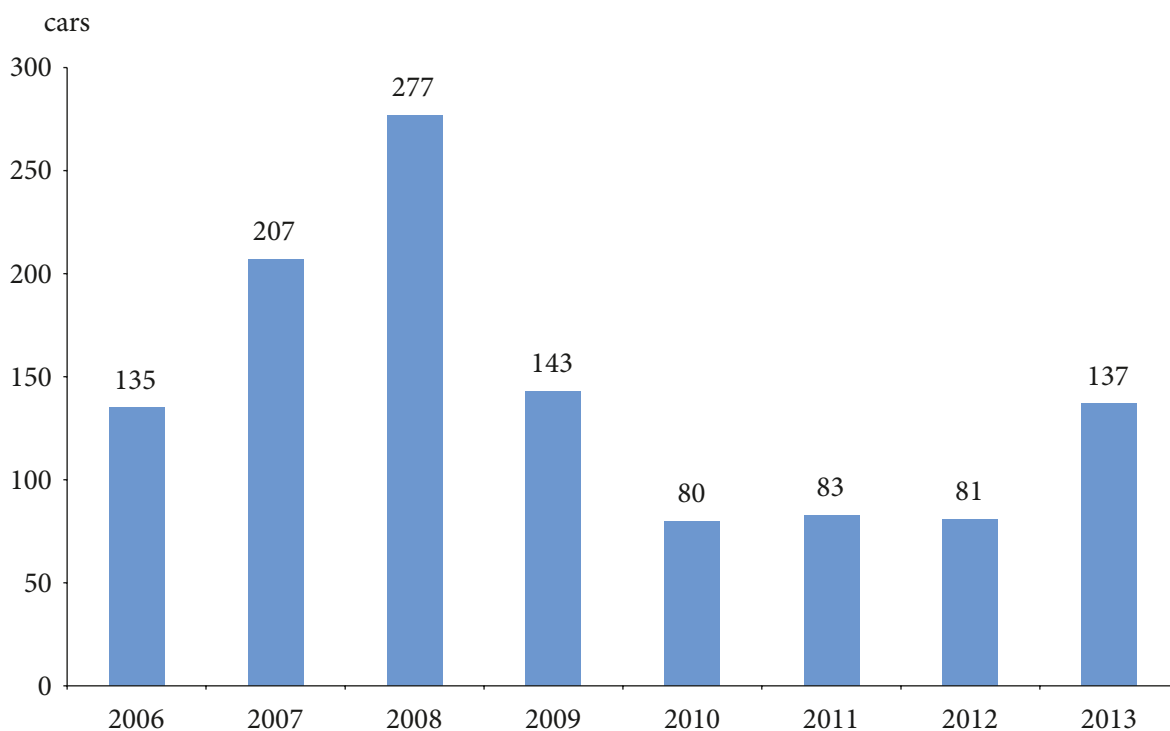


Fig. 5. Tramcars Production over 2006–2013



Fig. 6. Metro Cars Production during 2006–2013

3,000 metro cars. Metro car production figures for 2006–2013 are shown in Figure 6.


Local manufacturers have sufficient capacity to meet demand for metro vehicles in the Russian market. However, while these companies have demon-

strated the competence to compete and export their products to international markets in the past, they are increasingly facing competition from international players that are being encouraged to enter the Russian market through tender-based purchasing.

Conclusions

Following the collapse of the Soviet Union over 20 years ago and the loss of some manufacturing facilities, Russia has pursued a policy to develop its railway vehicle manufacturing capacity to satisfy the increasing and changing requirements of its domestic market. As a result the manufacturing facilities available today are capable of covering local customers' potential needs for state-of-the-art rolling stock products. However, at present demand is struggling to sustain this manufacturing capacity in some areas, most notably certain passenger vehicle segments, despite the obvious need to replace life-expired equipment.

The Strategy of Transport Industry Development in Russia up to 2030 was updated in 2013 by IPEM in liaison with the Ministry of Industry and Trade of the Russian Federation. This strategy is intended to address the systematic problems facing transport manufacturing and engineering in Russia and the latest update recommends increasing state support in order to secure the future of the sector.

Without taking such measures, as current trends already indicate, the report argues that it will not be possible to achieve further sustainable development and improve the competitiveness of Russia's rail transport sector in both domestic and international markets. 

About new railway technical regulation system in the Custom Union



Vladimir Matyushin,

Dr.-Ing., Prof. Dr., Vice President of Union of Industries of Railway Equipment (UIRE)

On August 2, 2014 uniform technical regulations for the operation of railway vehicles came into effect in the Custom Union member-states of Belarus, Kazakhstan, and Russia. The specific regulations are:

- 001/2011 rolling stock safety,
- 002/2011 high speed railway safety, and
- 003/2011 railway infrastructure safety.

Under the regulation system, a certificate or declaration of compliance is issued by an authorised agency, eliminating the need for additional inspections in each of the member states. The system is supported through a common register of issued and filed certificates and declarations as well as a shared technical regulation database.

The Technical Regulation of the Custom Union and the Common Free Market Zone is based on the following principles:

- shared essential requirements set out in the technical regulations
- shared standards which increase conformity while integrating safety requirements and inspection methods, and
- a shared verification mechanism, and a uniform product authorisation mark.

Moreover, these principles are used as the foundation for the respective assessment agencies' accreditation rules by defining their responsibility for monitoring performance, and establishing market regulation and assessment procedures for product supervision.

The requirements for railway rolling stock technical regulations cover a wide-range of technically sophisticated products. As a result the decision was taken to include regulations outlining key safety requirements, established safety standards and control methods as part of the universal standards regime, with these standards duly validated by the Custom Union Board.

As a result regulations outlining compliance with the technical regulations for every product are now available. These are deemed sufficient to verify the safety requirements for a specific product if all of the safety-related requirements are confirmed.

The Technical Regulation Act states that an applicant providing proof of a product's compliance with the standards outlined in the regulations are free from in-service safety demonstrations and risk estimations. As a result proof of the product's conformity is provided at the document development phase, which is essential in developing and enforcing standards that meet the regulations. At the same time, attention was placed on simplifying the mandatory requirements for a product, which would reduce the homologation period but continue to guarantee safe operation in all conditions.

Consequently, the following requirements were considered:

- a clear definition and validation of the mandatory safety-related requirements for every standard, and
- a list of standard requirements which guarantee safety for more sophisticated products.

Over the three-year period of transition to the new technical regulations, about 300 documents, and 15 bodies of infrastructure-related guidelines were developed, along with specific standards stating the safety requirements for controlled products and inspection methods.

The Custom Union Board will validate this list of standards, which includes a number of items which provide the user with reassurance that they meet the necessary regulations.

The technical regulations also specify that the documents certifying a manufacturer's compliance with the operating and maintenance regulations are available before the issuance decision. The regulatory authorities subsequently follow

up the execution of this documentation at the point when the product enters service.

Homologation in the Custom Union member-states is carried out by local accredited certification authorities and testing centres. As a result an agreement for mutual recognition of certification agencies and testing centres is in place to ensure that certification agencies active throughout the Custom Union are competent. A certification process similar to the international ISO/IEC 17000 standards is also in place, which will be enhanced following the adoption of the modified ISO/IEC 17025 and 17065 standards this year. These standards will assess the competence of certification and testing agencies which offer their services to the railway market, and take into account the unique features of the industry, the technical complexity of products, and the high level of responsibility required to operate rolling stock.

The following agreements are currently under negotiation between the members of the Custom Union:

- the mutual audit agreement,
- an agreement on a common vocational training and assessment system for certification experts and testing personnel, and
- an agreement outlining the procedures for handling claims and disputes against certification authorities and test centres.

All certification agencies and test centres accredited in each state are included in the Custom Union's register. As a result each national accreditation authority lists the organisations, test centres and laboratories registered as a legal entity under local laws which have an impeccable record of approving products that have not subsequently breached the regulations, with only these entities permitted to conduct compliance assessments in the union.

The Railway Technical Regulations specify that certification is only carried out by registered certification authorities under the agreement made with an applicant. For the purposes of certification, an applicant must be a legal entity (including an individual working in the capacity of a private entrepreneur) registered under the legislation of a Custom Union member-state that manufactures and sells their own products, or those on behalf of a foreign manufacturer under a license within the requirements of the technical regulations and its non-compliance liability.

As a rule, the applicant files an application to domestic certification authorities, while a foreign manufacturer's representative may apply to an

accredited country's authority or the authority in its customer's country. The application should be submitted with the required documents attached, as specified in the technical regulations.


In the case of rolling stock, a certificate is only issued if all certificates and declarations are available for all components subjected to mandatory compliance assessments as specified in the regulation's appendix.

Following the submission, the certification authority is required to evaluate the quality of the documents, identify the certification scheme, and details of testing conducted within the specified certification process.

Moreover, the certification authority identifies a testing centre or centres from a list included in the Register, and submits a draft service agreement or contract to the applicant.

In cases of homologating innovative or foreign-manufactured products not previously deployed in the Custom Union states, the product may be entirely or partially non-compliant with the standard's requirements. In this situation, the applicant should prepare proposals to modify the safety requirements used as the basis for the assessment process, as well as estimate the risk of operating the product on the Custom Union railway network. The certification authority should then conduct an expert appraisal of the submitted documents and in the case of a positive result, initiate a standards modification process which will, if necessary, alter the inspection and assessment procedures.

Following the adoption of these new regulations there is a strong possibility that the scope of the new regulations may increase, particularly given the continuing development of the 1520mm-gauge network in the CIS as well as in Estonia, Latvia, and Lithuania.

The Eurasian Economic Commission recently adopted an agreement reached between the member-states of the Custom Union which aims to remove the technical barriers preventing trade between the CIS countries outside of the Custom Union. Under the agreement it is possible for these countries to join the Custom Union and to adopt the universal technical regulations at the domestic level. The possibility of integrating these standards beyond the three countries which currently make up the union could eventually result in the adoption of uniform safety requirements for rolling stock products supplied to the entire 1520mm-gauge region, thus substantially enhancing the approvals process and removing the barriers to cross-border operations. 

The Sapsan high-speed train development and acceptance tests procedures

Oleg Nazarov, Dr.-Ing., Deputy General Director, Railway Research Institute of Russian Railways (VNIIZhT JSC)

Dmitry Kiryushin, Dr.-Ing., Chief of Laboratory, VNIIZhT JSC

Boris Khomyakov, Dr.-Ing., Senior Researcher, VNIIZhT JSC

The development of an EMU is a complex process which integrates several stages: the development of the train's technical requirements with due regard to regulatory documents, local rolling stock and existing operations, the integration of tests including field trials, and updates to technical requirements that improve performance.

In an effort to improve and enhance the rolling stock development process, experts from the Railway Research Institute (VNIIZhT) worked in conjunction with Siemens and Deutsche Bahn as well as developers of subassemblies and subsystems to analyse the various phases of development.

National railway authorities in European countries currently follow their own unique and established project management rules when it comes to developing and approving rolling stock. For example, the UK's organisation process incorporates procedures for approval of certain specifications, rolling stock development, testing, acceptance, safety validation and type approval. The key stakeholders are the customer and rolling stock supplier, with seven regulatory and supervisory agencies engaged during the process.

The work management practices required for all companies participating in the process are prescribed in ISO 9001, the IRIS International Quality Management System Standards, IEC 60300, the Dependability Management Standard, and Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) for Railway Applications outlined in IEC 62278.

The lists of documents for mandatory approval and compliance validation procedures are included in Technical Specifications for Interoperability (TSIs) which have EC legislative status. In addition, national statutory documents issued by railway traffic safety authorities are also required.

These established practices all share very similar goals and objectives, with the majority of countries using standard methods, rules, terms and procedures. However, each country applies these in a specific manner and has its own in-house procedures.

As part of the exercise undertaken by VNIIZhT, the validation process for new rolling stock engineering documentation was defined in cooperation with German engineering companies, with particular emphasis on the glossary, technical documents, and test performance methodology. Technical documentation status and name interpretations currently vary between countries. The process helped to put these in order for the first time, with specification requirements, technical design assignment and technical specifications receiving precise definitions and names in German in line with their legal status. The above efforts avoid the risk of translation-related errors at the engineering documentation development stage since the names assigned to each document and procedure are understandable to any German specialist according to the local legal status of the document and procedure (see Figure 1). In addition, detailed bilingual block diagrams of all backup processes were prepared.

These efforts demonstrate that a copy-paste approach for European norms does not work, primarily due to difficulties with the technical compatibility of foreign solutions with Russian 1520mm railway system, and secondly, due to the local legislative environment.

To come to this understanding, dozens of exercises were performed jointly with foreign specialists. These tasks included comparing device requirements, testing procedures, and simulations of machine operations and systems in conditions and with operational loads similar to those found in Russia.

For example, nine types of catenary with various parameters were investigated during research tests, which included compatibility with three

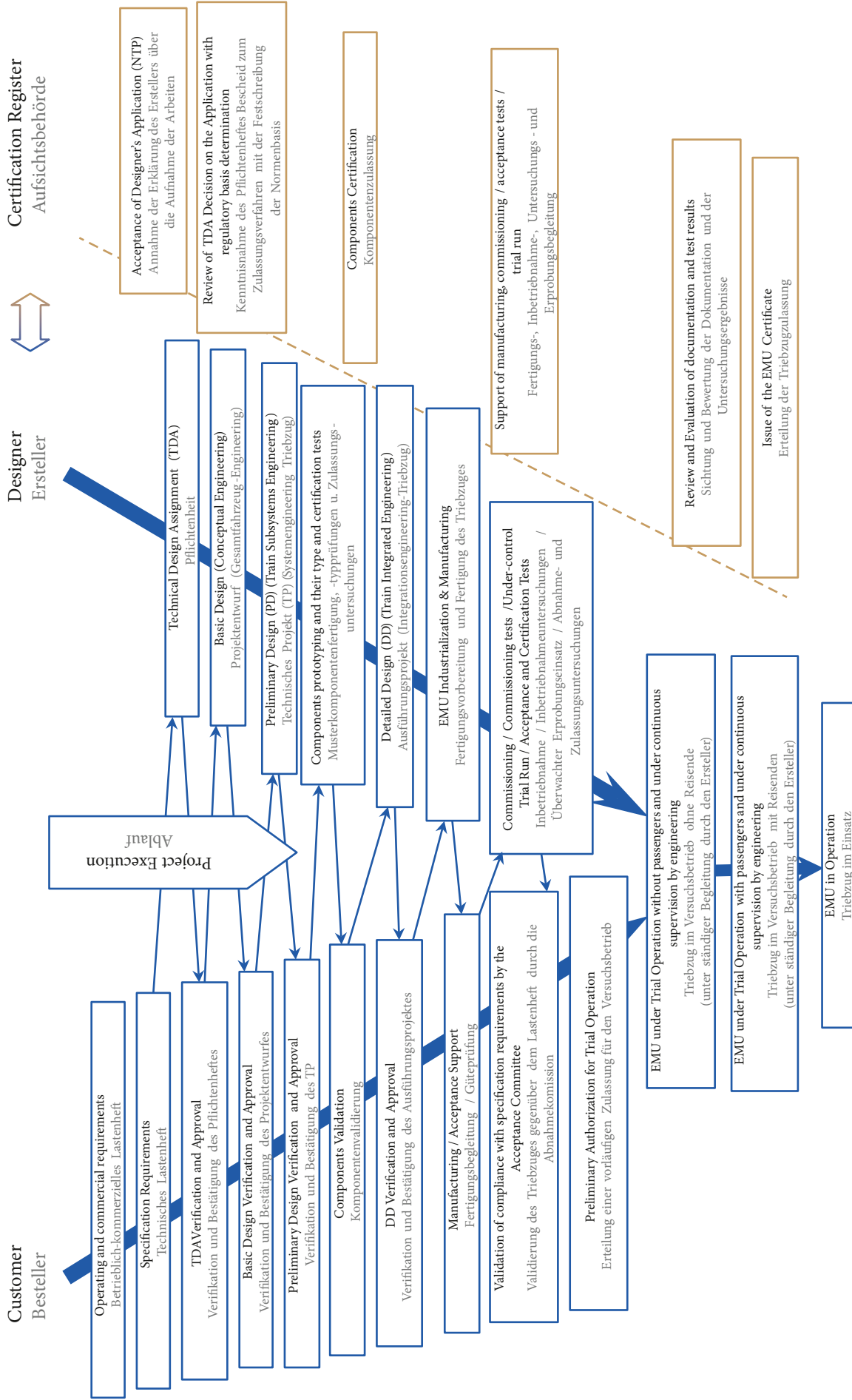


Fig. 1. Prototype building and operation permit process milestones under EN 50126 and Russian OST 32.181 standards

types of pantograph at speeds up to 260km/h. The pantograph subsequently installed on the Sapsan high-speed train was among the units tested. These multi-stage efforts resulted in the selection of a catenary solution¹ that conformed best to the specified operating conditions, which led to recommendations to alter the pantograph's design in order to guarantee reliability in tough winter conditions.

Experts from both countries successfully identified and implemented new project management processes which support integrated projects and enabled the launch of innovative rolling stock solutions for the Russian market. Almost all successful international rolling stock projects are now implemented in line with this procedure (see Figure 2).

The development process identified the need to organise a system of feedback for each project. This element is critical to allow the timely correction of error-bearing or non-optimal engineering solutions, applicable technical norms and specifications. The process must also allow

for the development of new solutions, norms and specifications when required. Critically Russian rolling stock engineering companies must be able to implement the updated norms and standards almost overnight resulting in their timely introduction into products entering service.

Russian Railways' (RZD) interpretation of the new technical requirements reflects the unique circumstances of operating in Russian conditions, particularly the traffic management process, and Russian mentality. This, along with the international experience of the leading manufacturers and operators, resulted in efforts to optimise the cost and quality of a rolling stock product.

One of the principal know-how in requirements definition was the description and using of a various operational modes as a basis. For instance, each scenario during EMU operation was assigned with a corresponding operational mode.

The specified modes are interconnected with each having its own exact condition for rolling stock components and subsystems.

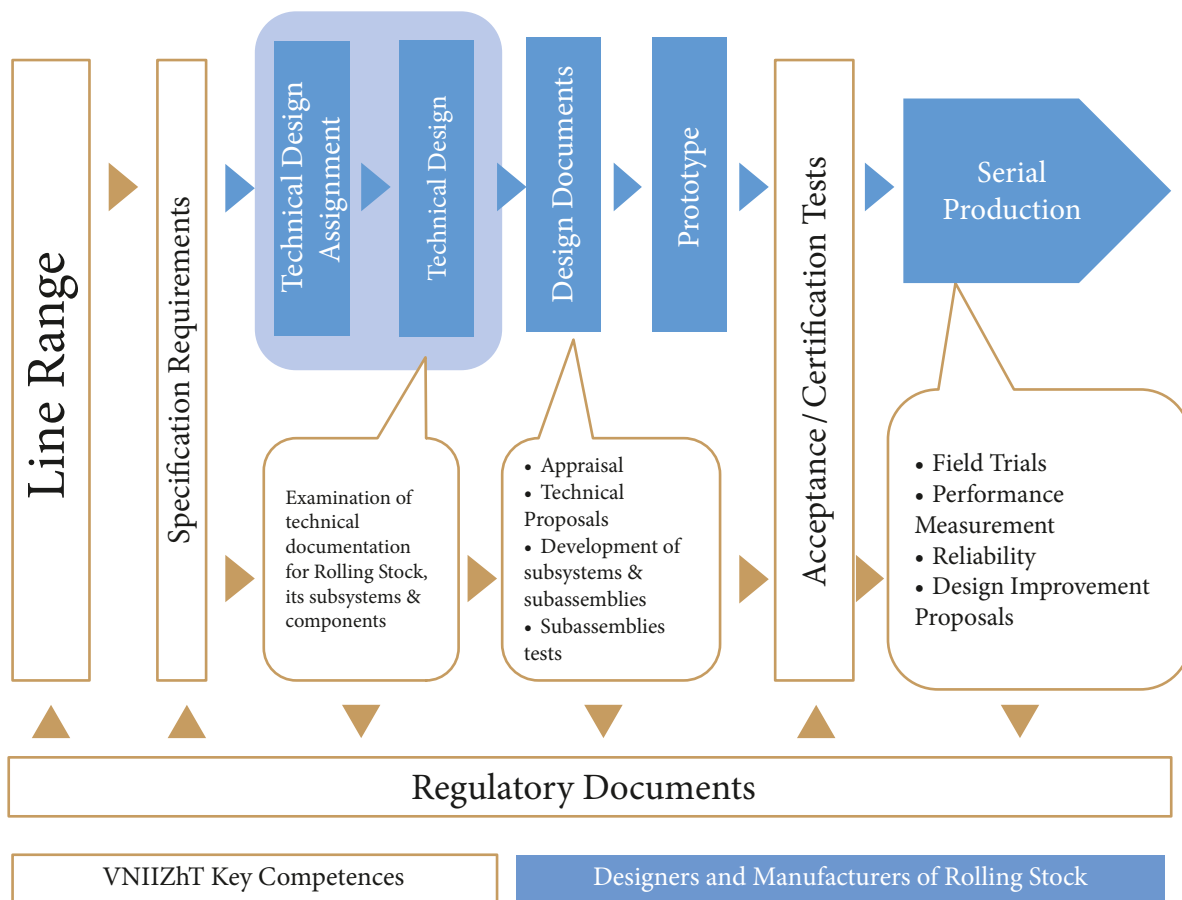


Fig. 2. Interaction with rolling stock designer and manufacturer during product life cycle

The general-to-specific principle is an important element in establishing the technical requirements for rolling stock. This approach is applicable to both the rolling stock as a complete system, and to its components. For example, Figure 3 presents the structure of the technical requirements for electrical equipment enabling to set requirements to internal equipment configuration and its function as a part of the complete system. Furthermore, the rolling stock and its external environment are envisaged as a single functional organisation of different classes (equipment, systems, actions) combined on the similarity basis. From here, the specific classes perform similar functions, are responsible for to the operation of the rolling stock and are intrinsically linked in the common framework, which in turn affect or are affected by the rolling stock's other systems.

With due regard to the goals of modern rolling stock products to offer better performance, high efficiency, enhanced safety and comfort levels, the newly developed technical requirements

imply a commitment to using the advanced solutions from different industrial sectors. This includes aluminium carbodies, up-to-date semiconductor-based traction drive systems, and high performance braking systems, all of which enhance safety during operations. Developers are also challenged to incorporate solutions that meet increased passenger comfort requirements, including modern air conditioning systems, passenger information systems, audio and visual information displays.

As a result, it was particularly important to specify rolling stock reliability, dependability, maintenance, and availability requirements. The validation procedures and availability assessments are possible through reliability indices, which are now part of the specification requirements and are expressed in terms of the failure rate with failures categorised according to their severity. As a result, the customer receives guarantees that following manufacturing and commissioning it will possess complete knowledge

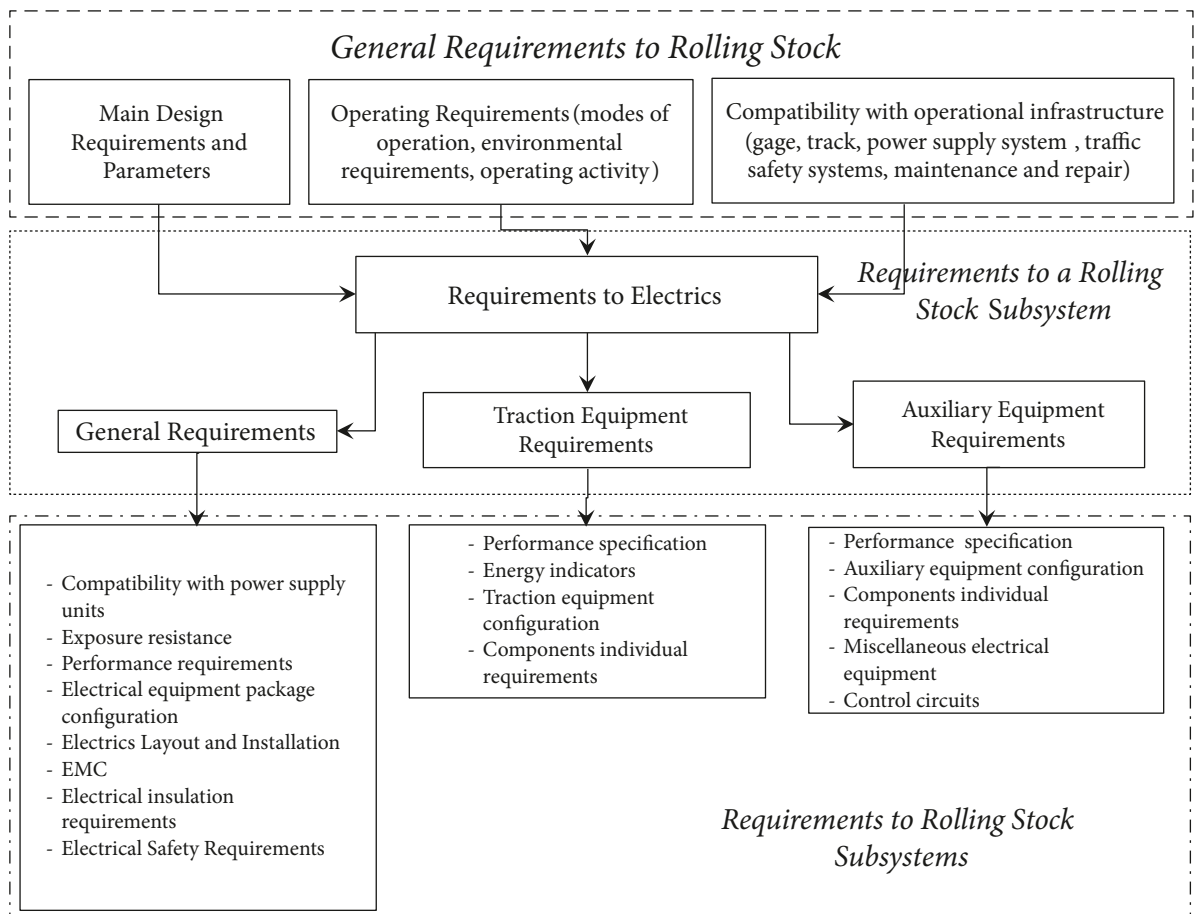


Fig. 3. Structure of Electrical Equipment Technical Requirements

of the product's in-field performance beyond the assurances provided by the manufacturer.

In turn, the validation procedure cannot be performed without diagnostic and recording systems identifying specific failure locations. As a result a train must be equipped with multi-path diagnostic systems, which record the status of specific train equipment, and notify locomotive staff to when specific maintenance is required. These systems ensure both safe and efficient operation and optimise rolling stock maintenance and repair.

The use of diagnostic systems onboard trains requires modifications to depot equipment to maximise their effectiveness. Indeed by consolidating jigs, fixtures and tools there is an opportunity to redefine train maintenance and repair requirements.

A railway's economic performance, competitive position, and the retention and expansion of its transport market share largely depend on its rolling stock's operating expenses over its service life. As a result consideration of the life-cycle cost model is an essential requirement for any rolling stock designer. The model taking into account the product's design features and the anticipated operating and maintenance conditions permitted to optimize to the maximum as early as the conceptual design stage the operating costs over the service life with due regard to allowed to optimise performance while guaranteeing reliability, availability and that the product meets safety requirements. The LCC analysis allowed the customer to select the best technical solution among the proposed ones.

The Technical Design Assignment (TDA) and approval of conceptual design, acceptance of prototypes and certification tests results, as well as supervised operation of the prototype on the Oktybrskaya Railroad are the key factor of project success.

The joint efforts made of the train designers at TDA and the conceptual design approval phases resulted in the adoption of the following design features:

- spring suspension system meets the requirements of existing track characteristics and profiles,
- carbody shells successfully designed for safe operation in a wide range of temperatures, and which take variations in carbody length into consideration,

- an air intake system on the roof of the train which cools traction equipment components but prevents the accumulation of snow which might impact electrical equipment,
- the head car of the high-speed train meets aerodynamic requirements, and allows the driver to operate the train in a standing position as well as providing sufficient space for an assistant driver and a third person to supervise driving when required,
- a system which incorporates protective skirts and protects the underframe equipment against damage from snow, ice and gravel,
- the use of short-stroke compressed air cylinders for pantographs which prevent the pantograph from freezing,
- a high voltage connection which enables simultaneous operation of two 3kV DC pantographs,
- a backup system for DC pantographs in which two pantographs are installed side by side on the same car,
- a dual voltage heating system which offers redundancy and can operate at 3kV DC and 440V AC,
- the use in of ad hoc multi-stage filters which limit traction current harmonics in rail circuits to meet 1520mm EMC requirements,
- radio interference filters which meet Russian safety norms,
- a system which measures energy consumption independently for traction, for regenerative braking, for consumption by auxiliaries and 3kV heating circuits,
- protective sides which provide electrical safety of the pantograph,
- a notification system warning the train crew to prevent the idle cab being accessed by non-authorised persons,
- CLUB-U safety system (or integrated train safety system) which is adapted for operation at speeds of up to 300km/h,
- a SA-3 coupler casing for the head car's coupling,
- an onboard CCTV system and video cameras instead of rear-view mirrors,
- an electric interlocking system which is integrated with the electrical safety system and prevents raising the pantograph and can close the main circuit breaker,
- a ventilation air drying and disinfection system both in passenger cars and the driver's cab.

The EMU's engineering solutions underwent comprehensive acceptance and homologation tests on the Oktyabrskaya Railway, and at VNIIZhT's test facilities in Shcherbinka and Belorechenskaya. Special attention was paid to planning, and to accelerate the process, the tests were carried out on three EMU trains. The test programme, a list of measured values and methods were agreed with the customer and EMU designer.

A very important step in securing the operations permit was trial runs of the Sapsan trains with passengers on the Oktyabrskaya Railway. The purpose of these tests was to evaluate the functional performance of the train's subsystems and components, including in winter conditions, which incorporates the results of acceptance tests results and feedback from the acceptance committee.

Including these trial operations as part of the acceptance process is advantageous both for the customer and designers. Firstly the designers have the opportunity to respond to comments from passengers participating in the tests and modify specific systems for the entire batch of trains. In addition, the information collected during the trial run is essential for the designer to understand what is required during preparation for regular service, as well as indicating what scheduled and un-scheduled repairs might entail.

An action group consisting of representatives from RZD and railway industry research institutes was established during the trial operations to define the test conditions, plan operations and delegate responsibility for recording data from operation and maintenance procedures. Recording data helped to identify specific costs and engineering parameters for train operation, as well as maintenance and repair procedures that would take place at the depot.

The following works were carried during the supervised operation of Sapsan trains:


- an assessment of the impact of ambient negative temperatures on braking distance and wheel slide,

- a determination of the wear rate of pantograph's collecting elements and catenary to forecast service life,
- a functional check of HV circuits via the main circuit breakers before operation on ac sections,
- an assessment of battery charge including the impact of incomplete charge on battery capacity,
- an outline of hygiene and sanitation rules, and
- an evaluation of the safety and communications device performance.

The line trials detected, among other things, a non-optimal match between wheel tread and rail surface profiles, resulting in high contact pressure and wheel tread surface deformation.

This problem, along with the others specified above, was resolved, and Sapsan trains entered service on Oktyabrskaya, Moskovskaya and Gorkovskaya Railways.

Strong communication between stakeholders was established from the very beginning of the project and was essential in its success. Any decision made was based on a thorough study of the complete aspects of the engineering system and its interoperability rather than the recommendations of the design companies. The significant research and testing efforts made in the early stages of the project helped to eliminate initial misunderstandings between local and foreign specialists and overcome the significant variations that exist between European and Russian standards.

Nearly five years since Sapsan was introduced into service, and it is clear that Russia's inaugural high-speed train project has emerged as a commercial and technical success. Many companies and organisations, including international institutions were engaged in the project. As a result, RZD and VNIIZhT, in conjunction with NIIAS¹, VNIIZhG² and VNIKTI³, successfully fulfilled their roles as system integrators and the drafters of regulatory documents. Each party also expanded its knowledge and understanding of applying new solutions in challenging conditions and ensuring compatibility through work at major test centres. 

¹ R&D Institute of Informatization and Automation on Railway Transport

² Russian R&D Institute of Railway Hygiene

³ Russian Institute of Rolling Stock Research, Design and Technology

AVAILABLE IN THE PRINTED VERSION

The Experience of Launching Sapsan and Allegro high-speed trains in Russia



Alexandr Nazarov,
Head of Technical Policy Department, Russian Railways JSC

It is impossible to imagine railways in the 21st century without high-speed traffic. Russia has made good progress since it launched its inaugural high-speed project, the deployment of high-speed Sapsan trains between Saint Petersburg, Moscow and Nizhniy Novgorod in 2009 and 2010, which reduced the journey times between the cities significantly. This was subsequently followed by the introduction of the Allegro high-speed service between Saint Petersburg and Helsinki in December 2010. With high occupancy rates on these services, more and more passengers are reaping the benefits of the advanced method of travel, which boasts high-levels of service and reasonable fares.

The development of high-speed and very high-speed railway services is contributing to the evolution of transport by primarily enhancing the speed of travel which reduces journey times, but also improves comfort for passengers by offering a safe and reliable means of travel. The nature of high-speed and very high-speed railway operations, which use high-capacity rolling stock,

can reduce the demands on an operator's rolling stock fleet, and also support and encourage progress in the fields of science and engineering. This has the potential to benefit the technical know-how of the domestic industry with local factories in a position to secure orders for the production of advanced technologies required by the high-speed operation.

Sapsan: A Russian take on an established design

Russian Railways JSC (RZD) selected Siemens as its partner to assist with the introduction of new high-speed EMUs on existing railway infrastructure between Moscow, St Petersburg and Nizhniy Novgorod. Siemens proposed adopting Velaro RUS, a variation of its existing Velaro platform for the trains, which were named Sapsan (Russian for Peregrine Falcon, see Figure 1). A team of German and Russian engineers developed the exact specifications for the train which implemented many solutions not previously used in Siemens' products (see Table 1 and 2).

The apparent benefits of Sapsan over traditional Russian long-distance locomotive-hauled trains are:

- improved ride performance,
- better adhesive coefficient at acceleration, as long as 50% of axles in the vehicle have driving capability,



Fig. 1. The view of Sapsan EMU train

- ability to travel on steep profiles,
- equal weight distribution over the train leads to lower axle load thus reducing the impact on track as well as bogie maintenance. Equal weight distribution also improves ride behaviour and comfort.

Four independent converters fitted to Sapsan offer significant benefits for long-distance operations:

- if one converter fails this does not impact the other converters and the train can still reach its destination with 75% of its maximum tractive effort,
- three-phase asynchronous motors with squirrel-cage rotors ensure high availability and require minimal maintenance,
- with a traction power of 8,000 kW, even a fully loaded train can demonstrate high acceleration and braking performance.

A train communication network (TCN) comprising wire train bus (WTB) and multifunctional vehicle bus (MVB) supports reliable and continuous communication between several traction blocks. The TCN subsystem provides the following additional benefits:

- significant increase in the availability of communication paths,
- costs saving due to the reduced quantity of hardware and installation works, lower weight and LCC costs,
- improved data transparency and better propagation times due to the reduced number of interfaces.

The Velaro’s efficient electrification system, which reduces overall power consumption, was optimised for Sapsan to provide a complete energy

Table 1. Main Specifications

Single voltage mode	3 kV, DC
Dual voltage mode	3 kV DC + 25 kV, 50 Hz AC
Max operating speed	250 km/h, can be upgraded to 330 km/h
Qty of cars	10
Train length over couplers	250.3 m
Total power-to-weight ratio	12.0 kW/ton
Max starting tractive effort	328 kN
Max braking effort, electrical, regenerative	326 kN
Average acceleration to 60 km/h	0.43 m/s ²
Average acceleration to 120 km/h	0.40 m/s ²
Track gauge	1520 mm
Operating ambient temperatures	(-50 °C) -40 °C ... +40 °C
Length of intermediate car body	24,175 mm
Rail-to-floor height	1,360 mm
Platform heights over the rail	1,100 mm; 1,300 mm
Annual mileage	500,000 km
Train weight with passengers	667 tonnes
Service life	30 years

supply system. The chosen configuration incorporates fewer energy conversion steps thus improving the overall system efficiency due to reduced losses of power resulting from fewer conversions. Moreover, a backup principle provides a reliable supply of all auxiliary loads in any operating situation. Indeed when passing through a catenary section insulator, the EMU’s power supply is cut off for a short period of time but , auxiliary loads are

Table 2. Comparison of Sapsan (Velaro Rus) and ICE-3

	Sapsan (Velaro RUS)	ICE-3
Main Parameters		
Production years	2008-2009	2006
Country of origin	Germany	Germany
Manufacturer	Siemens, Siemens Mobility	Siemens, Siemens Mobility
Number of manufactured trains	8	63
Operated in	Russia	Germany
Track gauge	1520 mm	1435 mm
Technical Parameters		
Catenary parameters	3 kV DC, 25 kV 50 Hz AC	15 kV 16 2/3 Hz AC; 25 kV 50 Hz AC, 1.5 kV DC; 3 kV DC
Design speed	250 km/h, can be upgraded to 330 km/h	330 km/h
Number of cars in a train	10	8
Passenger capacity	604	415
Length of head car / length of intermediate car body	25,535 mm/24,175 mm	25,675 mm/24,775 mm
Width	3,265 mm	2,950 mm
Height	4,400 mm	3,890 mm
Carbodyshell	ALU	ALU
Power output	8,000 kW	8,000 kW
Traction motor type	three-phase asynchronous	three-phase asynchronous
Traction motor output	500 kW	500 kW

supplied without any breaks in supply. In addition the train's heating system was upgraded to 3 kV to enable direct supply to heaters from catenary in the event of a power system failure.

Sapsan's mounted SF500 bogies ensure outstanding ride stability and comfort. With deceleration performance more crucial than acceleration, the train is equipped with a braking control system that automatically switches from electric to pneumatic mode when necessary. In addition when the grid is unable to absorb surplus braking energy from the train, the system gradually switches to pneumatic braking. This arrangement provides significant energy savings and reduces mechanical wear.

The requirements for the train were agreed between RZD and Siemens and set forth in the Technical Design Assignment. In parallel, RZD engaged several Russian Research and Development Institutes to participate in engineering efforts and to check whether the design met the desired requirements. As a result, the institutes were closely involved in the train's development.

Sapsan was designed to comply with both European and Russian norms and standards, while certification was required for operation on the Russian network.

With Russia's climactic conditions demanding that trains operate with no decline in performance at temperatures as low as -40°C, some components were winterised. Special low-temperature-resistant materials were developed, which prevented the requirement for additional heating. In addition, in order to protect traction drive components from excessive precipitation experienced during the winter, air intake louvres were incorporated into the roof to allow the flow of cool air and further streams into the protection buffer.

The Russian requirements for electromagnetic compatibility (EMC) are far more stringent than in Europe and these were satisfied by installing numerous interference protecting solutions like filters, and shielding.

Northern Express

Another major Russian high-speed undertaking is the 220km/h international service between St Petersburg and Helsinki which began operations in December 2010 and is operated by VR Group in Finland and RZD in Russia.

In Russia, drivers operating a train for more than three hours are required to have the capability to work in a standing position. The driver's cab in the original Siemens Velaro trains is only 1450mm high and thus only allowed the driver to work from a sitting position. As a result for the Velaro Rus, the cab was redesigned to enable a 190cm tall driver to stand while operating the train. In addition the cab was adapted to accommodate two staff members. Powerful headlights were also installed to improve the visibility of the track ahead.

Due to the different track gauge and its condition in Russia, the Sapsan's bogies were upgraded from their European equivalent, which included the use of wheel profile suitable for high-speed operation.

The train utilises CLUB U (Integrated Locomotive Safety System, Upgraded), the latest Russian railway operating safety system, as well as local telecommunications system. Communication between the driver and the assistant driver is enabled by a three-band communication system operating at traditional Russian frequencies of 2 MHz and 160 MHz as well as at 460 MHz. The train manager's compartment features a dual-band telecommunication system operating at 160 MHz and 460 MHz. Both CLUB U and the train's telecommunication systems are connected to TCMS via a special interface in the lead car which includes a diagnostic function. In addition the lead cars are fitted with a standard Russian CA3 coupler, while the train complies with local standards for carbody and coupler shock resistance. A video surveillance system is also installed inside the passenger coaches and outside of the train.

As a result of engineering efforts that took place during the development of Sapsan, several patent applications were filed in the patent offices of the Russian Federation, Kazakhstan, and Ukraine. Over 60 patents were obtained with the EPO specifying RZD and Siemens as the patentees.

The development of Technical Specifications for the high-speed EMUs in collaboration with VR experts started in 2002. In 2006, RZD and VR Group established Oy Karelian Trains, an equally owned joint venture company, which purchased

the high-speed Allegro trains (see Figure 2) and leased the sets to the line's operators.

The EMU purchasing process was organised as an open international tender award procedure as stipulated under the EU law and the contract was awarded to Alstom in 2007.

The Sm6 EMUs delivered to Oy Karelian Trains are technically derived from the Pendolino Sm3 train operated by VR since 1995. The Finnish model Sm3 was based on the second generation of Pendolino tilting train that was developed in the early 1990s for Italian State Railways (FS). For the Allegro project modifications were made to the train concept to make it suitable for operation in cold climatic conditions and to the specific requirements of Finland's railway infrastructure (see Table 3). The Sm3 trains have undergone a number of modifications and upgrades over the past 10 years which have enhanced their reliability and also to adjust to changing passengers requirements. The



Fig. 2. The view of Allegro EMU train

Table 3. Comparison of Sm6 Allegro and Sm3 Pendolino

	Sm6 Allegro	Sm3 Pendolino
Main Parameters		
Manufacturing years	2009-2010	1995-2006
Country of origin	Italy	Italy
Manufacturing site	Alstom	Alstom
Manufacturer	Alstom (design by Fiat Ferroviaria)	Alstom (design by Fiat Ferroviaria)
Number of manufactured trains	4	18
Operated in	Finland, Russia	Finland
Operator	Oy Karelian Trains Ltd	VR-Group
Track gauge	1520 mm/1524 mm	1524 mm
Launch in operation	December 12, 2010	1995
Technical Parameters		
Catenary parameters	3 kV DC, 25 kV 50 Hz AC	25 kV 50 Hz AC
Design speed	220 km/h	220 km/h
Number of cars	7 (4 motor cars, 3 trailer cars)	6 (4 motor cars, 2 trailer cars)
Passenger capacity	352 seats + 2 for wheelchair passengers	262 seats
Car length	25,000 mm – head car 27,200 mm – intermediate car	27,650 mm – head car 25,900 mm – intermediate car
Carbody width	3,200 mm	3,200 mm
Distance between rail and roof top	4,270 mm	4,100 mm
Power output	5,500 kW	4,000 kW
Traction motor type	asynchronous	asynchronous

work on Sm3 is continuing with upgrades to outdated equipment and passenger comfort the primary objectives of the latest undertaking.

The class SM6 EMUs supplied to Oy Karelian Trains are the third generation of the Pendolino family. The Sm6 is equipped to operate on both the Finnish and the Russian railway networks accommodating the differences in track infrastructures from 1524mm Finnish gauge to 1520mm used in Russia, along with variations in safety and telecommunication systems, and power supply. While the Sm3 and Sm6 have only a slightly different exterior appearance, the interior varies greatly due to the onboard passport and custom checks which take place when crossing the Finland-Russia border.

The Pendolino bogies integrate primary and secondary helical suspension which guarantees high safety and comfort levels, while the entire bogie, along with the individual bogie frames, suspension springs, motor bogie and trailer bogies axles are interchangeable. These advanced solutions provide easy access for crews carrying out maintenance and replacement work.

The braking system consists of three brake disks for a trailer bogie axle and two for a motor bogie axle. The traction motors are positioned under the bodyshell and are connected to the gear by a driveshaft which reduces the suspended weight. In light of the severe climatic operating conditions experienced in Finland and Russia, all bogies are equipped with special devices designed to prevent snow and ice accumulation on the secondary suspension springs and on the body-to-bogie connection.

The Pendolino Sm6 utilises a distributed power system which enables it to operate on both 25 kV AC 50 Hz and 3 kV DC. The use of various independent traction units ensures a high level of reliability and redundancy, while the pantograph frame support is connected directly to the non-tilting bogie bolsters which guarantees the

availability of a continuous power source. The traction equipment, which is positioned under the body of the train, includes a transformer for AC lines and an IGBT traction converter, an advanced technology in railway traction. Traction motors are three-phase asynchronous type and offer a total traction power of 5,500 kW and a total effort at the rim of 226 kN.

The advanced technical solutions adopted in the traction system, together with the use of composite materials, significantly reduces the weight of the train and as a result its power consumption, making the Pendolino Sm6 a particularly environmentally-friendly solution.

Additional train features include:

- air-conditioning,
- pressure-tight cars,
- automatic internal and external doors,
- a vacuum toilet system,
- adjustable seats, tables and footrests,
- a play area for children,
- passenger information and entertainment systems,
- adaptability to different platform heights,
- wheelchair lift.

One of the project's major challenges was to overcome the variations in technical standards that exist when certifying and approving rolling stock for operation in Russia and Finland. The importance of this is reflected in Russian and Finnish experts accounting for these potential differences as early as at the technical specification development stage. After the project launch, technical teams continued to keep this in mind as they reviewed all the design alternatives, subsystems and materials elements for the train in order to come up with the optimum solution. However, it must be noted that European and Russian technical regulations only differ to a certain extent. The major differences are found in the requirements for testing, with Russian regulations to a certain degree more stringent than those used in Europe.

Preparation and performance

The launch of the high-speed Sapsan and Allegro trains required extensive efforts to prepare infrastructure for use by state-of-the-art trains, and to train staff and all relevant stakeholders to use the trains correctly.

Much of Western Europe suffered from extremely difficult conditions in the winter of 2009 with freezing temperatures and snow causing travel chaos in many areas. While some high-speed services in these countries suffered from

severe disruption, during its first winter in operation Sapsan reported positive results. The train successfully withstood the large temperature swings and rapid changes in humidity common during a Russian winter and operated without any major incidents. These positive outcomes were achieved through paying special attention to the impact of these conditions on train components during the development of the train, and in the maintenance and special winterisation practices which were subsequently introduced. As a result Sapsan has continued to operate successfully every winter since it entered service.

It is no a secret that in the early stages of introducing the Sapsan and Allegro high-speed services, staff at RZD's High Speed Service Division encountered some difficulties:

- lack of practice in operation of EMUs with TCMS, integrated traction and braking control system,
- problems were reported by the High Speed Service Division's locomotive crews at the frontier station between Russia and Finland due to the variations between the electrification and the radically different signalling systems in use,
- maintenance and repair of the Allegro emus is performed solely at facilities in Finland which resulted in a time consuming information exchange process due to language differences.

The High Speed Service Division engaged in the following initiatives to overcome these problems:

- Regulations for maintenance procedures and train handling management for Sapsan and Allegro which take into account the specific design features of the trains design have been developed, validated by RZD, and deployed. The Regulations specify the requirements for handling traffic by personnel and those involved in maintenance of high-speed infrastructure facilities. The regulations also outline education and training procedures for train crew and staff using the Sapsan and Allegro trains.
- Training Center, a business unit of High Speed Service Division, has developed special training modules to train staff operating the Sapsan and Allegro trains. The modules describe specific procedures for controlling the braking

systems, with a training module comprising a classroom element, as well as direct practical and simulator training using a specially developed Sapsan simulator.

- In partnership with Siemens, Alstom, and VR Group, RZD experts developed instructions for emergency procedures that are taught to train crews in the Training Center.
- During the preparation of the launch of Allegro high-speed trains into revenue service, special training sessions were organised for operating staff at VR Group's staff training centre at the Ilmala Depot in Finland. As part of the training procedure Allegro trains performed trial runs on the Helsinki - St Petersburg route in order to practise the border crossing procedures.
- The maintenance and repair procedure for Allegro trains was established through a tripartite agreement between RZD, VR Group and Oy Karelian Trains. Working groups meet on a regular basis to discuss the work and to suggest possible improvements.

Since Sapsan began operating daily services between Moscow, St Petersburg and Nizhniy Novgorod the service has grown in popularity. More than 9 million passengers have used the high-speed service and seat occupancy is impressive; 89.8% of seats are now occupied on Moscow- St. Petersburg services, while the Moscow- Nizhniy Novgorod trains have a 79.8% occupancy rate.

Since the launch of high-speed Allegro service between Helsinki and St Petersburg on December 12, 2010 more than 800,000 passengers have enjoyed the 3h 26min journey, which compares with 6h 18 mins previously. Railway services between Russia and Finland now accounts for 52% of RZD's international passengers, with the launch of Allegro high-speed EMUs resulting in significant increases in tourism. The service has also helped to improve business relations between the two countries.

In December 2011, Russian Railways and Siemens signed a delivery contract for eight additional 10-car Velaro RUS EMUs for use on the Moscow – St Petersburg line as well as a 30-year maintenance agreement. Like the original Sapsan EMUs, the new trains will be manufactured at Siemens Krefeld plant in Germany. 

The philosophy of diagnostics as a tool of intelligent control of the railway infrastructure



Igor MIKHALKIN
General Director,
INFOTRANS



Oleg SIMAKOV,
First Deputy General Director,
INFOTRANS

Russian company INFOTRANS is at the forefront of the railway infrastructure diagnostics automation process in the “Space 1520”. It’s been 25 years since the company began focusing on the development and production of diagnostic tools as well as techniques for their efficient use. The company’s specialists, who have created a large range of modern diagnostic tools for various applications, including multifunctional measuring trains, have long felt that there is a need to extend and deepen the analysis of the data they have accumulated.

For many years, railway infrastructure diagnostics was not a homogeneous process, with priority generally given to localised improvements to traffic safety. The diagnostic process primarily relied on manual measurements and subjective opinion from experts and almost inevitably these techniques suffered from low performance, inaccuracy and scarcity of results and information. And we must pay tribute to the railway workers, which not only defended achieved frontiers, but also moving forward in these difficult conditions.

The advent of automated diagnostic tools produced a sort of revolution, providing not only the possibility of obtaining reliable information, but also allowing to accumulate it in databases. New diagnostics tools focused on automated processes for measuring as well as evaluating results from analogue mobile diagnostic aids, subsequent diagnostic devices that incorporate state-of-the-art functions have the potential to significantly ex-

tend the range of railway infrastructure parameters it is possible to control.

The multifunctional measuring train ERA is an obvious example of a modern diagnostic tool that is utilising these measuring systems. During a single operation, the train can monitor the condition of track infrastructure, catenary, automation, communication and telecommunications systems as well as provide references to railway and geodetic coordinates from GLONASS/GPS applications. More than 120 various parameters of the technical objects are available to provide a complete understanding of the condition of rail infrastructure. And by eliminating the potential for human error at all stages of measuring, evaluation and analysis, the process offers highly objective results.

Construction of speed and high-speed railway main lines and the growth of heavy-haul traffic requires the introduction of new diagnostic approaches. In 2012, Valentin Gapanovitch (Senior Vice President of RZD JSC) initiated the development of a new direction - family of locomotive-based diagnostic laboratories. Locomotive-laboratories help to determine the behaviour of the track and its elements during real interaction with locomotive, which moved on high-speed operation and gave the stress of heavy axle loads.

The success of the two year project to develop and prove the world’s first high-speed motorised track measuring laboratory, SPL-ChS200, which utilises a ChS200 double-section electric locomotive, resulted in the development of the SMDL-2TE116 motorised multi-purpose diagnostic laboratory in a heavy-weight locomotive.



Fig. 1. Multifunctional Diagnostic Laboratory

This project again adopted the advanced technical solutions found in the ERA project, but consolidated them within the limited space of a single locomotive section. Limiting the size of these solutions is also important for diagnostic tools used on very high-speed trains given the trend to merge diagnostic and passenger transport functions into a single rail vehicle.

The diagnostics equipment's new capabilities have led to the establishment of new objectives for their application. Specifically this has changed from identifying individual non-conformities to determining the precise condition of infrastructure and predicting when specific components may fail with the intention of introducing preventative maintenance. This results in greater efficiency in the use of resources and helps improve the performance of the transport system, allowing it to meet its overarching goal of meeting specified traffic levels within a preset risk level and predetermined maintenance system. Hence, diagnostics has become an active component of infrastructure which directly impacts its quality and capability to deal with specific challenges.

Nevertheless, a rail infrastructure diagnostic system alone is no longer sufficient to support an effective condition monitoring and preventative maintenance regime, with the diagnostic tools themselves no more than sensors which provide information on the current condition and status of infrastructure. With the process of diagnostics becoming more and more complex, the means of processing and analysing diagnostics data requires greater resources. As a result it is now almost impossible to capture and understand the variety of incoming data without the tools to aggregate, visualise, analyse and prepare information that can inform decision making.

To meet these concerns, INFOTRANS specialists have developed the EXPERT information analysis system which integrates diagnostics data to monitor railway infrastructure. The system is designed to collect and store data from automated diagnostic tools which it subsequently synchronise and processes to evaluate the infrastructure's technical condition and calculate the cost of and plans for repairs, taking into account track category, traffic loads, and prescribed speed limits, and etc.

EXPERT's primary selling points are its openness, scalability, web-based functionality, and ease of use. For example, a user is able to access information stored in the system using a general interface from any location in the world.




Fig. 2. The EXPERT information analysis system for integrated railway infrastructure diagnostics and monitoring

The EXPERT database contains information about the complete lifecycle of infrastructure, and is easily adaptable to changing requirements.

The users of information of the system are heads and specialists who through the Web-based user interface have an easy and intuitive access to the data from their workplaces, in accordance with their status and the level of access. Access to the system is granted through a personal account which is adaptable to the user's specific preferences and current tasks, and will automatically display all of the required information immediately after log-in.

The system's external applications carry out in-depth data processing and analysis. The following EXPERT-based external applications have been developed and successfully deployed in each of infrastructure-related units of RZD:

- proactive determination of infrastructure pre-failure based on the condition of track geometry and rail fastenings (as a part of URRAN-RAMS technology for the integrated reliability, risks and LCC control of railway transport),
- assignment of track maintenance operations based on actual status and evolution,
- an integrated evaluation of the condition of continuous welded rails, and
- monitoring of temporarily unstable road-bed sections.

The EXPERT system has proven itself as a reliable tool for the intelligent monitoring and control of railway infrastructure since it was installed on the Russian railway network in 2012. 

DP-M: A New-Generation Russian DMU



Nikolay Polukhov,
Project Engineering Manager, Metrowagonmash JSC

Metrowagonmash, a subsidiary of Transmashholding JSC, which is located in Mytishchi, near Moscow, has produced railway rolling stock products since it was founded in 1987. In 2013, the plant diversified its product range by introducing its DP-M diesel-multiple unit (DMU). Unveiled at the Fourth International Rolling Stock Exhibition, EXPO 1520, in September 2013, the new train is designed for passenger operations on non-electrified main lines with high traffic volumes.

Background of DP-M Development

Coaches and DMUs produced by Metrowagonmash (MWM) are currently operating in Russia, Hungary, Lithuania, the Ukraine, the Czech Republic and Serbia. MWM's core product is the RA2 DMU. However, with significant future demand for non-electrified rolling stock in Eastern Europe and the CIS, the company is expanding its product range.

Non-electrified lines still make up a significant portion of RZD's suburban railways, many of which have significant traffic flows. This includes the Novomoskovsk – Tula – Kaluga, and Oryol –

Yelets routes. Four to six cars DMUs are consequently ideal rolling stock solutions for these lines. And with most of the Soviet class D1 and DR1A DMUs now removed from service, there is significant demand for new diesel rolling stock in Russia.

To meet this challenge, MWM engineers chose to develop an entirely new train, Diesel-Train of Mytishchi (DP-M) (see Figure 1), which is suitable for both 120 km/h suburban and 160 km/h regional operations.

Perhaps the DP-M's most significant design feature is the incorporation of a unique traction



picture by Y.I. Subbotin

Fig. 1. The view of DP-M DMU

system. Instead of locating the diesel genset in power cars at either end of the train, or through a distributed traction solution under the car body, the DP-M's diesel genset is located in a stand-

alone autonomous power module located in the centre of each driving car. Here it utilises two two-axle motorized bogies, which support the lead car's two passenger sections.

Power Module

Integrating an independent power module in each of the train's two driving cars offers significant benefits over traditional solutions. Power cars located at either end of the train and distributed diesel traction systems can sometimes produce excess vibrations and noise emissions, which decreases comfort for passengers. Moreover the risk of fire is greater in these vehicles, while passengers often complain about the smell of fuel when travelling on older DMUs which use distributed traction or power cars. As a result MWM engineers argue that by locating the genset in a separate power module it is possible to increase passenger comfort, while also enhancing performance. The articulated design allows complete loading of the power module's bogies from passengers in the neighbouring sections, which improves weight distribution, while passengers can still pass through the length of the whole train by using the power module's walkway. In addition the power module's motorised wheelsets enhance the train's overall traction performance, and locating all of the power equipment in a single space improves and simplifies maintenance.

Stadler Rail was selected as the preferred supplier of the power modules. MWM says Stadler demonstrated sufficient engineering and manufacturing competencies as well as the capacity to deliver a power module tailored to meet its precise requirements.

One particular area where Stadler stood out as a suitable supplier was its willingness to localise production in Russia. While the first trains are set to be equipped with power modules manufactured in Switzerland, with bogie and equipment installation taking place in Russia, localised production of the propulsion modules is expected to shift to Russia as orders for the DP-M DMUs pick up.

The power module utilises a QSK38 V-shaped 12-cylinder diesel engine supplied by Cummins, United States, which has a 37.7 litre displacement. The 1.19MW engine weighs 4,200kg and has a 159mm square-stroke cylinder. TSA, Aus-

tria, supplied the engine's traction generator as well as four 250kW asynchronous traction motors in continuous mode (see Figure 2). ABB, Switzerland supplied the traction inverter.

The train's bogies all feature a two-stage spring suspension system with primary metallic and secondary pneumatic suspension. Transversal shock absorbers on the bogies offer enhanced bogie performance, while the bogies house a mixture of motorised and non-motorised wheelsets. Non-motorised wheelsets are used on passenger cars and use brake discs fitted to the axle. Brake disks on the motorised bogies located under the power modules are fitted to the wheels.

Basic technical data DP-M DMUs

Number of cars in basic configuration train, driving car (h), trailer car (t)	2 (h) + 3 (t), 2 (h) + 1 (t), 2 (h) + 2 (t), 2 (h) + 4 (t)
Design speed	
Suburban	120 km/h
long distance regional	160 km/h
Car gauge	T
Number of seats	
driving car	2nd class – 96 + 4 3rd class – 132 + 4
trailer car	2nd class – 143 3rd class – 184
Total number of passengers per car	
driving car	2nd class – 190 3rd class – 226
trailer car	2nd class – 143 3rd class – 184
Rail-to-floor height	1,300 mm
Wheel diameter (new)	860 mm
Expected service life	40 years
Power module weight	~ 54 tonnes
Axle load	21 tonnes
Car empty weight	
Driving car	113 tonnes
Trailer car	43 tonnes
Basic train composition weight	355 tonnes



Fig. 2. Power Module

Train Arrangement

The DMU's flexible design means that it is possible to configure it in several formations. With two power modules, one per each driving car, the basic arrangement encompasses five cars - two driving cars (see Figure 3) and three trailer cars (see Figure 4). The train can also consist of two driving cars and one trailer, or two driving cars and two trailer cars. The maximum train composition consists of two driving cars and four

trailers. It is also possible to couple two trains together to provide a 12-car train, with the leading driving car managing the extended unit.

The train's basic configuration weighs 355 tonnes, with an empty driving car weighing 113 tons (including the power module) and each trailer car weighing 43 tonnes. Schaku couplings supplied by Voith are used for the project, with the overall capacity of draft gear elements at least 3MJ.

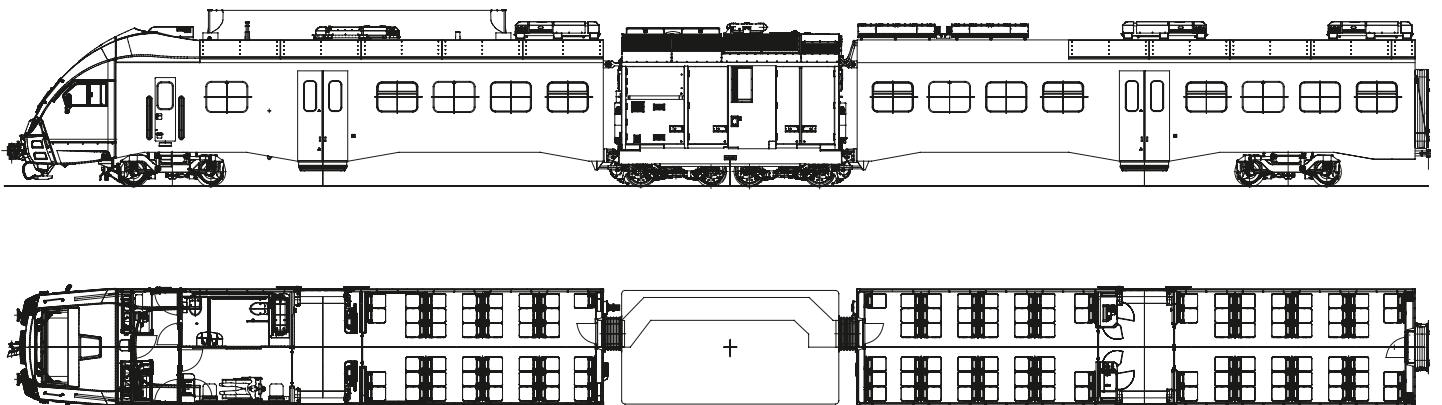


Fig. 3. Driving Car Layout

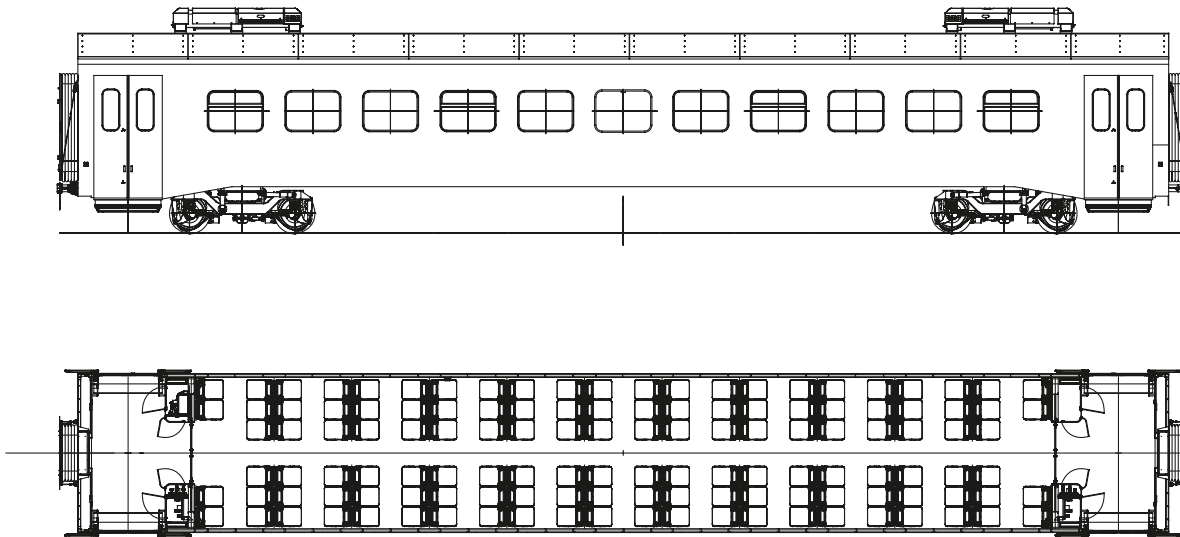


Fig. 4. Trailer Car Layout

Interiors

The DP-M trains consist of a stainless steel car-body while the driver's cab, which was designed by engineers at MDS, Ukraine, is constructed from fibreglass. The interior linings of the driver's cab and passenger cars are of similar design and were engineered by Petroplast. KMT supplied windows, while IFE Automatic Door System, Austria, supplied the doors. Seats were provided by Grammer, Germany.

The train's 1,300mm-high floor is intended to accommodate the high platforms common on Russia's railway network. Fixed and retractable steps and folding vestibule plates are also available to allow easy access to and from low platforms. In addition the driving cars have special wheelchair lifts to accommodate disabled passengers. These passengers are also assisted by the presence of two sets of access buttons which are designed to allow easy access from low and high platforms, and a staff

call-button in the driving car to alert a lift operator. Special wheelchair seating areas are also available.

A preset air temperature in the driver's cab and passenger cars is maintained through Heating Ventilation and Air Conditioning (HVAC) units, supplied by Webasto, Germany. Additional heating, which is often required during Russia's harsh winters, is offered through fan heaters mounted in the driver's cab and passenger cars.


For DMUs intended for suburban services, two toilets are located in each of the driving cars, with one accessible to passengers, including those with disabilities, and the other intended solely for driving staff. Additional toilets are provided in trains intended for regional services, with one located in each trailer car and an extra toilet in the second section of the driving car. All of the train's vacuum toilet equipment is supplied by Promtechmontazh.

Future Outlook

The new DMU platform is an opportunity for MWM to offer low-cost and customisable passenger rolling stock that is operable in variety of suburban and regional operating conditions.

In addition to the aforementioned solutions, the train can also accommodate a customer's re-

quirement for the inclusion of bicycle racks, mobile telephone signal amplifiers, onboard WiFi, and electrical sockets.

The DP-M prototype is currently undergoing tests and it is expected to enter service in 2015. 

Applying composite materials in locomotive components



Mikhail Lobov,
Technical Director, MYS CJSC

Composite materials are now commonly used for interior finishes in driver's cabs and passenger coaches of regional and long distance trains. As well as their aesthetic properties, these materials possess other characteristics that offer structural and high-tech benefits.

From 1999 to 2000, MYS developed, tested and launched various products made from composite materials. FRP fan blades used for the centralised air supply system for TEP70 diesel locomotive (see Figure 1) is a good illustration of an effective application of this product. In 2001, MYS secured a patent for its manufacturing line for flame-and-explosion proof blades, which are based on technologies used in the aviation industry. During product development, MYS engineers optimised the design to the extent that it was possible to manufacture a cold press-mould from innovative materials developed by a partner supplier. Their efforts resulted in a reliable product that is suitable for mass production and offers lots of additional benefits.

This new product significantly reduces the cost of producing fan blades. In addition to its

economic advantages, the internal press-forming process for the blade butt makes the product both structurally robust, and capable of withstanding temperatures of up to 120°C, an essential requirement for any locomotive fan. The company subsequently developed blades and butts that can withstand 270°C, with the products proving their worth in TEP70BS and EP2K series locomotives for the past nine years.

The introduction of non-metallic blades has also optimised the attachment process by enabling the gluing of moulded butts into position rather than relying on mill-finishing and mechanical fixing. This method has also made the process of adjustment, assembly and gluing much easier, and it can be applied to thin blades with a thickness of up to 10mm (see Figure 2).



Fig. 1. Composite Ventilator Blades



Fig. 2. Cooling Fan with Butt Blades



Fig. 3. Cooling Ventilator with Bar Blades

A further evolution of the concept occurred in 2006 with the development of impellers with a depth and diameter of up to 2m. Patents for the blade and fan for the new method, which complement the earlier blade manufacturing process, were secured in 2009. In this method, the reinforced structural element bears the primary load (the longitudinal beam). This solution is particularly effective at handling the longitudinal loads of centrifugal pull with part of the longitudinal load absorbed by reverse torque which occurs during the aerodynamic bending of the blade. The blades used in this case are hollow, which means they are far lighter than their aluminium equivalents, while imbedded poroelastic elements have been applied to increase the shell's durability as well as to harden the thin-wall structure following polymerisation in the same manner as caissons (see Figure 3).

As was the case with the earlier method, this development offers substantial safety benefits during operation. For example in the event of failure from external exposure, the blade's kinetic energy is entirely spent during the breakage process minimising any potential damage to neighbouring components. In addition with the fibre-reinforced plastic acting as an insulator, no short circuits, voltage breakdowns or sparking will occur during operation. The design of the lightweight FRP ventilator impellers also acts to extend the service life of locomotive drive and cooling system's components. For instance, compared with a metallic impeller, the FRP now installed in TEM18W locomotives has cut inertia momentum almost in half thus improving the performance of the ventilator system. Moreover, this solution is proving effective during locomotive refurbishment by extending the service life

of the components while reducing noise and aerodynamic vibration levels.

More than 15,000 blades and 800 impellers have now been manufactured and are successfully operating in cooling ventilators installed in diesel and electric locomotives manufactured by Transmashholding and Zheldorremmash.

A further example of a smart combination of design and aesthetic aspects is evident in a plastic window unit created by MYS for new and existing locomotives, which consists of both inner and outer mounting elements. For the outer mounting, the window unit is integrated with a casing which makes adjustments easier while compensating for incidental clearances when the window is open. For inner installation, all units have linings allowing the window unit to be matched with almost any available interior (see Figure 4). MYS currently offers more than 15 versions of its window units, which include features such as heated window leafs and triple-panes for inner and outer mountings. All units may also be complemented by side mirrors and paravanes (see Figure 5). MYS' window unit and transport vehicle window designs were patent-protected in 2007, while patents for the driver window and transport vehicle sliding window were secured in 2008.

However, this is far from the full range of MYS products. Today our factory produces the following parts and components for Russian Railways' rolling stock:

- fairing for electric locomotive (front end),
- driver's cab and passenger coach interiors,



Fig. 4. Sliding window unit in EP2K Locomotive




Fig. 5. Standard sliding window unit for track machines

- locomotive roof sections,
- ventilator systems, and dust cleaner ventilators which can be fitted as an option including with

pressure and vibration sensors, and pneumatically-operated flow straighteners,

- non-metallic components for rail ventilator systems, and
- air ducts, noise insulating systems and airflow directing systems.

MYS ventilator systems are now installed in 52 2TE25 and 45 EP20 locomotives, while its electric locomotive fairing and driver's cab interiors are present in 253 EP2K units. Driver cab interiors and ventilator impellers are also in use in 290 TEP70BS, TEP70U and 2TE70 diesel locomotives.

With many companies now using MYS' manufacturing and engineering solutions in their products, the company's intelligent approach to design, which is resulting in advanced and efficient products, is stimulating significant demand for its ideas and expertise. 

MYS develops, manufactures and supplies composite products used for fitting out locomotive driver's cabs and passenger coach interiors, as well as for locomotive power packs' air supply and cooling systems. MYS integrates innovative engineering solutions and technologies in its products which are now in widespread use.

Key Company Facts and Dates

- 2000.** Launch of mass production of a ventilator blade for the TEP70 locomotive's central air supply system, and a family of chemically-stable ventilator blades.
- 2004.** First Russian FRP heated sliding window unit for the driver's cab and roof sections of the TEP70 diesel locomotive developed, manufactured and put into operation.
- 2007.** Under the technical design assignment of VNIKTI, manufacturing of ventilator systems for the first Russian GT1h gas turbine locomotive begins. In parallel, manufacturing commences on the ventilator system for the 2TE25 locomotive's engine cooling unit, which features a pneumatically-operated flow straightener.
- 2007.** The company adopts a corporate standard which complies with international requirements for quality in product design and development, production, assembly and maintenance.
- 2008.** Mass production begins of plastic, steel and aluminium roof sections for electric and diesel locomotives.
- 2010.** The rail ventilator package for EP20 electric locomotive was finalised and production launches.
- 2012.** An aerodynamic laboratory with certified aerodynamic testing cells established.
- 2012.** The company received ISO Certificates for quality management system compliance with the requirements of GOST R ISO 9001-2008, reference number POCC RU.0C03.CMK00045.
- 2013.** A new 2000 m² factory began operations.
- 2013.** Launch of the complete family of rail ventilator systems for shunting and main line locomotives produced by Bryansk Engineering Plant.
- 2014.** Launch of IRIS-compliance certification activities.

For more details about our products:

7a, Zelyonaya St., vil. Vysokinichi, Kaluga Region, 249180, Russia
 Tel./Fax: +7 (48432) 2-82-00
 E-mail: mands@kaluga.ru
 www.mpsplastik.ru

New Messenger Wire – as Strong as Bronze, as Conductive as Cuprum

Cuprum-based alloys with Cd, Mg, Cr, Zr and other metallic additions are used in catenary wiring because of their enhanced durability, strength and resistance to thermal softening. However, while offering various improvements to the wire's mechanical parameters, these additions inhibit the wire's electrical characteristics, significantly increase production costs, and crucially cannot be used on dense traffic lines.

To overcome these difficulties, Russian engineering company Energoservice began to develop a messenger wire without these alloys. Emphasis during the development phase was placed on identifying a solution which offers high mechanical reliability and only slight temperature-related linear deformations all while being as reliable a conductor of electricity as cuprum. The wire must also be rust resistant and demonstrate enhanced aerodynamic properties, standard diameter values, and be suitable for mass production. Moreover, the price should not be significantly higher than existing solutions, and the product should meet existing standard fittings.

The company's engineering efforts resulted in a copper product of the same diameter as existing wires but which offers both higher impedance (electric impedance of a Ø 14mm wire is $1.1369-1.383 \times 10^{-4}$ Ohm/m) and improved mechanical performance (breaking strength of Ø 14mm wire is 58-60 kgf/mm, a 25-30% improvement).

Energoservice's design increases the service life of the wire by enhancing its swinging amplitude and strength, which reduces the probability of wires breaking following physical damage and material fatigue caused by vibrations and self damping. It also prevents significant accumulation of snow and ice.

Manufacturing is undertaken by Severstal-Metiz and differs from traditional processes by incorporating crimping, shearing, bending, and kinking. This solution produces a strong copper messenger wire (see Figure 1), which by not using alloys, increases its range of applications. This is of particular significance for high-speed rolling stock that require higher current intake leading to more intensive heating of the messenger wire.

The messenger wires used for high-speed lines experience higher tension and intensive heating during operation, which leads to increased wire low-temperature creep. Due to improved performance and less need for replacement, the copper messenger solution developed by Energoservice




Fig. 1. Messenger wire for rail

eliminates many of these issues and as a result can offer a return on the initial investment in 10-20 months by energy loss reduction.

The wire has been tested extensively by Russian Railways (RZD). Tests performed include covered thermal softening checks at 155°C and multiple temperature increases to 100°C. Test engineers also carried out arc resistance checks, low-temperature creep checks, heave oscillation (eolian vibration) resistance tests, as well as some other tests used for the first time on a messenger wire.

Pilot tests carried out during several seasons on the South-Ural Railroad, which experiences heavy traffic, also demonstrated the resilience of the wire in severe conditions.

Energoservice has extensive experience in producing efficient engineering solutions for high-strength cables and earthing wires for 35-750 kV overhead power lines. The positive results for the messenger wire are considered the direct consequence of the wire's design rather than the alloys used, and offer significant potential for future applications.

For 20 years, the team of Energoservice, LLC have been developing, testing and deploying innovative products (wires and steel wire ropes) for Russia's leading companies: Norilsk Nickel, RZD, FGC UES, etc. The company's references include the Ostankino Television Tower, deep mine hoistings, and thousands of kilometers of electric mines. Our solutions compete successfully with European products. Visit our website at www.energoservice.com. 

Application of Composite Materials in Wagon Manufacturing

Alexandr Dorozhkin, Design Director, Ural Wagon Constructing Office (UKBV)

Sergey Ozerov, Design, STTC ApATeCH-Dubna

Maxim Aginskikh, Head of Carbody Department, UKBV

Andrey Ushakov, General Director, SPE ApATeCH-SM

Alexandr Izotov, Deputy General Director, SPE ApATeCH-SM

The Russian rail transport sector's current high growth rate is placing greater demand on rolling stock manufacturers to offer innovative products that meet customer preferences while complying with all related infrastructure requirements and standards. Expanding the range of available rolling stock products that feature advanced technical components and offer high operating performance is a primary focus of research and production at Uralvagonzavod JSC (UVZ Group) and UKBV, which recently completed the development of an innovative freight wagon. By using the latest technologies and materials, the company hopes the product will enable them to stand out and succeed in a competitive marketplace.

Fluctuations in demand for rolling stock is a significant challenge to rolling stock manufacturers in a market where they are consistently required to develop new freight vehicle solutions with improved technical and cost parameters to meet the demands of customers.

The development of the innovative 19-5167 hopper-wagon which utilises a composite carbody is a clear example of one manufacturer answering the challenges and demands of the market.

In 2013, under the contract between UVZ Group and SPE ApATeCH-SM, Ltd, the parties developed and built what they say is the first hopper wagon in the world to incorporate a composite carbody manufactured using a Vacuum Infusion Process¹.

The hopper wagon's carbody is fabricated from composite materials and is designed for storing, covering and transporting chemical fertilizers and other non-hazardous materials such as grain.

The developers aimed to design a wagon which could meet the conventional functions of a hopper wagon all while utilising enhanced technology in a cost-effective manner that meets customer requirements as outlined in the techni-

cal design assignment. Among the requirements was mounting the carbody on a metallic frame, and for the design to prevent ingress of atmospheric precipitations inside the wagon. The hopper carbody should also be capable of operating in all weathers and in a temperature range of -60 °C to 45 °C.

The major dimensions and parameters of the composite carbody prototype are specified in Table 1.

As a part of the development process, the designers of the composite carbody, SPE ApATeCH-SM and STTC ApATeCH-Dubna, reviewed several structural layout scenarios. These included various arrangements of strength members and shells based on the results of research on steel structures used for hopper wagons and world-best practices. As a result, mathematical models were built for these scenarios while an analysis of various specified loading cases was carried out for specific designs. The selection of materials and manufacturing processes for future mass production was performed in parallel, which resulted in the identification of the Vacuum Infusion Process as a suitable technology for mass production that

¹ The process of manufacturing composite materials and large parts through pressure impregnation, or the Vacuum Infusion Process, requires the injection of resin into laminate by applying pressure in a vacuum

Table 1. Main Dimensions and Parameters of Composite Carbody Prototype

Parameter Description	Parameter Value
Rail-to-body height, mm, max	4,800
Body length, mm	13,850
Body width, mm	3,200
Carbody inside volume, m3, max	130
Number of charging hatches	4
Dimensions of hatches (mm)	1,630×600
Number of discharge gates	6
Dimensions of gates (mm)	1,400×540
Inclination vs horizontal of hopper boxes and end walls, α°, min	55
Wagon gauge under GOST 9238-83	1-T
Weight of composite carbody, kg, max	6,000

would produce the desired results. This process significantly improves the fiber-resin ratio of composite material thus offering a more rigid but lighter product.

Figure 1 shows the general view of the hopper wagon, and the dimension limits specified by the customer. Stress models compliant with the load cases specified in the TDA were created in order to perform strain-stress computations of the carbody's load-carrying capability. Simulation finite element models were computed with respect to the reinforcement of selected structural arrangements. Figure 2 shows the 3D model of the hopper carbody with boxes.

S4 shell-type multi-layered finite elements, with a typical size of 40mm for regular load zones and 10-20mm for stress concentration zones, were used to build the simulation models. To evaluate the carbody's design margin, applied stresses were compared with rated values (as shown in Figure 3).

The load patterns of the load bearing frame and diagonal elements were obtained through a calculation of the stress at the points of attachment between the carbody and boxes' subassembly and both the center sill and side beams, and the end walls diagonals via pull-type fasteners (see Figure 4).

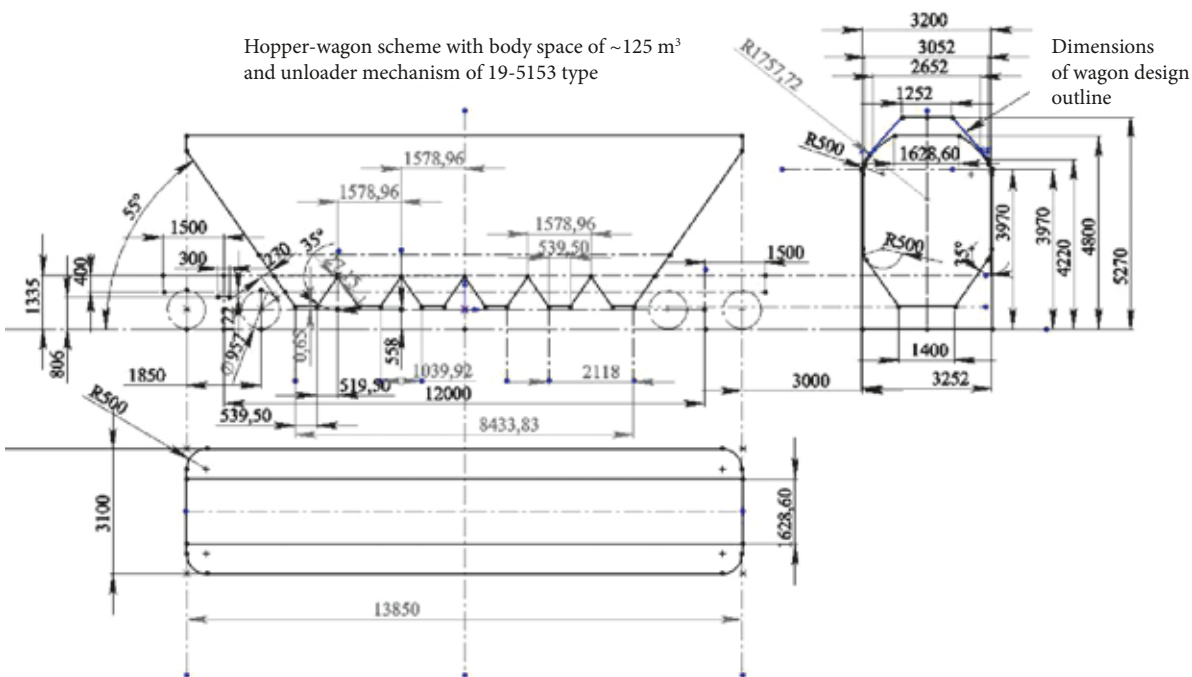


Fig. 1. Dimensional drawing of a hopper-wagon

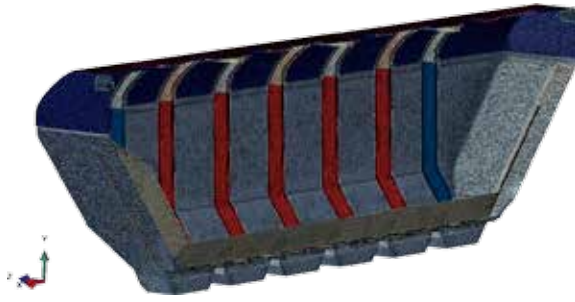


Fig. 2. A finite element model of a composite hopper carbody

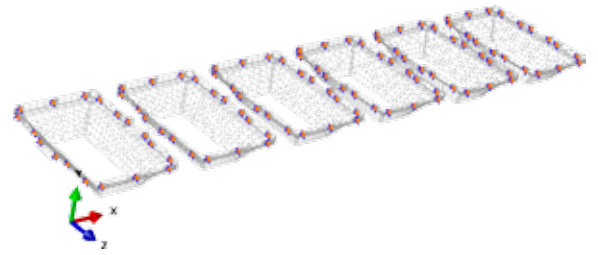


Fig. 4b. Attachment of hopper boxes to the frame and end walls diagonals

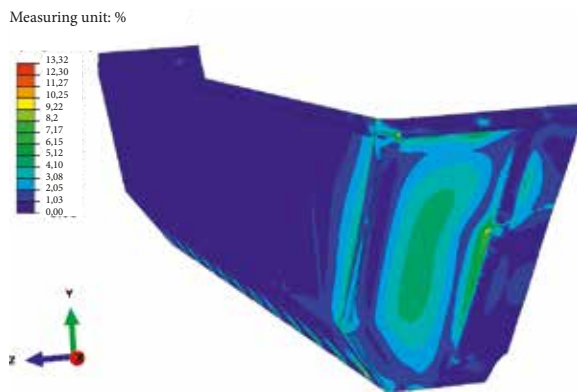


Fig. 3. Max tensile stresses in carbody end walls and side walls

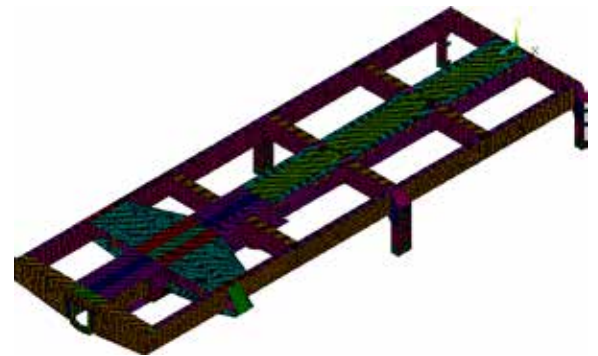


Fig. 5a. Finite element models of hopper frame

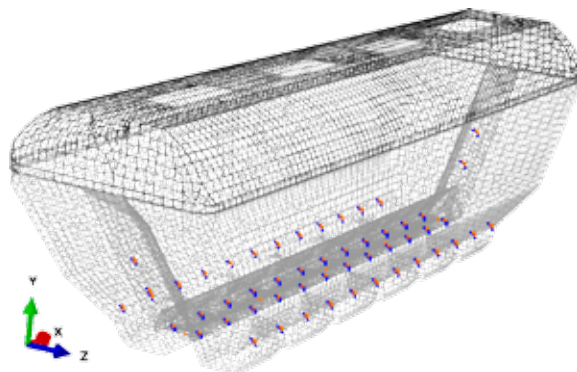


Fig. 4a. Attachment of body shell to the frame and end walls diagonals

The strain-stress behaviour analysis of hopper load bearing members was carried out through respective finite element models. The stress model of the hopper underframe (see Figure 5a) was built with ANSYS Mechanical software using finite elements of SHELL63-type which have varying thickness (as per engineering specifications). The stress simulation model for end walls diagonals (see Figure 5b) was derived from ANSYS Workbench software using SOLID187-type finite

elements in accordance with nominal dimensions outlined in the engineering specifications.

Under the requirements relating to unpowered vehicles outlined in Norms of Engineering and Design of Rail Cars for 1520mm-gauge Network, the strain-stress analysis was performed on



Fig. 5b. Finite element models of hopper end walls diagonals

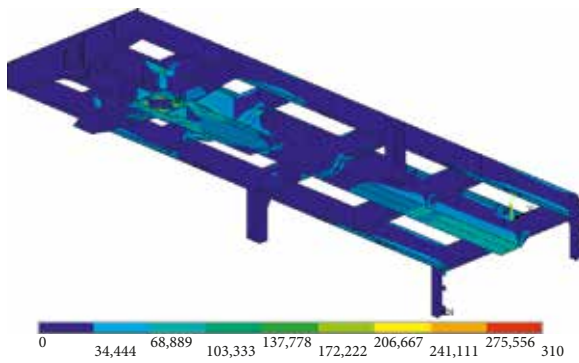
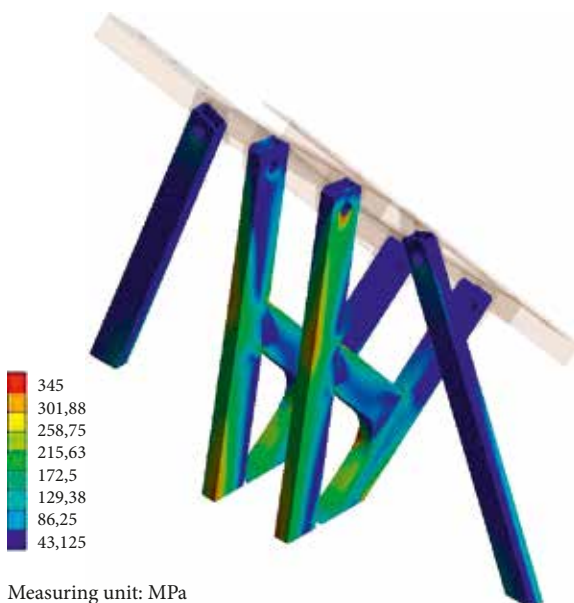


Fig. 6. Data found using von Mises yield criterion calculation for the worst possible load combination on impact with the hopper frame as per I simulation scenario

the basis of strength calculations using von Mises yield criterion for the frame and diagonals, as well as for the diagonals' critical-load design (as per scale factors of stresses applied). Data from these calculations are presented in Figures 6 and 7.

A programme of testing 19-5167 hopper car materials, subassemblies, parts subsequently took place through the development of a full-scale prototype carbody, which was built using the composite materials (hereinafter the Programme). This wagon was developed to validate the data retrieved from the simulation models and the Programme focused on validating the strength parameters of composite carbody parts, components and connections as well as to verify the strength (stiffness) evaluation technique.



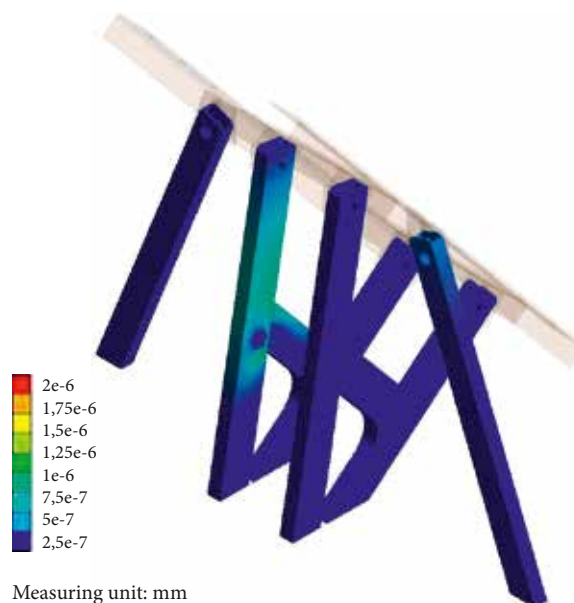
Measuring unit: MPa

Fig. 7a. Data from von Mises yield criterion showing the calculation of the worst possible workload combination on impact as per I simulation scenario for the diagonals of more bearing end wall

The Programme involved conducting mechanical tests on various combinations of prototype parts used in the structural design of hopper wagons. The optimal configuration identified for the ApATeCH composite hopper encompasses a self-supporting monocoque shell, which consists of an inner frame containing seven transverse frames and a central backframe which overlaps the end walls. The wagon supports longitudinal loads from a loaded wagon and the transmission of forces to the metallic frame by utilising special steel braces which are fitted to the wagon's end walls. ApATeCH-STINK is a material approved for use in Russia by the Russian Ministry of Regional Development and is already being used in bridge construction.

With the design established, metallic moulds were developed, manufactured and used to produce the large composite carbody underframe elements and the composite roof for the class 19-5167 hopper wagon.

The dimensions of the mould match those of the fabricated part and take into account manufacturing tolerances. Reliable dies are established by using automatic plasma cutters which offer longitudinal and transversal patterns. Figure 8 below shows the completed moulding die for the hopper carbody underframe, which takes into account maintenance walkways, before it is placed inside the workshop.



Measuring unit: mm

Fig. 7b. Data of stability coefficient (von Mises) for the diagonals of more bearing end wall at the worst possible workload combination on impact as per I simulation scenario



Fig. 8. Moulding tools for the hopper underframe



Fig. 10. Prototype of hopper-wagon 19-5167

Before producing carbody elements from composite materials, the impregnation process was simulated on PAM-RTM software². Based on simulation data (see Figure 9), the impregnation time for the main element (including load-bearing strakes) is about 80 minutes. The total impregnation operation, including that for the tops of frames, is about 115 minutes.

The weight of the composite carbody is 5,500 kg, which is lower than the value prescribed in the TDA.

After the carbody underframe, and other components and subassemblies such as the hopper boxes, charging covers, ladders, and metallic inserts, are manufactured, composite car elements were fitted on the underframe. Shoring was also installed in the end walls, and all specified systems and elements were fitted to the completed prototype (see Figure 10).

The class 19-5167 hopper wagon, which utilises a composite carbody, is in compliance with

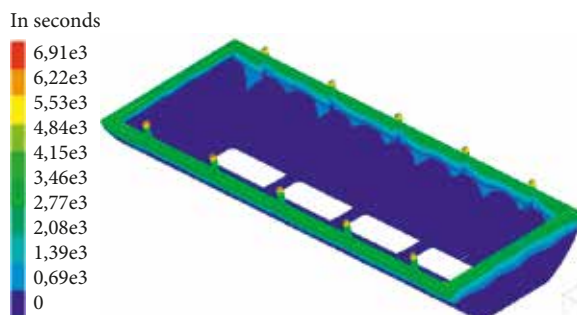



Fig. 9. PAM-RTM simulation data of impregnation time for roof element and distribution of binder front in roof body

UKHL³, which ensures reliable performance at the -60°C minimum operating temperature, and suitability for operation on 1520mm-gauge infrastructure. As intended at the outset of the project, the hopper is suitable for bulk transportation of non-hazardous chemical fertilizers and other non-hazardous bulky cargos.

The wagon rests on innovative bogies which have capacity for a 25-tonne axle load. The volume of the carbody is 125m^3 , and it has a maximum load capacity of 74 tonnes. Moreover, the wagon integrates a state-of-the-art automatic bogie which uses modern automatic braking which features a separate braking system for each bogie, has connections for unthreaded-end pipes, and an advanced automatic coupler with SA-3U coupling. The wheelbase of the wagon is 12m-long, and the total length, including couplers is 16.22m.

While composite materials are commonly used in the aviation and space industries, they remain rare in the rail sector. Yet as this example shows there are many potential advantages of adopting this material. In addition to offering enhanced vehicle strength, the application of composite materials for freight wagons carbodies has the potential to reduce repair and maintenance costs for all operators and can increase the mileage between schedule maintenance events. For example using a composite carbody is expected to extend the life of a hopper wagon to 32 years from the expected 26 years currently achieved by all-steel freight wagons. 

² PAM-RTM – specific licensed software for the simulation of production process of vacuum-impregnated items

³ UKHL – application version associated with boreal climate under GOST 15150

TVEMA – Safeguarding track safety



Maxim Tarabrin,
Deputy Director General, TVEMA CJSC

Data from railway infrastructure diagnostic systems plays a critical role in informing the maintenance tasks which help to sustain a safe and efficient railway. In the context of increasing demands on infrastructure from very high-speed railway traffic and longer and heavier freight trains, diagnostics has never been more crucial. Diagnostics system deployed in Russia have consistently shown their reliability and regard for safety, and are set to play a key role as high-speed and freight traffic continues to grow in the next few years.

Founded in 1989, TVEMA is a leading global manufacturer of railway infrastructure diagnostic equipment. We value our long lasting and extensive cooperation with railway companies in the CIS states, and the relationships that we have built recently in Germany, China, Hungary, Israel, Poland, Armenia, Mongolia and Turkmenistan.

We currently supply nearly 50 different products and services for use on railways and with other applications. Each offers value for money and is characterised by a simple and modular design which can integrate numerous manual and portable multi-purpose diagnostic tools. They are also suitable for installa-

tion in various carriers and vehicles; from deployment in portable and easily-detachable units that are usable in multiple vehicles, to highly mobile dedicated diagnostics trains and laboratories. The products are designed for use on a stand-alone basis, or can be combined with several inspection tools that measure a range of components and parameters. The software used in our products also has flexibility to execute these inspection tasks effectively.

Below is a detailed presentation of the products we offer for railway infrastructure diagnostics, which demonstrate TVEMA's scientific and engineering resources.

Immediate data interpretation

One of TVEMA's latest developments is the ASTRA software and hardware suite for automatic interpretation and analysis of non-destructive and destructive test data (NDT-TD). The ASTRA suite carries out a real-time automatic analysis of the measurements received from various NDT and TD systems, providing a rating for rails and switch components, while evaluating the diagnostic system's performance and inspection methods.

A significant advantage of this system is its capability to offer on-stream training to staff through their observations of the software's behaviour during deployment in diagnostics vehicles or during analysis in laboratories.

In November 2011, the ASTRA SW and HW suite successfully passed Russian Rail-

ways' network acceptance tests. Early in 2012, the first units entered service in diagnostic centres and vehicles in Ukraine, and in 2013 it was deployed in diagnostics vehicles used by Moscow Metro.

ASTRA's reliability and capability to quickly interpret defects was evident during both track tests and in field operations. More than 20,000km of fault-inspected track data has now been analysed during the course of various tests with ASTRA, with the system filling in all reporting forms automatically, and thus far detecting 78 critical rail defects. Furthermore, additional manual verifications conducted following ASTRA Suite operations failed to show any unrecorded critical defects.

Fast ultrasonic flaw detection

Even the top of the range intelligent flaw detection systems rely on data supplied by a measuring system. Indeed the ASTRA suite can not perform effectively without another solution from TVEMA: the ECHO-COMPLEX-2 multi-channel NDT analyser (see Figure 1).

The analyser utilises a wide range of ultrasonic channels, while its hardware capabilities and control software help to dramatically reduce the impact of unstable acoustic contact and the limited skills of operating personnel on inspection results. Thus it also offers the same advantages of wheel-type probe systems, which are less prone to fluctuations in acoustic contact than other measuring systems.



Fig. 1. ECHO-COMPLEX-2 multi-channel NDT analyzer

As well as more ultrasonic channels, the other advantages offered by the system include innovative circuit engineering solutions and a broader range of control software functions, including those which allow inspections to take place at higher speeds than on previous ultrasonic inspection systems.

The acoustic unit protector eliminates the impact of ultrasonic waves allowing a temporary window during which the system can record the condition of the rail at any height, thus offering a significant improvement in inspection reliability. The acoustic unit's design and the wide range of converters manufactured by TVEMA are suitable for any scanning pattern and can meet the specific flaw detection standard requirements of any railway network in the world.

Ultrasonic inspections have traditionally been associated with limitations in their maximum operating speed. However, by utilising its extensive experience of design and manufacturing mobile NDT equipment, in 2013 TVEMA developed a unique high-speed system for ultrasonic inspection of rail conditions.

Thanks to its original design, the undercarriage NDT system equipment can be mounted both on a dedicated NDT bogie and between the wheelsets of a standard bogie used by the vast majority of rail vehicles. This is an innovative solution for NDT equipment as it eliminates the need to use a dedicated bogie to carry out these tests.

Track Measurement under any Conditions and on any Railways



Fig. 2. SOKOL-2 track geometry assessment system

TVEMA has supplied track recording systems for many years and its family of products has evolved from mechanical devices based on track geometry chord sounding methods to modern optical-inertial systems.

The SOKOL-2 track geometry assessment system (see Figure 2) integrates two profile meters which measure rail geometry on the gauge profile, and a high-precision inertial navigation system. The SOKOL-2 generates data on the condition of the track gauge as well as elevation and any horizontal and vertical track irregularities, and the rail contour parameters. Such systems are installed in INTEGRAL diagnostic trains and in track

geometry laboratories in converted VL-11m electric locomotives.

The company's most recent track measuring product is SOKOL-3, a modular multiple inertial measuring system. TVEMA's Russian and German engineers developed a system which offers high-precision measurement of track geometry at speeds up to 350km/h within wavelength ranges D1, D2 and D3, all within a unit that is less than 1.5m long. During the system development process, a special emphasis was placed on ensuring operability in all climate conditions. An air surplus pressure subsystem was consequently incorporated to provide the system's crystal clear

lens, while heating and cooling subsystems allow SOKOL-3 to operate effectively in temperatures ranging from -40 to 65°C.

A laser was designed specifically for the system and operates in the visible blue colour range. It is distinguished by its micro size, high-power electronics of 1.6W, and extraordinary distribution diagram. The use of state-of-the-art lasers and cameras together with reliable high-precision inertial navigation systems as well as the fact that it is compatible with Russian and German subsystems have established SOKOL-3 as one of the best track measuring systems in the world.

Most Reliable and Rapid Video Inspection

The latest product to emerge from TVEMA's engineering efforts, and a new element of diagnostic appliances, is the introduction of video inspection systems. So far we have equipped more than 50 vehicles with high-speed video inspection systems, which serve as an additional data source for the operators of flaw detection and track measuring trains.

In 2011 the company developed its SVOD-2 modular multi-purpose system for high-speed visual inspections (see Figure 3), which is now being used to detect defects to the rail tread and joints, and cracks in rails and cross-sleepers. High-speed linear cameras located in the im-

mediate vicinity of the inspected subjects offer images with a resolution of 0.2mm/pixel in both planes at speeds up to 140km/h. A dedicated lighting system also enables the system to capture clear and well-contrasted images at any time of the day or in any weather. Today the SVOD-2 system is the world's fastest at checking the rail running surface for defects.

Three SVOD-2 systems are installed in flaw detection trains used by Deutsche Bahn (DB) while the multicamera systems, which consist of six-camera sets, are installed in INTEGRAL-2 and SYNERGY-1 diagnostic trains used by Russian Railways (RZD) and Moscow Metro.



Fig. 3. SVOD-2 multipurpose system for high-speed visual flaw detection

The SVOD-3 is the latest addition to TVEMA's visual flaw detection family and combines high-speed linear cameras, which capture the state of track superstructures, and profilometers which measure the elevation and geometry of track superstructure elements. The system's unique analytical software is capable of processing enormous data packages about track condition and automatically detects more than 50 defects including track pumping, defective junctions, faulty sleepers, and rail surface flaws.

With its additional features, and new regulatory requirements permitting the deployment of automated track inspection processes, the SVOD-3 system is regarded as one of the company's most promising products and several European and African operators have already expressed an interest in the system.

The public presentation of the SVOD-3 system will take place at InnoTrans in Berlin this September, where TVEMA will display its latest products in Hall 26, stand 133.

Affordable diagnostics solutions

The company's latest production activities focus on diagnostic modules for hi-rail vehicles based on the Mercedes Unimog series. Engineers from TVEMA and Zagro, a leader in rail-road ve-

hicles based in Sinsheim, Germany, are currently working on a joint project to develop a flaw detection, track measuring, and clearance gauge measuring vehicle.

Current and future partnerships

In accordance with our relationships with our various partners, we are ready to demonstrate our products in real life operating conditions and in recent years, we have tested many of our shared products in various countries. For instance, the LDM-LR hi-rail inspection vehicle (see Figure 4) was successfully tested in Germany in 2012,

and in July 2013, a track NDT analyser successfully passed tests following installation in a flaw detection vehicle operated by the Hungarian Diagnostic Center. In May 2014, similar tests were conducted in Poland. Practical demonstrations of the flaw detection systems in China and Kazakhstan helped us to illustrate the advantages of our systems, and very soon they will be implemented in diagnostics systems monitoring railway infrastructure in those countries.

TVEMA is also involved with processes to develop codes and standards for railway infrastructure. For example, in 2014 TVEMA became an affiliated enterprise of the Organisation for Cooperation between Railways (OSJD) and is now sharing its experiences with railway communities in various countries, which is proving useful in the development of relevant guidelines for effective operation and maintenance of transport networks in the OSJD member states.


The joint efforts of TVEMA and various railways to develop guidelines for railway infrastructure diagnostic systems have already made significant improvements to railway traffic safety and infrastructure performance over the last few years. 



Fig. 4. LDM-LR Hi-rail Mobile Inspection Laboratory

Innovative Hybrid Shunting Locomotive



Oleg Kravchenko,

Director of Test Center, Bryansk Machine Building Plant (BMZ CJSC)

Transmashholding JSC's new shunting locomotive, TEM35, which is designed to diversify the company's shunting locomotive offerings, is the first Russian-built shunter to incorporate both domestic and imported technologies, components and materials. The technologies used in the locomotive are intended to increase repair intervals, decrease the number and duration of scheduled maintenance and repair events, as well as reduce energy consumption, and harmful emissions.

TEM35 is a CoCo shunting locomotive (see Figure 1) that utilises a hybrid power unit, as well as ac electric transmission and asynchronous traction drives. The locomotive is designed for shunting and non-revenue operations in depots, rail yards and at industrial sites that use 1520mm-gauge track.

The locomotive and its components are manufactured under GOST 31428 requirements and meet the «U» climatic category (temperate cli-

mate) regulations outlined in GOST 15150. As per GOST 16350 requirements, the shunter can operate in I2, and II4 through II10 climatic areas at ambient temperatures from 223K to 313K (-50°C to 40°C). Testing of the TEM18DM was carried out by BMZ, a subsidiary of Transmashholding, which provided the foundation for the development of TEM35 locomotive featuring wheelsets fitted with axle hung traction motors and antifriction bearings (see Table 1).



Fig. 1. TEM35

Table 1. TEM35 Specification

Engine rated output, kW (hp)	571 (777)
Operating weight (with 2/3 of fuel and sand store) tonnes	123±3%
Wheel arrangement	CoCo
Travelling wheel tractive effort at normal mode of operation (with new wheel treads) kN (tf)	
– from gen set	226.0 (23.0)
– from gen set and capacitor	226.0 (23.0)
Design speed, m/s (km/h)	27.8 (100)
Min storage capacity, kg	
– fuel	4,900
– sand	1,000
Min locomotive service life, years	40
Gage under GOST 9328	1-T
Locomotive dimensions	
– coupled length, mm	17,500
– width (over handholds)	3,160
– height from rail	5,080
Exhaust emission and smoke	compliant with GOST R 50953
Transmission	individual per each axle
Locomotive body type	with hood, underframe, and a driver's cab

Details of TEM35 Design

**Fig. 2.** Electrochemical capacitors

To accumulate power, the locomotive uses Russian 30EK404-45 electrochemical capacitors with overall capacity of 100F and storage power output of 22.7 MJ.

Locomotive control is performed by means of intelligence vector control systems. When a hybrid locomotive is moving, the power generated by the genset is supplied to asynchronous motors which feed the actuator of ventilators, variable speed control compressor and of electrochemical capacitors (see Figure 2). In addition to helping the locomotive achieve its maximum output, these electromechanical capacitors have the capability to store energy captured during braking for reuse by the unit.

The TEM35's hybrid technology is the first of its kind to be developed in Russia, and subject to locomotive operational conditions and duty cycle, the TEM35 outperforms its peers on fuel economy by 20-30%.

As well as its hybrid drive system, the locomotive integrates a 571 kW, 1,800 rpm Caterpillar CAT C18 ACERT diesel engine which offers low fuel and oil consumption, and emissions levels, all while enhancing the locomotive's operating performance. The engine's cooling system uses an antifreeze solution which enables the locomotive's engine to start at -10°C.

The locomotive also utilises the latest braking equipment supplied by MTZ Transmash. The system installed secures overall braking control by transmitting pneumatic control signals into the train braking system, which provides synchronous braking to each of the unit's moving elements. To achieve this, the shunter is fitted with a helical screw compressor AKRV 3,2/10-1000 which is installed in a pneumatic module along with compressed air and drying units, with a compressor supplying compressed and dried air into the locomotive's braking and auxiliary equipment.

In contrast to the pneumatic system which uses stainless steel pipes, the locomotive's traction generator GS523UKHL is connected to the diesel engine by means of a rubber metallic coupling. The locomotive also benefits from IGBT-based traction converters, and takes advantage of the latest wheelset subassembly technology, (see Table 2 and Figure 3) which features a traction motor hanging on an axle with press-fitted antifriction bearings. The antifriction bearings are positioned in a tube-shaped bearing case enclosing the axle. The tube ends have different flanges to fit different bearings (roller journal spherical



Fig. 3. Wheels-and axle subassembly consist of a DC traction motor and a standard design wheelset with an antifriction axle hung bearings designed by BMZ CJSC engineers.

bearing and taper roller bearing) and the bearing box is bolted to the traction motor case on special fastening lugs fitted along a longitudinal shear between the flanges.

TEM35 uses antifriction bearings and AD917A asynchronous motors which demonstrated their efficient performance in technical condition monitoring during operations at Sverdlovsk Passazhirsky Depot in January 2011. Among the advantages the locomotive provides operators are leakage-free axles which eliminate potential pollution charges, improved locomotive energy-efficiency and productivity, better power intake by traction, as well

Table 2. Technical Parameters of Antifriction Axle Bearing

Traction motor model	AD917A UKHL1
Effective horsepower, kW	470
Traction motor	asynchronous type
Traction motor suspension	pendulum type
Track gauge	1520 mm
Distance over axle box centers	2,134 mm
Taping line diameter	1,050 mm
Gear type	single reduction, straight-toothed
Gear ratio	4.41
Axle box	two-link type
Distance between axle box springs	690 mm
Axle load	24 tonnes



Fig. 4. TEM35 is operated by a single driver eliminating the need for a driver's assistant

as reduced fuel consumption. Repair-and-maintenance-free antifriction bearings similarly decrease operating costs by eliminating the need for the seasonal replacement of axle oil, with expected consumption on the TEM35 comparing favourably with the approximately 149kg expected average annual axle oil consumption by a comparable TEM18DM locomotive equipped with friction-type bearings. Estimated consumption per 100 engine/km and per hour by a locomotive with antifriction bearing technology is better than those of TEM18DM control group by 6.6% and 5.6% respectively. Antifriction bearings also contribute to improved traction motor and gear reliability and durability, and extend the anticipated lifetime of the wheelset subassembly.

The design of the driver's cab, which features two control desks and a turret-type full vision cab, meets current safety, ergonomics and health requirements. The position of the locomotive's control system, the driver's seat and leg support as well as the use of Webasto heater, insulating materials and glass units which minimise noise levels, offer a comfortable experience for the driver when seated and standing (see Figure 4). The use of a multifunctional TCMS system, which supplies locomotive performance data to control desks displays, also helps the driver to easily monitor the locomotive's performance.

The locomotive incorporates communications, automatic train control, fire extinguishing, skid and slip control, independent fuel



Fig. 5. TEM35 Modules

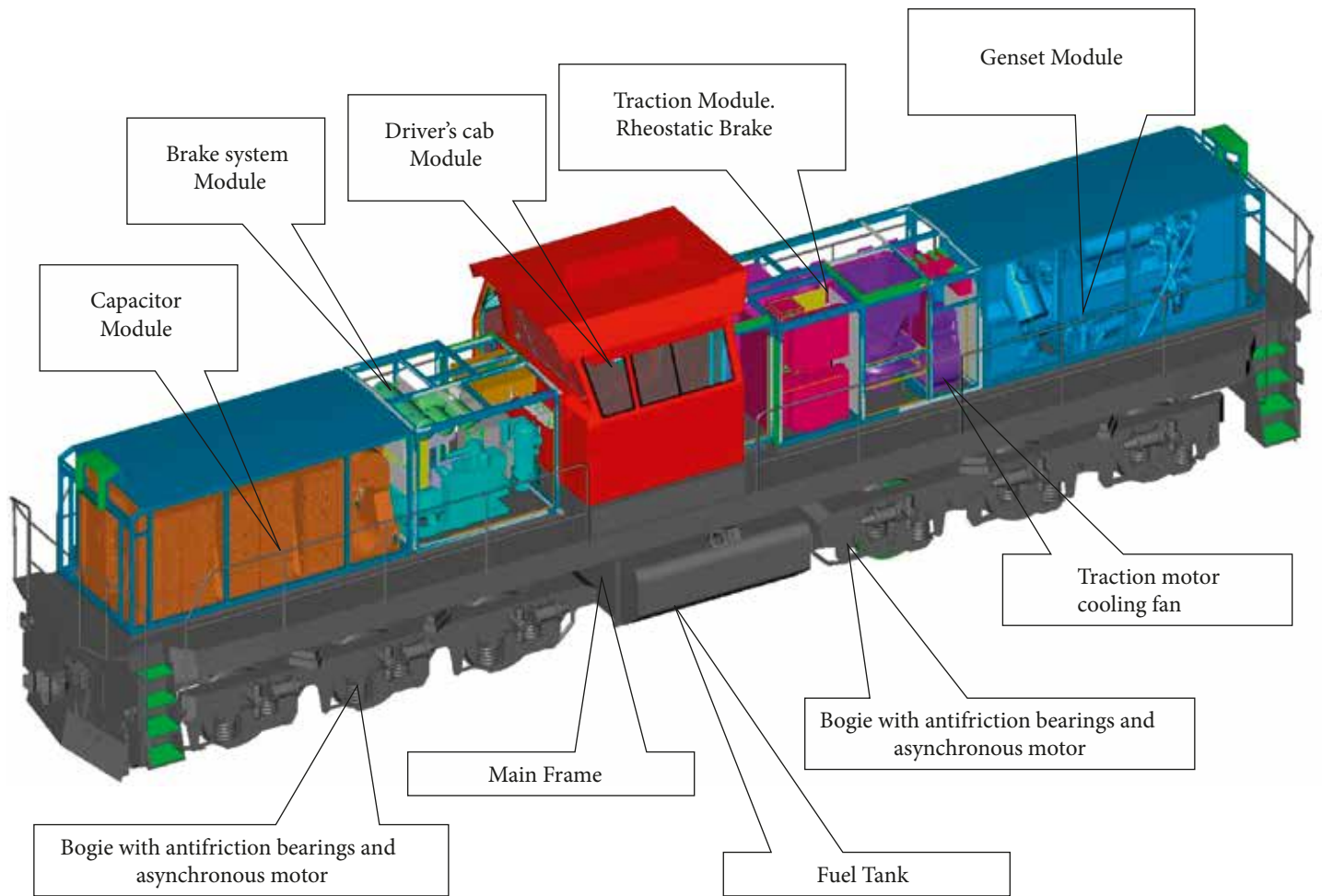


Fig. 6. TEM35 Layout

and coolant preheating, and wheel rim collar lubrication systems. It also features an automatic fuel flow meter, a washbasin with water heating, and a biotoilet. In addition the driver is aided by the unit's on-board diagnostic system, which offers a departure and operational diagnostics function and data storage that can be used to define the scope of scheduled maintenance and repairs.


The TEM35 shunter has a modular architecture with subassemblies located in the following separate modules (see Figure 5):

- genset module,
- electrical module,
- modular driver's cab,
- pneumatics module,
- capacitor module.

The main modules integrate smaller submodules, which cover the rheostatic brake, air com-

pressor, traction inverters, and auxiliary converter. Such modular design improves both operation and maintenance. And with key components using a standard design manufacturing costs are reduced (see Figure 6).

A similar modular approach is used by Transmashholding engineers in the design of other TEM TMH shunting locomotives with modular design allowing a straightforward replacement of the capacitor with a second genset module in a single maintenance shift.

The new advanced TEM35 locomotive offers improved energy-efficiency, reduced emissions and better mileage between maintenance events. Tests performed have demonstrated the success of both the locomotive's overall design and its technical and technological solutions. The shunter was exhibited at the EXPO 1520 event in Shcherbinka, in September 2013. 

Automatic Driving Systems for Locomotives



Dmitry Tikhonov,
General Director of AVP Technology LLC

Preventive measures designed to improve traffic safety and reduce energy consumption from traction, including automotive processes that eliminate human error, have always warranted special attention. The inaugural intelligently control 'automatic driving' solution for rolling stock traction dates back to 1957, when the first trial autonomous automated deriving unit for suburban trains was conceived. However, it was not until 1998 that the first Automatic Driving System (ADS) was industrially manufactured for EMUs and introduced on vehicles operating in Moscow and maintained at Kurovskaya, Zheleznodorozhnaya and Ramenskoye depots. From 2000 onwards, automatic driving and recording systems have been gradually installed on Russian passenger and freight electric locomotives, which was followed by the deployment of the systems on main line and shunting operations in 2004.

ADS Purpose

Currently more than 7,000 rolling stock operated around the world, including in Russia and the CIS, are equipped with automated driving and recording system units manufactured by AVP Technology (see Figure 1). For example, the standardised automatic driving systems for freight trains (USAVP-G, where G is 'Freight', 'gruzovoi' in Russian) are installed in VL10, VL11, VL80, VL85, 2ES5, 2ES5K, 3ES5K, KZ8A (Alstom), 2ES6 (Siemens) electric locomotives. More than 40% of the systems have been upgraded to Intelligent System for Automatic Control of Distributed Power (ISAVP-RT). The passenger

locomotives ChS2, ChS2K, ChS2T, ChS4T, ChS6, ChS7, ChS8, ChS200, EP1, EP2K, EP20, KZ4AT (Alstom) are fitted with standardized Automated Driving System (USAVP-P) (P = 'Passenger'), while all series EMUs utilise standard Automatic Suburban Train Driving Systems (USAVP). The introduction of AD systems into TEP70, 2TE10, TE33A diesel locomotives is also growing rapidly. Moreover, the event recorder RPDA-T is installed in shunting and main line freight and passenger diesel locomotives TE10, TE116, ЧМЭ3, TEM2, TEM7A, TEM18DM, TGM3, TGM4, TGM6, TEP70, along with special-purpose rolling stock and small diesel locomotives.

ADS is intended to offer automatic control of locomotives in the most economical power consumption mode available while preserving traffic safety norms and respecting train time schedules. The critical difference between the presented ADS system and the majority of conventional automated control systems that perform only uniform motion function, such as cruise control, is that the ADS offers real time calculations of track profile from which it can implement the most economical traction and braking mode for a particular locomotive at a specific time.

At the heart of the ADS is an onboard computer loaded with software which calculates the most

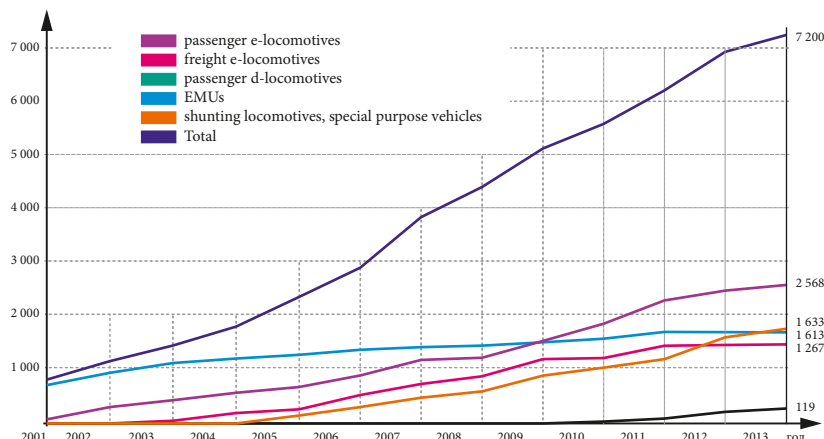


Fig. 1. Rolling stock fitted with ADS and Event Recorders as of 01.01.2014

effective energy-saving motion pattern for a train on a specific line section. The programme identifies the track profile and selects the correct steering modes for the locomotive which ensure safe motion and strict respect of the time schedule. In order to perform the calculation, the software analyses the following parameters (see Figure 2):

- current status of a locomotive and catenary (fed from various vehicle sensors like pressure gauges, current meters, voltage, speed, and temperature sensors),
- train data (such as weight, length, quantity of cars), which is entered automatically or manually before operations start,
- route identified from the routes database,
- traffic time schedule, which is found in the database, and may be adjusted through wireless communication channels in the event of a change in the traffic situation, and
- speed restrictions and location of infrastructure facilities.

The ‘autodriver’ software monitors any changes to the train’s environment and can apply traction, electric and pneumatic braking, and sanding, when required. Thus the system offers a complete train driving experience by accounting for speed restrictions, track profile and other track infrastructure facilities, variations in train weight, and signals, all of which enables the system to accurately fulfil the service schedule. Furthermore, the system reduces energy consumption, cutting fuel and energy costs, and minimises longitudinal dynamic response all while respecting traffic safety standards. In addition the driver is able to switch his attention to monitoring the train environment and traffic safety.

EMU motion and automatic operation parameter recorders (RPDA) constitute an integral part of ADS, and may also be used on a stand alone basis, which is particularly useful for shunting and special purpose vehicles. These systems record speed, current, voltage, and

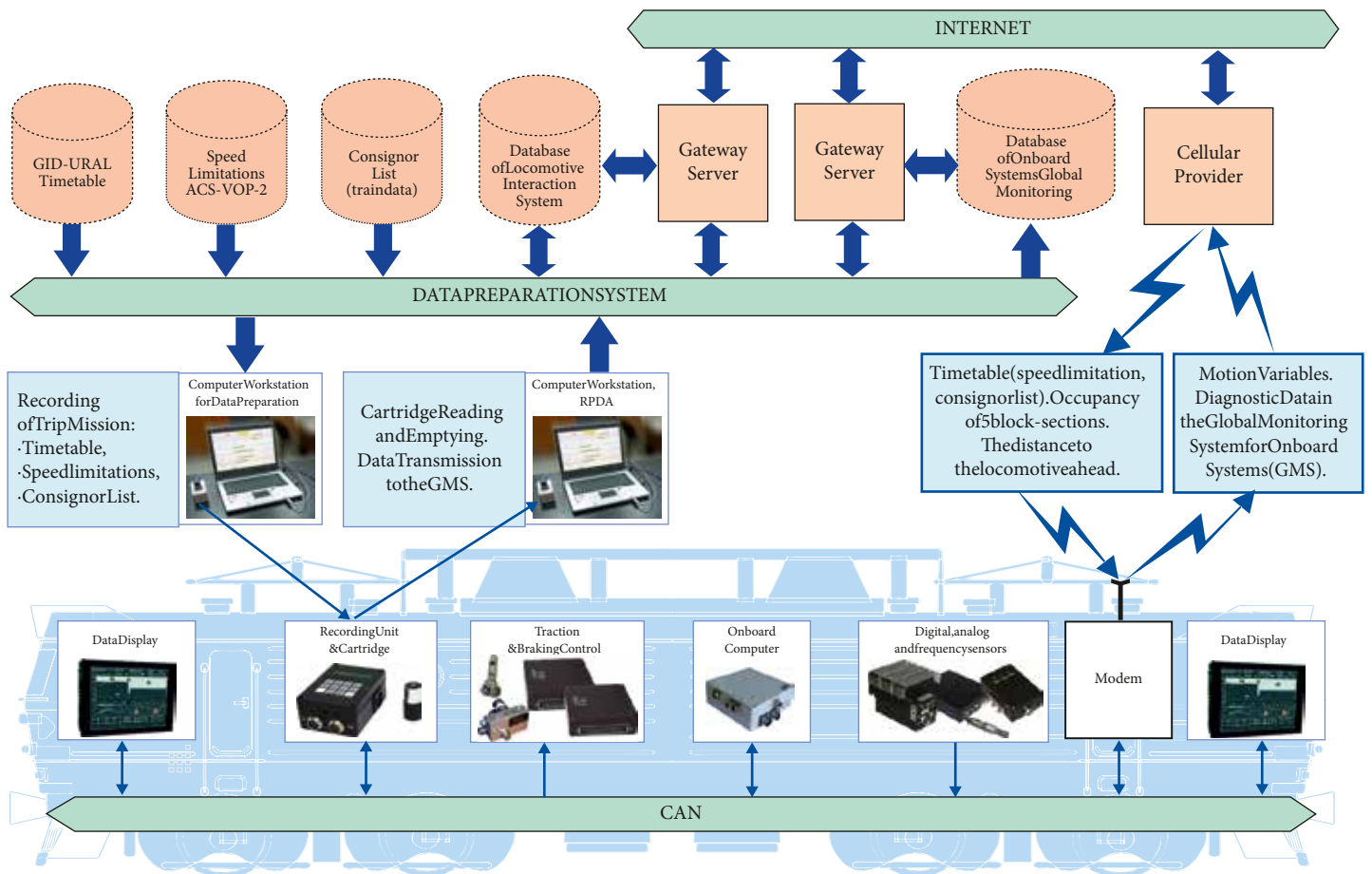


Fig. 2. ADS Operation Block-Diagram



Fig. 3. Tracking and condition monitoring of the locomotives equipped with ADS and Event Recorder is based on data sent to the server via wireless links

perature of fuel. These measurements are performed with reference to track and current time (see Figure 3), thus allowing an understanding of energy consumption for shunting operations, traction and heating, as well as that consumed by an specific section of the network: particular railway, railway division and haulage substations (for electric locomotives). When compared with regular metering devices, RPDA recorders and integrated RPDA instruments offer higher accuracy in measuring electrical energy or fuel consumption (rating 0.5S for AC and 1 for DC). An innovative computation technique which utilises data from dedicated ultrasonic sensors is the source of the more accurate fuel weight and density data measurements. The set of measured parameters is dependent on the specific rolling stock, and may be easily adjusted by connecting sensors and related processing units to the recorder.

pressure levels instantly, and in the case of diesel locomotives, can also monitor oil and water temperatures, and the level, density and tem-

Calculation Data and Algorithms

To monitor a particular locomotive’s technical status, location and/or its consumption of fuel or electrical energy, companies using ADS and the event recorder system are provided with conven-

ient tools to collect and process the transmitted and logged data into reports. The fuel and energy savings offered by ADS when it is in operation for over 75% of a trip may reach 10%, and in case of

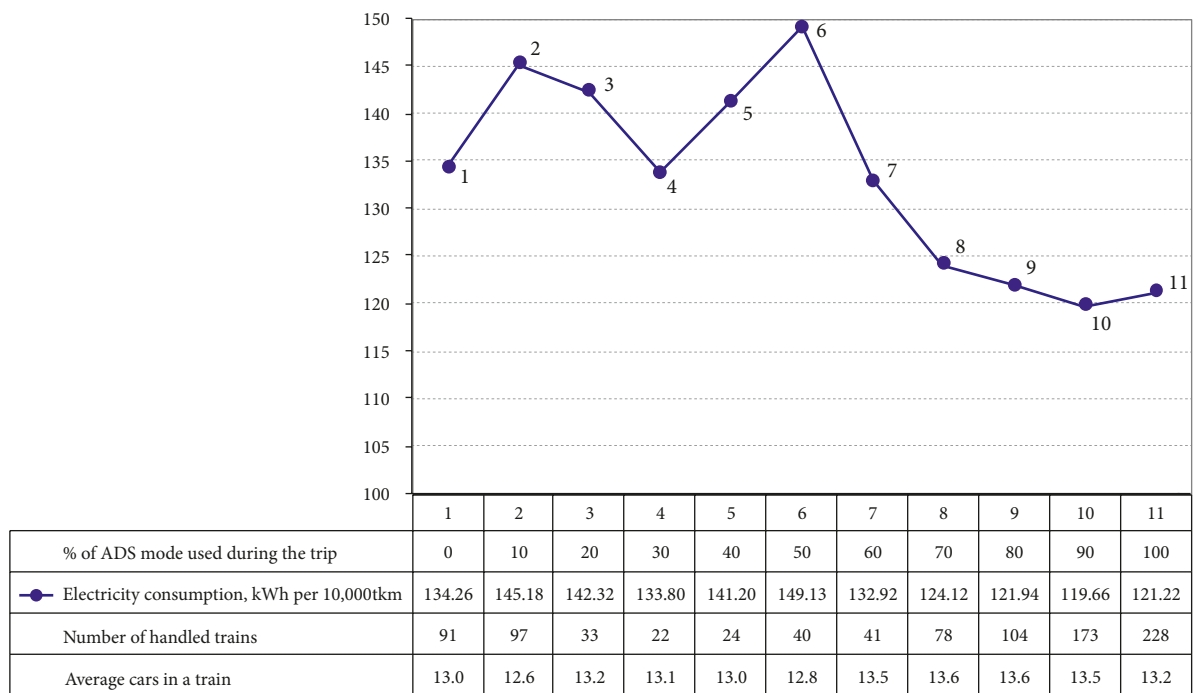


Fig. 4. Traction energy consumption compared with distance covered under ADS mode on the Krasnoyarsk – Mariinsk line

ADS when applied to pairs of freight trains which are operated using distributed power, it can be as high as 15% (see Figure 4).

The cumulative distance of lines operated using the ADS system now exceed 100,000km, with electronic maps available and regularly updated for each of the routes. The initial challenges to the system posed by rolling stock with contactor-type or silicon-controlled rectifiers (SCR) with partial and full control of dynamic, regenerative, electro-pneumatic and pneumatic braking have been resolved.

The ADS units installed on new locomotives like EP20 (see Figure 5), 2ES5K, 3ES5K, KZ8A, KZ4AT, TEP70BS, TEP33A, EP1, EP1M, and EP2K are integrated with onboard MPU systems which already comprise all necessary sensors and peripheral controls for the locomotive's subsystems and unit management. The use of these measuring and control units reduces the cost of ADS and its payback period considerably.

The ADS' specially-designed algorithms, which determine an operation pattern that maximises energy savings by taking into account the locomotive's traction performance and the train weight along with the track profile, are also used to update train schedules. For example, 2,110 passenger trains were transferred to energy-saving schedules in 2009-2013, including



Fig. 5. A passenger train hauled by EP20 Locomotive in automatic driving mode

122 diesel-hauled trains, which resulted in excess of 100 million kWh of savings.

Increases in railway productivity and traffic inevitably lead to greater workloads for drivers and higher labour costs. Greater demand on drivers also increases the risk of emergencies arising from human error which currently account for 90% of railway traffic accidents. As a result ADS' ability to decrease driver workload is a major benefit of the system and the pursuit of enhanced railway safety.

Manual Operation vs Automatic Operation

It is readily acknowledged based on analyses of drivers' actions when passing stations during manual operation that they are more likely to become mentally and physically overstressed¹. Moreover, this is intensified when the driver is required to perform high levels of interface control, which may take up 75% to 90% of their time during normal operation.

Time and motion studies have shown that in these situations drivers compensate for time shortages by carrying out fewer checks of control desk indicators. They also sometimes fail to perform a complete report when transferring re-

sponsibilities to an assistant driver. In the context of traffic safety, all of these factors could result in a critical emergency. In addition, violating resting time rules, exceeding overtime allowances, and deviating from the correct selection of locomotive crew can make the situation even worse.

While the application of ADS during station passes does not result in any substantial reduction in driving algorithm complexity, driver workload is considerably reduced from 90% down to 60%, which inevitably decreases the risk of driver error.

The manual driving algorithm on busy lines analysed by Russian R&D Institute of Railway

¹ Based on Conclusion Decision No 0/-076/380 by Russian R&D Institute of Railway Hygiene (VNIIZhG) dd 19.09.2002

Table 1. Data showing drivers' mental and physiological state from a study of manual and automatic driving modes

Characteristic	Manual	ADS
Workload ratio	0.7	0.57
External Environment Control	42.7%	51.6%
Mental capacity	80.6-91.6	83.2-85
Visual-Motor reaction time during outbound trip	560-549 ms	522-497 ms
Visual-Motor reaction time during return trip	544-536 ms	522-497 ms

Hygiene (VNIIZhG) has a margin both in the complexity of the algorithm and the driver load factor, which when fulfilled, does not exceed permitted levels. At the same time, the application of ADS on the section allows variation in the control algorithm by increasing the number of operations and the time available to monitor infrastructure facilities, inspect trains and other diagnostics instruments, thus contributing to improvements in traffic safety.

The analysis also shows the value of deploying ADS as a means to avoid excessive locomotive driver fatigue in poor weather conditions such as fog, rain, snowfall, during night operations, and at poorly lit platforms.

The psycho-physiological study of drivers revealed that during manual operation the first signs of overwork appear after three to four hours, which compares with after five to six hours under ADS. As a result it is clear that ADS reduces the risk of human error.

In automatic driving mode, the driver is not required to calculate the travelling speed necessary to stay on schedule, read the motor's amperage when changing traction and pressure notches during braking, as well as perform routine operations with manual controls.

The positive effect on a driver's condition from the ADS is demonstrated by using the system on what is perceived as a difficult trip (see Table 1).

**Fig. 6.** Joint trainsets running in automatic control mode (ISAVP-RT) with distributed power

ADS is now used regularly between Murmansk and Svir on the Oktyabrskaya Railway, and by East Siberian Railway. In the Far East Railway, ADS is successfully used by a crew of two drivers on extended trips of more than 11 hours.

The benefits of ADS are also illustrated by deployment on South Ural Railway's ChS7 passenger locomotives. Since installation in 2000, the locomotives have reported noticeable improvements in performance. A scientific study of the effect of automatic driving on crew function concluded that this was one of factors that led to an increase of a turnaround trip of one crew to 525km from Chelyabinsk to Petropavlovsk com-

pared with a 258km journey from Chelyabinsk to Kurgan previously. The revised trip eliminated the need to change crew at Kurgan reducing the stop time, and allowed the deployment of this crew to a freight service. Up to 18 pairs of automatically driven trains with distributed power and a weight of up to 12,000 tonnes now operate on the South Ural and West Siberian Railroads on a daily basis (see Figure 6). These trains can operate for over 1,000km in this formation, a practice which significantly reduces longitudinal dynamic reactions, and provides a 15% improvement in energy consumption as well as enhancing capacity on busy lines.

Service Functionality & Safety


Meeting the demands of fulfilling schedules to a 1 min degree of accuracy for conventional operations and 30 sec for high-speed services is a major benefit of ADS. Data retrieved from RPDA event recorders show that trains operated with ADS experience three to four times fewer delays compared with manual operation, enhancing the Elbrus system's ability to schedule passenger and freight trains to the highest possible degree of accuracy.

Updated ADS equipment featuring modems and colour LCD screens are included in the Driver Information System (DIS) fitted to VL10, VL10U, VL11, and VL80S electric locomotives operating on South Ural, West Siberian, Sverdlovsk and Kuibyshev Railways. These ADS system receive real-time schedules, changes to speed restrictions, and train data, eliminating the need for a driver to switch to manual operation in the event of a delay or change to traffic schedules. The DIS system also provides the driver with details of block section vacancies, train position and speed limits.

By providing real-time information it is possible to switch to the complete automation of all trains operating on a specific line or network, which as already demonstrated will improve safety and reliability.

The leading rail equipment suppliers are now paying considerable attention to the benefits offered by automatic driving and event recording systems. For instance, General Electric's (GE)

LOCOTROL distributed power locomotive systems and TRIP OPTIMIZER automatic throttle control system are well known solutions. LOCOTROL is the most popular distributed power control system in the world. However, it offers only synchronous or part-synchronous control of remote locomotives, in which secondary locomotives repeat the traction settings of the master locomotive or perform some preset shift. In Moreover, LOCOTROL requires high-speed communication with dense coverage for smooth operation. In contrast, ISAVP-RT intelligent distributed power control system developed by AVP Technology offer reliable performance through 20-30 byte/s communication channels, with completely asynchronous throttle control.

It is important to note that automation is already a global trend in aviation, water and highway transport. The large-scale implementation of ADS and RPDA event recorders on railway networks is linked directly to the joint efforts and shared interests of the developers, manufacturers and operators. Thus, AVP Technology has a long and effective history of cooperation with Russian Railways, and has executed projects with Gazpromtrans, Sibur-Trans and RUSAL. International projects with Alstom and GE intended to preserve fuel and cut energy costs as well as improve safety are also well underway. 

Contents of previous issues



InnoTrans 2012

- **Nikolay Lysenko.** UIRE: 5 years along the way of integration partnership events
- **Valentin Gapanovich.** Innovative development of Russian Railways
- **Evgeniy Rudakov.** Results of the industrial production condition monitoring based on the indexes of the Institute of Natural Monopolies Research (IPEM)
 - 1520 – 1435: prospects for cooperation
- **Yury Saakyan, Natalia Porokhova.** Russian machinery: State support in crisis and post-crisis periods
- **Ilham Galiev, Victor Nekhaev, Victor Nikolaev.** Competitive ability of Russian railways, its connection with dynamic properties of freight car running gear and the ways of their improvement
- **Sergey F. Podust, Sergey S. Podust.** Lean production tools effect on efficiency of Novocherkassk Electric Locomotive Plant LCC (NEVZ)
- **Oleg Trudov, Konstantin Kostrikin.** Life cycle cost (LCC) methodology application to determine the promising directions of innovative product development
- **Vladimir Kutergin, Dmitry Tarasov.** Peculiarities of price formation for innovative products with account of the ownership cost
- Survey of russian transport engineering industry performance in 2011
- **Andrey Marchenko, Konstantin Soltus, Konstantin Dorokhin.** Into the future - in the new Russian electric locomotives
- **Alexey Tishaev, Alexey Zaycev.** Triple-diesel engine locomotive CME3 ECO: with care about future
- **Vladimir Mironov.** The second floor of efficiency
- **Yury Boronenko, Anna Orlova.** Possible ways for unification of freight car bogies, their units and parts at 1520 mm rail gauge
- **Yuri Ivanov.** Computer vision technologies for the supervision over objects of railway infrastructure
- **Vladimir Matyushin.** The “unconquerable” heights of quality
- **Sergey Gapeev.** IRIS standard is the most important component of transformation of Russian railroad industry
- **Yury Babkov, Valery Perminov, Elena Belova.** Influence of reliability and utilization indexes values on locomotives technical readiness



InnoTrans 2010

- **Vladimir Yakunin.** Key problems of railway engineering and possible solutions
- **Valentin Gapanovich.** JSC “RZD”: Innovation-based development
- **Yury Saakyan.** Effects of the volume and structure of the RZD’s investment program on the situation in railway engineering and related economy sectors
- **Konstantin Kostrikin.** Overview of the preliminary results of railway industry performance in 2009
- **Oleg Trudov, Natalia Porokhova, Evgeniy Rudakov.** IPEM indices as an alternative approach to online monitoring of the industrial production
- **Konstantin Ivanov.** Innovation in railway engineering development
- **Sergey Palkin.** Strategic tasks of quality maintenance
- **Vladimir Matyushin, Viktor Morozov.** Urgent issues of technical regulation in rail transport legislation
- **Yury Saakyan, Alexandr Polygalov.** Development of limit price calculation methodology for rolling stock
- **Arkadiy Murashov, Natalia Ivanova, Evgenia Stavrova.** Life cycle cost (LCC) as a basis for price calculation of railway equipment
- **Christian Ponticelli.** Life cycle cost of railway rolling stock: from theory to practice
- **Vladimir Matyushin.** Standartization in UIRE: it’s objectives and plans, and their implementation
- **Vasily Zorin.** Development of safety systems and train traffic interval control system based on satellite navigation and digital radio channel to increase the speed and intervals of train traffic
- **Vladimir Rudenko.** Gas turbine locomotive: timely and successful testing
- **Sergey Usvitsky.** Electric locomotive EP20 - basic platform for new generation electric locomotives

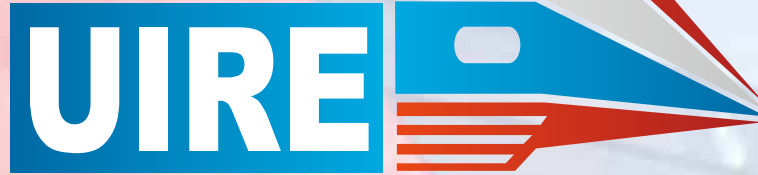


InnoTrans 2008

- **Oleg Trudov, Vladimir Savchuk.** Matching of rail transport and railway engineering development strategies
- The Russian Railway s programme for updating rolling stock fleet during 2008–2012
- **Konstantin Kostrikin.** Life cycle cost estimation – a new approach to railway equipment pricing policy
- Overview of Russian Railway Engineering Manufacturers
- **Sergey Palkin, Vladimir Matyushin, Nikolay Lysenko, Oleg Senkovskiy.** Union of Industries of Railway Equipment – moving forward
- **David Kirzhner.** A new model lineup of locomotives
- **David Kirzhner, Vladimir Rudenko.** Development and production of the world’s first main line freight gas turbine locomotive running on liquified natural gas
- **Sergey Adadurov.** Satellite technologies for innovative development in transportation management

All articles are available in the Railway Equipment magazine section
at www.ipem.ru

union of
industries of
railway
equipment



UIRE NP consists of 165 enterprises from 35 Russian regions that manufacture 90% of all rail production in the RF. Goods turnover of the enterprises of the partnership makes up more than 380 billion Russian roubles. Enterprises from Ukraine, Belarus, Germany, Uzbekistan, the Slovak Republic and the Republic of Kazakhstan involved in the activities the partnership.

COOPERATION OF UIRE NP WITH OUTSIDE ORGANIZATIONS FOR ACHIEVEMENT OF STATUTORY OBJECTIVES OF PARTNERSHIP



European Rail Industry

DIE BAHNINDUSTRIE.

VDB VERBAND DER BAHNINDUSTRIE IN DEUTSCHLAND E.V.

German Railway
Industry Association (VDB)

BAHNINDUSTRIE.at

Verband der Bahnindustrie

Austrian Railway
Industry Association



french railway industry association

French Railway Industry Association

ACRI

Association of Czech
Railway Industry (ACRI)

SWISSRAIL
Industry Association

SWISSRAIL Industry
Association (SWISSRAIL)



Association of
American Railroads

Non-profit partnership «Union of industries of Railway Equipment» (NP «UIRE») is founded in June, 2007 in Russia by the companies of Russian Railways, Transmashholding, Kontsern Traktornye zavody and Holding UK «Russian Corporation of transport machine-building»

3 Rizhskaya Square,
107996, Moscow
Tel.: +7 (499) 262-27-73
Fax: +7 (499) 262-95-40
www.opzt.ru
opzt@opzt.ru



INSTITUTE OF NATURAL MONOPOLIES RESEARCH



RAILWAY INDUSTRY
RAIL TRANSPORT
ENERGY INDUSTRY

ANALYSIS
STATISTICS
RESEARCH
FORECASTS
REVIEWS



Malaya Bronnaya st., 2/7, bld. 1, Moscow, 123104, Russia
Phone: +7 495 690-00-56; fax: +7 495 603-61-11
ipem@ipem.ru, www.ipem.ru