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РЕДАКЦИОННАЯ КОЛЛЕГИЯ

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СОДЕРЖАНИЕ

A summit devoted to the Belt and Road (BRI) initiative took place on October 17–18 in Beijing, as this year marked the 10th anniversary of the project since it had been launched by Chinese leader Xi Jinping in 2013.

The heads of participating delegations at the Third Belt and Road International Forum. Photo by RIA News[1]

BRI is a proposal of the joint projects of the Silk Road Economic Belt (an overland route) and the Maritime Silk Road of the XXI Century (a sea route). The initiative is to improve existing and create new trade and transport corridors connecting Central Asian, European, Latin American and African states, as well as is to promote the development of trade relations between them and China. The concept involves constructing bridges, ports, highways and railways, power plants, oil and gas pipelines, telecommunications projects and other infrastructure facilities related to these. Belt and Road's magnitude is difficult to underestimate, while over 60 % of world's population lives on the project's territory.

The summit — already the third of a kind — brought together representatives of 130 countries and 30 international organizations in China's capital. However, most of European leaders were missing. Mass media actively speculated on whether they intentionally skipped an event in order to express solidarity with the United States, a well-known opponent of China (in economic field especially), or they just simply did not receive an invitation. Anyway, their absence really

The map of China's Belt and Road Initiative[2]

[1] URL: http://www.kremlin.ru/events/president/news/72528/photos/73259
[2] URL: https://theasiatoday.org/news/east-asia/the-green-belt-and-road-of-china/

Putin's speech during the Belt and Road forum. Photo by TASS

only means one thing. In words of the Guardian, *«Xi Jinping's relations with the west become increasingly frosty»*[3].

A lot of foreign guests did attend though, including the president of Russian Federation Vladimir Putin. He warmly congratulated Chinese colleagues on their success, noting that *«considering such global dimensions, 10 years ago it was hard to believe that everything would work out»*[4]. Indeed, the initiative can surely be called ambitious, yet seemingly does not fail to take all of the participant countries' interests into consideration.

Previously during the interview with the Chinese press Putin highlighted that *«the main advantage of interaction's concept proposed by China is that no one imposes anything on anyone. It is not only the seeking of acceptable solutions, but also the searching for projects and methods which all parties can accept to achieve common goals»*[5].

Basically, all the principles that are a cornerstone of cooperation in BRICS are still of primary importance particularly in the Belt and Road initiative. Inclusivity, solidarity and openness towards cooperation remain the main values in terms of economic relations within BRICS' states. Moreover, BRICS declarations often mention providing help to developing countries. Belt and Road is a great example of how words are put into practice. For instance, according to the World Bank report, by providing jobs and financing important regional projects this initiative has already lifted more than 7 million people out of extreme poverty and 32 million from moderate poverty[6].

Speaking of BRICS, during the speech at the Belt and Road forum, Putin mentioned the intent to broaden the cooperation in transport system within the alliance. *«Russia, which will chair the expanded BRICS next year, has taken the initiative to establish a permanent commission on transport logistics within the framework of this association and other interested states, could deal with the development of international transport corridors all over the globe»*[4], — Russian leader proclaimed. Bearing in mind that BRICS is going to welcome several new members, it is worth-noting that Belt and Road initiative might expand accordingly then.

[3] China woos global south and embraces Putin at belt and road Beijing summit. *The Guardian*. URL: https://www.theguardian.com/world/2023/oct/16/china-woos-global-south-and-embraces-putin-at-belt-and-road-beijing-summit
[4] The head of the Russian state spoke at the opening ceremony of the third International Forum "One Belt, one way". Kremlin. URL: http://www.kremlin.ru/events/president/transcripts/72528
[5] China proposes Belt and Road Initiative not to crush others, but offers opportunities: Putin // Global Times. URL: https://www.globaltimes.cn/page/202310/1299879.shtml
[6] The Belt and Road Initiative: Economic, Poverty and Environmental Impacts. *World Bank*. URL: https://documents1.worldbank.org/curated/en/126471554923176405/pdf/The-Belt-and-Road-Initiative-Economic-Poverty-and-Environmental-Impacts.pdf

Putin also used participation in the summit as an opportunity to tell a few of Russia's plans that complement other infrastructure projects in Eurasia (BRI included). He invited interested states to participate directly in the development of the Northern Sea Route, as Russia is ready to provide reliable ice wiring, communications and supplies. Putin announced that, starting next year, navigation for ice-class cargo ships along the entire length of the Northern Sea Route will become year-round. At the summit he, like other leaders, proceeded to negotiate with heads of participating delegations directly. Judging by the subsequent feedback from the leaders, negotiations were productive and successful.

In addition, it is necessary to emphasize that the forum was not purely about trade and economics. China made it clear that BRI is more than a transport system. Development of a project also tackles other burning global issues, such as environmental and ethical ones, as well as rapid advancement of digital technologies like artificial intelligence. They were reflected in the discussion topics of the forum. During the summit there were held panel events, including 3 high-level meetings on digital economy, interconnectedness and green development, alongside with 6 thematic discussions: uninterrupted trade, rapprochement of peoples, exchanges through think tanks, the so-called honest Silk Road, interregional cooperation and maritime cooperation.

Within the framework of the forum, agreements were reached on 458 projects — the number impressively surpassed the results of the second Forum. Not only general challenges were discussed and solved: specific tasks such as training 100,000 specialists for partner countries by 2030, increasing the number of joint laboratories to 100 were set, too. It was decided to create a Secretariat, which should play its role to improve the institutional framework and implement projects. In closing speech Chinese Minister of Foreign Affairs Wang Yi pointed out that the success of the summit *«proves that peaceful development and win-win cooperation represents the prevailing trend and people's common aspiration. Cold War-style confrontation and decoupling efforts go against the tide of history and will lead nowhere»*[7]. He concluded with expressing hope to start a shared journey towards global modernization and a better future.

Ekaterina Sergeeva

* * *

Federal state budget establishment additional professional education "Educational and instructional center for railway transportation (UMC ZDT), Russia took part in the International Industrial Exhibition "EXPO-RUSSIA IRAN 2023", which was held on October 10-12, 2023 in Tehran Business Forum.

The exhibition is organized by "Zarubezh-Expo", JSC with the support of the Ministry of Foreign Affairs, Ministry of Industry and Trade, Ministry of Economic Development of Russia, industry departments of Russia and Iran under the patronage of the Chamber of Commerce and Industry of the Russian Federation.

The objectives of the business forum are to promote further development and strengthening of trade and economic ties between Russia, Iran and EAEU, promotion of Russian export high-tech products to the Iranian market, expansion of investment cooperation and presentation of the most promising investment projects of Russia at the exhibition, stimulation of interaction between the educational systems of the two countries.

Within the framework of the business program of the exhibition, special attention was paid to cooperation between Russia and Iran in the field of education.

The round table "Tasks and Prospects of International Inter-University Cooperation in Overcoming New Challenges and Threats of the World Order" was held, where Mz. O.V. Starykh, Director of UMC ZDT, reported a speech. In her report "Priority areas of cooperation in science, higher and secondary vocational education at the present stage of training qualified personnel for the economy and business of Eurasian countries" Mz. O.V. Starykh outlined the main areas of cooperation in the field of education: publication of educational literature, electronic educational programs, electronic library, BRICS Transport magazine. The round table was attended by heads of Russian and Iranian universities, discussed the issues of the current state of international youth cooperation, existing problems and ways to overcome them on the basis of a systematic approach, organization of interaction

[7] Wang Yi Talks about the Important Outcomes of the Third Belt and Road Forum for International Cooperation. *Ministry of Foreign Affairs of People's Republic of China*. URL:https://www.fmprc.gov.cn/eng/wjb_663304/wjbz_663308/activities_663312/202310/t20231020_11165149.html

Tehran International Exhibition and Commercial Centre — Tehran Business Forum, where the exhibition was held. Photo by UMC ZDT

Grand opening of the exhibition on October 10, 2023. Photo by UMC ZDT

with foreign subjects of educational activities in the field of international scientific and technical cooperation.

UMC RDT took part in the International Conference "Cooperation in the field of transportation and logistics, development of the North-South ITC, construction of transportation routes and facilities". In the report "Electronic Library of Railway Transport Publications", Deputy Director of UMC ZDT Mr. A.Yu. Pavlov emphasized the importance of educational and technical literature. Pavlov emphasized the importance of educational and technical literature in the training of personnel for the transport industry in Iran. The conference was attended by representatives of the Ministry of Roads and Urban Development of Iran, Department of Transportation Planning and Economics, State Corporation "Iranian Railways", Road Maintenance and Transportation Department, Transportation Department of Tehran Municipality and others. The following issues were discussed: prospects and ways of development of the North-South ITC, improvement of the transport system of South-West Asia in the process of development of trade and economic relations between the CIS countries and Iran, transport safety of cargoes passing through Iran, organization of railway-ferry communication between ports of the countries, transit of cargoes through Iran.

Round table "Tasks and Prospects of International Inter-University Cooperation in Overcoming New Challenges and Threats to the World Order". Photo by UMC ZDT

At the stand of UMC ZDT presented educational and methodical literature, training manuals, dictionaries, magazines "Transport Technician: Education and Practice" and "BRICS Transport", and handouts.

Negotiations were held at the exhibition with: Mr. Zeinollah Kalymbetov, Program Director of the Directorate of Transport and Communications of the Economic Cooperation Organization (ECO), on the publication of a dictionary of railway terms in Persian; Mr. Morteza Bagheri, Director of the Transport System and Logistics Research Laboratory (TSL), on the publication of literature in English; Mr. Shari Naderi, Manager of Mapna Company, on the supply of educational literature. Iranian colleagues showed interest in the BRICS Transport magazine.

Further mutually beneficial and fruitful cooperation in the field of education is planned.

By the results of the exhibition, UMC ZDT was awarded a diploma.

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* * *

On **October 20, 2023**, the online opening ceremony of the II International Youth Internet camp "InterTransCamp" took place at the **Far Eastern State Transport University** (DVGUPS, Khabarovsk).

During the whole of this year, the team of organisers, which included representatives from the Russian side and representatives of the Chinese side from Shandong Polytechnic College, Jiean Hi-tech Co. Ltd., not only the organisers but also the participants were preparing, collecting and translating materials, preparing the programme for work on the virtual simulator. Taking into account the experience of last year, when not every computer technically met the requirements of the virtual simulator, and many people who wanted to participate in the competition were not able to take part in it, this year educational institutions allocated more powerful technical means for teams of participants or bought them in advance for the opportunity to participate in the international competition.

On October 20, 2023, the online opening ceremony of the II Youth International Internet Camp "InterTransCamp" was held at the Far Eastern State Transport University (DVGUPS). The opening ceremony was attended by the heads of Roszheldor (Federal Railway Transport Agency), DVGUPS, Training and Methodological Centre for Education in Railway Transport, Association of Colleges and Technical Schools of Transport of Russia, students from Russian railway technical schools, and heads of these educational institutions.

Among the foreign participants were Jiang Xiaoyang, Consul General of the Consulate General of the People's Republic of China in Khabarovsk, the management of the Shandong Polytechnic Institute, managers of the Chinese company Jiean Hi-tech Co. Ltd., representatives of the University of Kuala Lumpur (Centre for Railways of Asia) from Malaysia, Professor Li Dawei of Beijing University of Transport and others.

Last year the online camp brought together 22 teams from Russian railway technical schools to prepare for the international championship of professional mastery in railway competences. This year 30 teams from 23 Russian cities took part, as well as 30 Chinese teams from Shandong Polytechnic University, and three teams each from Malaysia and Indonesia. That is 142 participants. It is positive that these competitions are expanding quantitatively!

In his welcoming speech, Arkady Rudolfovich Yedigaryan, Acting Rector of DVGUPS, thanked Shandong Polytechnic University for its active participation, for training experts who will lecture to students. He also expressed his gratitude to the co-organiser of the online camp and championship — Chinese company Jiean Hi-tech Co. Ltd.

Jiang Xiaoyang, Consul General of the Consulate General of the People's Republic of China in Khabarovsk, said in his opening remarks:

— *Providing staff support remains the basis for the development of a modern transport system and transport co-operation between China and Russia. The InterTransCamp Youth International Camp is a unique project that brings together teams from secondary vocational education institutions in China and Russia.*

Igor Petrovich Chirva, Deputy Head of the Administrative and Personnel Department of the Federal Railway Transport Agency, said:

— *Improving professional skills and abilities in accordance with the best practices in the field of railway transport, gaining new knowledge and developing personal qualities remains important for both the self-fulfilment of the contestants and the efficient operation of the railway company*.

Olga Vladimirovna Starykh, Director of the "Training and Methodological Centre for Education on Railway Transport", drew attention to the fact that *"InterTransCamp" is one of the most relevant and modern tools for improving professional skills at the international level.*

The participants of the opening ceremony were also welcomed by Tamara Sukhareva, Executive Director of the non-profit organisation "Association of Colleges and Technical Schools of Transport of Russia", First Deputy Director of the Moscow College of Transport RUT (MIIT), Gu Peiqiang, Rector of Shandong Polytechnic Institute, representative of the Chinese company Jiean Hi-tech Co. Ltd. Gao Zhishen and others.

This year, unlike the first camp and championship, students (as competitors) and teachers (as experts) of educational organisations of secondary vocational education (SVE) in professions and specialties were invited to participate: 23.01.09 Locomotive driver; 23.02.06 Technical operation of railway rolling stock (locomotives); 23.02.06 Technical operation of railway rolling stock (freight cars). Last year there were only representatives of 23.02.06 Technical operation of railway rolling stock (freight cars).

The ITC camp programme includes training and advanced training of Experts from among teachers of Russian educational organisations implementing educational programmes in railway specialties and professions. The total amount of training of experts is 12 hours (during 4 days). The tasks of an expert are as follows:

- assistance to the student team of their educational organisation in preparation in the ITC process;
- control and evaluation of the work of student teams in the process of their participation in the international InterTransChampionship.

After ITC training and participation in the Championship, each Expert receives an international certificate confirming the scope of training, his/her participation in the preparation of teams, work on the evaluation of participants, the status of Expert of the InterTransChampionship 2023. The certificate is signed by the organisers from the Chinese and Russian sides.

The training programme for the competitors, recruited from among the students of Russian educational organisations implementing educational programmes in railway specialties and professions, includes a total training volume of 53 hours (13 days). The task of the contestant is to learn to master the virtual simulator "OnlineSystem_WS3C" for participation in the International Championship "InterTransShampionship" and to be trained in four modules including 24 technical tasks.

As a result of the ITC training and participation in the championship, each contestant receives an international certificate confirming the scope of the training as well as his/her participation in the championship. Contestants who have completed the training course but did not pass the intermediate selection for the championship also receive the above-mentioned certificate of participation in the ITC. The certificate is signed by the organisers from the Chinese and Russian sides.

For 15 days Russian students and teachers prepared for participation in the championship, it was intense days and sometimes sleepless nights.

The success of the participants depended on the coordinated work of all team members:

- teachers from the Chinese side, who will transfer competences and teach Russian participants the basics of working on the virtual simulator and solving relevant technical problems;
- consultants from among Russian students who already have experience of participation in the International Championship "InterTransChampionship" and help Russian competitors to understand the solution of technical problems on the virtual simulator;
- technical specialists from the Chinese and Russian sides helping to solve the issues of the virtual simulator operation;
- hosts and translators of the online camp.

It is good to see that such a young championship is being renewed and this year it included a competition for Russian students on knowledge of railway and technical terms in English. This contributes to the professional development of young specialists who can participate in international projects.

So, on 10–11 November 2023, the InterTrans-Championship between teams from Russia, China, Malaysia and Indonesia took place. As last year, the jury and experts evaluated the participants in two categories national championship and international championship. In the national championship, after a meeting of experts and jury of the Russian and Chinese sides, it was decided to award two second places. The results of the championship are summarised below.

International Championship

1st place Shandong Polytechnic Institute
1. Chen Xunan
2. Sun Yirong
99.791 points

2nd place Amur Institute of Railway Transport (DVGUPS)
Expert: Yana Sergeevna Zamyslova
1. Evgeny Sergeevich Bakhtin
2. Nikita Vasilievich Shupilov
99.687 points

3rd place Shandong Polytechnic Institute
1. Wang Chenxin
2. Wang Haocheng
99.644 points

All-Russian Championship

1st place Amur Institute of Railway Transport (DVGUPS)
Expert: Yana Sergeevna Zamyslova
1. Evgeny Sergeevich Bakhtin
2. Nikita Vasilievich Shupilov
99.687 points

2nd place Taiga Institute of Railway Transport (OmGUPS)
Expert: Pavel Valerievich Suglobov
1. Vadim Vadimovich Efunyaev
2. Kirill Nikolaevich Savchenko
98,4 points

2nd place Khabarovsk Railway College (DVGUPS)
Expert: Aleksandr Leonidovich Kostyrko
1. Roman Sergeevich Kolobov
2. Gleb Olegovich Gaevoy
98.4 points

3rd place VTZHT — branch of RGUPS
Expert: Andrey Aleksandrovich Kornyushkov
1. Nikita Alekseevich Bulygin
2. Oleg Dmitrievich Nikolaev
98.009 points

Also, as noted earlier, a competition for Russian students to learn railway, technical terms in English was held in 2023 as part of the InterTransCamp online camp. For it, they developed a vocabulary of professional terms (300 words), nine accompanying intermediate tests, and one final extended test. 54 students took part in it.

Winners of the contest

1st place	**Georgiy Valerievich Tsogoev**	**MKT (RUT) MIIT**	**35 points**
2nd place	Maksim Sergeevich Nesterov	SamGUPS, Saratov	34 points
2nd place	Ivan Yurievich Gorshenin	Orenburg Railway College	34 points
2nd place	Denis Nikolaevich Kozhaev	Orenburg Railway College	34 points
3rd place	Danila Dmitrievich Dronenko	SamGUPS, Saratov	33 points
3rd place	Timur Dmitrievich Pulatov	MKT (RUT) MIIT	33 points
3rd place	Ivan Denisovich Savchuk	Orenburg Railway College	33 points

At the ITC opening ceremony, a video of the workflow on the simulator is shown to Chinese students

Jiang Xiaoyang, Consul General of the Consulate General of the People's Republic of China in Khabarovsk, welcomes ITC participants

Announcement of the results of the competition

In conclusion, we would like to note that improving professional skills and abilities in accordance with the best practices in the field of railway transport, acquiring new knowledge and developing personal qualities remains important both for the self-realisation of the contestants and efficient work.

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On **October 26, 2023**, the **Central Museum of Railway Transport of the Russian Federation (CMZT RF)** celebrated the 210th anniversary of its foundation.

The building of the Central Museum of Railway Transport of the Russian Federation, built in 1902. Saint Petersburg. Photo by the Central Museum of Railway Transport of the Russian Federation

On September 26, 2023, the opening of the anniversary exhibition "Treasures of the Special Hall" took place in the museum building at 50, Sadovaya Street. The exhibition presents more than 100 unique museum objects of the XIX–XX centuries, reflecting the history of the formation of the museum fund, starting with a collection of models made under the supervision and with the direct participation of the founder and first inspector (rector) of the Institute of the Corps of Railway Engineers (IKIPS) – now Emperor Alexander I St. Petersburg State Transport University (PGUPS) Augustin Betancourt.

On the same day in the auditorium of PGUPS a scientific and practical conference dedicated to the 210th anniversary of the Russian Railway Centre, which began with the screening of the movie "History is Written Today!", prepared by the museum staff.

In his report, Vladimir Mitelenko, Director of the Central Railway Transport Centre of the Russian Federation, reminded the audience that throughout its history the museum was inseparably connected with the first transport higher education institution of Russia and by the highest state Manifesto was established simultaneously at the Institute of the Corps of Railway Engineers: on November 20 (December 2), 1809 Emperor Alexander I signed the Manifesto "Establishment on the management of water and land communications". In Chapter VIII, devoted to the organization of the Institute, in paragraph 133 it is written: "In a special hall will be kept models of all important in Russia and other lands, the construction of existing or only predetermined, as well as machines used in hydraulic works".

Opening of the jubilee exhibition at the Central Museum of Railway Transport of the Russian Federation. October 26, 2023

Opening of the jubilee exhibition at the Central Museum of Railway Transport of the Russian Federation. October 26, 2023

Exhibit of the Jubilee Exhibition of the Central Museum of Railway Transport of the Russian Federation. Portrait of General Adjutant, Admiral, Minister of Railways of the Russian Empire K.N. Posyet

One of the first exhibits were 24 models made under the guidance and with the direct participation of Augustin Betancourt, the first inspector (rector) of the Institute, the chief director of railroads, the founder of engineering education in Russia. Over 210 years, the museum's holdings have accumulated more than 70,000 items, which represent a real wealth of treasures.

Tamila Titova, Acting Rector of Emperor Alexander I St. Petersburg State Transport University, who on behalf of the Rector, teaching staff and students congratulated the museum on its 210th anniversary.

Boris Piotrovsky, Vice-Governor of Saint Petersburg, Igor Chirva, Deputy Head of the Administrative and Personnel Department of Roszheldor, Natalia Astakhova, Deputy Chairman of the Standing Commit-

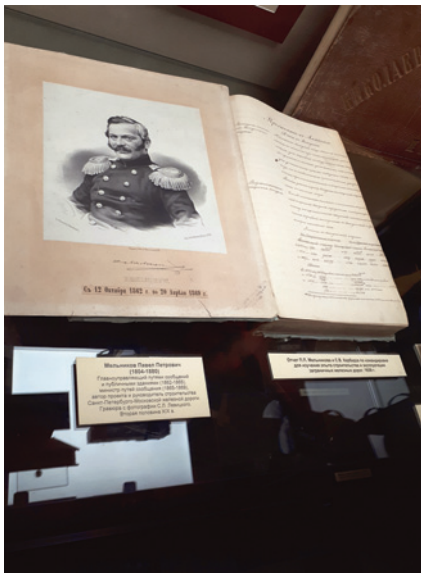

Exhibit of the Jubilee Exhibition of the Central Museum of Railway Transport of the Russian Federation. Report of P.P. Melnikov and S.V. Kerbedz on their business trip to study the experience of construction and operation of foreign railroads. 1830

Exhibit of the Jubilee Exhibition of the Central Museum of Railway Transport of the Russian Federation. Diploma of congratulatory address to the Managing Director of the Kolomna Machine Building Plant N.K. Antoshin from employees. Leather, silver. 1890. Jewellery factory Carl Faberge

Exhibit of the Jubilee Exhibition of the Central Museum of Railway Transport of the Russian Federation. Diploma of graduation from the Institute of Railway Engineers of Emperor Alexander I in the name of Nikolai Gribanov. 1910

Exhibit of the Jubilee Exhibition of the Central Museum of Railway Transport of the Russian Federation. Model of a cantilever bridge. The middle of the XIX century

Presidium of the scientific and practical conference dedicated to the 210th anniversary of the Central Museum of Railway Transport of the Russian Federation. PGUPS assembly hall. October 26, 2023

tee on Industry, Economics and Entrepreneurship of the Legislative Assembly of Saint Petersburg, Natalia Astakhova, Deputy Head of the Oktyabrskaya Railway for Interaction with Authorities, I. Lobko, representatives of the engineering and technical community, heads of museums and leading educational institutions came to congratulate the museum on its anniversary.

Press Service of PGUPS. Photo by PGUPS

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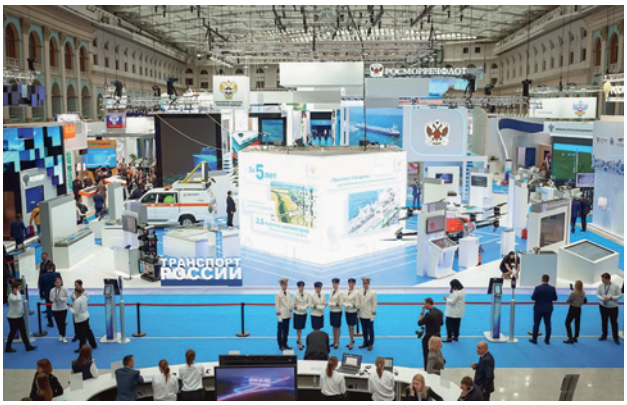
"Transport Week" — an annual event of the country's transport industry was held in the Moscow Gostiny Dvor. On **November 14–16**, the XVII International Forum and Exhibition "Transport of Russia" took place in Moscow as part of "Transport Week". Traditionally, the programme of Transport Week was opened by the XIII International Spartakiade of students of transport universities and the International Festival of creativity of students of transport universities "TranspArt".

Mikhail Mishustin, Chairman of the Government of the Russian Federation, visited the forum and exhibition on November 15. The Head of the Government inspected the expositions of the largest organisations of the transport complex, listened to the reports of the heads of enterprises on the latest achievements of the industry. Mikhail Mishustin also presented state awards to distinguished representatives of the transport complex and spoke at the plenary discussion "Russia 2035: Towards a New Transport Economy". Prime Minister congratulated the workers of the industry on the upcoming professional holiday and emphasised that despite the sanctions challenges, transport is moving forward dynamically, providing a reliable supply of all necessary goods and services to the industrial sector, businesses and citizens.

Within the framework of various discussion formats, participants in the forum's business programme discussed such priority areas for the industry as road construction, development of transport and logistics corridors, transport security, construction of port, railway and air infrastructure, passenger traffic on inland waterways, road transport, as well as issues of digitalisation and staffing of the transport complex.

More than 320 speakers took part in the industry formats, and the total number of participants in the business programme exceeded 3,700 people. Over 20 business formats were held during the three days,



Exhibition "Transport of Russia" in the Moscow Gostiny Dvor. 2023[8]

[8] Photo by "Transport of Russia". URL: https://transportrussia.ru/meropriyatiya/10386-transportnaya-nedelya-2023-sostoitsya-v-moskve-11-17-noyabrya.html

Participants of the industry conference "Talent shortage. Shortage of working professions at railway transport enterprises. Ways of solving the problem". Photo by PGUPS

which were viewed 440,000 times online. As part of the forum, 36 landmark agreements were signed. The event was attended by 17 heads of regions, delegations from 70 Russian regions, and 10 foreign delegations. The participants also included 970 companies and organisations from the industry. The total area of the exhibition was 3,900 m^2, 87 exhibitors took part. Over 10,000 people visited the exhibition over 3 days, and over 700 journalists from 244 media outlets provided information support.

Emperor Alexander I St. Petersburg State Transport University took part in the **International Forum and Exhibition "Transport of Russia"** held in Moscow on November 14–16, 2023. The university delegation was headed by Rector Oleg Valinsky.

On the margins of the forum the issues of development of all major modes of transport were discussed with the participation of industry leaders and representatives of the Russian Ministry of Transport. The main theme of this year was "Russia 2035: Towards a New Transport Economy".

The exhibition presented significant achievements of the industry and the most breakthrough projects, including a unique development of the Centre for Computerised Railway Technologies and the Department of Automation and Telemechanics on Railways of PGUPS — the "Block of Formation of Rail Frequencies".

One of the key events of the forum was the industry conference "Talent shortage. Shortage of working professions at railway transport enterprises. Ways to solve the problem", which was attended by the rector of the university Oleg Valinsky. In his speech, the head of the transport university emphasised that today the university is faced with the task of training railway universalists who will be adapted in advance to the requirements set by the employer.

At the forum Oleg Valinsky took part in the ceremony of signing Agreements in the field of education, scientific activities and joint developments. In particular, Cooperation Agreements were signed with Donetsk Institute of Railway Transport, JSC "NIIAS", with "Edu-

Signing of an agreement between Transmashholding Engineering Corporation and Emperor Alexander I St. Petersburg State Transport University. CEO of Transmashholding Kirill Lipa (left) and Rector of PGUPS Oleg Valinsky. Photo by PGUPS

cational Consulting Mindin Yinglian Beijing", LLC from the People's Republic of China, as well as with the machine-building corporation "Transmashholding".

A trilateral agreement on co-operation in the field of educational activities was signed between Emperor Alexander I St. Petersburg State Transport University, TMH Corporate University and Bauman Moscow State Technical University.

Press Service of PGUPS

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On November 15–17, 2023 in the Emperor Alexander I St. Petersburg State Transport University at the Department of "Water Supply, Drainage and Hydraulics" the XI International Scientific and Practical Conference "New Achievements in the Fields of Water Supply, Drainage, Hydraulics and Water Resources Protection" was held in continuation of traditional readings founded in 2001 by Academician of the Russian Academy of Architecture and Construction Sciences V.S. Dikarevsky.

Vitaly Sergeevich Dikarevsky (1926–2019), railway engineer, prominent scientist in the field of water supply and drainage, Doctor of Technical Sciences, Academician of the Russian State Academy of Architecture and Construction Sciences (RAASN), Honoured Worker of Science and Technology of the Russian Federation,

Stanislav Bosov. Portrait of Professor V.S. Dikarevsky. 2020. Oil on canvas, 60 x 80 cm. Art gallery of alumni and personalities of the Emperor Alexander I St. Petersburg State Transport University

Head of the Chair "Hydraulics, Water Supply and Sewerage". At present practically all the teachers of the department are his pupils. Since 2001, on the initiative of V.S. Dikarevsky, every two years PGUPS has organised conferences devoted to topical issues in the fields of water supply, water disposal, hydraulics and water resources protection.

Water supply, wastewater disposal and hydraulics issues have been in the field of attention of the university scientists, including its first rectors, renowned hydraulists, since the university was founded.

Augustin Betancourt, the first inspector (rector) of IKIPS (1809), even before coming to Russia, was engaged in issues of river flood regulation in Spain. In Russia he continued his activities in the field of water supply, drainage and hydraulics.

P.P. Bazen — French engineer, mathematician, mechanic and builder, professor, Corresponding Member of the Saint Petersburg Academy of Sciences (AS), Honorary Member of the Saint Petersburg Academy of Sciences (1824), in 1824–1834 he worked as Director (Rector) of the institute. In 1816 he was included in the Committee for Structures and Hydraulic Works, in 1824 he became its chairman. He developed the project of a dam to protect Saint Petersburg against floods (1825), which became the basis of modern dam construction. He created the project and organised the construction of the Shlisselburg sluices.

Great importance was given to the issues of water supply, water drainage and hydraulics by Professor P.P. Melnikov — engineer of railways (1825), professor, head of the Northern Directorate for the construction of the Saint Petersburg-Moscow railway, honorary member of the Saint Petersburg Academy of Sciences, Minister of Railways.

P.I. Palibin (1811–1881), a railway engineer graduated in 1828, is considered to be the first plumber of the capital on the basis of historical facts and documents.

A.I. Delvig (1813–1887), a railway engineer graduated in 1832, engineer-general, was a famous plumber.

In 1884, Professor F.E. Maksimenko (1874 graduate of the Institute), a well-known scientist in the field of hydraulics and water supply, was elected head of the Department of Practical Mechanics.

The first head of the Water Supply and Drainage Department (since 1895) was V.E. Timonov (1862–1936), a railway engineer graduated in 1886, professor (1895), a specialist in hydraulic engineering.

In 1920 the Institute was divided into faculties: land, air and waterways. Professor A.A. Surin, who had defended his thesis by that time, was elected head of the Water Supply Department at the Faculty of Land Transport, and D.P. Ruzsky was appointed head of the similar department at the Faculty of Water Transport. According to A.A. Surin's memoirs, the staff of these faculties worked as a single department.

This year the conference was dedicated to the 210th anniversary of the birth of A.I. Delvig, a graduate of the University in 1832, engineer-general. According to his projects the water supply system of Moscow, Saint Petersburg and many other cities was thoroughly reconstructed. He is the "pioneer" of water supply in our country, his printed works in this field in French and Russian were among the first in Russia.

The plenary session of the conference on December 16, 2023 was opened by A.V. Benin, Acting First Vice-Rector — Vice-Rector for Scientific Work of the University, noting A.I. Delvig's contribution to the establishment of water supply systems in our country. M.S. Abu-Hasan, Dean of the Faculty "Industrial and Civil Engineering" and N.V. Tvardovskaya, Head of the Department "Water Supply, Water Disposal and Hydraulics", addressed the participants with a welcoming speech, emphasising the importance of engineering systems and the need to improve the environmental situation in the modern world.

The Conference was attended by representatives of various organisations, teachers, researchers, postgraduates and students of the People's Republic of China, the Republic of Belarus and the Russian Federation from Saint Petersburg, Moscow, Vologda, Kazan, Tyumen, and Komsomolsk-on-Amur.

The reports on the activities of the State Unitary Enterprise "Vodokanal of Saint Petersburg" to improve the quality of water supply and wastewater disposal services in the city and environmental protection, on the modernisation of wastewater disposal facilities in Tyumen, on the problems of ensuring environmental safety of water intake and treatment facilities of small settlements in the Astrakhan region aroused great interest at the conference. At the same time, the speakers noted that taking into account the difficult geopolitical conditions, when the usual imported equipment is subjected to sanctions restrictions on the part of manufacturers, special attention is paid to the study of alternative technological solutions for water supply and wastewater disposal systems using domestic equipment and Russian software products to implement digitalisation approaches to the operation of such engineering systems.

In more detail, the conference addressed the issues of improving the efficiency of operation of water supply and sewerage pipelines, dissipation of kinetic energy of water flow and recovery of air flow energy when using mines in wastewater disposal systems in Russia and China, use of vacuum technologies in wastewater transportation. Ways of improving technologies of drinking water preparation from surface and underground sources, including the use of membrane technologies, by increasing the efficiency of water coagulation processes, new disinfectants in disinfection were considered. The participants of the conference listened with special attention to the report of E.E. Navogonsky on the development of water supply system at Kokhanovo station of the Belarusian railway.

One of the important tasks in environmental protection is not only the removal and treatment of domestic wastewater, but also the disposal of liquid industrial wastes, especially those containing toxic ions of heavy and non-ferrous metals, oil and petroleum products. It is known that not only industrial but also atmospheric wastewater flowing from the territory of industrial enterprises and transport infrastructure facilities causes damage to water sources. These problems and ways of their effective solution were also considered at the conference in the reports of the speakers.

At the end of the scientific-practical conference the results of its work were summarised and recommendations were given on the need to continue research in the field of water supply, drainage and environmental protection, the results of which are planned to be discussed in two years at the university at the XII International Scientific and Practical Conference "New achievements in the fields of water supply, drainage, hydraulics and protection of water resources", dedicated to the 130th anniversary of the Department of "Water Supply, Drainage and Hydraulics".

Nadezhda Tvardovskaya,
Head of "Water Supply,
Drainage and Hydraulics" Department of PGUPS

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On December 2, 2023, on the 214th birthday of one of the oldest universities in Russia — Emperor Alexander I St. Petersburg State Transport University (PGUPS)[9] — the V Betancourt Engineering International Forum concluded its work in Saint Petersburg. The Forum has been held at PGUPS since 2018 in honour of the first rector of the Institute of the Corps of Railway Engineers, Augustin Betancourt — an outstanding statesman, scientist, engineer and builder. The Forum is intended to unite all those who understand the significance of engineering creativity and the need to form a worldwide unified engineering educational space. The programme of the V Betancourt Engineering International Forum included events significant for the development of the Russian transport industry and for Russian engineering.

[9] On December 2 (November 20, as they say in Russia according to the "old" Julian calendar), 1809, the Manifesto of Emperor Alexander I approved the first engineering institute in Russia — the Institute of the Corps of Transport Engineers, today — Emperor Alexander I St. Petersburg State Transport University (PGUPS).

The first building of the Emperor Alexander I St. Petersburg State Transport University (PGUPS) is the former palace of the Yusupov Princes on the Fontanka River embankment in St. Petersburg. An architectural monument of the VIII century. Architect Giacomo Antonio Domenico Quarenghi. Classes with students began here on November 1, 1810. Now it is one of the academic buildings of the PSUPS, the cultural and historical center and the museum of the university

One of the educational and laboratory buildings of the PSUPS campus

On **November 28, 2023** the start of the forum was marked by a hackathon[10] "Railway Station of the Future", which included 40 participants, who had been announced in advance, representing team projects. The main problem of the hackathon was to find a solution to the question of a railway station that would maximally combine passenger convenience and optimal technical characteristics of a transport hub. Hackathon 2023 was held at the Centre for Innovative Development of Oktyabrskaya Railway in Saint Petersburg.

At the grand opening of the forum, which began with the hackathon "Railway Station of the Future", the opening speech was delivered by Ilya Terekhin, Vice-Rector for Educational Work and Industrial Relations of PGUPS, Daniil Starkovsky, Director of Lenpolygraphmash Technopark and Viktor Ivanov, Chief Engineer of the Oktyabrskaya Railway.

After the official welcoming part, the presentations "Business Model as the Foundation of a Startup" by Daniil Starkovsky, Director of Technopark "Lenpolygraphmash", "Railway Stations and Airports of the Future in Transport Interchange Hubs" by Tatiana Leontieva, Head of the Laboratory of Technological Entrepreneurship of the Engineering School of GUAP; "Setting a Case Study" by Vitaly Kudryavtsev, Head of the Oktyabrskaya Centre for Innovative Development; "Effective Project Management" by Yan Demidov, Head of the Corporate Management and Strategy Implementation Department of Oktyabrskaya Railway; "Railway Station of the Future: New Professions and Technologies" by D. Lelyukhin, Head of the Computer Vision Centre, Saint Petersburg branch of "NIIAS", JSC; "Generative Design in 3D Design" by Semen Zimin, successful start-up engineer, were heard.

In anticipation of the hackathon and in order to prepare for it, a theoretical intensive course was organised in the form of evening lectures on November 10–22, 2023 in the framework of the announced issues. The training course was attended by teachers of PGUPS, representatives of Russian Railways, Research Institute of Automated Systems (NIIAS) and Technopark "Lenpolygraphmash" of Saint Petersburg. As part of the course, the participants were immersed in the problematic issues of technical equipment, work regulations and logistical innovations of the "Railway Station of the Future".

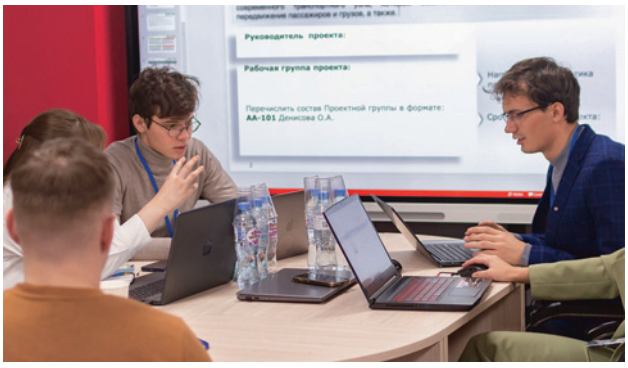
On November 21–22, 2023, a two-day practical educational programme "How to Organise Your Idea" was held at the Oktyabrsky Centre for Innovative Development, aimed primarily at students of PGUPS. The programme was a logical conclusion of the theoretical training course and was aimed at preparing students for participation in the hackathon.

On November 28, 2023, at the V Betancourt Engineering International Forum hackathon, six participating teams presented preliminary designs for railway stations, which were discussed with invited experts.

"Representatives of Moscow, Severnaya, Kaliningrad, Gorkovskaya, Severnaya, North, North-Eastern and Oktyabrskaya Railways took part in organising this year's hackathon", commented Daria Ponomareva, the event coordinator and leading technologist of the Oktyabrskaya Innovation Development Centre.

Associate Professor Evgeny Korovyakovsky with a group of students participating in the hackathon

On November 29, 2023, as part of the hackathon, the finalised projects of the six participating teams were presented to the expert committee. According to the results of the "Expert Carousel", the projects were announced the winners of the hackathon:



Group of students participating in the hackathon

[10] Hackathon ("hacker" + "marathon") is a forum for developers, during which specialists from different areas of software development (programmers, designers, managers) work together to solve some problem for a while. Sometimes hackathons are intended for educational or social purposes, but more often the goal of a hackathon is to create complete software. Each hackathon focuses on a specific area, e.g. programming language, operating system, application, software interface.

Photo of hackathon participants and winners with Rector of PGUPS O.S. Valinsky (in the centre)

1st place —"Container station of new generation" (made by the team "Christina and guys from UPL"); 2nd place — "Comfort of the future" (made by the team "Letter "E"); 3rd place — "Concept of development of TPU "Yakhtennaya", introduction of clock traffic on the line "St. Petersburg–Sestroretsk" (made by the team "Dvizhentsy").

The main ideas of the projects were commented by the captains of the winning teams. Jonas Vodopolas, captain of the team "Dvizhentsy": *"The main idea of the project is to introduce clock traffic in the direction of Saint Petersburg (Finnish railway station)–Sestroretsk. Now this is an area of active development. And the transport infrastructure in this area is currently poorly developed. This project develops it thanks to the introduction of transport hubs and clock traffic"*. Andrey Pimenov, captain of the "Letter "E" team: *"The main idea of the project is to track the number of people filling the rolling stock and display this information on the scoreboard and in the Russian Railways application. In order to promptly solve logistical problems, it is important for passengers to know how many seats are available in which car"*.

On **November 30, 2023** the **conference of the International Association of Colleges of Transport** took place at the Saint Petersburg Technical College of Railway Transport (SPTZT). The conference was opened by Eugene Shehtman, Director of the Saint Petersburg Technical College of Railway Transport, a structural subdivision of PGUPS. The participants were welcomed by Berlik Kapezov, Director of the State Municipal Enterprise on the right of economic management "Higher College of Transport and Communications" (Astana), Elena Panyushkina, Head of the Department for work with branches of PGUPS and Elena Kozlova, Director of Orsha College — branch of Belgorod State University of Transport (BelGUT).

Russian participants of the teleconference

During the conference of the International Association of Colleges of Transport the issues of priority improvement of the quality of professional training of students, the importance of mentoring and professional development in this priority, the possibility of a differential approach to the evaluation of professional activities of teaching staff were discussed. Presentations were made by 7 speakers.

Press Service of PGUPS

On **November 30, 2023, round table meetings** on pre-declared problems were held in different buildings of PGUPS. Within the framework of the V Betancourt Engineering International Forum worked sections

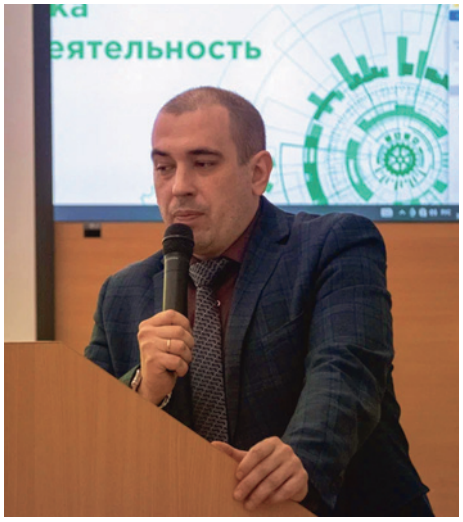
"Problems and achievements in the field of construction engineering"; "Betancourt's legacy as an impetus for the development of management and economic education for engineering growth"; "Logistic transport systems and technologies: education, science and practice"; "Safe ecosystem of intelligent transport infrastructure"; "Land transport and energy systems"; "Design, construction and operation of railway tracks"; "Design, construction and operation of railway infrastructure".

For consideration of the round table **"Problems and Achievements in the Field of Construction Engineering"**, which worked under the guidance of the Dean of the Faculty of "Industrial and Civil Engineering" Mahmoud Abu-Hasan, 12 reports of students, postgraduates and teachers of PGUPS were presented, the problems of which broadly cover the current trends and prospects of the construction industry, going far beyond the construction of railways.

These trends, in particular, are demonstrated by the report of Alina Gavrilova, senior lecturer of the Department of "Technosphere and Environmental Safety", "Analysis of manganese and copper accumulation in ecosystem links in urbanised areas". *"One of the big problems of modern urbanised areas," explains Alina Gavrilova, "is the accumulation of heavy metals and their impact on living organisms. To reduce the negative impact on the surrounding space coming from the roofs of buildings, as part of this study we simply covered the roofs with paint. We found such a simple but very effective way".*

The main problematic precipitated at the round table **"Logistic Transport Systems and Technologies: Education, Science and Practical Activity"**, moderated by the Dean of the Faculty of Transport and Logistics Management, Associate Professor Alexander Badetsky,

The round table "Logistic Transport Systems and Technologies: Education, Science and Practical Activity" is held in the company auditorium of JSC Russian Railways



The moderator of the round table was Dean of the Faculty of Transport Management and Logistics, Associate Professor Alexander Badetsky

The round table "Logistic Transport Systems and Technologies: Education, Science and Practical Activity" is held in the company auditorium of Russian Railways

concerned the definition of the main modern logistic trends in the field of transport systems and technologies in practical activity, education and science. Within the framework of the round table there were 12 speakers. The problems of the reports were presented very widely: from the need to solve the problem of delays of goods trains in the neck of the railway bed due to hostile routes (speaker — Denis Yazev, postgraduate student of the Department of "Railway Stations and Hubs" of PGUPS) to the need to bring the regulatory documents governing freight transport in Russia in line with the requirements of modern engineering (speaker — Dmitry Poluektov, postgraduate student of the Department of "Operations Management" of PGUPS).

Within the framework of the round table **"Safe Ecosystem of Smart Transport Infrastructure"** under the guidance of the moderator Dean of the faculty "Automation and Intelligent Technologies" Associate Professor Olga Stepanskaya 11 reports were heard, six of them were presented by representatives of production.

At the round table **"Land Transport and Energy Systems"**, the work of which was led by the dean of the faculty "Transport and Energy Systems" Sergey Chuyan heard 11 reports. The geography of speakers extended to Saransk (Aleksey Grigoriev, Deputy Chief Designer for alternative advanced products of "Rail Engineering", JSC) and Khabarovsk (Ivan Ignatenko, vice-rector for scientific work of DVGUPS). The problems of the round table were related to the results of research in the field of land transport and energy systems, development of scientific ties between scientists and activation of scientific and innovative activities of young people.

Round table meeting "Land transport and energy systems"

Round table meeting "Land transport and energy systems". Professor Anatoly Gorsky is speaking

The round table **"Design, Construction and Operation of Railway Track of Increased Resource for Heavy-Weight Train Traffic"** represented a strategic direction for "Russian Railways", JSC, which is a priority for the company's development until 2030. The round table was moderated by Lyudmila Blazhko, a major expert in the field of railway track structures for extra-heavy loads, Professor of the Railway Track Department, Professor Emeritus of PGUPS.

Round table "Design, Construction and Operation of Railway Track of Increased Resource for Heavy-Weight Train Traffic" in the Mendeleev Auditorium

Round table moderator Professor Lyudmila Blazhko (pictured right). Professor Evgeny Dudkin of the Department of Road Construction of the Transport Complex speaks

Round table "Design, Construction and Operation of Railway Track of Increased Resource for Heavy-Weight Train Traffic" in the Mendeleev Auditorium

"Based on the words of the rector of our University (PGUPS) Oleg Valinsky that traffic is the driver of development, it should be noted that the amount of freight increases year by year", commented the coordinator of

the round table, Associate Professor of the Department "Railway Track" of PGUPS A. Kiselev, *"this poses new challenges for us. Firstly, the need to create a new rolling stock that is capable of travelling with high axle loads. Secondly, the creation of infrastructure that will be able to provide the increasing freight intensity of traffic at a shrinking traffic interval"*. The round table heard 7 reports on topical issues.

Alexander Kabanov, Dean of the Faculty of Economics and Management, moderated the round table **"Betancourt's Legacy as an impetus for the development of managerial and economic education for engineering and technical growth"**. 7 reports were heard, in which acute and topical issues of the economic content of transport projects and improving the level of training of engineers in the field of economics were raised.

Round table meeting "Betancourt's Legacy as an Impetus for the Development of Management and Economic Education for Engineering Growth" in the white hall of the Yusupov Palace on the Fontanka Embankment

Round table moderator Aleksandr Kabanov, Dean of the Faculty of Economics and Management

On **December 1**, 2023, the V Betancourt Engineering International Forum continued with the round table **"The State and Development of High-Speed Rail Transport in Russia"**. The round table was led by Alexanedr Misharin, President of the Russian Academy of Transport. The meeting was attended by Rector of PGUPS Oleg Valinsky, First Vice-Rector, Vice-Rector for Research Tamila Titova.

Round table "The State and Development of High-Speed Rail Transport in Russia"

Presidium of the round table "The State and Development of High-Speed Rail Transport in Russia". Pictured from left to right: Tamila Titova, First Vice-Rector, Vice-Rector for Research of PGUPS, Alexander Misharin, President of the Russian Academy of Transport, and Oleg Valinsky, Rector of PGUPS

Round table "The State and Development of High-Speed Rail Transport in Russia"

Participants of the round table. Pictured from left to right: Olga Efimova, Chief Scientific Secretary of the Russian Academy of Transport; Ilya Potapov, Executive Director of the Russian Academy of Transport; Igor Kiselev, Professor of PGUPS and Chief Scientific Editor of the BRICS Transport journal

Anatoly Burkov, Professor of the Department of Railway Electrical Supply, participating in the round table

Participants of the round table. In the photo from left to right: General Director of "Railway Transport Engineering Centre", JSC Alexander Kireytsev, Chief Project Engineer of "Roszheldorproekt", JSC Viktor Kolomiets, Director for Technical and Technological Development of "Roszheldorproekt", JSC Alexander Alhimovich

Round table participants Pavel Popov (on the left), Deputy General Director — Director of the Saint Petersburg branch of "NIIAS", JSC, and Andrey Guryev, Editor-in-Chief of the magazine "Transport of the Russian Federation", expert of the Public Council under Rostrasnadzor

Participants of the round table — scientists of PGUPS. In the photo from left to right: Vladimir Seronosov, Associate Professor of the Department of Railway Electrical Supply, Associate Professor Andrey Romanov, Head of the Department of Wagons and Wagon Maintenance, Professor Yuriy Boronenko, Head of the Department of Electric Traction, Professor Andrey Evstafiev

Round table participants — scientists of PGUPS. In the photo from left to right: Head of the Department "Railway Track", Associate Professor Andrey Romanov, Head of the Department "Wagons and Wagon Service", Professor Yuriy Boronenko, Head of the Department "Electric Traction", Professor Andrey Evstafiev, Head of the Department "Road Construction of Transport Complex", Associate Professor Aleksey Kolos

Major experts in various fields of knowledge related to the organisation of high-speed rail traffic in Russia, construction of high-speed railways and production of Russian high-speed rolling stock, professors and associate professors of PGUPS were involved in a serious conversation about the organisation of high-speed rail traffic in Russia.

The round table was attended by heads and specialists of a number of enterprises and institutions involved in the development of the High-Speed Railway project and rolling stock for it: "Railway Transport Engineering Centre", JSC, "Roszheldorproekt", JSC, "Federal Passenger Company", JSC, "NIIAS", JSC and others.

The next issue of our journal "BRICS Transport" will contain a detailed report on the round table meeting "The State and Development of High-Speed Rail Transport in Russia".

Plenary session of the V Betancourt International Engineering Forum

Speakers of the panel discussion at the forum's plenary session. Pictured from left to right: moderator of the plenary session — Russian Railways TV presenter Marianna Ozherelieva, panel members: Oleg Valinsky, Rector of the Emperor Alexander I St. Petersburg State Transport University; Sergey Pavlov, First Deputy General Director of JSC Russian Railways; Valentin Enokaev, Chairman of the Saint Petersburg Transport Committee; Evgeny Charkin, Deputy General Director of JSC Russian Railways; Alexander Misharin, Chairman of the Board of Directors of Sinara Transport Machines JSC (STM), President of the Russian Transport Academy; Dennis Minkin, Director of the St. Petersburg City Electric Transport Company "Gorelektrotrans"

The relevance of the forum programme attracted a large number of participants to the university: transport specialists, scientists, representatives of educational institutions, heads of large industrial enterprises and businesses.

PGUPS received a greeting from the Minister of Transport of the Russian Federation Vitaly Savelyev, who wished the participants of the V Betancourt International Engineering Forum fruitful work and noted that the popularisation of the ideas of the brilliant engineer, scientist, courageous practitioner Augustin Betancourt deserves respect and support.

At the forum a discussion was held, where important questions were raised, in particular, what steps universities and the industry as a whole should take to cope with the so-called "talent shortage", which is becoming more and more tangible every year. How to saturate the transport industry with workers and engineers? What does a modern transport engineer look like?

"The problem of talent shortage is relevant for the industry as a whole, not only for the railway," said Oleg Valinsky. According to him, a number of measures should be taken to solve this problem. Firstly, it is necessary to have a modern training base. Students should be trained on the equipment they will have to work on in the future. Simulators and stands, digital systems, quantum technologies adapted to production as much as possible are required.

"The transport industry needs specialists of the appropriate level — engineers who, after leaving the walls of the educational institution, will be able to immediately start solving the tasks at hand," emphasised Oleg Valinsky.

The second prerequisite is internships of the teaching staff at advanced production enterprises and leading scientific institutions.

"The classical education should be overlaid with new knowledge, which is acquired during internships at advanced production facilities. The teacher must understand the tasks faced by companies — potential employers of university graduates," concluded Oleg Valinsky.

Evgeny Charkin noted that the company has interaction with universities, there are educational programmes for specific tasks of the railway, but there is also a need for specialists who will deal with database management, the Internet of Things, research in the field of artificial intelligence, information security.

"The most important task is technological sovereignty. This is where our success in the future lies," emphasised Evgeny Charkin.

In his speech, Alexander Misharin noted the key areas of interaction between the university and business. In his opinion, the university should select talented students, train a specialist with the required knowledge and competences, plan joint modern educational programmes together with business.

"How independent, sustainable and efficient we will be in implementing the main state programmes depends on engineering training," emphasized the President of the Russian Academy of Transport.

Sergey Pavlov noted in his speech the uniqueness of the education system established in Russia and the high demand for students from abroad to study at the country's transport universities, adding that an effective partnership with foreign colleagues starts from the university.

Denis Minkin noted: — *"In a changing world, the task of a teacher is to foresee the future. But in order to look into the future you need not only professionalism, but also a relaxed mind, freedom, which is characteristic of the young. In this regard, it is important to exchange opinions, to discuss where we are going?"*.

Valentin Enokaev in his speech noted the comprehensive historical links of the first engineering higher education institution with many sectors of the city economy and not only transport. The construction industry, public utilities, water supply, energy and many, many other things, in which professors, teachers, scientists and graduates of the institute — today — university have proved themselves for two centuries. But time does not stand still and poses new challenges. In order to meet the modern challenges a graduate of the university must be competent in digitalisation, economic analysis, knowledge of the most advanced achievements of their industry.

On **December 2, 2023**, on the final day of the forum, several culturally significant events took place. Thus, the participants of the V Betancourt Engineering International Forum visited the place of the city foundation and the main historical museum of Saint Petersburg — the Peter and Paul Fortress.

In the Peter and Paul Cathedral (the Cathedral of the Holy Apostles Peter and Paul) in the Peter and Paul Fortress of Saint Petersburg there was held a solemn

PGUPS Rector Oleg Valinsky fired a blank shot from the signal cannon of the Peter and Paul Fortress in honour of the 214th anniversary of the founding of the Emperor Alexander I St. Petersburg State Transport University. December 2, 2023

Delegation of PGUPS after the firing of the signal cannon of the Peter and Paul Fortress

PGUPS Rector Oleg Valinsky and students of PGUPS laying a wreath on the tomb of Emperor Alexander I, the founder of the University

and commemorative ceremony of laying a wreath on the tomb of the founder of the St. Petersburg University of Railway Transport, Emperor Alexander I, which is traditionally held annually on the day of the next anniversary of the founding of the University

Forum participants attended the traditional noon shot[11] from the Naryshkin Bastion of the Peter and Paul Fortress, which was performed on this day in honour of the 214th anniversary of the founding of the Emperor Alexander I St. Petersburg State Transport University by Rector Oleg Valinsky.

Yana Ledina, Press Service of PGUPS.
Photo by PGUPS

[11] According to a custom introduced under Peter the Great, the cannon mounted on the bastion of the Peter and Paul Fortress signalled the start and stop of work at the city's enterprises and construction sites with blank shots every day, and, if necessary, announced a dangerous rise in the water level of the Neva River. On September 24, 1873 from the Naryshkin bastion of the Peter and Paul Fortress for the first time sounded the noon shot, by which the citizens could now check their watches. To signal the cannonier about the shot, the Peter and Paul Fortress was connected to the clock from the central telegraph station by a special cable. After October 1917 the noon shots were stopped and they were resumed on March 8, 1926. In 1934 the noon shots were cancelled as an anachronism. On June 23, 1957 the tradition was resumed. Nowadays, at the request of various organisations, the right to fire the noon shot may be granted to deputies or individual prominent citizens to mark significant public events.

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Problems and prospects of decarbonization of road transport in the Russian Federation*

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ABSTRACT On the way of decarbonization of certain sectors of the economy, new types of climate risks arise, and associated losses as a result of actions by the public and private sectors aimed at containing these changes, and not at adapting industries to climate change. Measures for decarbonization of motor transport are considered. The most effective of them in the medium term are measures to diversify the use of natural gas, traction electric drive and hydrogen fuel cells as energy sources. The key organizational, technological and economic problems that hinder the widespread use of these alternative energy sources in road transport are highlighted. The requirements for achieving the competitiveness of cars with traction electric drive and hydrogen fuel cells in comparison with oil-fueled cars are formulated.

It has been established that the total gross GHG emissions of the Russian vehicle fleet in 2050, the expected number of which will decrease from 59.8 to 51.7 million units compared to 2021, may amount to 126.8 million tons of CO_2 equivalent, which is 28.5 % less than in 2021. Compared to previous projections, the value of total GHG emissions from the vehicle fleet in 2050 will lag behind by about 5 years. At the same time, the vehicle fleet in 2050 will be dominated by automatic telephone exchanges with internal combustion engines on hydrocarbon fuels (liquid, gaseous). Only after 2045, the share of sales of electric vehicles of all types can exceed the share of sales of these types of automatic telephone exchanges with internal combustion engines [1].

KEYWORDS: automobiles; decarbonization; greenhouse gas emissions; natural gas; traction electric drive; hydrogen fuel cells; events

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Научная статья

Проблемы и перспективы декарбонизации автомобильного транспорта в Российской Федерации*

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АННОТАЦИЯ На пути декарбонизации отдельных отраслей экономики возникают новые виды климатических рисков и связанные с ними потери в результате действий государственного и частного секторов, направленных на сдерживание этих изменений, а не на адаптацию отраслей к изменению климата. Рассмотрены мероприятия по декарбонизации автомобильного транспорта. Наиболее эффективными из них в среднесрочной перспективе являются меры по диверсификации использования в качестве источников энергии природного газа, тягового электропривода и водо-

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родных топливных элементов. Выделены ключевые организационно-технологические и экономические проблемы, которые сдерживают широкое использование данных альтернативных источников энергии. Сформулированы основные требования, выполнение которых позволит обеспечить конкурентоспособность электромобилей с тяговыми аккумуляторными батареями и водородными топливными элементами по сравнению с автомобилями на нефтяном топливе.

Результаты прогноза выбросов парниковых газов (ПГ) автомобильным транспортом на период до 2050 г. с учетом реализации рассмотренных мероприятий показали, что суммарные валовые выбросы ПГ автомобильным парком России в 2050 г., ожидаемая численность которого сократится по сравнению с 2021 г. с 59,8 до 51,7 млн ед., могут составить 126,8 млн т $CO_{2\text{-экв.}}$, что на 28,5 % меньше, чем в 2021 г. По сравнению с ранее составленными прогнозами значение суммарных выбросов ПГ автомобильным парком в 2050 г. будет отставать примерно на 5 лет. При этом в автомобильном парке в 2050 г. будут преобладать автотранспортные средства (АТС) с двигателями внутреннего сгорания (ДВС) на углеводородном топливе (жидком, газообразном). Только после 2045 г. доля продаж электромобилей всех типов может превысить долю продаж этих типов АТС с ДВС [1].

КЛЮЧЕВЫЕ СЛОВА: автотранспортные средства; декарбонизация; выбросы парниковых газов; природный газ; тяговый электропривод; водородные топливные элементы; мероприятия

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INTRODUCTION

The climate agenda became popular after 198 states signed the Paris Climate Agreement[1], which provides for a set of measures at the national, supranational, regional and corporate levels to decarbonise the economy, including the transport sector, including the following:

- Adopting long-term low-carbon development strategies;
- Establishing a regulatory system to incentivise low greenhouse gas (GHG) emission development, including price regulation and measures to protect national markets;
- Introduction of international and national standardisation of climate action (calculation of direct and indirect GHG emissions by different sectors of the economy and their uptake, validation of calculations);
- Technological development of generating capacities, energy- and carbon-intensive industries with regard to the use of renewable energy sources (RES), increasing the energy efficiency of natural resources consumption;
- Reorientation of investment and financial flows in the direction of technological development with a minimal carbon footprint.

Countries' measures to decarbonise their economies create new types of risks — climate transition risks. The associated losses do not arise from climate change, but from public and private sector actions aimed at curbing these changes (introduction of cross-border carbon tax (CBT), introduction of new technologies, changes in energy consumption patterns, etc.).

1. As noted in the report of the Bank of Russia[2], in countries with a significant share of carbon-intensive exports in GDP, such as Russia, despite changes related to sanctions restrictions in 2022, climate risks continue to pose a significant threat to the Russian economy in the medium and long term due to the following factors:

- expected decline in global demand for key Russian export goods from the second half of the 2020s;
- incomplete reorientation of exports from unfriendly to friendly countries, as well as to domestic markets;
- stricter requirements for reporting on the carbon footprint of products in trading partner countries, inconsistency of Russian regulation with foreign regulation;
- introduction of cross-border carbon regulation in China and other Asian countries in the late 2020s and early 2030s; transfer of EU CBT costs through supply chains with friendly countries;
- accumulation of technological lag (including against the background of restrictions on imports of high-tech equipment), which may lead to increased costs of energy efficiency and carbon footprint reduction projects.

These circumstances directly affect the issues of transport decarbonisation, i.e. improvement of re-

[1] The Paris Agreement under the UN Framework Convention on Climate Change, regulating measures to reduce carbon dioxide in the atmosphere from 2020. URL: https://unfccc.int/files/meetings/paris_nov_2015/application/pdf/paris_agreement_russian_.pdf
[2] Climate risks in changing economic conditions: report for public consultation // Bank of Russia. 2022. 51 p. URL: https://cbr.ru/press/event/?id=14418

source and energy efficiency of the transport complex in the course of transportation by different types of transport, production, use, restoration of serviceability, recycling of vehicles, road construction equipment, operational, structural, construction materials, equipment and technologies. According to the National Report on the inventory of anthropogenic emissions by sources and absorption by sinks of greenhouse gases not regulated by the Montreal Protocol[3], which is being developed in accordance with the obligations of the Russian Federation under the UN Framework Convention on Climate Change and the Kyoto Protocol to the UN Framework Convention on Climate Change, in 2018 the volume of GHGs from combustion of motor fuel (direct emissions) by all types of transport (except pipeline transport) in the Russian Federation was 176.2 million tonnes of CO_2 equivalent, including 153.8 million tonnes by road transport, 12.6 million tonnes by civil aviation, 7.05 million tonnes by railway transport and 2.29 million tonnes by water transport.

If we also take into account indirect GHG emissions by all types of transport, taking into account mobile and stationary sources [2], the share of road and urban electric transport in the total gross GHG emissions by transport in 2018 was 79.2 %. Forecast estimates [3, 4] showed that the situation will not change in the medium term as well. Thus, road transport is the main source of GHG emissions in the transport sector in the Russian Federation with an unfavourable trend of change in gross emissions over the last 20 years and in the mid-term perspective.

MEASURES FOR DECARBONISATION OF ROAD TRANSPORT

As a result of analysis and generalisation of domestic and foreign experience [5, 6] it has been established that GHG emissions reduction by road transport is possible due to the implementation of measures united in three groups:

Group I — improving the energy efficiency of motor vehicles (GHG emission reduction) and transport technologies using traditional types of motor fuels;

Group II — diversification of the use of different energy sources in vehicles with lower GHG emissions;

Group III — mobility management — reduction of excessive, irrational, unjustified movement of goods and passengers, curbing hypermobility of the population through the development of information systems for data collection, intelligent processing, analysis and exchange, as well as the use of enhanced communication capabilities between humans, motor vehicles and road infrastructure.

Table 1

Effectiveness of measures to reduce GHG emissions from road transport, % [10]

Groups of measures	2020	2030	2040	2050
A – improving the energy efficiency of vehicles and transport technologies using conventional motor fuels	97	80	40	3
B – mobility management	2	5	10	20
C – diversification of the use of different energy sources with lower GHG emissions for vehicles	1	15	50	77
Total	100	100	100	100

Group A activities provide for:

- rationing of specific CO_2 emissions from new motor vehicles;
- maintenance of the technical condition of vehicles and transport infrastructure facilities in a standardised state[4].
- formation of an optimal structure (stimulation of renewal) of the rolling stock fleet by managing the processes of its replenishment and retirement.

As follows from Table 1, for the period up to 2030, the share in the total effect on reduction of GHG emissions by road transport from the implementation of measures of group A will be determinant.

Group B activities include:

- management of demand for transport services;
- formation of a rational structure of transport networks in cities and agglomerations;
- low-carbon organisation of the transport process with mutual complementation (but not competition) of different modes of transport (digital transport and logistics technologies, intelligent transport systems, etc.);
- formation of a “smart” system of road toll collection (based on distance travelled, weight of vehicles, level of their energy and environmental efficiency), etc.

Group C measures are related to the substitution of traditional liquid motor fuels (petrol, diesel fuel) for natural gas in compressed (compressed) or liquefied

[3] National inventory report on anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol. Part 1. Moscow: FSBI “IGCE”, 2020;480.

[4] A road is considered to be in a normative condition when its parameters and characteristics provide values of the complex indicator of transport-operational condition not lower than normative (EF = EFn) during the whole autumn-spring period. Rosavtodor. Road industrial methodical document (ODM) 218.4.039-2018.

form, as well as for traction electric drive from accumulator batteries or hydrogen fuel cells in vehicles with internal combustion engines.

Mass transition of road transport to alternative fuels in the medium and long term is determined by objective reasons, such as limited world oil reserves, increasing environmental requirements, climatic risks, decarbonisation policy, as well as regional peculiarities. Let us consider the key organisational, technological and economic aspects constraining the process of decarbonisation of road transport.

USE OF NATURAL GAS AS A MOTOR FUEL

The environmental advantages of natural gas as a motor fuel for vehicles with internal combustion engines are well known – an order of magnitude lower emissions of fine particles with exhaust gases compared to diesel-fuelled internal combustion engines and 17 % (at best) lower CO_2 emissions.

At present, the range of commercially produced compressed natural gas (CNG, LNG) vehicles in the Russian Federation includes 227 models, including 127 models of trucks, 43 units of passenger vehicles, 36 units of special vehicles, 19 models of light commercial vehicles and 2 modifications of passenger cars [7].

For several decades the share of CNG (LNG) vehicles in the vehicle fleet remains at the level of less than 0.2 % and as of 01.01.2022, according to Gazprom, PJSC, is about 260 thousand units, including 152.8 thousand units of passenger cars, 51 thousand units of light commercial vehicles, 33.6 thousand units of buses, 20.7 thousand units of trucks of groups 2, 3, as well as 0.8 thousand units of road and municipal equipment. As of 01.01.2023, the increase in the number of the fleet was 30.5 thousand units as compared to 2022. At the same time, the number of automotive gas filling compressor stations (AGFCS) on the territory of the Russian Federation as of 01.01.2022 (64 regions) is extremely small and amounts to 419 units, the maximum capacity of which does not exceed 2 billion m^3 per year. According to Gasprom, PJSC, the volume of natural gas consumption by motor transport in 2022 was 1,720.0 million m^3 (CNG — 1,550.8 million m^3, LNG — 121.7 million tonnes).

Let us highlight the key organisational, technological and economic issues that hinder the widespread use of natural gas as a motor fuel.

1. To maintain the range of vehicles when using CNG it is necessary to install from 1–2 (on passenger cars) to 10–12 cylinders on trucks and buses, which reduces their passenger capacity and load capacity. The cost of vehicles increases by 25–30 %.

2. Filling points (CNG filling stations) are “connected” to the pipeline network of gas pipelines. As a result, the territory of CNG vehicles use is limited, excluding the northern and other regions, which hinders the development of intercity and interregional road transport and the development of the refuelling network.

Insignificant share of CNG (LNG) vehicles in the Russian vehicle fleet (0.5 % as of 01.01.2023) due to lack of demand and, consequently, low production (supply) volumes of both CNG vehicles and CNG equipment kits for retrofitting of CNG vehicles. The draft concept of NGV market development in the Russian Federation for the period until 2035[5] developed by Transport Integration, LLC, provides for a significant increase in the production and retrofitting of natural gas-powered vehicles and provision of the backbone transport network with gas fuelling infrastructure facilities (bringing the number of NGV fleet to 1,373.1 thousand units by 2035). up to 1373.1 thousand units through the production and supply of 616.7 thousand gas-fuelled vehicles to the fleet and conversion of 583.5 thousand vehicles for the use of NGV fuel over the period 2023–2035 and the retirement of 117.6 thousand units of such vehicles over this period).

Due to the need to fulfil the requirements on fire and explosion safety of refuelling points, their location in cities is constrained by the lack of free (uninhabited) areas of the territory.

It is necessary to attract significant financial resources for reconstruction (construction) of production and technical base (PTB) of transport enterprises due to the need to fulfil strict requirements for fire and explosion safety of cylinders and equipment under high pressure. According to MADI (the Moscow State Automobile & Road Technical Unversity) data, the costs of transport enterprises for reconstruction of bus fleets with 200–250 bus units in the Moscow region reach up to 440 million rubles. The costs are associated with the construction of a gas cylinder filling station, CNG release and cylinder degassing station; with the reconstruction of the production building (additional redevelopment; ventilation, additional ventilation works, commissioning works, ventilation dismantling; technological equipment: automation of ventilation systems; communication and alarm system; fire extinguishing pump station, automatic foam fire extinguishing unit; installation of gas alarms; equipment for maintenance and repair of CNG buses).

[5] Development of the concept of the NGV fuel market development in the Russian Federation for the period up to 2035. Transport Integration, LLC, 2023;22. URL: https://www.asroad.org/wp-content/uploads/2023/04/Prezentatsiya-Kontseptsii-GMT-dlya-Gosud.-Dumy-RF_12.04.2023.pdf?ysclid=ln7cjslgp6691572040

The need to attract significant financial resources for the reconstruction (construction) of the production and technical base of transport enterprises restrains the growth of the number of CNG-fuelled vehicles in the fleet.

Calculations have shown that taking into account the above circumstances, *the cost of owning a CNG vehicle, taking into account the full life cycle of a CNG vehicle and refuelling infrastructure, will be higher than the cost of owning a petrol or diesel vehicle, i.e. there is currently no economically justified motivation for economic entities and the population to switch to natural gas*.

The cost of owning a natural gas-powered vehicle can be significantly reduced if it is stored on board in liquefied (LNG) rather than compressed form due to the following:

- dimensions, weight of fuel tanks are reduced (during compression the volume of gas is reduced 200–250 times, during liquefaction at a temperature of –161.5 °C — 600 times);
- the range of vehicles increases 2–3 times (CNG — 300–450 km, LNG — 750–1500 km) [7];
- refuelling time will be reduced (the same as for diesel fuel);
- cryo-fuelling stations[6] can be located in all regions of Russia without being tied to a gas pipe, using cryo-fuelling trucks;
- there is a technological possibility of regasification of LNG into CNG when refuelling vehicles;
- the risks of fire and explosion hazards of vehicles and infrastructure are significantly reduced, as the pressure in cryogenic cylinders and tanks is an order of magnitude lower than in CNG cylinders; the relevant requirements for the location of refuelling stations and PTBs of transport companies are relaxed and the investment attractiveness of the construction of these facilities is increased.

Of course, there are new problems that need to be solved. These include: the lack of serial production of domestic LNG-powered vehicle designs; small number of cryo-fuelling stations (13 units); high cost of cryogenic equipment; lack of benefits and preferences for manufacturers and consumers of cryogenic equipment; lack of state regulation of LNG prices [7].

Meanwhile, the development of domestic designs of vehicles with internal combustion engines on CNG and especially on LNG, refuelling infrastructure allows directing the available technological reserves to the creation of designs of vehicles on hydrogen fuel cells with hydrogen storage on board in compressed or liquefied form, which can ensure high competitiveness of domestic automotive equipment.

ELECTRIC TRACTION DRIVE

It is fundamentally easier to develop, manufacture and maintain a car with traction batteries than a car with an internal combustion engine that meets modern and prospective environmental requirements. For creation and production of electric cars, there is no need for the corresponding technological reserves available at the firms-manufacturers of vehicles with internal combustion engines. In addition, all global car manufacturers are implementing corporate strategies to decarbonise their products, gradually abandoning the production of internal combustion engine vehicles.

As a result, the size of the global fleet of electric vehicles (Battery Electric Vehicle — BEV[7]) and plug-in hybrids (Plug-in Hybrid Electric Vehicle — PHEV[8]) is growing very rapidly. The leader in the production of light electric vehicles and hybrids are automakers from China, which by the end of 2022 should reach 7 million units of such vehicles. These are modern designs of vehicles with battery electric traction drive. According to the Ministry of Industry and Trade of Russia, large-scale assembly of some models is organised in autumn 2022 in Lipetsk Region (Motorinvest plant) and in Moscow. Table 2 shows the technical characteristics of electric passenger cars produced in Lipetsk Region.

Since 2018, competitive electric city buses have been mass-produced in Russia by KAMAZ, PJSC, GAZ, PJSC, and Volgabus, LLC (300 units per year).

At present in Russia the process of electromobilisation of road transport is in the initial phase, as according to the data of the Analytical Agency “Avtostat”, the number of electric vehicles in the fleet is a hundredth of a percent of the total number of vehicles in the fleet (about 20 thousand units).

The key organisational, technological and economic problems that hinder the development of the electric vehicle fleet with traction batteries and refuelling infrastructure are related to:

- absence of a long-term state strategy for the development of the electric vehicle industry and the electric vehicle fleet, as well as a comprehensive state

[6] Cryo-fuelling station — a filling station that runs on NGV fuels, including liquefied natural gas, compressed gas and hydrogen.
[7] Electric vehicle — an all-electric vehicle powered by an electric motor using energy from a battery installed in the vehicle.
[8] Hybrid electric vehicle (internal combustion engine + electric motor) with a high-capacity battery — the main energy source. The internal combustion engine is predominantly used to charge the battery or serves as a backup in case the battery is completely discharged. A key difference between a PHEV and a standard hybrid vehicle is the presence of an additional battery in the initial version of such a vehicle.

Table 2

Technical specifications of Evolute electric passenger cars (manufacturers' data)

Model in the Russian Federation	Model in China	Electric engine power, kW	Battery capacity, kWh	Drive range, km	Acceleration to 100 km/h, sec	Price, mln rubles
Sedan Evolute i-Pro	Dongfeng Aeolus E 70 (Nissan Bluebird Sylphy G11 2005 model year)	110	53	420	9.5	2.99
Crossover Evolute i-Joy	Dongfeng Fengon E 3	129.4	53	405	No data	3.49
Crossover Voyah Free	Dongfeng Voyah Free	179.4 + 179.4	106	600	4.7	7.99

support system for the market of electric vehicles and plug-in hybrids;
- limited range of electric vehicles and hybrids offered on the market, insufficient development of charging infrastructure, and lack of service infrastructure;
- the need to improve the design and serial production of domestic electric cars and hybrids (increasing the range, reliability, energy efficiency, comfort and safety); lack of a testing base for certification and refinement work when designing cars with a low carbon footprint;
- lack of serial production of domestic lithium-ion battery cell designs with the required specific energy and in sufficient volume based on the most advanced cathode materials (NMC and LFP) with differentiation depending on specific applications;
- lack of efficient technologies and infrastructure for utilisation of electric vehicles and their components (batteries);
- imperfect legislation in the sphere of utilisation/sale of accumulated electric power by batteries; lack of infrastructure for secondary use of batteries for accumulation of electric power from RES;
- high cost of electric cars and hybrids, which requires introduction of state support measures for consumers, vehicle manufacturers and fuelling equipment.

It should also be taken into account that the intensive increase in the number of electric vehicles and plug-in hybrids in the car fleet in certain regions may cause a shortage of generating capacity in the energy sector in the medium term.

HYDROGEN TECHNOLOGIES

Electric vehicles using traction batteries are unsuitable for long distances and harsh weather and climate conditions. Electric vehicles using hydrogen fuel cells and the excess heat they generate, which can be used for heating the interior, solve these problems.

Based on the analysis of the current world experience, we can first of all talk about conversion to hydrogen fuel (for use in fuel cells) of heavy intracity transport (buses, intracity freight transport, special transport). This is due to:
- absence of the need to create a wide network of fuelling stations due to the localised nature of the application;
- difficulty of using battery electric transport due to the need to combine high capacity, high power and fast charging of batteries;
- possibility of targeted financial incentives.

The key problems of decarbonisation of transport using hydrogen technologies are related to the lack of a technological backlog of fuel cell electric vehicle designs, as well as stationary and mobile refuelling complexes, infrastructure for maintenance and repair of such vehicles.

Only prototypes of hydrogen fuel cell power units, as well as electrolysers for the production of "green" hydrogen and units for the production of hydrogen from natural gas have been manufactured in Russia. Prototypes of hydrogen vehicles were presented at the Comtrans-2021 exhibition: large class buses — KamAZ-6290, CITYMAX Hydrogen (85 passengers) and small class buses — GAZelle City (22 passengers); Aurus Senat passenger car (NAMI); KAMAZ road train with GVW of 44 tonnes (6×2 configuration) powered by hydrogen fuel cells, which develops 570 hp and has a range of 500 km [7].

Meanwhile, the use of hydrogen fuel cells in vehicles reveals a number of relatively new technical challenges related to the safety of on-board storage, refuelling tanks that need to be addressed. The sources of potential risks of fires and explosions on board the vehicle and infrastructure facilities are [8]:
- maximum hydrogen cylinder pressure can reach 87.5 MPa when refuelling in on-board vehicle hydrogen storage systems;
- the diffusion coefficient of hydrogen in air is several times greater than the diffusion coefficient of methane, propane. This means that when hydro-

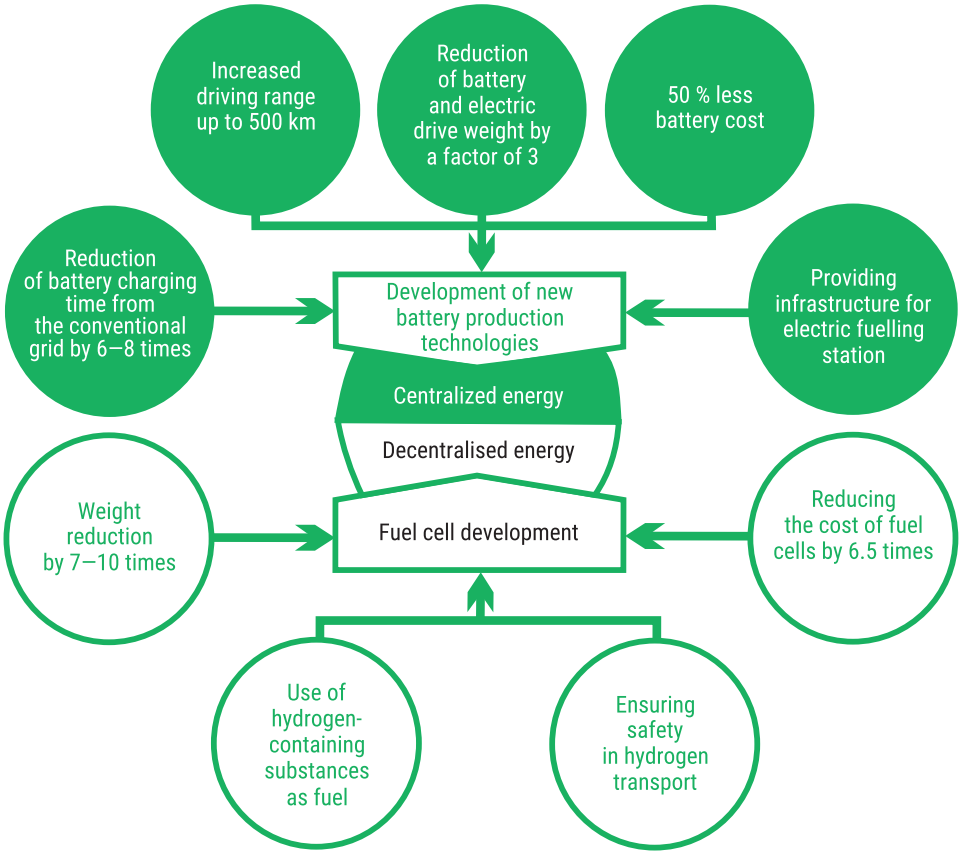

Fig. Requirements for achieving competitiveness of electric vehicles with traction batteries, hydrogen fuel cells compared to petroleum-fuelled vehicles (source "Institute of Petroleum Refining and Petrochemistry" of the Russian Academy of Science, MADI, 2021)

gen leaks into the environment, hydrogen is able to mix and form an explosive mixture with air faster than methane or propane. This is true if hydrogen escapes into an enclosed or top-restricted space such as a garage, tunnel or car park under a domed canopy;

- metals and alloys become more brittle in interaction with hydrogen[9].

Problems of safety, environmental efficiency on the way of decarbonisation may arise not only with storage, transportation, as well as distribution, consumption of hydrogen in electrochemical generators of motor vehicles, but also with the production of "green" hydrogen (from renewable sources). In this case hydrogen becomes a source of renewable electricity storage. And as an energy storage device, hydrogen competes with other types of storage devices, first of all, rechargeable batteries. It is required to solve the complex problem of ensuring the balance of production and consumption of "green" hydrogen in transport, taking into account the seasonal and daily irregularity of electricity production at wind and solar power plants, seasonal irregularity of water resources, as well as to take into account the risks of low-water years. Therefore, the unevenness and low predictability of electricity generation for "green" hydrogen production by water electrolysis at wind and solar power plants will require the creation of a complex system of electricity storage, storage of raw and distilled water, as well as of hydrogen.

A promising direction for obtaining high-purity hydrogen in significant volumes for vehicles is the creation and use of a nuclear energy technology complex — the tandem "high-temperature gas-cooled reactor — methane vapour conversion" [9].

The figure contains a scheme showing the main requirements, fulfilment of which will allow to achieve competitiveness of electric vehicles with traction batteries, hydrogen fuel cells in comparison with petroleum-fuelled vehicles.

[9] As it is known, hydrogen does not form compounds with metals that adversely affect their strength, but at the same time it increases the harmful effect of macro- and microflaws, contributes to a sharp decrease in the plastic properties of the metal and its brittle fracture.

FORECAST OF DECARBONISATION OF MOTOR VEHICLES

Taking into account the implementation of the above measures, the solution of the above problematic issues related to the diversification of energy sources in road transport, new global threats and risks associated with the disruption of established supply chains, insufficient rates of renewal of the fleet of vehicles (moral and physical aging), the need to develop infrastructure for the mass use of electric vehicles, autonomous and connected cars, gas-powered vehicles, which is specified in the Strategy for the Development of the Automotive Industry of the Russian Federation [1].

It has been established that compared to earlier forecast estimates [2, 3, 10], the share of electric cars and hybrids by 2050 will account for 24 % of the number of passenger cars in the car fleet, light commercial vehicles — 12 %, electric trucks and electric buses — 15 % of the total number of these types of vehicles in the car fleet. However, if we assume that in 2045 a political decision will be made to stop access to the Russian market for passenger cars with liquid fuel combustion engines in favour of electric vehicles, then by 2050 the share of electric passenger cars may reach 48.5 % of the total number of passenger car fleet in this year.

As a result, total gross GHG emissions from the Russian car fleet in 2050, the expected number of which will decrease from 59.8 to 51.7 million units compared to 2021, may amount to 126.8 million tonnes of CO_2 equivalent, which is 28.5 % less than in 2021. Compared to earlier forecasts, the value of total GHG emissions from the car fleet in 2050 will lag behind by about 5 years. At the same time, the vehicle fleet in 2050 will be dominated by vehicles with internal combustion engines using hydrocarbon fuels (liquid and gaseous). Only after 2045 the share of sales of electric vehicles of all types may exceed the share of sales of these types of combustion engine vehicles [10].

CONCLUSION

Road transport is the main source of GHG emissions in the transport sector with an unfavourable trend in emissions for the medium term. The most effective in reducing the carbon footprint of motor transport in the medium term is the replacement of traditional motor fuels with natural gas, electric drive on traction batteries and hydrogen fuel cells.

At present, there is no economically justified motivation of economic entities and population to switch to natural gas use, as the cost of owning a CNG vehicle, taking into account the full life cycle of a CNG vehicle and refuelling infrastructure, is higher than the cost of owning a CNG vehicle using petrol or diesel fuel. Motivation may appear when natural gas is stored in liquefied rather than compressed form at the motor vehicles.

The key problems of decarbonisation through the development of the electric vehicle fleet on traction batteries and hydrogen fuel cells are related to the lack of technological backlog of electric vehicle designs, stationary and mobile refuelling complexes, infrastructure for servicing and repair of such vehicles.

The basic requirements are formulated, fulfilment of which will allow to achieve competitiveness of electric vehicles with traction batteries and hydrogen fuel cells in comparison with oil-fuelled vehicles.

It has been established that the total gross GHG emissions by the Russian automobile fleet in 2050, the expected number of which will decrease from 59.8 to 51.7 million units compared to 2021, may amount to 126.8 million tonnes of CO_2 equivalent, which is 28.5 % less than in 2021. Compared to earlier forecasts, the value of total GHG emissions by the automobile fleet in 2050 will lag behind by about 5 years. At the same time, the vehicle fleet in 2050 will be dominated by vehicles with internal combustion engines using hydrocarbon fuels (liquid and gaseous). Only after 2045 the share of sales of electric vehicles of all types may exceed the share of sales of these types of combustion engine vehicles.

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ТРАНСПОРТНЫЕ СРЕДСТВА И ПОДВИЖНОЙ СОСТАВ

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Social and economic prerequisites and trends in the development of transport innovations*

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ABSTRACT In the context of innovative development of modern economy, innovative ideas in the field of transport, which are indicators of trends in the development of transport systems, are considered. The attention is focused on the current trends of individualisation of vehicles, greening of transport and increasing traffic speeds. The aim of the study is to analyse specific examples of the implementation of these trends. The scientific novelty of the author's approach refers to the identification of "weak signals" in the analysis of transport innovations, indicating the emergence and development of promising trends.

The authors used actual materials devoted to transport innovations, Internet information sources, and scientific literature. Foresight methodology was applied.

Examples of innovative developments within the framework of the trends under consideration have been analysed. It is revealed that these trends are often combined with each other within the framework of specific transport vehicles and technologies, which generates synergistic effects important for the transport industry and the economy as a whole.

The analysis of transport innovations has shown that individualisation, greening and increasing vehicle speeds have become important conditions for the effective functioning and development of the transport industry. These trends exist both in isolation and in combination with each other. The combination of different trends in one vehicle or technology allows not only to bring the transport industry to a qualitatively higher level, to create new transport systems and products with the necessary consumer characteristics, but also to increase the economic efficiency of transport-related industries and the economy as a whole.

KEYWORDS: transport; innovation; foresight; individualisation of transport; greening; bionics; transport acceleration; economic efficiency

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Научная статья

Социально-экономические предпосылки и тенденции развития транспортных инноваций*

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АННОТАЦИЯ В контексте инновационного развития современной экономики рассматриваются инновационные идеи в сфере транспорта, являющиеся индикаторами тенденций развития транспортных систем. Внимание сфокусировано на актуальных тенденциях индивидуализации транспортных средств, экологизации транспорта и повышения скоростей движения. Цель исследования — анализ конкретных примеров реализации указанных тенденций. Научная новизна авторского подхода состоит в выявлении при анализе транспортных инноваций «слабых сигналов», свидетельствующих о зарождении и развитии перспективных тенденций.

Использованы актуальные материалы, посвященные транспортным инновациям, информационных интернет-источников; научная литература. Применена методология форсайта.

Проанализированы примеры инновационных разработок в рамках рассматриваемых тенденций. Выявлено, что эти тенденции нередко сочетаются друг с другом в рамках конкретных транспортных средств и технологий, что генерирует синергетические эффекты, важные для транспортной отрасли и экономики в целом.

Проведенный анализ транспортных инноваций показал, что индивидуализация, экологизация и повышение скоростей транспортных средств стали важными условиями эффективного функционирования и развития транспортной отрасли. Данные тенденции существуют как обособленно, так и в сочетании друг с другом. Сочетание различных тенденций в одном транспортном средстве или технологии позволяет не только вывести транспортную отрасль на качественно более высокий уровень, создавать новые транспортные системы и продукты, обладающие необходимыми потребительскими характеристиками, но и повысить экономическую эффективность смежных с транспортом отраслей и экономики в целом.

КЛЮЧЕВЫЕ СЛОВА: транспорт; инновации; форсайт; индивидуализация транспорта; экологизация; бионика; ускорение перевозок; экономическая эффективность

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INTRODUCTION

Digitalisation is becoming the driving force of the new industrial revolution [1], changing not only production technologies, but also the system of social interaction and people's lifestyles [2]. The transition from mass to individualised production is beginning [3], and economic growth is combined with the growth of environmental friendliness within the paradigm of "green economy" [4, 5].

Transport, playing an active and very significant role in ensuring economic growth and increasing public welfare [6], stimulating innovative development and implementing industrial revolutions [7, 8], should be in line with these trends, and not just change following other spheres of activity, but be at the forefront of such changes. Already almost a century ago, economists who dealt with transport problems began to understand that for the successful development of the economy and society, transport must develop at an accelerated pace. *"Modern ways and means of transport <...> go far ahead of other branches of the national economy and facilitate their further movement. <...> First, new ways and means of transport are created, which open up the possibility of receiving and marketing in all directions, and only then production in turn can begin to be built on the basis of these new conditions"* [9, p. 43].

Further development of economic thought in the field of transport allowed to formalise this understanding in the form of the law of advanced development of transport infrastructure [10]. But it should be not only about quantitative advancement (creating reserves of throughput and carrying capacity for prospective transport flows), but also about qualitative. Transport should be one of the leaders of innovative development. In the early 19th century, railways, being an epochal innovation [11], played a key role in the realisation of the industrial revolution and the establishment of the era of modern economic growth [12, 13] (in synergy with the development of steamship traffic). *"From about the 1830s, railway construction and factory construction moved in tandem... The industrial revolution was by necessity also a revolution in transport"* [14, p. 181].

Now the emergence of numerous transport innovations may indicate the approach of a new "transport revolution", which will actively affect socio-economic changes [15].

It is important to identify trends in the development of railways [16, 17] and transport in general [18, 19] in a number of studies conducted and to determine, on this basis, the strategic directions of transport system development in the long term [20].

At the same time, along with the identification, analysis and forecasting of already emerging trends in transport development, it is important to identify, on the basis of the so-called "weak signals", only incipient trends, which is one of the elements of foresight [21]. Weak signals, according to I. Ansoff's definition, are vague early indications of upcoming important events [22]. Therefore, it is necessary to identify by weak signals the phenomena and processes that may dominate in the future [23]. Important indicators of weak signals are innovative ideas arising from scientists and inven-

tors. Their identification can be carried out on the basis of such foresight methods as review of sources, scanning of sources, bibliographic analysis [24].

What innovative ideas in the field of transport engineering and technology can be considered weak signals of upcoming important events — those phenomena and processes that can have a significant impact in the future? In our opinion, these are the ideas and conceptual developments that meet the priority needs of people, and therefore will be demanded with a high probability.

Comparing the results of the analysis of transport innovations conducted over a number of years (some results of which are reflected in [5, 7, 15, 25, 26]) with the priority human needs allows us to identify important trends that should dominate the development of transport systems in the future. These are:

- individualisation of transport facilities and services;
- the greening of transport in the broad sense, understood not simply as a reduction of the burden on the environment ("green transport"), but as a harmonisation of transport systems and the natural environment;
- and, finally, the trend towards faster transport, which is not new but is becoming a priority.

INDIVIDUALISATION OF TRANSPORT

According to D.V. Dragunsky's apt remark, the development of culture is the development of privacy [27]. People's need for privacy, for individualisation of transport means and services, if sometimes it sometimes took a back seat to other important characteristics of transport, it never disappeared. It is worth remembering how the characters of N.S. Leskov, praising the railway for the speed of travelling compared to the horse-drawn railway (we are talking about the 1880s), *"found one thing better on horses, that you can ride in your own company and stop anywhere"* [28, p. 169]. That is, choosing to travel by rail because of the high speed, people retained the need for a more private, flexible, in a word, individualised transport. It is no coincidence that the bicycle, invented in the late 19th century, was in demand. *"The bicycle has become a mass means of transport, and the impact it has had on urban lifestyles is beyond all estimation. The bicycle in a sense paved the way for the car and motorbike, becoming a cheap and democratic, but still a personal vehicle"* [29, p. 207].

It is the need for private door-to-door travelling with the possibility of *"stopping anywhere"* that made cars so attractive, despite the high costs and serious problems associated with road "congestion" [30]. The solution to these problems must lie in new forms of individualisation of vehicles and transport services.

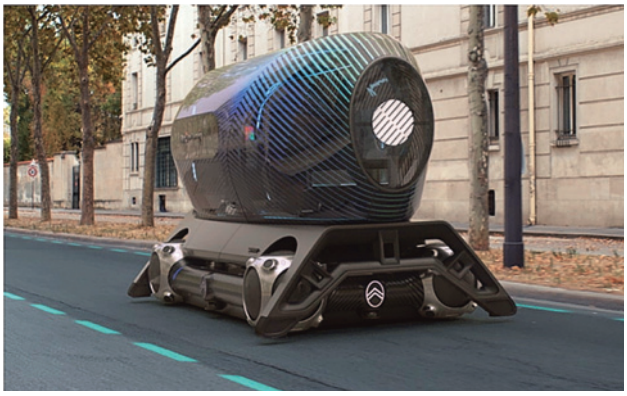

Fig. 1. Citroën Skate

Fig. 2. Caravan NV350 Office Pod

Therefore, it can be assumed that the numerous ideas and concepts of such vehicles that are emerging will be in demand and are signals of emerging important trends in the evolution of transport.

For example, the French car manufacturer Citroën has presented an interesting mobility concept that combines several promising transport technologies into one universal vehicle, the Citroën Skate [31]. This is a platform for an unmanned electric vehicle that can be equipped with different interchangeable types of add-on modules depending on the work to be performed (*Fig. 1*).

Another major car manufacturer — the Japanese company Nissan, promptly responding to the new social challenge — remote work, has developed a new type of office space — Caravan NV350 Office Pod, which differs from typical designs of motorhomes in that it is an office [32]. The office, located in a retractable section, allows working outdoors in a very real sense (*Fig. 2*).

The contours of future urban mobility are gradually taking shape. It is likely to include vehicle types such as "flying cars", "flying taxis" and "flying motorbikes". With regard to the development of flying motorbikes, mention should be made, for example, of the French company Lazareth. The American firm JetPack Aviation has already successfully tested its Speeder

Fig. 3. Speeder motorbike

Fig. 4. XTurismo Limited Edition flying motorbike

motorbike (*Fig. 3*), which is based on the operation of a vertical take-off and landing (VTOL) aircraft. It is expected to have a top speed of 96 km/h and a range of 15 minutes. The second variation of the flying motorbike has a speed of 240 km/h and a flight time of 10 to 22 minutes [33].

Japanese startup A.L.I. Technologies has launched the XTurismo Limited Edition flying motorbike (*Fig. 4*), which has six propellers powered by a conventional engine and four electric motors. The motorbike weighs 300 kg and can fly at 100 km/h for about 40 minutes [34].

When it comes to urban mobility and the customisation of vehicles, the modernised wingsuit is not to be overlooked[1] with an electric motor, on which Austrian stuntman Peter Salzmann made the first flight in history (*Fig. 5*).

The speed after switching on the engines was more than 300 km/h. For the first time in history, a person in a wingsuit flew not only downwards but also upwards, achieving an unprecedented freedom of flight [35].

Mobility is a major challenge in Africa where transport infrastructure is underdeveloped. This was the starting point for Phractyl engineers to develop the Macrobat, a uniquely shaped flying machine. Thanks to its wings and two "legs", this device shares common features with birds, thus the device performs an almost vertical take-off and landing (*Fig. 6*). This feature is in great demand today by all those who are trying to create compact flying machines [36].

One of the visible trends of emerging innovations is the combination of several weak signals (development trends). For example, modern transport is becoming both personalised and environmentally friendly. A good example is the Eximus IV rail vehicle, which has become the most fuel-efficient vehicle in the world (*Fig. 7*) [37].

Fig. 5. Austrian stuntman Peter Salzmann flying in a motorised wingsuit

Fig. 6. Macrobat aircraft

Fig. 7. Rail vehicle Eximus IV

[1] Wingsuit ("wing" + "suit") — a special suit-wing, the design of which allows the rushing air flow filling the wings between the legs, arms and body of the pilot, thus creating an aerodynamic profile. This makes it possible to perform gliding flights.

Fig. 8. A "solar-powered" electric car Aptera

Fig. 9. A car made of recycled rubbish called "Luca"

Fig. 10. Roadster electrotrike

Combining individualisation and environmental friendliness are electric cars with ultra-aerodynamic shapes and ultra-light weight, for which a solar panel located on the roof can provide a range comparable to the average daily mileage of a typical city dweller's car.

For example, the American electric car Aptera, which has 180 solar panel modules on its roof and bonnet, with a total area of just over three-square metres, has adapted this idea for the consumer class (*Fig. 8*). The Aptera car's solar panels are capable of generating enough energy for 72 kilometres of driving under ideal conditions. The car's two-seater body has an air resistance coefficient of 0.13 (for comparison, the very low resistance coefficient of the Volkswagen ID Space Vizzion is 0.24) [38].

Another example of an eco-friendly individual vehicle is Project Luca (*Fig. 9*), created by a team of enthusiasts from the Eindhoven University of Technology in the Netherlands, which consists almost entirely of skilfully recycled rubbish.

The car has an electric drivetrain and two electric motors, and since it is very light, it can accelerate up to 90 km/h. The energy reserve is enough for 220 kilometres. The car is designed for two passengers [39].

American company Arcimoto has developed a new version of the electrotrike[2] Roadster (*Fig. 10*), with a top speed of 120 kilometres per hour [40].

The trend towards individualisation of vehicles covers various modes of transport, including air and even rail, and is often combined with greening. Of course, the trend towards greening transport goes beyond individualised vehicles and requires special consideration.

TRANSPORT GREENING

The development of transport has played an important role in shaping the ecological component of human consciousness. *"...'Reverence for nature,' as Aldous Huxley noted, 'resulted from good means of communication. In the seventeenth century no sane man loved wilderness.' The change came when the French began to pave roads over the Roman roads, so that nobles could travel and 'gaze upon the wilderness with comfort and without serious risk'..."* [41, p. 9].

When analysing the prospects of transport greening, attention should be paid to a wide range of innovations that ensure both the reduction of transport load on the environment and harmonious "embedding" of vehicles and objects into the natural environment.

An important component of greening is the reduction of noise pollution. Trailing edge noise is the strongest source of sound from rotating aircraft and gas turbine engines used in aeroplanes, unmanned aerial vehicles and wind turbines, and its suppression is an important task. One of its solutions becomes the use of the characteristics of extremely quiet owl wings to determine the design of airfoils. Interestingly, the use of asymmetrical teeth (similar to the tips of owl feath-

[2] Electrotrikes (electric tricycles) are three-wheeled vehicles with an electric motor that are designed for personal journeys but can also be used to transport goods or passengers on commercial sites, parks, businesses or private farms.

Fig. 11. High-speed electric train with distributed traction KTX-Eum

Fig. 12. Train with hybrid propulsion system of HC85 series

ers) reduces noise more than conventional symmetrical teeth. This is a prime example of using bionics[3] for transport innovations [42].

Bionics is a promising direction of transport innovations, which allows increasing not only the environmental friendliness but also the efficiency of transport systems [43]. Along with the application of bionics principles for individual innovations in the field of transport equipment and technologies, they can also be used to effectively harmonise the interaction and development of different modes of transport, following the example of mutual positive interactions between different biological species and their symbiogenesis [44].

Despite the fact that the railway is the most environmentally friendly mode of transport, there are projects aimed at further increasing its environmental friendliness.

For example, the Canadian National (CN) railway and Progress Rail (part of Caterpillar Corporation) have begun working with biodiesel producer Renewable Energy Group (REG) to test fuel blends that include both biodiesel and diesel from renewable components. The tests conducted and the results obtained were an important step in reducing harmful emissions from the operating locomotive fleet [45].

The government of the Republic of Korea plans to completely eliminate diesel trains by 2029. They will be replaced by high-speed electric trains with distributed traction KTX-Eum (*Fig. 11*). Replacing diesel traction with electric traction will reduce greenhouse gas emissions by 70 thousand tonnes, which is equivalent to planting 10 million coniferous trees [46].

Hydrogen-fuelled locomotives are a promising alternative to diesel-powered rolling stock. The Republic of Korea Railway Research Institute (KRRI) is developing a hydrogen fuel cell traction system that can run 600 km on a single charge at a speed of 110 km/h [47].

It should be noted that developments on the use of hydrogen fuel for train traction are underway in a number of other countries, including Russia [48, 49].

The Japanese railway company JR Central has completed tests of a train with a hybrid propulsion system. The new HC85 series trains developed by Nippon Sharyo are designed to run at a speed of 120 km/h (*Fig. 12*).

The HC85 train is equipped with a 145 kW diesel generator set and a 40 kWh battery pack. The use of battery packs during acceleration and braking of the train reduces the level of harmful emissions into the atmosphere. When the diesel engine is idling at the station, the fuel supply system switches it off. Compared to the 85 series diesel train, the new train's fuel consumption is reduced by 35 %, CO_2 emissions by 30 % and NOx emissions by 40 % [50].

The American company Progress Rail will build a shunting locomotive with traction batteries for the Pacific Harbor Line railway. The six-axle locomotive with an output of 3200 hp is equipped with new generation lithium-ion batteries and asynchronous traction drive. The capacity of the EMD Joule traction battery pack is 2.4 MWh, the duration of operation without recharging depends on the mode of locomotive use and can reach 24 h [51].

If electrification is a traditional tool for improving environmental friendliness in railway transport, and only in recent years the search for alternative solutions has intensified, then in motor transport the use of electric energy is a serious reserve of greening.

It should be noted that electric vehicles are relatively expensive. However, this problem is being actively addressed. An example is the electric car Wuling by a Chinese manufacturer (*Fig. 13*) [52], which managed to reduce its price to 4.3 thousand dollars. In China, it overtook the American company Tesla Model 3 electric car in sales.

[3] Bionics — applied science of application of principles of organisation, properties, functions and structures of living nature in technical devices and systems.

Fig. 13. Wuling Mini EV in GameBoy configuration in Russia (photo by Aleksey Shvaikov)

Fig. 14. Zero Labs

Fig. 15. "Green" Aframax class tanker "Vladimir Monomakh"

Fig. 16. The reduced-gas-fuelled passenger ship "Chaika" on the Neva River in Saint Petersburg

It is likely that it is China that will become the dominant player in the growing global electric vehicle market. China already controls a significant part of the global electric car supply chain, starting with the processing of critical minerals. In doing so, China is the leading electric vehicle market in the world. The Chinese government predicts that by 2025, electric vehicle sales will account for up to 25 per cent of all car sales [53].

The environmental benefits of electric cars are undeniable. But not everyone is ready to part with classic cars and replace them with compact, quiet electric vehicles. Companies such as Zero Labs are working specifically for them, which seeks to convert an existing car to an electric chassis. Zero Labs offers a ready-made electric platform on which all that is required is to mount the desired body and connect the controls (*Fig. 14*). In fact, by contacting the company, the customer buys a ready-made electric car, but retains complete freedom to choose how it will look like [54].

Concepts and innovations aimed at maintaining the industry's environmental friendliness are also appearing in water transport. An example of such environmental innovations is the first Aframax-class "green" tanker in Russia, the Vladimir Monomakh, built at the Zvezda shipbuilding complex (*Fig. 15*). This liquefied natural gas (LNG)-powered vessel is designed to transport oil in an unlimited navigation area and meets high standards of environmental safety. The tanker can be powered by LNG, which minimises harm to the environment [55].

In Tatarstan, where work is underway to expand the use of LNG as a motor fuel in transport and industry, the Zelenodolsk plant is building LNG-powered passenger vessels of the Chaika type (*Fig. 16*). Passenger capacity of the vessel is 170 people. The range of navigation on fuel reserves is 400 km, autonomy — 24 hours [56].

An interesting trend in the greening of water transport is the use of sails. The French company Airseas has installed the first Seawing kite-sail with an area of 500 square metres on the 154-metre cargo vessel Ville de Bordeaux (*Fig. 17*), which will save about 20 % of

Fig. 17. Seawing sail on a cargo ship Ville de Bordeaux

fuel and reduce the amount of harmful emissions by a corresponding amount [57].

As for the aspect of greening transport, such as the harmonisation of transport systems and the natural environment, it is related to the aforementioned bionics. Illustrative examples are innovative proposals such as the chameleon design of high-speed trains, allowing them to blend in with their surroundings, or the technology of creating cars from biological materials capable of adapting to the environment [5]. Examples of the use of bionics in innovations in transport and related fields are numerous and deserve to be systematised and analysed.

INCREASING VEHICLE SPEEDS

A key human need fulfilled by transport is to reduce the time taken to cover distances. Increasing travelling speeds have played a key role in the development of human society [58]. The logical prediction made two decades ago about the priority of increasing speeds in transport [59] is confirmed by practice. Nevertheless, increasing the speed efficiency of transport systems remains an urgent task [60]. Therefore, the emerging ideas of creating fundamentally new vehicles that can dramatically increase the speeds of people and goods deserve increased attention as signals of future changes in transport systems.

Researchers in China have built and tested a prototype hypersonic TSV X-plane (*Fig. 18*). Unlike most hypersonic aircraft concepts with an engine on the lower hull, the TSV X-plane has two separate engines on each side. At lower speeds, they operate as conventional turbojet engines. This configuration gives the aircraft the ability to quickly switch to high-speed mode. The aircraft can accelerate to speeds up to five times the speed of sound. This means that the TSV X-plane can fly around the planet in a few hours [61].

An interesting project is the Super Sub, a new high-speed submarine with a long plumage and advanced wing design, which is the most hydrodynamic submarine on the market (*Fig. 19*). It was developed by U-Boat Worx, a Dutch submarine manufacturer.

The submarine has a best-in-class propulsion system with four powerful thrusters, allowing it to travel at eight knots underwater. This is two knots faster than the maximum cruising speed of a dolphin-aphaline and five knots faster than the average speed of similar submarines. The Super Sub's 62 kWh battery has enough capacity to operate underwater for up to eight hours without recharging, and if something goes wrong, the life support system will last for at least 96 hours. The new submarine can carry a captain and two passengers [62].

Fig. 18. A model of Chinese aeroplane TSV X-plane

Fig. 19. Mini submarine Super Sub

Fig. 20. Snoek velomobile

The Dutch company Velomobiel has presented an innovative development that combines answers to two modern trends at once — increasing speed and individualisation. It has developed a racing velomobile[4] Snoek (*Fig. 20*).

[4] A velomobile is a tricycle with an aerodynamic body, which the rider controls from a recumbent position. It is not particularly off-road, especially on rough terrain, but thanks to its streamlining on a good road it can be driven at a relatively high speed with less effort.

Fig. 21. Spirit of Innovation aircraft

It is purely foot-powered, with Sturmey Archer drum brakes. Snoek can accelerate up to 60 km/h [63].

When it comes to increasing the speed efficiency of vehicles, Rolls-Royce's Spirit of Innovation electric aircraft meets two trends at once: increasing speeds and environmental friendliness (*Fig. 21*).

The Spirit of Innovation is powered by a 400 kW electric propulsion system, which is supplied by a battery system that has the highest energy storage density of any aerospace system. The aircraft reached a maximum flight speed of 623 km/h, making it the world's fastest all-electric aircraft [64].

Another interesting concept of the Vox aircraft combines high flight performance with the ability to land on almost any helipad. At the same time, its speed is three times higher than that of a helicopter, and fuel consumption is half that of a helicopter, i.e. acceleration is combined with increased energy efficiency and, therefore, environmental friendliness [65].

In the modern world, most of the population lives in cities, and the most important task is to accelerate urban transport, primarily in megacities and agglomerations, where the speed of cars and public transport is limited due to "traffic jams" [66]. An interesting approach to solving this problem is the development of air transport ("helicopter taxi") in megacities and agglomerations [67].

Thus, innovative solutions aimed at accelerating the movement of both passengers and freight appear in different modes of transport, while other trends of individualisation and greening are often implemented.

CONCLUSION

Global trends always emerge from the aggregate of many micro-trends. These, in turn, are based on breakthrough ideas and "weak signals" of upcoming important events. For sustainable economic development, it is strategically important for the transport industry to be well oriented in the ongoing changes, to meet the existing socio-economic challenges and human needs, as well as to competently forecast the upcoming significant changes. To do this, it is necessary to timely identify "weak signals", as well as to know the "rules" of formation of "microtrends" [67].

The analysis of transport innovations has shown that individualisation, greening and increasing vehicle speeds have become not just trends, but important and even necessary conditions for the effective functioning of the industry. Their transition from "weak signals" to "necessary conditions" for further development is taking place rather quickly.

These trends exist both in isolation and in combination with each other. This conclusion seems important because the combination of different trends in one transport vehicle or technology generates synergetic effects, which allows not only to bring the transport industry to a qualitatively higher level, to create new transport systems and products with the necessary consumer characteristics, but also to increase the economic efficiency of transport-related industries, and thus of the economy as a whole.

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Ground laser scanning of the flyover through the railway for the purposes of its reconstruction

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ABSTRACT The article presents the possibility of obtaining geometric parameters of an flyover passing through a railway using ground–based laser scanning technology using modern equipment Leica ScanStation C10. The practical significance of using the chosen method lies in the fastest and most convenient scanning of the object, reducing production costs and, of course, high accuracy of the spatial data obtained necessary for the reconstruction of the flyover. A study of the use of ground-based laser scanning technology to obtain spatial data of the flyover was conducted, as a result of which the advantages of the chosen method were revealed. Also, based on the data obtained, a comprehensive three-dimensional model and two-dimensional drawings were prepared, such as the facade of the flyover, its plan and drawings of transverse profiles. Thanks to the compiled drawings and models of the bridge structure passing through the railway, the design work on the reconstruction of the facility has become much easier and more efficient. The presented experience confirms the need to introduce modern technologies, namely ground-based laser scanning in survey activities in order to develop and detail design solutions for the reconstruction of flyovers.

KEYWORDS: spatial data; ground laser scanning; flyover (overpass); linear structures; railway; reconstruction

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Научная статья

Наземное лазерное сканирование путепровода через железную дорогу для его реконструкции

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АННОТАЦИЯ Рассмотрена возможность получения геометрических параметров путепровода, проходящего через железную дорогу, с помощью применения технологии наземного лазерного сканирования с использованием современного оборудования Leica ScanStation C10. Практическая значимость выбранного метода заключается в наиболее быстром и удобном выполнении сканирования объекта, снижении затрат на производство и высокой точности полученных пространственных данных, необходимых для реконструкции путепровода.

Проведено исследование применения технологии наземного лазерного сканирования для получения пространственных данных путепровода, в результате которого выявлены преимущества этого метода. На основе полученных данных выполне-

на подготовка комплексной трехмерной модели и двумерных чертежей, таких как фасад путепровода, его план и чертежи поперечных профилей. Благодаря составленным чертежам и модели мостового сооружения, проходящего через железную дорогу, проведение проектных работ по реконструкции объекта стало значительно проще и эффективнее.

Представленный опыт подтверждает необходимость внедрения современных технологий, а именно наземного лазерного сканирования в изыскательскую деятельность с целью разработки и детализации проектных решений по реконструкции путепроводов.

КЛЮЧЕВЫЕ СЛОВА: пространственные данные; наземное лазерное сканирование; путепровод; линейные сооружения; железная дорога; реконструкция

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INTRODUCTION

In modern scientific literature, the issue of overpasses operation and monitoring of their deformations is considered frequently [1–3], as there are many reasons for changes in their qualitative characteristics. In the process of long-term operation of flyovers, various defects and damages gradually appear, which leads to the problem of their utilisation and large expenditure of resources for reconstruction [4, 5]. Modernisation of bridge structures passing through railways is aimed at improving the reliability performance not only of the whole object, but also of its constituent parts [6].

Documentation for flyover reconstruction includes many components, one of them is drawings of various structures and a three-dimensional model of the object [7]. To obtain such information, the technology of terrestrial laser scanning was chosen.

MATERIALS AND METHODS

Currently, there are various ways of obtaining spatial data on objects, but the most promising and modern direction is terrestrial laser scanning [8–11]. During scanning, the directions of laser beam propagation and the distance to the object points are determined. Terrestrial laser scanning is carried out in order to obtain an accurate and most complete three-dimensional image of the filmed object in the form of a point cloud [12].

The creation of a complex spatial model and drawings for the reconstruction of the flyover on Ofitserskaya Street over the railway in Krasnodar on the basis of terrestrial laser scanning data using Leica ScanStation C10 is considered. In the city this flyover serves as one of the main and always busy entrance routes. The survey was carried out to assess

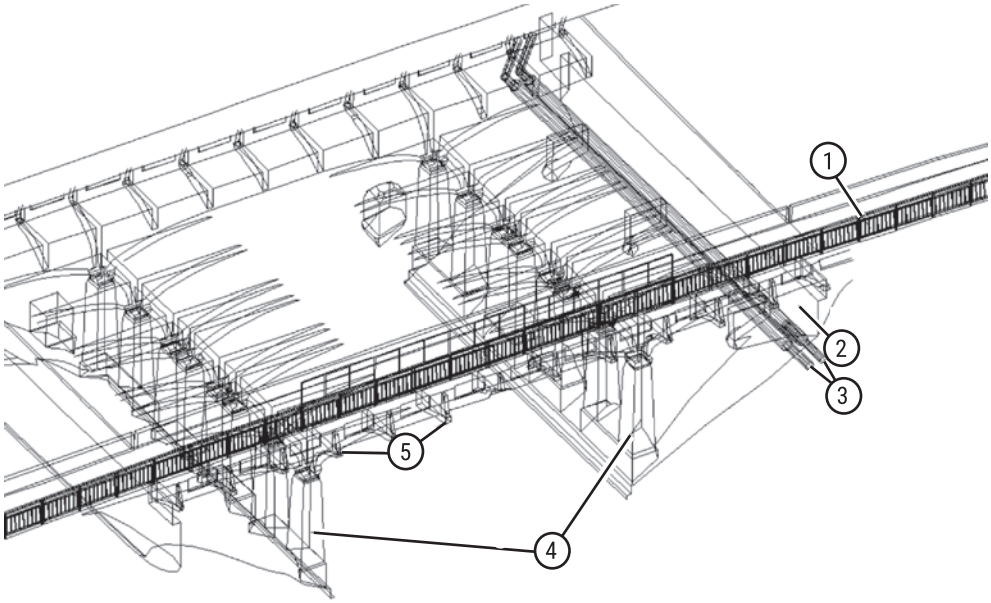

Fig. 1. Three-dimensional model of the flyover: 1 — railing; 2 — support body; 3 — metal pipes in the casing; 4 — reinforced concrete ribs of the superstructure; 5 — support posts

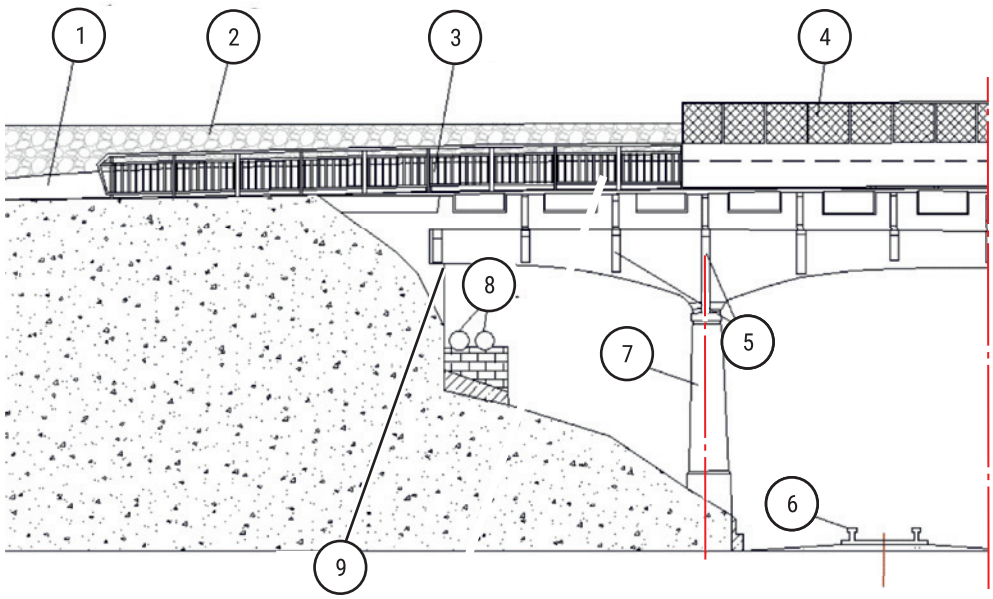

Fig. 2. The facade of the flyover: 1 — reinforced concrete barrier fence; 2 — reinforced concrete communication box; 3 — railing fence; 4 — protective shields; 5 — reinforced concrete ribs of the superstructure; 6 — railway track; 7 — support posts; 8 — metal pipes in the casing; 9 — support body

the technical condition of the flyover building structures, to identify damages and defects affecting the strength and load-bearing capacity of the structure, as well as to carry out further work on its reconstruction.

FINDINGS OF THE STUDY

When flyovers are being reconstructed and design documentation is missing or outdated and inadequate, new spatial data is required.

The Leica ScanStation C10 scanner provides spatial data with a point position accuracy of 4 mm per 50 metres. On the basis of the obtained information a 3D model, 3D and 2D drawings are created.

Extraction of geometric information from spatial scanning data is performed by point cloud, first it is processed in ReCap and Cyclone programmes. Then the processed point cloud data is exported for modelling in Revit software (*Fig. 1*). Due to the fact that the obtained point cloud is dense, the data from the drawing results are reliable and accurate. As a result, the centres of the supports and the distances between them are identified. Based on the results of modelling the point cloud in AutoCAD programme, drawings were made for the preparation of performance documentation.

The results of terrestrial laser scanning allowed to draw the facade (*Fig. 2*) and plan (*Fig. 3*) of the flyover with indication of qualitative characteristics of its ele-

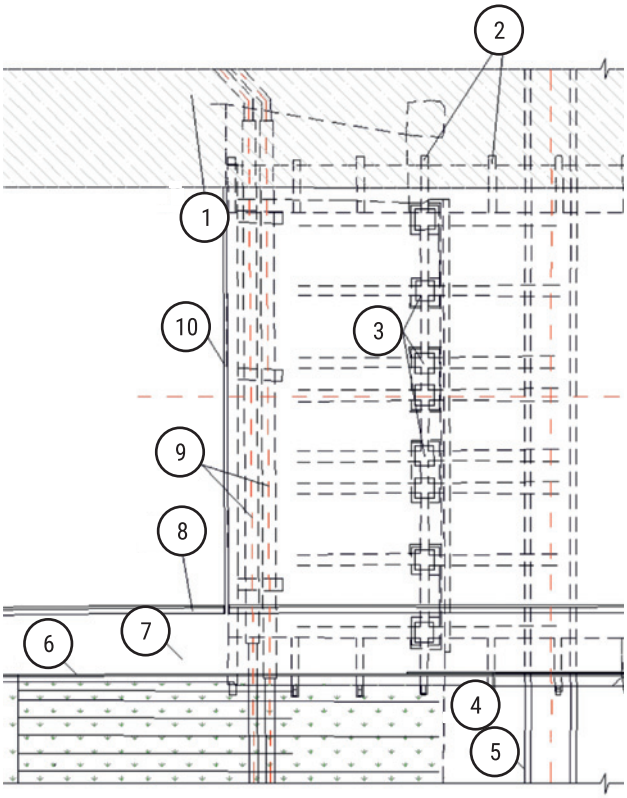

Fig. 3. Plan of the flyover: 1 — reinforced concrete communication box; 2 — reinforced concrete ribs of the superstructure; 3 — support posts; 4 — protective shields; 5 — railway track; 6 — railing; 7 — sidewalk; 8 — reinforced concrete barrier fence; 9 — metal pipes in the casing; 10 — deformation seam

Table

Specification of the fittings for the flyover

Item	Name		Quantity, pcs.	Weight, kg	Total, kg
	Assembly units				
	DSh-BSh-50		2 pcs./(13,93 + 14,07) = 28 RMT		
	Support 1 (4)				
1	∅12 AIII GOST 5781-82*	*L* = 14 000 mm	16	12.432	198.912
2	∅12 AIII GOST 5781-82*	*L* = 145 mm	560	0.129	72.240
3	∅14 AIII GOST 5781-82*	*L* = 450 mm	560	0.545	305.200
4	∅16 AIII GOST 5781-82*	*L* = 420 mm	280	0.664	185.920
	Expansion joint base				
5	∅16 AIII GOST 5781-82*	*L* = 1420–1990 mm	280	2.694	754.320
6	∅16 AIII GOST 5781-82*	*L* = 14 000 mm	48	22.120	1061.760
	Monolithic reinforced concrete, class B25, F200, W8		6.28		
	Filling the gate				
7	∅12 AIII GOST5781-82*	*L* = 1466–1990 mm	280	1.426	399.280
8	∅12 AIII GOST5781-82*	*L* = 14 000 mm	32	12.432	397.824
	Monolithic reinforced concrete, class B25, F200, W8		10.3		
	Materials				
9	Transition zone “MMCreat” or equivalent		m^3		1.18
10	Monolithic reinforced concrete, class B25, F200, W8		m^3		4.47
11	Chemical anchor “BIT-EASF” or equivalent		L		9.76

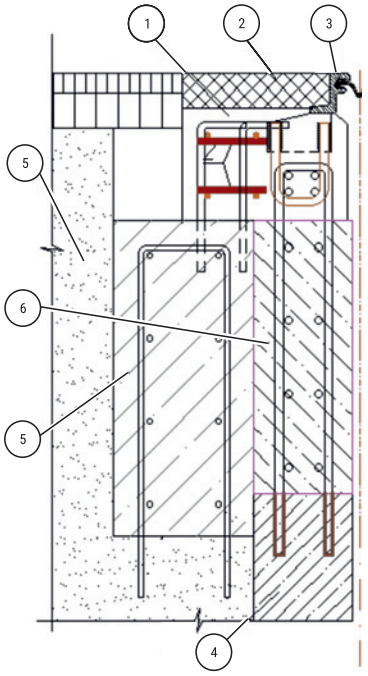

Fig. 4. Design drawing of the expansion joints of the flyover: 1 — monolithic concrete; 2 — transition zone; 3 — extreme load-bearing profile; 4 — cabinet wall; 5 — filling the gate with monolithic reinforced concrete; 6 — monolithic reinforced concrete base for the expansion joint

ments in scale 1:100. Also based on the measurement data, drawings of cross-sectional profiles were made with the determination of slope values and slope directions.

In order to reconstruct the flyover, a condition survey is also required. For this purpose, a construction drawing of the expansion joints (*Fig. 4*) with the accompanying specification of reinforcement for the flyover (*Table*).

CONCLUSION AND DISCUSSION

The article presents the experience of using the technology of terrestrial laser scanning of flyovers, based on the results thereof it can be concluded that the use of this technology for surveying engineering structures is relevant, taking into account its advantages. During reconstruction laser scanning is used to obtain executive documentation, to monitor geometric deviations from the design or permissible parameters for the flyover, as well as to obtain characteristics of its structural elements — flyover condition survey. The obtained data are reliable and can be used for development and detailing of design decisions on reconstruction.

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Presentation of Russian Transport Universities
Представляем российские транспортные университеты

Editorial article
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Samara State Transport University

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Редакционная статья

Самарский государственный университет путей сообщения

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Samara State Transport University (SamGUPS) is the largest transport university in the Volga Federal District, training highly qualified specialists for the railway industry and the country's transport and logistics cluster. The SamGUPS university complex is located in 10 regions of our country, including Samara Region, and has branches in Kazan, Nizhny Novgorod, Kirov, Izhevsk, Saratov, Penza, Ufa, Orenburg, Rtischevo and Alatyr.

The University was founded on the basis of a branch of the All-Union Correspondence Institute of Railway Transport Engineers (VZIIT) on March 5, 1973. The idea of creating a railway institute in Kuibyshev in the 60's was put forward and achieved by the head of the Kuibyshev railway D. Sugak. He saw the need to train qualified personnel for the mainline and railway network. Due to this, the Kuibyshev Institute of Railway Transport Engineers was established on the basis of the Decree of the Central Committee of the Communist Party of the Soviet Union and Council of Ministers of the USSR dated 09.05.1963 No.533 and Order of the Ministry of Railways of the USSR dated 05.03.1973 No.320 on the basis of the VZIIT branch.

The first rector of the Institute was Doctor of Technical Sciences, Professor E. S. Pavlovich (1973–1984). He was awarded the title "Honoured Worker of Science and Technology of the RSFSR", for his labour successes he was awarded the Order of the Red Banner of Labour, the Badge of Honour, the Badge "Honoured Railwayman" and others.

In 1988, in honour of the 15th anniversary of its foundation, the Kuibyshev Institute of Railway Engineers was named after the first Commissar of Railway Transport of the USSR M.T. Elizarov.

In 1991, in connection with the return of the historical name to the city, the university was named Samara Institute of Railway Transport Engineers (SamIIT).

In April 2002 the Samara Institute of Railway Transport Engineers was accredited as a higher educational institution of the "Academy" type and renamed into the Samara State Transport Academy (SamGAPS).

On March 1, 2007, by the decision of the accreditation board of the Federal Service for Supervision of Education and Science, the Academy was granted the status of "University" and renamed Samara State Transport University (SamGUPS). Two years later the SamGUPS educational complex was established, which included branches in the cities of Orenburg, Ufa, Ruzaevka, Orsk, Penza, Saratov, Alatyr, Rtischevo, Kazan, Izhevsk, as well as a structural subdivision "Samara Technical School of Railway Transport

SamGUPS training building (photo by SamGUPS)

named after A.A. Buyanov". Today more than twenty-three thousand students study at the university complex.

The university implements secondary vocational education (SVE) and higher education (HE) programmes. The university complex is located on the polygon of five railways: Kuibyshev, Privolzhskaya, South-Ural, South-Eastern and Gorkovskaya. One of the priority directions in the innovative scientific activity of the university is the development of projects under the orders of "Russian Railways", JSC and various Russian transport enterprises.

In March 2021, SamGUPS and Kuibyshev Railway (KbZD) signed a cooperation agreement aimed at improving the level of professional training of university students, creating a modern material and technical base and the development of joint scientific initiatives. The document provides for the implementation of joint programmes to use modern technologies to train students and create new innovative products for the benefit of Russian Railways.

In March 2022, a procedural simulator class for the operation of traction rolling stock appeared at the university. The equipment was installed by specialists from the Locomotive Design Bureau (DB CT) of Russian Railways in accordance with the Holding Company's Programme of Cooperation with University Complexes of Railway Transport.

June 2022 was marked by the opening of a training ground on the basis of the university for the training of railway power supply specialists. The equipment was provided to the university free of charge by the university's industrial partners — Kuibyshev Directorate for Power Supply and "Group of Companies "Elektroshchit", JSC — TM Samara".

In April 2022, representatives of KbZD, the Ministry of Education and Science of the Samara Region, and Samara State University of Railway Transport signed a partnership agreement on the implementation of the Professionality project.

M. Garanin has been the Rector of the university since September 2022 and up to the present time.

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ADVANCED ENGINEERING TRAINING FOR THE ECONOMY 4.0
ОПЕРЕЖАЮЩАЯ ПОДГОТОВКА ИНЖЕНЕРНЫХ КАДРОВ
ДЛЯ ЭКОНОМИКИ 4.0

Review paper
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Mission of Samara State Transport University

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ABSTRACT Samara State Transport University (SamGUPS) is the largest transport university in the Volga Federal District, training specialists for the country's railway transport and for many other areas of the national economy.

The institution was founded in 1973 as the Kuibyshev Institute of Railway Transport Engineers, primarily to meet the need for highly qualified engineering staff of the Kuibyshev Railway, one of the largest railway enterprises of the USSR.

In 1991, in connection with the renaming of the city of Kuibyshev and the return of its historical name Samara, the university was renamed Samara Institute of Railway Transport Engineers (SamIIT).

Over the past period the higher education institution has consistently raised its academic status — first to the Academy, becoming Samara State Transport Academy, and in 2007 — winning the right to be called Samara State Transport University.

The article presents the main goals and objectives of the university and the achieved results of the university development, tells about the interaction of Samara State University of Railway Transport with related branch and engineering universities in our country and abroad, tells about the interaction with transport, construction and infrastructure enterprises in the cities of the region.

KEYWORDS: universities; railway transport; engineering transport education; import substitution

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Обзорная статья

Миссия Самарского государственного университета путей сообщения

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АННОТАЦИЯ Самарский государственный университет путей сообщения (СамГУПС) — крупнейший транспортный вуз в Приволжском федеральном округе, ведет подготовку специалистов для железнодорожного транспорта страны и для многих других областей народного хозяйства.

Учебное заведение было основано в 1973 г. как Куйбышевский институт инженеров железнодорожного транспорта, прежде всего, для удовлетворения потребности в высококвалифицированных инженерных кадрах Куйбышевской железной дороги – одного из крупнейших железнодорожных предприятий СССР.

В 1991 г. в связи с переименованием города Куйбышева – возвращением ему исторического названия Самара, вуз стал именоваться Самарский институт инженеров железнодорожного транспорта (СамИИТ).

За прошедший период высшее учебное заведение последовательно повышало свой академический статус — вначале до академии, став Самарской государственной академией путей сообщения, а в 2007 г. — завоевав право называться Самарским государственным университетом путей сообщения.

Представлены основные цели, задачи университета и достигнутые результаты развития вуза, показано взаимодействие САмГУПС с родственными отраслевыми и инженерными университетами в стране и за рубежом, предприятиями транспорта, строительства.

КЛЮЧЕВЫЕ СЛОВА: университеты; железнодорожный транспорт; инженерное транспортное образование; импортозамещение

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SamGUPS is one of the largest transport universities in Russia, and its graduates are in demand not only in the territories where its branches are located, but also beyond their borders.

Highly qualified specialists are the main resource of modern railways. The mission of SamGUPS is to train highly qualified personnel with an active civil position, devoted to the interests of the Fatherland and possessing competences that allow successfully solving the problems of operation of existing transport systems, their development, creation of new ones on the basis of expanding the boundaries of scientific research and integration of the latest developments in the world transport system.

SamGUPS is a member of the consortium of scientific and educational centre (SEC) of Samara Region. Consolidating joint efforts with strategic partners and other higher education institutions participating in the SEC, the university is actively involved in creating technological innovations and in training new teams capable of using the developments in real production.

The goal of the university's scientific sector is to obtain new technologies and products with subsequent commercialisation.

To solve major scientific and technological problems in the interests of the development of science and economy sectors in accordance with the priorities of scientific and technological development of the Russian Federation, SamGUPS carries out large-scale work on the development of resource-saving technologies, VR-technologies, technologies related to improving the efficiency of railway infrastructure facilities, train safety and passenger complex. Activities on the development of technical solutions include the application of process automation and intelligent systems.

The University successfully cooperates with the country's leading universities — Far Eastern State University of Railway Engineering, National Research Technological University (NITU) MISiS, Samara National Research University named after Academician S.P. Korolev and Russian University of Transport (RUT (MIIT)) in the implementation of joint educational programmes, using effective teaching tools, methodological and technological resources.

In the 2023–2024 academic year, 50 first-year students of SamGUPS speciality "Railway Rolling Stock" started studying the discipline "Computer Studies" at the Far Eastern State Transport University in the format of network interaction. And students of the Far Eastern State Transport University started studying the discipline "General Course of Railways" on the basis of SamGUPS.

Interaction between the universities takes place in a distance format using the technical and human resources of both parties.

For the second year in a row, SamGUPS cooperates with the National Research Technological University "MISIS" (Institute of Steel and Alloys) in the study of the discipline "Chemistry" on the basis of an agreement on the network form of implementation of educational programmes.

MISIS educational resources are available on the Open Education platform. This year about 800 1st and 2nd year full-time and part-time students started studying chemistry.

In addition, SamGUPS students joined the Priority 2030 project as part of co-operation with Samara University. Under the federal project "Development of IT industry personnel potential", 25 best students of SamGUPS receive additional education in the educational programmes "Data analysis", "Web layout", "IT project management", "Frontend-technologies" and "Development and maintenance of solutions on the 1C-Enterprise platform".

To develop scientific thought and attract students to innovative research, the university organises various scientific events: strategic sessions, conferences, open lectures and scientific and technical exhibitions to demonstrate scientific achievements and developments of the university. At such events our scientists are given the opportunity to actively participate in the creation of new trends and directions of science development at the university.

Young scientists of SamGUPS are actively involved in grant activities, annually become winners of prestigious competitions: "Young Scientist of Samara Region", "Designer of Samara Region", "UMNIK", "Start", "Gubernian grants in the field of science and technology". The effective participation of the university scientists speaks about the relevance of research topics and significant contribution to scientific activity in accordance with the priorities of development of the region and the country.

The results of interaction with industrial partners, support of scientists, creation of conditions for science development and contribution to the economy become one of the key performance indicators of the university, along with scientific articles and high performance of scientists.

Another promising direction of scientific and educational activity is the application of distance learning technologies in the university in the organisation of the educational process. One of such technologies is the e-learning system, which provides support of the educational process by means of e-learning, allows organising effective synchronous and asynchronous interaction between the participants of the educational process. Several types of e-learning courses are implemented in the e-learning environment: discipline/practice courses (in which the teacher can independently add forums, chats, meetings to coordinate all stages of the educational process, there is also an opportunity to add to the e-course elements that allow collecting, checking and storing reporting and other documentation), system courses and author's courses. It was on this site that training sessions and scientific research of students during the pandemic were conducted. In the e-learning system it is possible to include a version adapted for people with disabilities.

Consultations of scientific supervisors and teachers for students can be conducted online both individually and for a group on any of the videoconferencing platforms presented in the electronic information and education environment (EIEE) of SamGUPS: BigBlueButton, Jitsi, and Yandex.Telebridge.

To make it easier for students to navigate and work comfortably with the SamGUPS EIEE resources, the discipline "Digital Technologies for Self-Education" was introduced in all implemented educational programmes of higher education.

In 2023, the university opened an automated digital video studio "Jalinga", designed to create high-quality video content by just one person, at the expense of the university's industrial partner "Russian Railways", JSC. Jalinga is an innovative Russian-made tool designed to capture high-quality educational materials and videos, making them interactive through the use of a touch screen board.

The main technical solution of Jalinga is a transparent sensor board, a programme for creating video presentations, and all the elements of a modern video studio (cameras, lights, monitors, special wall and floor coverings, etc.). The system is capable of recording simple speeches of speakers and creating full-fledged video lessons, as well as working in the format of online conferences with integration in social networks and other platforms.

Teachers can independently create training and presentation videos on their subject or speciality, and conduct webinars with students in a new format. At the same time, they can use the full functionality of the studio — WOW-interactive, advanced software and equipment, and their own presentation editor.

Ready-made training videos in innovative format are posted in the university's EIEE, social networks, and on various interactive educational platforms.

SamGUPS currently implements training according to individual study plans both full-time and part-time. In order to realise an individual approach to education, the university, within the framework of the admission campaign of the 2022/23 academic year, offered for SVE graduates to obtain a higher education degree with a reduction in the period of study while continuing their studies in the previously chosen specialty. And this reduction is significant: from 1.5 to 2 years depending on the chosen educational programme and previously mastered disciplines. Thus, a graduate of a technical school can receive both secondary vocational and higher education in 7 years (starting from the moment of enrolment in vocational education programmes, i.e. after the 9th grade.

In the process of study, students have the opportunity to receive additional education on a wide range of educational programmes ranging from working professions to professional retraining with the receipt of relevant documents on education and qualification.

The University, being a sectoral higher education institution, has always had the closest ties with future employers of graduates. Of course, the most important and largest of them is "Russian Railways", JSC, which currently has more than 800 thousand employees. "Russian Railways", JSC provides places for internship and practical training for students, which allow them to acquire not only knowledge, but also to hone their skills in a real industrial environment. The University is open for co-operation with other representatives of both the transport industry and employers in the fields of economics, finance, management, personnel management, IT-technologies, and power engineering.

In the course of training, each bachelor's student undergoes at least 4 different internships, and in speciality programmes their number is even higher — at least 7. SamGUPS educational programmes allocate from 700 to 1000 hours for internships, and the university strives to increase their number. The educational programmes have already reflected the changes in legislation regarding the introduction of practical training: the university has signed more than 70 agreements on practical training with relevant organisations in 10 regions of the Russian Federation.

SamGUPS graduates have the opportunity to take part in the diploma project competition, which is held annually by "Russian Railways", JSC.

In 2022, the university took part in the federal project "Professionalism", which included the purchase of

In SamGUPS locomotive driver's simulator class.
Photo by SamGUPS

new teaching and laboratory equipment. This equipment is used both in the educational process under vocational and higher education programmes, as well as for advanced training of railway transport employees.

In addition, within the framework of cooperation with Russian Railways, three new computerised simulators have been added to the university over the last three years: "Railway Station Sorting Hill", "Simulation Simulator for the Train Operator/Train Dispatcher on Duty at the Sorting Hill", and "Train Driver Simulator".

The programme of interaction between "Russian Railways", JSC and university complexes of railway transport, which runs until 2025, has become an important step towards the development of the industry education system in terms of training personnel for the industry.

Main characteristics of the educational segment of the industry's personnel supply:

- reliability, sustainability and efficiency of public-private partnership of transport universities, institutes and academies with the real sector of economy, primarily with large transport business, Federal Railway Transport Agency and Ministry of Transport of the Russian Federation in order to implement the Transport Strategy of Russia in the educational and scientific spheres;
- integrity, dynamics and efficiency of activity, availability of a large potential for development of the system of educational institutions of higher education, subordinated to Federal Railway Transport Agency, providing quality training of the main number of young specialists with higher and vocational education, a significant volume of programmes of additional professional education;
- availability of effective mechanisms for reliable personnel support of the Transport Strategy of the Russian Federation, absence of a general deficit of qualified specialists in the main professional qualification groups of railway transport employees;
- the leading role in staffing of educational organisations providing training for young specialists, skilled workers, additional vocational education, as well as training centres providing vocational training and advanced training, including corporate centres for professional qualifications;
- efficiency of creation and development of universities as unified complexes combining the implementation of secondary, higher and additional education programmes with general education units and territorial branches, which allows to provide continuous education from schoolchildren to doctoral students in conditions of rational proximity to the objects of transport activity;
- uniqueness in terms of scale and efficiency, which has been fully justifying itself for a number of decades and has always been highly appreciated by the country's leadership, of the system of targeted admission and training, which ensures guaranteed reproduction of qualified personnel for all regions of transport activity;
- high employment rate of graduates directly after graduation in the transport industry, which is almost 100 % for students of targeted training, characterising both the compliance of training areas and volumes with the requirements of the industry business and the high interest of young people to work in transport;
- high level of fundamental, professional and practical training of young specialists in general, wide coverage of the student contingent by industrial practice;
- positive dynamics of the educational organisation's development aimed at achieving a high level of practical competences of students, development of practice-oriented researches, wide integration of their results into the educational process, development of innovative activity in cooperation with business;
- orientation to multilevel training of bachelors, specialists and masters in a range of areas beyond the training of engineering and operating personnel, providing a combination of unified methodological approaches to work in the conditions of a unified transport network and the necessary transport specialisation.

At the same time, there are a number of external conditions necessary for the further development of personnel provision, including legislative support for the development of personnel training, improvement of state and corporate support measures for railway universities.

The analysis of the strengths and weaknesses, risks and opportunities inherent in the existing system of personnel training for railway transport shows that, despite the presence of a large number of potential threats, there are real opportunities to neutralise them. The weaknesses are not of an intra-system nature and

can be corrected through comprehensive measures to modernise and improve the quality of the existing educational system.

The fundamental requirements to the quality of transport industry specialists' training are specific and are conditioned by the technological conditions of the transport process implementation as a complex of systemically interrelated technologies.

These include:

- combination of fundamental engineering training with practical skills (from obtaining a working profession to mastering technologies actually used in transport), which dictates, among other things, the need to retain the 5-year engineering training programme within the framework of a specialist degree;
- necessity of inter-level coordination of the content of SVE and HE curricula due to unified technologies;
- need to train and concentrate narrowly disciplined teaching staff at HEIs;
- need for expensive training and laboratory equipment, operating models used exclusively in certain sectoral services;
- bringing training places closer to the places where transport companies operate, including to ensure the possibility of conducting practical classes and using real equipment and techniques for training;
- conducting classes and practical training at enterprises, participation in the training of current industry professionals;
- retention of graduates at line enterprises;
- maintaining special requirements for students due to the need to ensure the safety of the transport process and its technologies in terms of health status.

These conditions can only be fulfilled if the existing system of railway education at universities, which provides profile specialisation and a full course of study under SVE and HE programmes, is preserved.

For example, with the support of "Russian Railways", JSC, SamGUPS has completely upgraded simulator complexes for the departments that graduate specialists in traffic management. With the introduction of the Russian Railways branded zone, new opportunities have opened up for the introduction of interactive forms of training with master classes on new educational technologies.

"We have an understanding of how to meet the demands of the holding company. We are actively working on the creation of a single effective programme for the development of the university, taking into account the requirements of "Russian Railways", JSC for the training of specialists in modern realities. For example, we plan to ensure the digital transformation of the university, the effective work of the dissertation council, and the growth of scientometric indicators. Among the strategic objectives is to improve the university's position in the educational services market," says M. Garanin, Rector of the university.

The prerequisites for the successful implementation of projects and plans are already in place. For example, in March 2022 SamGUPS won the competition for the right to update the main professional educational programmes with a digital component for professions of the priority industry "Transport Infrastructure" for a number of railway specialties.

As part of the project "Personnel for the Digital Economy", the university's scientists adapted digital educational programmes and included modules on cross-cutting digital technologies: artificial intelligence, robotics and sensorics, the Internet of Things, new generation mobile networks, new production technologies, virtual and augmented reality technologies, and quantum communications.

The educational programmes developed under the project have been tested at transport universi-

SamGUPS branded auditorium of JSC Russian Railways. Photo by SamGUPS

ties across the country and are used in the training of transport industry specialists.

Another major event in 2022 was the inauguration of a joint student business incubator (SBI) with Kuibyshev Railway, which has become an integral part of the innovation ecosystem of Russian Railways. For the successful and effective functioning of the SBI, a separate organisational structure was created within the university and a BIM laboratory was opened where students can design any objects in 3D models at the request of Russian Railways.

The business incubator was created as an auxiliary tool for growing technological innovation projects for "Russian Railways", JSC, and the discipline "Building a Business Model" is included in all educational programmes of the university. The SBI operates on the open innovation model, which makes it possible to attract student ideas and projects, and then, with the support of experts from KbZD and the All-Russian Public Organisation "OPORA ROSSII", they will be brought to technological readiness demanded by Russian Railways, with the prospect of opening startup companies.

In September 2022, 100 first-year students started classes at the Samara College of Railway Transport of SamGUPS as part of the federal educational programme "Professionalism". Under this programme, "Russian Railways", JSC together with SamGUPS organise the training of specialists from secondary vocational schools in relevant railway professions within a shortened period of time. All the conditions have been created to solve this problem and the project is taking on new forms and tasks, relevant, first of all, to the real sector of the economy.

The Samara railway transport education and production cluster (centre) has been established on the university's site, where thematic classes and co-working spaces have been opened, and practical training has been organised at the enterprises of the Kuibyshev Railway. The first graduates will be certified in the form of a demonstration examination in accordance with the corporate standards of "Russian Railways", JSC. After the training, graduates will have a guaranteed employment opportunity at the railway enterprises of the Kuibyshev Railway.

Today SamGUPS is a scientific, innovative and cultural centre, a leading transport university in the Volga Federal District. The university has organised and actively operates institutes of additional education, professional and corporate competences, where not only students but also railway employees are trained. The main task remains the training of graduate railway engineers for the railway transport of "Russian Railways", JSC. Entering independent life, the university graduates should be equipped with the latest achievements of science and practice, possess competences corresponding to new challenges and tasks.

INTERNATIONAL ACTIVITY OF THE UNIVERSITY

International activities are a key factor in the integration of Samara State University of Railway Transport into the global educational space through active implementation of innovations in the educational process, conducting breakthrough research, increasing academic, student and faculty mobility.

The number of foreign students from 11 countries receiving higher education at SamGUPS is over 500 people. Internationalisation of educational and research process is among the priority tasks of Samara State University of Railway Transport and is a strategically important vector of the university development.

The effective tools for achieving the set goals are:

- intensive development of student and academic mobility programmes;
- active assistance in international co-operation in solving priority scientific problems;
- effective representation of the university in international regional and global rankings;
- participation in international professional associations and unions.

The main directions of international activities of SamGUPS are integration of the university as an equal partner in the world scientific and educational space, innovation and research environment, formation and maintenance of the image of the university as a world-class educational and research centre, development of international relations.

The University is interested in developing and strengthening the international reputation of the university in educational, scientific and innovative spheres, as well as in interregional cooperation with Russian universities and universities of the CIS countries in order to jointly solve the problems of entering the international educational and scientific community.

The university is developing and implementing joint international educational programmes in the educational process. Comprehensive support is provided for the process of adaptation and education of international students.

With the support of the university administration, favourable conditions are created for the organisation, activation and coordination of international academic mobility programmes for students, undergraduates, postgraduates and teachers.

SamGUPS is actively involved in the formation and implementation of joint international programmes and projects, including international grants.

The Centre for International Relations and Marketing Services at the university organises international exchange and cooperation activities in the field of higher and postgraduate professional education, teaching

and research activities, professional development of specialists.

The university also organises admission, training and internship of foreign citizens in accordance with the state educational standard.

The development of partnership relations with the world's leading universities is one of the priority areas of international co-operation.

Today the University has more than 20 bilateral agreements with universities and research organisations from 10 countries. One of the key foreign partners with whom the most active and fruitful cooperation has been established is Shaanxi Railway Vocational Institute (PRC).

The joint educational project of SamGUPS and Shaanxi Railway Vocational Institute was created to attract high-quality foreign resources, search for innovative forms in the field of education. Participation of the two countries in the formation of the Eurasian high-speed transport corridor Moscow–Beijing is one of the main points of the agreement, which is based on China's initiative "One Belt, One Road". The implementation of joint educational and research projects on the bases of railway transport universities determines the success of joint solutions of railway companies of the Russian Federation and China for the formation of the Eurasian high-speed transport corridor.

Cooperation between SamGUPS and foreign partner universities is based on mutual understanding, deep respect and awareness of the important task of joint activities for the prosperity of the international commonwealth states.

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ЭКОНОМИКА МЕЖДУНАРОДНЫХ ПЕРЕВОЗОК И ЛОГИСТИКИ:
ИНТЕЛЛЕКТУАЛЬНЫЕ И ЦИФРОВЫЕ РЕШЕНИЯ И ПРАКТИКА

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High-Speed Railways in the BRICS Countries

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ABSTRACT Today, about 59,000 km of specialised high-speed railway lines are in operation worldwide, about 20,000 km are under construction, and more than 50,000 km are planned to be commissioned. The maximum commercial speed of passenger trains has increased to 350 km/h. The world's first high-speed freight trains have been designed and put into trial operation. Mastering advanced technologies in the field of high-speed railway transport, as before, is an indicator of the country's development level. The construction of high-speed lines (HSL), along with others, solves an important problem on a global scale — it makes a significant contribution to environmental protection.

We used the materials of reports and papers published on foreign information platforms; the results of the research work of Russian scientists and engineers in the field of increasing train speeds.

In the BRICS countries, construction and design work on high-speed railways is underway, but given the unique conditions of each country, the pace of development is different. China is the leader of scientific progress in this sector of the railway industry, which attracts the attention of the world scientific community, including the Russian one.

In Russia, according to the Transport Strategy up to 2030 with a forecast for the period up to 2035, it is envisaged to develop a network of high-speed railway lines with the unification of the largest agglomerations of the European part of the country into zones of two-hour accessibility.

It is necessary to continue study and improve knowledge in the field of high-speed railway transport development.

KEYWORDS: the BRICS countries; Brazil; Russia; India; China; the Republic of South Africa; high-speed railway transport; high-speed railway lines; HSL; high-speed passenger train; high-speed freight train; passenger traffic; and speed

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Научная статья

Высокоскоростные железные дороги в странах БРИКС

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АННОТАЦИЯ Сегодня в мире эксплуатируется около 59 тыс. км специализированных высокоскоростных железнодорожных магистралей, строится около 20 тыс. км, планируется ввести в эксплуатацию более 50 тыс. км. Максимальная коммерческая скорость пассажирских поездов увеличилась до 350 км/ч. Сконструированы и запущены в опытную эксплуатацию первые в мире высокоскоростные грузовые поезда. Освоение передовых технологий в области высокоскоростного железнодорожного транспорта, как и ранее, является показателем уровня развития страны. Строительство высокоскоростных магистралей (ВСМ), наряду с другими, решает важную проблему мирового масштаба — вносит весомый вклад в защиту окружающей среды.

Использовали материалы отчетов и докладов, опубликованных на зарубежных информационных платформах; результаты научно-исследовательской работы российских ученых и инженеров в области повышения скоростей движения поездов.

В странах БРИКС ведутся строительство и работы по проектированию ВСМ, однако с учетом уникальности условий каждой страны темпы развития различны. Китай является лидером научного прогресса в данном секторе железнодорожной отрасли, что приковывает взгляды мировой научной общественности, в том числе российской.

В России, согласно Транспортной стратегии до 2030 года с прогнозом на период до 2035 года, предусмотрено развитие сети ВСМ с объединением крупнейших агломераций европейской части страны в зоны двухчасовой доступности.

Необходимо продолжение исследований и совершенствование знаний в области развития высокоскоростного железнодорожного транспорта.

КЛЮЧЕВЫЕ СЛОВА: страны БРИКС; Бразилия; Россия; Индия; Китай; Южно-Африканская Республика; высокоскоростной железнодорожный транспорт; высокоскоростные железнодорожные магистрали; ВСМ; высокоскоростной пассажирский поезд; высокоскоростной грузовой поезд; пассажиропоток; скорость

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INTRODUCTION

Fifty-nine years have passed since the first high-speed line (HSL) was opened. On October 1, 1964, the 515 km long Tokyo-Osaka High-Speed Line (Japanese: Shinkansen — New Big Road, New Main Line) with a maximum train speed of 210 km/h was commissioned in Japan. There was a paradigm shift in railway transport: the first specialised railway line designed exclusively for mass passenger transportation by trains moving at speeds of over 200 km/h was created. Prior to that, railway lines were multi-purpose and were mainly used for mixed traffic of relatively light passenger trains and freight trains, including heavy trains.

The concept of "high-speed" railway is conventional and historically established, for example, unlike the concept of "supersonic aviation", it is not associated with any physical quantity, as in this case – the speed of sound. At the beginning of the twentieth century, high-speed railway traffic included speeds of the order of 180–190 km/h, which today have increased to 300–350 km/h.

Today, high-speed railway transport continues to develop. Currently, 58,800 kilometres of high-speed railways are in operation, and 20,000 kilometres are under construction (see *Table* below).

In the long term, it is planned to build more than 50,000 kilometres of high-speed lines, increasing the length of the global network to more than 130,000 kilometres. High-speed railways may appear in such countries as Canada, Mexico, Brazil, Chile, Israel, Qatar, Iran, Egypt, the Republic of South Africa, Thailand, Vietnam, Norway, the Czech Republic and Hungary. These data were reported at the 11th World Congress on High-Speed Rail Transport, which was held in March 2023 in Marrakech, Morocco [1–3].

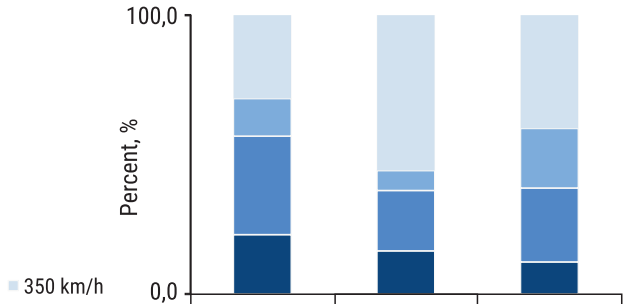
According to the accepted international classification, on high-speed railway lines the speed of passenger trains is more than 250 km/h, with combined freight and passenger traffic — 200 km/h. These are not speed limits in commercial operation. The maximum speed of passenger trains of 350 km/h is realised in the People's Republic of China, the share of such highways is 29.9 % of the total HSL network in the world. There is not a single HSL in the world designed for commercial operation with a speed of more than 350 km/h. As studies have shown, when travelling at speeds over 350 km/h, energy consumption increases dramatically due to the need to overcome the sharply increasing aerodynamic resistance, noise generation from the moving train increases significantly, especially in the zone of interaction between the current collector

Table

Length of HSL in the world in 2022 (in commercial operation and under construction) [1]

Area	Length of the high-speed network, km	
	In commercial operation	Under construction
Europe	11 990	3062
Asia Pacific[1]	44 428	14 416
Middle-East[2]	1501	2006
Africa	186	0
North America	735	274
Total:	58 840	19 758

Note: [1] – Asia Pacific: China, India, Indonesia, Japan, South Korea, Thailand, Vietnam, Australia; [2] – Middle-East: Qatar, Bahrain, Iran, Israel, Saudi Arabia, Turkey.



	In commercial operation	Under construction	Planned
350 km/h	29,9	55,7	40,6
300÷320 km/h	13,5	7,2	21,4
250 km/h	35,3	21,6	26,5
200 km/h	21,3	15,5	11,5

Fig. 1. Share of the world's HSL length depending on the range of maximum speed in commercial operation (for 2022) [2]

and the contact wire, and a number of other negative phenomena occur. The increase in each kilometre of speed in this range results in an increase in operating costs that is disproportionately large compared to the resulting reduction in travel time. In the coming years, the maximum speed in commercial operation will remain around 350 kilometres per hour. The dynamics of indicators of the share of high-speed railways in the world depending on the maximum commercial speed of the lines under construction and planned are shown in *Fig. 1* [2].

According to studies, a speed of about 350 km/h guarantees a safe and comfortable journey, and allows competing with air travel at distances of up to 800 km in cars with seats, and up to 1,500–2,000 km when including sleeping cars in high-speed trains, as the first experience of the People's Republic of China has shown. The implementation of high-speed railway passenger projects with speeds exceeding 350 km/h requires significantly higher costs for the construction and development of rolling stock, and currently there are no offers of a transport service called "high-speed railway traffic with speeds exceeding 350 km/h" on the international market [1–12].

MATERIALS AND METHODS

The materials of reports and papers published on foreign information platforms (websites of the International Union of Railways, foreign scientific journals on the development of the railway industry in the world, and the results of world congresses on high-speed railways) were analysed. The results of the research work of Russian scientists and engineers in the field of increasing train speeds, including the results of the last few years, were used in the study of the topic of high-speed railway traffic development in the Russian Federation. The key objectives of the development of the high-speed railway network in Russia according to the Transport Strategy of the Russian Federation until 2030 with a forecast until 2035 have been reflected.

RESULTS OF THE STUDY

The paper analyses the development of high-speed railway service in the BRICS countries for each country separately (Brazil, Russia, India, China, and the Republic of South Africa)[1].

The People's Republic of China

As of 2022, the world leader in high-speed railway transport is the People's Republic of China. The development of China's national high-speed rail network is the result of research and development work by Chinese scientists and engineers, as well as the adaptation of the best international experience and practices carried out in 1980–1990. In 1985, the Research and Development Centre for High-Speed Railway and Urban Rail Technology was established, and in 1995, China began operating an experimental test bed to simulate travel speeds of up to 400 km/h. By 1997, a programme to increase train speeds on major trunk lines had been developed. In 2004, the State Council of the People's Republic of China approved a plan to build at least 12,000 km of new high-speed railway lines by 2020 (*Fig. 2*, *3*) [5–9].

Significant state funding was provided for research projects to create high-speed rolling stock (from 1994 to 2004, China developed more than 20 types of high-speed trains [9]), foreign experience was studied and technologies were introduced (cooperation with such major engineering companies as Alstom, Bombardier, Siemens, etc.). The training of personnel with the necessary competences made it possible to set up the production of its own high-speed rolling stock [1].

The PRC has the highest rates of HSL construction (*Fig. 4*). In 2014, a record length of 5,900 kilometres of high-speed rail was commissioned). *Fig. 5* shows the length of the high-speed rail network in China de-

[1] The material was prepared prior to the XV BRICS Summit held on August 22–24, 2023 in Johannesburg (South Africa), where it was decided that six countries — Argentina, Egypt, Ethiopia, Egypt, Iran, Saudi Arabia, UAE and Saudi Arabia — would join BRICS in 2024.

Fig. 2. The world's first Chinese high-speed freight train with a design speed of 380 km/h, based on the latest generation of Fuxing high-speed passenger trains, is seen during a presentation at the Tangshan factory of CRRC Tangshan Co, Ltd. in Tangshan, Hebei province, on December 23, 2020 (Railway Transport. 2021. No. 11. P. 69)

pending on the realised maximum speed in commercial operation of passenger traffic: 200–300 km/h and 350 km/h, respectively. During the COVID-19 pandemic period 2020–2021, the construction rate remained high, at 2,200–2,500 kilometres per year. In 2022, 4,000 kilometres of high-speed railways were commissioned (the share of high-speed railways with a maximum commercial speed of 350 km/h was 75 % of the total high-speed rail network in China). By the end of 2023, 3,600 kilometres of highways are expected to be put into operation, of which 81.2 % are for speeds of 350 km/h [1–3].

The development of high-speed railway traffic in the People's Republic of China today is marked by unprecedented success, with 40,500 kilometres of high-speed lines commissioned over 29 years (69 % of the total HSL network in the world). High-speed railway routes are designed in difficult engineering conditions.

Chinese railway workers have critically reflected on what happened, learnt lessons and overcome the consequences of a severe — the world's first high-speed railway accident, which occurred on July 23, 2011[2]. Following these events, a decision was made to tighten the requirements for controlling design decisions and the quality of construction of new lines, and for additional safety, the maximum permissible speed on all HSLs was lowered by 50 km/h. These speed limits started to be selectively lifted in 2017.

The country has established its own production of high-speed rolling stock for both passenger and

a

b

c

Fig. 3. Chinese high-speed electric train for different track gauges with a design speed of 380 km/h during a presentation in Changchun, Jilin province, October 21, 2020: a — exterior view of the train standing on the gauge changeover device (URL: https://www.crrcgc.cc/g7992.aspx); b — operator's cab (URL: http://www.xinhuanet.com/english/2020-10/29/c_139476182.htm); c — business class car interior (URL: http://www.xinhuanet.com/english/2020-10/29/c_139476182.htm)

[2] On July 23, 2011, near Wenzhou, due to the failure of signalling devices and erroneous actions of personnel, one train was overtaken by another; as a result of the collision at a speed of about 200 km/h, 33 people were killed and more than 190 were injured.

Fig. 4. High-speed railway network of the PRC [2]

freight transport. In 2020, CRRC Tangshan created the world's first freight train capable of reaching speeds of 350 km/h with cars equipped with equipment for fast loading and unloading of special containers and delivery of goods with a total weight of 110 tonnes of cargo over distances of 600 to 1,500 km [13, 14].

The technologies of automated laying and welding of rail tracks are used in the construction of high-speed railways (the productivity of one machine is 2 km of track per day, 24 hours a day, 7 days a week). Recently, the process of introducing robotic machines with control systems (artificial intelligence) for the installation of the contact network (from the transport of materials and components, to the installation of supports and installation of contact suspension with spatial position accuracy of 1 mm) has been launched. The complex allows to perform work continuously even in unfavourable weather conditions [15].

First of all, the state is interested in high-speed railway projects, but the results of their implementation have a favourable impact on millions of residents of the Celestial Empire. There is continuous support, including financial support, throughout the entire life cycle — from the scientific concept to commissioning and maintenance. According to the approved short-term and long-term programmes for the development of high-speed railways in China, 13,000 kilometres of highways are currently under construction, and it is planned to build about 11,000 kilometres more [1].

For the first time in China, trains with sleeper cars have been put into operation on high-speed highways, which significantly expands the range of comfortable transportations on high-speed lines. All this explains the great interest of the international scientific community in projects to develop high-speed railway lines in the People's Republic of China.

India

India today has one of the fastest growing economies in the world. According to experts [16], this is largely due to the high growth of agriculture and industry, in particular, such an important sector as pharmaceuticals. There is also a number of serious problems for the country: the shortage of energy resources, poverty of a significant part of the population and overpopulation.

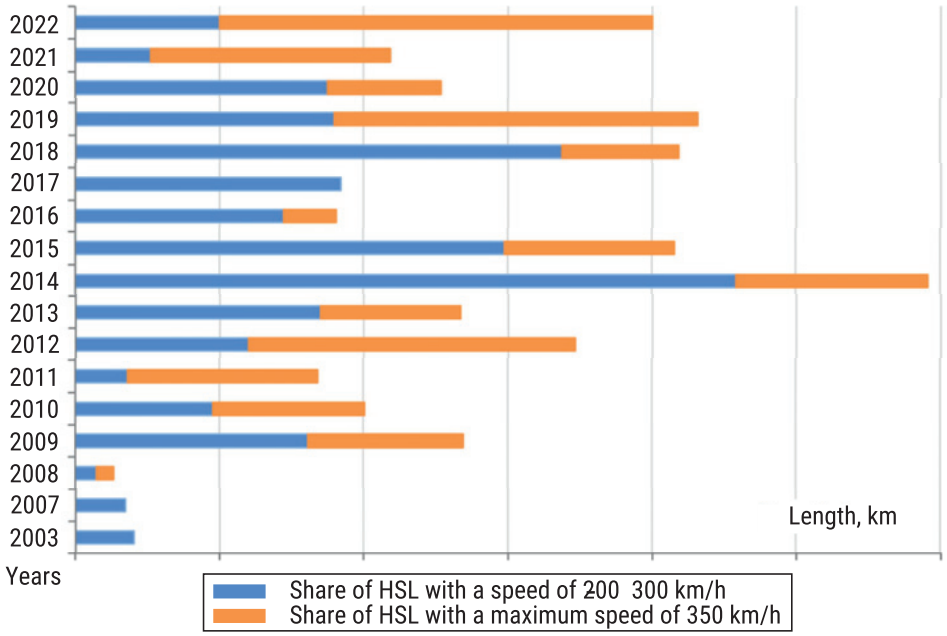


Fig. 5. Time progress of HSL construction in the PRC [2]

Fig. 6. High-speed rail network in India (under construction and long-term planning) [2]

Railway transport in India has the fourth longest network in the world and is a popular means of transport for both passengers and freight. The railway industry (Indian Railways (IR) is the largest employer in the country, the fourth largest rail freight carrier in the world, and the world's longest green network (the share of electrified sections was 77 % in 2022, with plans to convert all passenger transport to electric traction by 2025–2026) [17].

In 2017, jointly with Japan, the implementation of the project for the construction of an HSL along the Arabian Sea Mumbai-Ahmedabad with a length of 508 kilometres and a set maximum speed of 320 km/h was launched. The travelling time in this direction will be reduced from 6 h 45 min to 2 h (*Fig. 6*).

For the new high-speed railway, it is planned to supply rolling stock manufactured by Hitachi and Kawasaki, used on the Shinkansen lines in Japan [18]. The Mumbai-Ahmedabad railway has a standard European gauge of 1435 mm. In India, the railways have four types of incompatible gauges (1676, 1000, 762 and 610 mm). Over the last two decades, Indian railways have made significant progress in the Unigauge programme to convert the railway network to a single 1667 mm gauge over the last two decades. In 2022, the Indian railway network had 65,094 kilometres or 95.7 per cent of its total length on 1667 mm broad gauge. This has paved the way for the creation of a modern unified railway transport system and its optimal interaction with other modes of transport.

The route of India's first HSL includes 318 km of embankment track, 162 km of bridge crossings (one of which is 18 km long), 11 tunnels with a total length of 27 km, including an underwater seven-kilometre tunnel under the Gulf of Thana Creek (a bay on the coastline of the Arabian Sea, which isolates the city of Mumbai from the mainland of India) [19].

At present, the pace of construction of the Mumbai-Ahmedabad section of the Mumbai-Ahmedabad HSL has slowed down for a number of reasons (COVID-19 pandemic, problems with land acquisition in the area of the HSL route, etc.), and the date of commissioning has been postponed from the previously scheduled 2023. [20].

Having studied the foreign experience of HSL operation, India has taken a course for the development of relatively short routes. For example, the long-term perspective includes a network of high-speed railways with a total length of 7,500 kilometres with sections from 190 to 850 kilometres, covering the entire territory of the country (*Fig. 6*) [2]. Chinese experience has shown that on long lines, such as Wuhan–Guangzhou (1,079 km, maximum commercial speed 350 km/h), Beijing–Shanghai (1,318 km, 350 km/h), Lanzhou–Urumqi (1,785 km, 250 km/h), a smaller percentage of passengers travel between the end points (despite the impressive population and stable passenger traffic) compared to those travelling shorter distances on the same high-speed train, i.e. between intermediate points. i.e. between intermediate points [18].

The Government of India is continuing its drive to grow the economy, which is increasing demand for transport services. India is a participant in the UN-coordinated programme to reduce greenhouse emissions. It is important to redistribute passengers and freight in favour of environmentally friendly modes of transport, one of them being railways. Due to the growing freight traffic, there is an urgent need to increase the capacity of railways. This is not the case in the passenger sector, where there is a tendency for rail passenger traffic to decline due to the strongest competition of low-cost airlines and bus companies depending on the distance travelled [21].

There are good prerequisites for the design of the HSL network in India (promising passenger traffic, high population density in the area of gravitation to the HSL, with the distance between major cities up to 1,000 km — great competition of aviation and road transport, high percentage of employment in the railway industry, prospects of growing volumes of freight traffic on railway transport, etc.). However, the financial component raises doubts among experts [16, 21] regarding the priority programmes approved by the management for the implementation of the project for the construction of the high-speed rail network in the country. This is largely attributed to the unstable finan-

cial situation of IR and growing debt obligations to the corporation. Currently, the high-speed railway project is planned to be put into operation in 2026 [22].

Brazil

Brazil is a developing country. It has a strong industrial and agricultural potential and unique natural opportunities. At the same time, Brazil has underdeveloped health care and education, as well as a high poverty rate.

Most of the transport network is made up of road transport — the result of the decision of the governmental structures made in the 1950s, as it is now considered a mistake, to reduce the railway network and accelerate the development of road connections following the example of the USA. Over half a century, according to different sources, between 8,000 and 10,000 km of railways were closed in Brazil. Road transport accounts for 60 per cent of the total volume of goods transported and 90 per cent of passengers. Railway service is underdeveloped; despite the large territory, 30,000 km of tracks are in operation, of which only 6% are electrified. The tracks have four types of gauges, 79 % of which are of metre gauge (1000 mm). Rail transport is operated by private companies.

Most of the previously operating passenger railway lines are now closed. This affects the shortage of passenger trains in some of Brazil's densely populated coastal areas, such as the Rio de Janeiro-São Paulo agglomeration.

In 2008, the country's leadership announced a high-speed rail project along the Rio de Janeiro-São Paulo-Campinas route. The high-speed railway line was planned to be commissioned by the FIFA World Cup in Brazil in 2014, and later by the 2016 Summer Olympics. However, due to a number of reasons, construction did not start [23].

The revival of the BRT project in Brazil is currently under discussion. Negotiations are underway to build a 378 km long Rio de Janeiro-São Paulo section with two intermediate stops, a maximum train speed of 300 km/h and a reduction in journey time to 1.5 hours. It is planned to start construction in 2025–2026 and to put it into operation in 2032. The route of the future HSL runs in difficult topographical conditions and will include a large number of bridge crossings, viaducts and long tunnels, which increases the cost of the project. Large cities with millions of people are located in the zone of gravitation of the HSL, between which there are no railway lines, air and bus connections are organised. The preliminary forecast of passenger traffic attributable to the new HSL is 40 million people per year [24].

According to the data published at the World Congress on High-Speed Rail Transport 2023 in Morocco

Fig. 7. HSL network in Brazil (in long-term planning stage) [2]

[1], the future high-speed rail network with a total length of 511 kilometres includes the Rio de Janeiro-São Paulo section with its extension to Campinas (*Fig. 7*) [2].

The Republic of South Africa

The Republic of South Africa is one of the most developed countries in Africa. The country is rich in minerals, especially diamonds, gold, platinum, copper and coal. Another lucrative component of the South African economy is tourism. The transport industry includes air, rail, road and sea modes of transport. Passenger traffic between major cities is mainly redistributed between aviation and railway modes of transport, bus service on the same directions is available, but it is poorly developed.

Suburban railway service is considered to be the most affordable for passengers in terms of fares. By 2025. The South African Department of Transport plans to increase the capacity of the railway passenger sector (modernisation of tracks and stations, renewal of the rolling stock fleet) on 10 priority routes, 5 of which are operational and the main ones in the Mabopane–Pretoria–Johannesburg–Naledi corridor. On the railway lines today there is rolling stock, created jointly with Alstom, designed for a maximum speed of 120 km/h [25].

The South African government first mentioned high-speed railway projects back in 2010. Together with the Chinese Railway Corporation, it was planned to build the Johannesburg-Durban High-Speed Railway and reduce the journey time from 12 hours to three. The route was to run through the mountain ranges of the Drakensberg Park, a UNESCO World Heritage Site, which complicated the approval and design process. Due to the high cost and a number of other reasons, the project was not realised [26].

According to [1–3], the following HSL routes are included in the long-term perspective: Durban–Jo-

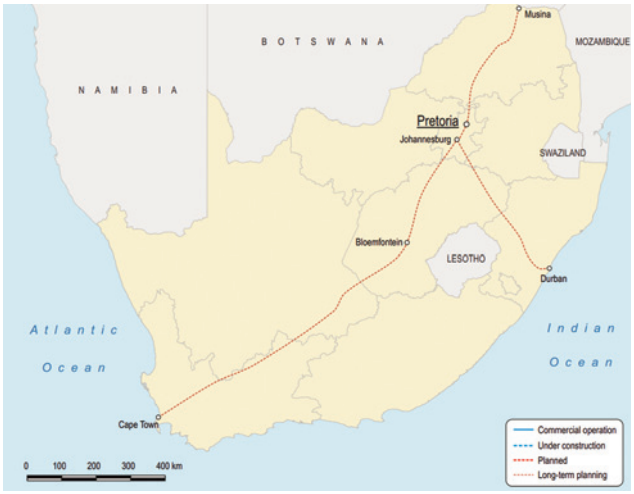


Fig. 8. HSL network in South Africa (in the long-term planning stage) [2]

hannesburg (610 km, 300 km/h), Johannesburg–Musina (480 km, 300 km/h), Johannesburg–Cape Town (1,300 km, 300 km/h) (*Fig. 8*).

The Russian Federation

According to the accepted international classification [1], there is no high-speed railway service in Russia today. The highest speed of passenger trains is realised on the Moscow–St. Petersburg route (trains "Sapsan" by Siemens, speed up to 250 km/h, journey time 3 h 45 min, "Nevsky Express" up to 200 km/h, journey time 4 h 10 min). Alstom's Allegro high-speed trains, which had been running at speeds of up to 220 km/h on the St. Petersburg-Helsinki line since 2010, will be discontinued in March 2022 due to the sanctions imposed on Russia.

Ideas of the need to increase train speeds in Russia were expressed at the beginning of the last century. The first scientific projects in the USSR were implemented in the 70s — "Moscow–South", "Uskorenie" (Acceleration), "Progress", "Skorost" (Speed). In 1988 the state scientific and technical programme "High-speed environmentally friendly transport" was approved, which envisaged the creation of highways with speeds of 300–350 km/h. It was planned to create a high-speed corridor Centre-South, as well as to build a trans-European network of high-speed lines Moscow–Minsk–Brest and Moscow–Minsk–Warsaw–Berlin. In the 1990–2000s, Russia developed a feasibility study for the Moscow–St. Petersburg High-Speed Railway, and a domestic high-speed train "Sokol" was being developed. Unfortunately, the projects were never continued [4, 10].

In the early 2000s, Russia underwent a number of reforms, including in the structures of the railway industry. The management of the transport process and all economic activities became the responsibility of the newly established in 2003 company "Russian Railways", JSC. The Ministry of Railways was abolished and the main management functions were transferred to the Russian Ministry of Transport, the Federal Service for Transport Supervision and the Federal Railway Transport Agency. In 2006, Russian Railways jointly with Siemens AG signed a contract for the supply of Sapsan trains. Since December 2009, high-speed trains have been running on the modernised tracks of the main line of the Oktyabrskaya Railway. The Sapsan passenger traffic began to grow rapidly, creating strong competition to air transport in this direction [10, 11, 27–30]. At the same time, the construction of a dedicated Moscow–St. Petersburg HSL remained among the discussed and promising tasks until 2013 [31, 32].

In May 2013, the President of the Russian Federation V.V. Putin announced the beginning of the design of the Moscow–Kazan HSL with further extension to Yekaterinburg with the delivery date in 2018. The Moscow–St. Petersburg HSL project was postponed [33]. It was supposed to operate along the dedicated high-speed railway Moscow–Kazan both passenger trains with a speed of up to 350 km/h and special cargo container trains with a speed of 160–250 km/h.

A team of scientists from the Emperor Alexander I St. Petersburg State Transport University together with specialists from a number of research and design organisations developed Special Technical Specifications (STS) for the design and construction of the Moscow–Kazan–Ekaterinburg high-speed railway line[3]. In accordance with the technical specifications, the parameters, characteristics and loads for the projected HSL are presented in complex combinations that have no analogues in the world. A total of 15 technical specifications were developed and approved by the Ministry of Construction, Housing and Utilities. They became the basis for the design of the High-Speed Railway.

In April 2019, Glavgosekspertiza approved several stages of construction [34], but a few days later, the media reported that "Vladimir Putin approved the HSL between Moscow and Saint Petersburg" [35]. A few months later, the Ministry of Finance of the Russian Federation blocked the financing of the Moscow–Kazan HSL project [36].

[3] Special technical specifications. Design of the Moscow– Kazan section of the Moscow–Kazan–Ekaterinburg high-speed railway line with traffic speeds of up to 400 km/h. St. Petersburg: Emperor Alexander I St. Petersburg State Transport University, 2017. 70 p.

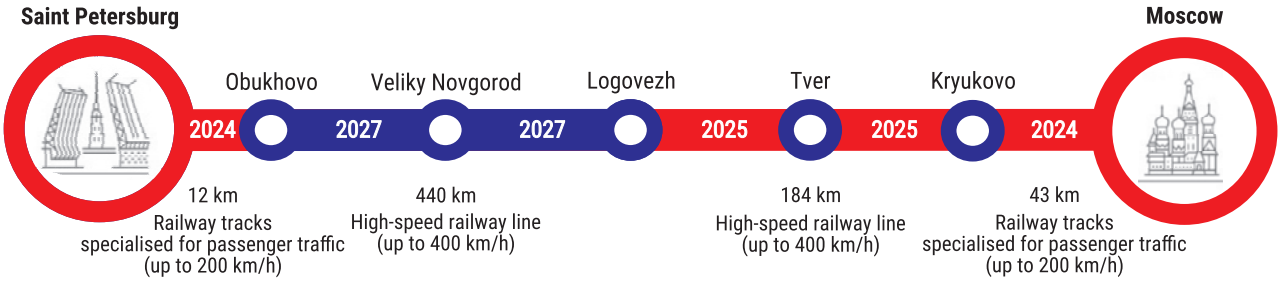


Fig. 9. Moscow–Saint Petersburg Hogh-speed Railway [37]

Today, according to the Transport Strategy of the Russian Federation until 2030, the task of creating high-speed railway traffic in the country remains relevant[4]. In the scheme of territorial planning of the Russian Federation, the Moscow–St. Petersburg High-Speed Railway is again named as a priority with commissioning in 2028. Engineering surveys are being carried out, as noted earlier, STSs have been developed[5] for the design and construction of the HSL [37].

On August 17, 2023 at the official opening of the Leningrad-Kazansky MCD-3 "Leningrad-Kazansky" [38] Russian President V.V. Putin noted that the country has approached the possibility of implementing the first project of the high-speed railway Moscow–Saint Petersburg, while the released transport capacity of the existing railway between the two capitals is necessary to ensure high-speed freight traffic, which is an important part of the development of the transport network of the European part of Russia[6].

O.V. Belozerov, General Director and Chairman of the Management Board of "Russian Railways", JSC, said at the same event: *"In the North-West, we currently transport 145 million tonnes, which is more than we can carry... In the transport strategy approved by 2030, the figure is 220 million tonnes, which means that today's figure needs to be almost doubled. The optimum is the construction of the High-Speed Railway, which will provide an opportunity for development, including for shippers from the Urals and Siberia — those who "go" to the ports of the North-West"*[7].

"As for the movement of passengers, emphasised V.V. Putin, of course, the speed of traffic will increase significantly and the journey time for passengers will decrease from today's 4 hours and 5 minutes to 2 hours and 15 minutes between Saint Petersburg and Moscow. Between Tver and Moscow it will already be 39 minutes, and between Veliky Novgorod and St. Petersburg it will be 29 minutes instead of today's 3 hours 10 minutes. Then, of course, we should also move to Nizhny (Novgorod), to Voronezh, from Nizhny to Kazan, from Kazan to the Ural regions. This will significantly not only reduce the travel time of people, but will also improve the connectivity of the country, as well as push the development of such areas as education and science"[8].

Various sources are involved in financing the project: both state and non-budgetary sources, in particular, Sinara Group, JSC and Sberbank, PJSC.

The 679-km route is to link six constituent entities of the Russian Federation, which is home to about 30 million people. The non-stop travelling time between the federal cities of Saint Petersburg and Moscow will be 2 h 15 min (*Fig. 9*) [37].

Work is underway to design a Russian high-speed train with a maximum operating speed of 360 km/h under an agreement between Russian Railways, Sinara Group, Ural Locomotives and Siemens Mobility[9, 10].

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CONCLUSION

According to UIC data [1–3], about 59,000 kilometres of high-speed railways are in operation in the world. About 20,000 kilometres are under construction, and another 53,000 kilometres are planned to be put into operation. The maximum commercial speed of passenger trains has increased significantly over the last ten years. The world's first high-speed freight trains have been designed and put into trial operation. This is especially relevant today, after the crisis covid period of 2020–2021, when the passenger transport sector was practically paralysed with simultaneous unprecedented growth of freight traffic in the world [27, 39]. Today, the mastery of advanced technologies in the development of high-speed railway transport, as before, is an indicator of the country's prestige. High-speed railways provide passengers with a fast, safe and comfortable journey. The construction of high-speed railways, among other things, solves an important problem on a global scale — a significant contribution to environmental protection.

As part of the analysis, we note that the BRICS countries are building and designing high-speed railway routes, but the pace of development is different given the unique conditions of each country. The world community and scientists, including Russian scientists, are now actively studying the experience of the implementation of high-speed railway projects in China, a country that is the leader in scientific and technological progress in this sector of the railway industry.

In Russia, according to the Transport Strategy, increasing the speed of both passenger and freight trains is one of the priority areas of research. Domestic scientific experience in the railway industry is the richest in the world; the first state programmes to organise high-speed railway traffic were approved in the country half a century ago. Domestic studies and foreign experience of high-speed railway operation [4–11, 27–32] prove the fact that Russia has a unique route for the creation of a dedicated high-speed railway. This is the Moscow–Saint Petersburg line, which is currently approved as a pilot project. The successful implementation of the Moscow–Saint Petersburg HSL project can play a key role in increasing the scientific and technical potential in the sphere of the transport system of Russia and international transport corridors, including those between the BRICS countries.

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