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"T" — loading gauge wagons: Prospects of creation and problems of introduction

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ABSTRACT The paper discusses the advantages of "T" — loading gauge freight wagons. It shows that their use will enable countries with the 1,520 mm track gauge to increase the carrying capacity of their railways by increasing the weight of trains, reduce the required fleet size on account of higher capacity of wagons and cut traction costs, while also reducing shipping costs for consignors. The paper reviews the challenges related to the introduction of "T" — loading gauge wagons due to the reduced clearances on the railway network and insufficient bridge load capacity.

KEYWORDS: rolling stock; freight wagons; "T" — loading gauge wagons; load capacity; capacity; linear load

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Научная статья

Перспективы создания и проблемы внедрения вагонов габарита Т

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АННОТАЦИЯ Рассмотрены преимущества применения грузовых вагонов габарита Т. Показано, что их применение позволит странам колеи 1520 мм повысить провозную способность железных дорог увеличением веса поездов, уменьшить потребный парк вагонов за счет их большей вместимости, сократить расходы на тягу поездов, а грузоотправителям — снизить расходы на отправку грузов. Анализируются проблемы внедрения вагонов габарита Т, связанные с наличием негабаритных мест на сети и недостаточной грузоподъемностью мостов.

КЛЮЧЕВЫЕ СЛОВА: подвижной состав; вагоны грузовые; габарит Т; грузоподъемность; вместимость; погонная нагрузка

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INTRODUCTION

The challenge of increasing the carrying capacity and throughput capacity of 1.520 mm gauge railways is becoming increasingly relevant as freight turnover is growing, even while rail loadings are decreasing. In 2018–2024, the main railway infrastructure in the Russian Federation underwent comprehensive modernization and expansion in accordance with the Decree of the President of Russia dated May 07, 2018. In 2024, more than RUB 1 trillion was allocated to infrastructure development and renovation projects alone [1].

The carrying capacity of railways at the approaches to the Azov and Black Sea Basin and in the Eastern operating domain increased 1.5 times compared to 2018. The construction projects completed in 2024 resulted in an increased carrying capacity of the Eastern operating domain which reached 180 million tonnes. However, even at this level, the carrying capacity is still not sufficient. The goal is to increase the carrying capacity to 210 million tonnes in the Eastern operating domain, to 152 million tonnes for rail lines to the ports in the Azov and Black Sea Basin, and to 220 million tonnes for the North-West Region. In addition, because of a shortage of public tracks, there is a problem of parking excessive empty freight wagons. How can these problems be solved in the future when the investment programme of Russian Railways JSC has been reduced by 40%?

The development of heavy-haul traffic is considered one of the solutions to the problems [2, 3]. There are three areas in the development of heavy-haul traffic:

- Operating longer trains with an increased weight;
- Operating trains of a standard length but a higher weight made up of wagons with a higher load capacity by increasing the allowable axle load to 27–30 tf;
- Operating trains of a standard length but a higher weight and increased linear load while maintaining the current permissible axle load of 25 tf.

OPERATING HEAVIER TRAINS: BALANCING HIGHER CARRYING CAPACITY AND RISKS FOR INFRASTRUCTURE

Making up longer trains of existing wagons will allow for some increase in carrying capacity. However, due to the need to occasionally break them down into sections to fit the length of receiving and departure tracks for the purposes of maintenance, handling of passenger trains, and replacement of locomotives and locomotive crews, this will reduce the throughput capacity of railways and can only be used on certain directions.

The most efficient way would be to operate heavier trains made up of wagons with an increased load capacity by increasing the axle load to 27–30 tf [4, 5]. However, according to some experts, this will result in lower strength and stability of the subgrade formation and in damaging artificial structures [6–8].

These concerns are shared by the management of Russian Railways and administrations of many other railways in the 1520 Space.

Therefore, the implementation of this solution has been postponed for an indefinite period, although it was included in the original Strategy for the Development of Railway Transport in the Russian Federation until 2030, and tests conducted on the Smychka–Kachkanar section showed that wagons with an axle load of 27 tf on improved bogies could be operated without a noticeable deterioration of the track condition [9].

Operating heavier standard-length trains with an increased linear load allows achieving higher carrying capacity without reducing the throughput capacity. After all, all the railways in the 1520 Space are designed for the permissible linear load of 10.5 tf/m, except for some older bridges. Therefore, in the modern context, this solution is seen as the primary one for increasing the carrying capacity of railways [10].

In order to increase the carrying capacity of railways, it is important to increase the net linear load, i.e. the weight of freight per metre of the wagon length, rather than the gross linear load. This can be achieved by increasing the wagon static load, reducing the wagon tare weight, and shortening the wagon length and spaces between wagons.

ASSESSING THE EFFICIENCY OF THE FLEET OF RUSSIAN RAILWAYS JSC BASED ON PERFORMANCE IN 2015–2024

To determine the efficiency of the existing wagon fleet, we analysed statistical data of Russian Railways JSC[1] [11] on the average static load of wagons $\bar{P}_{st}$ and the average load capacity utilisation rate $\bar{\lambda}$.

The statistical data of Russian Railways JSC define the average static load of wagon as a ratio of the weight of goods Q loaded on networks of Russian Railways or an individual line and the number of wagons loaded N:

$$\bar{P}_{st} = \frac{Q}{N},$$

[1] Report on loading of all wagon accessories and the use of their carrying capacity when transporting all goods. RZhD OJSC FGO-10A. Moscow: Main Computer Centre of RZhD OJSC, 2024.

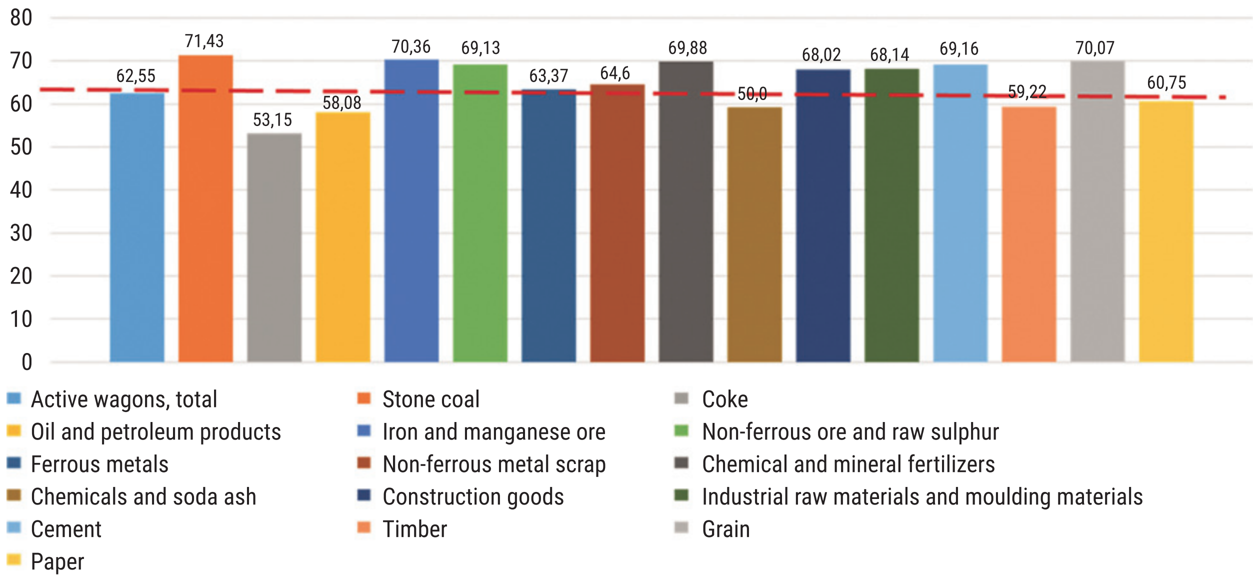

Fig. 1. Static load per wagon in 2024

or by type of goods

$$\bar{P}_{st\,i} = \frac{Q_i}{N_i},$$

where Q_i is the weight of loaded goods of type i; and N_i is the number of wagons loaded with goods of type i.

The average load capacity $\bar{P}$ is determined as a ratio of the sum of the nominal load capacity of wagons available for loading and the number of wagons loaded. The load capacity utilisation rate is determined as a ratio of the average static load and the average load capacity

$$\lambda = \frac{P_{st}}{P} \text{ or } \lambda_i = \frac{P_{sti}}{P_i}.$$

Table 1 and *Fig. 1* and *2* show data on static load of wagons and the utilisation of their load capacity when transporting basic bulk goods on Russian railways in 2015 and 2024. The average load capacity of a wagon increased from 68.1 tonnes to 69.9 tonnes.

Table 1

Static load and utilisation of load capacity of freight wagons in 2015 and 2024

Group of goods	Wagon static load, t		Wagon load capacity utilisation, %	
	2015	2024	2015	2024
Active wagons, total	61.38	61.97	90.1	88.7
Stone coal	69.2	71.5	98.3	98.8
Coke	45.45	53.97	69.3	76.1
Oil and petroleum products	58.24	58.23	91.6	90.3
Iron and manganese ore	70.58	70.64	98.5	99.0
Non-ferrous ore and raw sulphur	67.49	68.91	97.1	98.3
Ferrous metals	60.97	63.47	87.5	90.3
Non-ferrous metal scrap	63.16	64.87	93.3	93.8
Chemical and mineral fertilizers	67.63	70.57	96.4	98.0
Chemicals and soda ash	56.75	60.46	90.9	92.4
Construction goods	65.87	68.01	95.4	96.5
Industrial raw materials and moulding materials	65.85	67.23	95.8	96.4
Cement	69.11	69.58	97.0	96.9
Timber	56.54	59.44	84.0	87.3
Grain	64.95	71.18	92.4	97.0
Paper	56.81	61.77	84.0	91.2

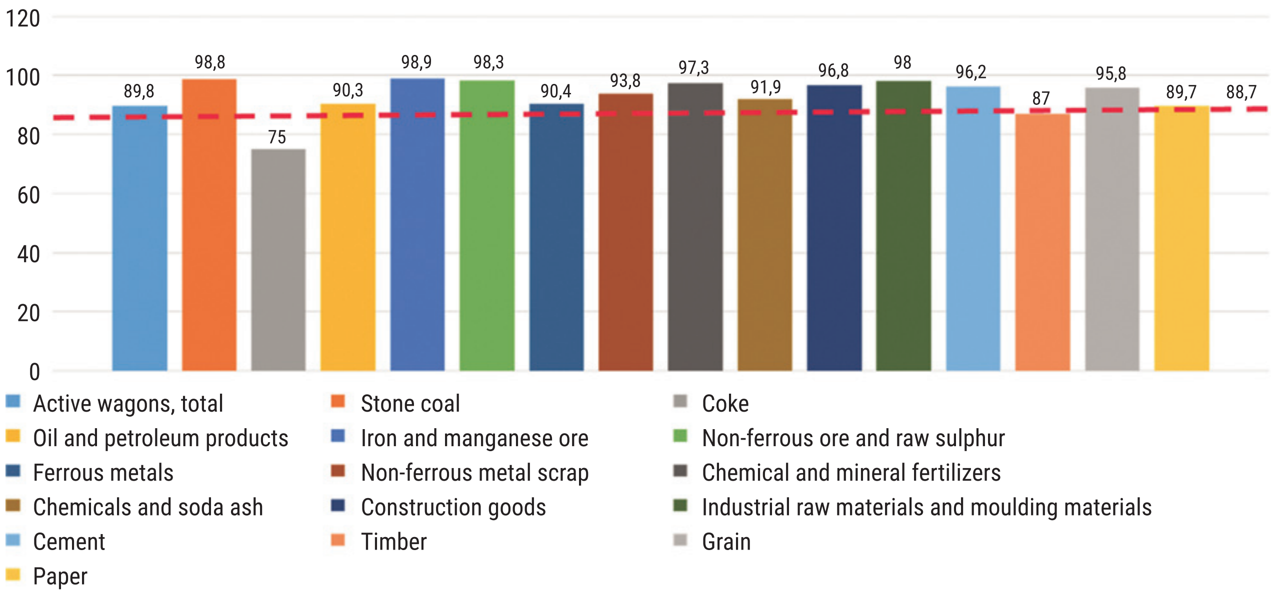

Fig. 2. Wagon load capacity utilisation rates in 2024

An analysis of this data allows us to conclude that the load capacity of gondola wagons is almost fully utilised when transporting coal and ore (underloading is below 2%). The average static load for hopper wagons when transporting chemicals and mineral fertilizers is also close to the average load capacity, with underloading of 2%. The static load of wagons is minimal when transporting:

- Coke: 53.97 tonnes;
- Chemicals and soda ash: 60.46 tonnes;
- Timber: 59.44 tonnes;
- Paper: 61.77 tonnes;
- Ferrous metals: 63.47 tonnes;
- Oil and petroleum products: 63.6 tonnes.

For other goods, the static load is close to the carrying capacity. Although more than 200,000 new innovative freight wagons with an axle load of 25 tf have been added to the network fleet over the last ten years, there has been no significant growth in the average load capacity (+2.6%) or the average static load across the freight wagon fleet (+0.96%), while the capacity utilisation has become even lower (–1.5%). This suggests that the cubic capacity is insufficient, preventing wagons from being loaded to their full capacity.

ANALYSIS OF THE IMPACT OF "T" – LOADING GAUGE WAGONS ON THE TRANSPORTATION PROCESS AND CARRYING CAPACITY

In our opinion, for the static load of wagons to be substantially increased, we should both increase their load capacity by switching to an axle load of 25 tf, and increase the transverse dimensions of wagons by using the "T" — loading gauge wagons and reducing their length. This will lead to an increase in the net linear load of trains, thus increasing their carrying capacity. What is particularly important is that this approach to increasing the carrying capacity will allow attracting private capital and somewhat reducing the need for government investment.

The task of preparing railways for the introduction of "T" — loading gauge wagons was set by the USSR Ministry of Railways in its Order No. 22/Ts "On Preparing Railways for the Introduction of Oversized Wagons with Increased Axle and Linear Loads" as early as May 3, 1982. The Order provided for completing the required reconstruction of the network over a period of 20 years. Unfortunately, it remained unimplemented; however the work to bring railways in line with the "C" — obstruction clearance requirements is still underway [11].

What effects can be achieved through the introduction of rolling stock with "T" — loading gauge wagons under the current conditions?

In order to assess the effect on the transportation process, the effects of the introduction of "T" — loading gauge wagons for the government, carriers, and operator companies are considered below.

Fig. 3 shows comparison of rolling stock gauge areas.

The use of the "T" — loading gauge wagons will increase the cross-sectional area of the wagon by approximately one square metre or approximately 10%. This will allow for building wagons with improved technical and economic parameters and increasing the carrying capacity of railways.

The main characteristics of the most common types of prospective wagons with the "T" — loading gauge wagons are shown in *Fig. 4–6*. The length of a gondola

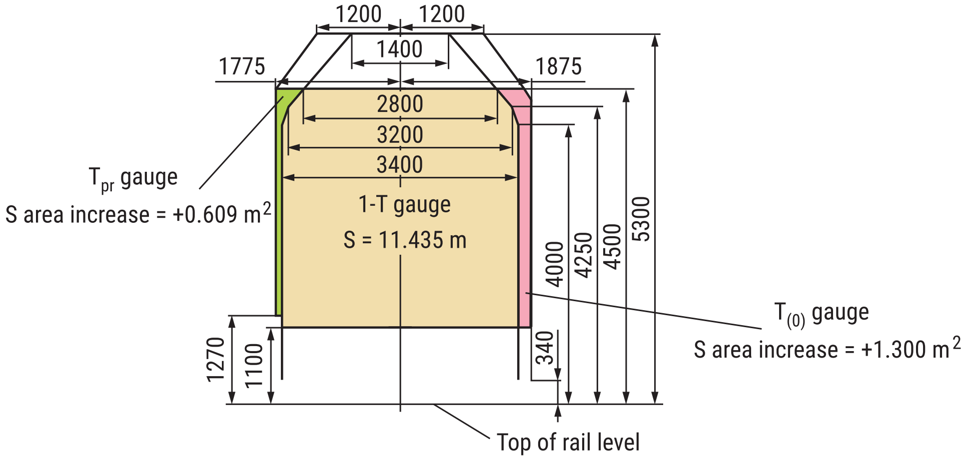

Fig. 3. Comparison of 1T, T_{pr}, and “T_a” — loading gauge wagons

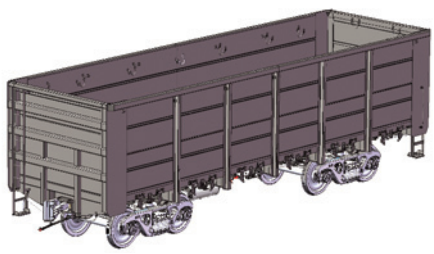

Fig. 4. Potential “T” — loading gauge wagons gondola wagon: Load capacity: 76 t; tare weight: 24 t; cubic capacity: 94 m^3; coupled length: 11,895 mm; maximum width: 3,540 mm; linear load: gross: 8.4 t/m, net: 6.4 t/m

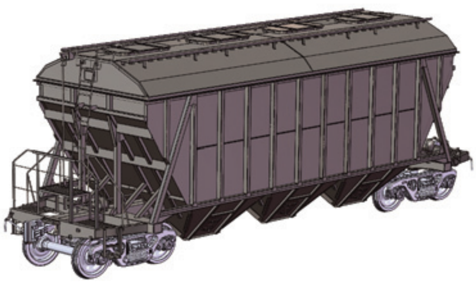

Fig. 5. Potential “T” — loading gauge wagons hopper wagon: Load capacity: 79 t; tare weight: 21 t; cubic capacity: 111–120 m^3; coupled length: 13,050 mm; maximum width: 3,570 mm; linear load: gross: 7.66 t/m, net: 6.03 t/m

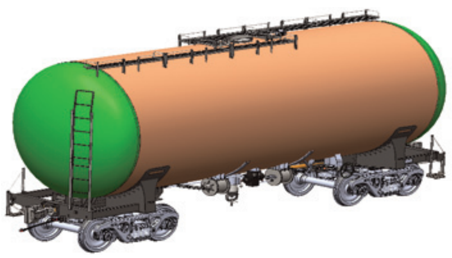

Fig. 6. Potential “T” — loading gauge wagons tank wagon for light petroleum products: Load capacity: 75 t; tare weight: 25 t; cubic capacity: 108 m^3; coupled length: 12,020 mm; maximum width: 3,580 mm; linear load: gross: 8.32 t/m, net: 6.23 t/m

wagon will be reduced by the length of the standard hatch, and its width will be increased by 322 mm. The length of a hopper wagon will be reduced by 1,470 mm, and its width will be increased by 320 mm. The length of a tank wagon will remain unchanged to enable loading and unloading at the existing loading and unloading racks, and its width will be increased by 315 mm. The cubic capacity of all three wagon types will increase. The increases in the train weight due to the use of these wagons are shown in *Table 2*.

INCREASING THE CARRYING CAPACITY OF RAILWAYS: PROSPECTS OF INTRODUCTION OF “T” — LOADING GAUGE WAGONS

Increasing the weight of trains by 6% (for tank wagons) to 17% (for gondola wagons) allows us to conclude that there is a potential for increasing the carrying capacity of railways and improving the efficiency of transportation.

- It is reasonable to link the design and introduction of “T” — loading gauge wagons with increasing the load capacity of wagons for transportation of oil and petroleum products, coke, paper, chemicals and soda ash, timber, and metals at an axle load of 25 tf. The transition to the “T” — loading gauge wagons will provide economic effects both for Russian Railways JSC and other transport market players.
- Without increasing the load capacity, shorter “T” — loading gauge wagons will enable Russian Railways JSC to increase the train weight to 7.600–8.300 tonnes, thereby increasing the carrying capacity by 11–17 %, reducing the required wagon fleet size, and reducing costs on traction and infrastructure maintenance. Both Russian Railways and the country as a whole will benefit from the implementation of this project. Owners, consignors, and manufacturers of wagons will not get any effect.

Table 2

Train weight increases due to reduced wagon length when using "T" – loading gauge wagons under GOST 9238-2022

Parameter	General-purpose gondola wagon		Oil tank wagon		Grain hopper wagon	
	"T" – loading gauge wagons	Comparison with model 12-196-02 UVZ, loading gauge 1-T	"T" – loading gauge wagons	Comparison with model 15-9993 OVK, loading gauge 1-T	"T" – loading gauge wagons	Comparison with model 19-1299 RM Rail, loading gauge 1-T
Wagon tare weight, t	24.0	24.5 ± 0.5	25.0	25.5–26.7	21.0	21.0
Load capacity, t	76.0	75.0	75.0*	68.6*	79.0	79.0
Axle load, t/axle	25.0	25.0	25.0	25.0	25.0	25.0
Cubic capacity, m^3	94.0	94.0	98.0	88.0	111.0...120.0	111.0
Net linear load, t/m	6.4	5.39	6.23	5.62	6.05	5.44
Gross linear load, t/m	8.4	7.18	8.32	7.87	7.66	6.88
Distance between bogie centres, mm	6,940	8,650	7,800	7,800	9,240	10,300
Coupled length, mm	**11,895**	**13,920**	**12,020**	**12,020**	**13,050**	**14,520**
Maximum outer width, mm	3,510 over posts	3,198 over posts	∅3,580	∅3,265	3,570	3,250
Interior dimensions, mm	Length 11,000 Width 3,296 Height 2,590	Length 13,030 Width 2,958 Height 2,436	∅3,560	∅3,240	–	–
ATR (above top of rail) height, mm	3,980*	3,866	5,157	4,797	4,840	4,910
Weight of a 71-conventional wagon train (994 m)	**8,300**	**7,100**	**8,200***	**7,085***	**7,600**	**6,800**
* – when transporting petrol.						

Given the expected effect from the use of "T" — loading gauge wagons, in 2024, RM Rail had negotiations with major operator companies to identify possible routes for operating "T" — loading gauge wagons freight wagons taking into account the existing limitations for loading and unloading on non-public tracks. As a result, the following prospective routes were identified:

- For gondola wagons:

Erunakovo, West Siberian Railway – Luzhskaya, October Railway;

Kostomuksha, October Railway – Koshta, Northern Railway;

Erunakovo, West Siberian Railway – Nakhodka Vostochnaya, Far Eastern Railway;

- For tank wagons:

Limbey, Sverdlovsk Railway – Luzhskaya, October Railway;

Stenshino, Moscow Railway – Luzhskaya, October Railway;

Afinskaya, North Caucasus Railway – Novorossiysk, North Caucasus Railway.

In response to an enquiry as to whether "T" — loading gauge wagons can be operated on these routes, the Directorate for Infrastructure Diagnostics and Monitoring stated that the proposed routes have 427 barrier sites on the October, Moscow, Northern, Gorky, East Siberian, and Far Eastern Railways, where they can only run on adjacent tracks subject to speed restrictions.

Because of 227 barrier sites within the limits of the North Caucasus, South Ural, Sverdlovsk, Krasnoyarsk and Transbaikal Railways, it will not be possible to operate "T" — loading gauge wagons wagons on these lines until 2036.

It is currently possible to launch the operation of "T" — loading gauge wagons on the lines Kostomuksha, October Railway–Koshta, Northern Railway and Stenshino, Moscow Railway–Luzhskaya, October Railway for gondola wagons and tank wagons, respectively.

The second problem is related to an increased linear load of the proposed "T" — loading gauge wagons.

According to the Guidelines for Handling of Rolling Stock on Railway Bridges of Russian Railways JSC, the permissible linear load for Category IV bridges is 8.2 tf per m of track with an axle load of up to 27 tf.

The permissible linear load for Category V bridges is even smaller and is determined by calculation.

This is the second problem to be addressed. A number of professionals [12, 13] believe that under certain conditions the permissible linear load could be increased to 9 tf/m.

According to the Directorate for Infrastructure Diagnostics and Monitoring, RUB 56 billion in investment is required to address the barriers on the routes suitable for the operation of "T" — loading gauge wagons. The amount may seem to be huge, but it accounts for just 7% of the costs spent by Russian Railways to modernise its infrastructure over the last two years.

CONCLUSION

To summarize the above discussion on the prospects of creation and problems of introduction of "T" — loading gauge wagons, we can conclude that the following benefits will follow from the introduction of wagons with an increased capacity and higher load capacity:

- Railways will benefit from reduced traction costs, required operating fleet, and reduced en-route maintenance costs;
- Wagon owners will receive new, more efficient wagons and benefit from reduced repair costs;
- Operators will benefit from reduced costs of operation and light running;
- Consignors will benefit from reduced shipping costs;
- Wagon manufacturers will benefit from a consistent demand for the renewal of the existing fleet;
- The government will be able to reduce investment in increasing railway capacity.

Unfortunately, the updated Strategy for Scientific and Technical Development of Russian Railways Holding Company until 2025 and in the Future up to 2030 (White Paper)[2] does not mention overcoming barriers to the introduction of the "T" — loading gauge wagons or increasing the permissible linear load on artificial structures among the objectives for the development of facilities and technologies for heavy-haul traffic management. Given the efficiency of "T" — loading gauge wagons, we suggest recommending administrations of 1,520 mm gauge railways to pay particular attention, when expanding operating domains for heavy-haul trains, to the fact that these lines need to be brought in line with the "C" — obstruction clearance structure requirements and the permissible linear load should be increased to at least 8.4 t/m.

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