Modeling of container freight and passenger traffic

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Abstract. International experience of demand and increase in container freight railway traffic has been analyzed. High-speed train traffic on the route Moscow – Nizhny Novgorod railway (Russia) has been actively developing since 2010, for instance, in some sections, the railway line has been modernized and new high-speed trains were put into operation. Research trends in the railway infrastructure on the route Moscow – Nizhny Novgorod remain relevant, despite the fact, that the project of high-speed railway line Moscow-Kazan is still not accepted for implementation, and the section of the route Moscow – Nizhny Novgorod should be a priority. The volume of passenger traffic only by high-speed trains by the end of 2020 in this area could reach 3.7 million people. Thus, with the introduction of high-speed traffic, the passenger traffic will approach or even exceed 5 million people, i.e. the high-speed railway will become quite effective. Offered the organization of container transportation with special trains with speeds of 200 km/h and 250 km/h.

1. Introduction

In October 2018, the International Transport and Logistics Forum “PRO // Motion.1520” was held in Sochi. Among the most discussed issues was the implementation of projects for the development of high-speed rail services in Russia. As part of the forum, the participants signed an agreement on the start of construction of the first section of the Moscow – Kazan high-speed railway, in particular, an agreement on the construction of a new, 301 km long high-speed railway from Zheleznodorozhnyi station (Moscow region) to Gorokhovets station (Vladimir region).

In this direction, it was planned to operate both passenger trains with speeds of up to 360 km / h and special cargo container trains with speeds of 160-250 km / h along the designated high-speed rail line. In addition, it was supposed to preserve the movement of passenger high-speed trains on sections of the existing infrastructure. The total length of the VSM (High-speed railway) Moscow – Nizhny Novgorod line was to be 408 km. The stops were planned to be organized in Noginsk, Orekhovo-Zuyevo, Petushki, Vladimir, Kovrov, Gorokhovets and Dzerzhinsk (Figure 1).
Six months later, after the PRO // Movement 1520 forum, on April 12, 2019, FAI Glavgosexpertiza approved several stages of the construction of the Moscow – Kazan High Speed Railway, in particular, a positive conclusion was made on preparing the area from the 410 km track station to the VSM Airport station Nizhny Novgorod with length of 14.02 km. However, shortly before this, the information that was commented by the presidential spokesman Dmitry Peskov was made public. Its essence is that the final decision on the Moscow – Kazan High-Speed Railway project was not made. Further, the events connected with the VSM Moscow – Kazan project developed very rapidly. On April 16, the media reported that President Vladimir Putin approved the proposal for the construction of the Moscow – St. Petersburg High-Speed Railway. On July 1, the Ministry of Finance of Russia blocked the allocation of funds for the Moscow-Kazan High-Speed Railway line.

The newspaper “Kommersant” expressed its opinion on the possible overestimation of the forecast data on passenger traffic. Perhaps this is true, but according to our calculations, which are given below, these expected traffic volumes on the Moscow – Nizhny Novgorod high-speed railway are rather high.

Now, the fate of the Moscow – Kazan High-Speed Railway project, including the Moscow – Nizhny Novgorod section of the High-Speed Railway, is unknown, therefore it is interesting to study the following questions:
- analysis of indicators of the passenger operation on the existing railway line Moscow – Nizhny Novgorod and the forecast for the near future;
- assessment of the additional prospects for the development of rail transport on this route, associated with the containerization of high-speed freight transit traffic.

2. The main indicators of passenger traffic operation on the route Moscow – Nizhny Novgorod

It should be noted that as early as 2007, in the direction of Moscow – Nizhny Novgorod, the work on the modernization of the railway line in order to increase speed to 160 km / h began. In the summer 2010, in this direction there was organized the movement of high-speed trains "Sapsan", which transported passengers through June 2015. Travel time was 3 hours 55 minutes. For the period from 2010 to 2015 more than 3.5 million passengers were transported.

By 2014, the route operated three “Sapsan” trains and two “Lastochka” trains by “Siemens AG”. Soon the new firm trains "Strizh" of the company "Patentes Talgo" were put into operation. In turn, the “Sapsans” were transferred to the line Moscow – St. Petersburg due to the high demand for passenger traffic. The journey time on the trains “Strizh” and “Lastochka” was about 4 hours.

Processing of the available data shows that the passenger traffic mastered by high-speed trains “Sapsan”, “Lastochka” and “Strizh” in the direction of Moscow – Nizhny Novgorod is growing.

So, from 2013 to 2017 the volume of passengers’ transportation between Moscow and Vladimir increased by nearly 2.5 times.
From June 01, 2015 on the route Moscow – Nizhny Novgorod the train "Strizh" runs. From June to September 2015, the trains transported 370 thousand passengers. Already on 7 April, 2016 the millionth passenger of the train arrived at the Kursk railway station in Moscow. An overview of high-speed trains that run on the Moscow – Nizhny Novgorod route from 2010 to the present time is shown in Figure 2.

Figure 2. Overview of high-speed trains running on the route Moscow – Nizhny Novgorod for the period from 2010 to the present time.

In general, in 2016, high-speed trains "Strizh" and "Lastochka" carried about 2.4 million passengers on the route Moscow – Nizhny Novgorod.

The volume of passengers transported by trains “Strizh” and “Lastochka” in 2017 compared to 2016 increased by more than 8% and reached 2.6 million people.

On March 1, 2018, the operation of trains "Sapsan" resumed on the route St. Petersburg – Nizhny Novgorod through Moscow.

In 2018, the trend of passenger traffic growth, organized by high-speed trains in the direction of Moscow – Nizhny Novgorod, remained. The annual passenger traffic was 3.2 million people, and the average annual growth since 2017 was 18.7%.

Let us analyze the available data on passenger traffic of high-speed trains on the route Moscow – Nizhny Novgorod in the period from 2014 to 2018.

3. Passenger traffic research method

There are two groups of forecasting methods: intuitive, based on expert assessments, and formalized, based on mathematical models [1]. It is formalized methods that allow to model the process of changing the value of the studied indicator over time. One of the most well-known methods is regression analysis. The mathematical models used in this method are based on the existing laws of known differential equations. As a rule, the estimation of parameters of regression models is made by the method of the least squares. Least squares method is a mathematical method based on minimizing the sum of the squared deviations of the experimental data from the corresponding data of the recommended function found. With linear regression, the quality assessment of the equation allows calculating the coefficient of determination R². The closer the value of the coefficient of determination to unity, the higher the amount of dependence. Based on the collected statistical data, a linear equation was compiled. Figure 3 shows the statistical data of the passenger traffic of high-speed trains (for the period from 2014 to 2018), as well as the results of the obtained linear regression until 2020.
The regression equation is:

\[ y=0.3122x+1.504, \ R^2=0.9543 \]  \hspace{1cm} (1)

where \( x \) – the observation number corresponding to the year; \( R^2 \) – the coefficient of determination.

Now we use the obtained equation (1) and will make a forecast of passenger traffic data for high-speed trains until 2020.

The forecast results showed that the passenger traffic of the “Sapsan”, “Lastochka” and “Strizh” high-speed trains for 2019 on the Moscow – Nizhny Novgorod route will be about 3.4 million people and by 2020 will reach 3.7 million people that is 2 times higher than 2014 passenger traffic.

The fact that passenger traffic in this area increases, is evidenced not only by the results of the forecast obtained, but also by the source. For example, in January-April 2019, high-speed trains “Sapsan”, “Lastochka” and “Strizh” transported 1.2 million passengers, which is 15% more than in January-April 2018.

It should be noted that with the addition of the mathematical model (1) with new statistical data, the predicted values of passenger traffic can be adjusted. It is interesting to study the total passenger traffic on the route Moscow – Nizhny Novgorod, taking into account the statistical data of air transport.

Currently on the route Moscow – Nizhny Novgorod one high-speed train “Sapsan”, 4 trains “Lastochka” and 5 trains “Strizh” operate. The work on the modernization of the existing railway line on the direction of Moscow – Nizhny Novgorod continues. Only in 2017, the speed of passenger trains increased to 200 km / h on sections 29.2 km long and to 180 km / h over a 59.5 km track.

Today, a lot of research is devoted to the issues of forecasting passenger traffic in railway transport [2, 3, 4, 5, 6]. A review of existing domestic and foreign methods of forecasting passenger traffic is presented, in particular, in article [7].

Passenger traffic, supposed to be operated on high-speed lines, is not the only source of its profitability [8, 9]. Significantly increased speed of transporting container freight on such routes can have a significant effect on the directions of large transit freight flows [10, 11]. Part of this direction is the route Moscow – Nizhny Novgorod.

4. Prospects for the development of container high-speed rail freight transit traffic on the route Moscow – Nizhny Novgorod

It is assumed that in the future the direction Moscow – Nizhny Novgorod – Kazan – Yekaterinburg – Chelyabinsk will become an integral part of the transport transit corridor Europe – Asia and Asia – Europe. Container transportation constitute a significant part of transit.

Container transit by rail until 2013-2014 were implemented mainly in the direction of North - South: between the countries of Eastern Europe (including the Baltic States) and Central Asia. Starting from 2014, the priority direction of transit traffic changes, and the territory of the Russian Federation includes railway container transit connecting Europe with the countries of East Asia.
The level of containerization in the world is growing today. The use of containers opens up new growth prospects for international transit [12].

The main factors for the growth of the container shipping market are:

- growth of the world economy and international trade;
- outrunning growth in the export-oriented economies of developing countries;
- concentration of production in regions with low costs, geographical polarization of production and consumption centers;
- enlarging of the list of containerized cargoes related to the development of containerization technologies.

The average growth rate of the Russian market for container traffic in 2001-2007 amounted to 18-20% per year, which significantly exceeds the growth rate in the world market. This is because the average level of containerization in Russia is significantly lower than the worldwide average level, which created the prerequisites for the rapid growth of container flow in the total volume of cargo transportation. The dynamic development of the container shipping market in Russia is determined by the following factors:

- integration of the Russian Federation into world trade;
- growing domestic demand for consumer goods;
- increasing the needs of a growing economy in industrial goods, machinery and equipment;
- high investment activity in the development of port and land infrastructure.

As OAO TransContainer estimates, the volume of rail container traffic is approximately half of the total container turnover in the Russian Federation. According to its data, in 2008 the level of containerization on the Russian Railways network was only 3.6%.

In 2017-2018 the Russian market of rail container traffic continued to grow steadily: if by the end of 2016, its growth rate was 10.2%, in 2017 the market grew by 19% and reached 3.9 million TEU (Twenty-Foot Equivalent Unit is a standard unit of measurement a vehicle’s cargo carrying capacity), and in 2018 - by 14% and reached 4.4 million TEU. The market growth rates became maximum since 2010 and significantly exceeded the initial forecasts.

In container traffic there are 4 segments: import, export, domestic transportation and transit. Accelerated transportation is the most effective in the implementation of the last segment.

Container transit by rail in 2018 became the fastest growing segment of the market. The volume of transit container traffic on the railways of Russia grew by 35.1% compared to the previous year and amounted to 559 thousand TEU, or 12.7% of the total rail container traffic.

The total volume of China – EU – China container transit in 2018 amounted to 376.8 thousand TEU, which is 35% higher than the 2017 level.

Recently, there has been a steady increase in the containerization of rail transport: 7.2% in 2018 compared to 6.6% in 2017 and 2.6% at the end of 2006. The use of containers is becoming increasingly popular; the proportion of containerization in countries with developed transport infrastructure is, as mentioned above, more than 60%.

Today there remain the following factors influencing the container market for rail traffic:

- social factor - the continuing excess of supply capacity over demand;
- environmental factor - the introduction of new environmental restrictions on the sulfur content in marine fuel since the beginning of 2020, which increases the attractiveness of container traffic, especially with the use of high-speed rail transport;
- political factor - significant influence of international relations (in particular, the USA and China, Europe and Russia and others) because of sanctions or internal differences.

Today, majority of market participants recognize that the Asia-Europe railway corridor has become a full-fledged delivery option, which is preferable for specific categories of cargo owners [13, 14]. We are talking about the bulk category “other goods”, in which the railways gave way to motor transport, as well as the high-tech market, where safe and fast delivery takes precedence [15]. Moreover, this corridor is developing at the political level, as it is of strategic importance for Asian countries as an
alternative to delivering cargo through the Suez Canal, in case geopolitical tensions increase in the Middle East. For example, Japanese and Chinese logistics companies actively cooperate in organizing a multimodal corridor for the delivery of goods in Europe [16, 17]. According to forecasts of the Eurasian Development Bank, by 2020 the volume of rail container traffic between China and the EU will reach 1 million TEU. China itself relies on 2 million TEU.

One of the main factors for successful competition of the segment of rail container traffic with other segments of the transport market is the well-considered tariff policy of OAO RZhD (“Russian Railways”) in relation to container traffic, simplification of documents and procedures for access to the railway infrastructure, the development of technologies for the movement of container trains and other measures that increase the attractiveness of this type of transport. In addition, an essential problem remains the shortage of special rolling stock, which hinders the development of container traffic.

The above data show that container rail transit is in demand and is developing (Figure 4). According to this preliminary estimate, by 2024 the volume of transit container traffic will reach 1,656 thousand TEU. The values of the indicator are given in accordance with the “Integrated Plan for the modernization and expansion of trunk infrastructure”, considering the implementation of measures of national projects “Railway Transport and Transit” and “International Cooperation and Export”.

Until 2025, OAO RZhD (“Russian Railways”) plans to carry out a deep modernization of the railway network, it is expected to allocate more than 8 trillion roubles in the project. Today, the average speed of delivery of cargo shipments in loaded cars is 385 km / day, and the average speed of transit container traffic is 810 km / day. If we consider this, then plans to increase them to 420 km / day and 1319 km / day respectively, can only be implemented with a significant increase in train speeds. Rail transportation can reach them, particularly owing to the construction of new high-speed rail lines. The presence of high-speed rail lines will significantly reduce the risks related to interruptions in train schedules on existing railways. Besides, with the reserve of carrying capacity for high-speed rail lines, container transit by special trains with speeds from 160 to 250 km / h has great prospects for further development.

5. Conclusion
1. By the end of 2019, passenger traffic served by high-speed trains on the Moscow – Nizhny Novgorod route can reach 3.4 million people, and in a year - 3.7 million people. Such growth rates require an increase in the speed of high-speed trains and the development of additional means of upgrading the existing infrastructure.
2. In its turn, with the development of “the first high-speed railway in the country - the High-speed railway Moscow - St. Petersburg”, the question of expanding the high-speed railway network in the country will arise eventually. One of the most promising additional directions for the organization of high-speed traffic in Russia, considering the main criterion of its efficiency - the volume of passenger traffic, can be the section Moscow – Nizhny Novgorod.

3. One of the promising areas for the combined movement of high-speed passenger trains and high-speed container special freight trains is the direction Moscow – Nizhny Novgorod – Kazan. The issues of organizing such a combined movement in this area and justifying its effectiveness require further deeper research.

References
[1] Kapitanov V, Silyanov V, Monina O, Chubukov A 2018 Transportation Research Procedia 36 pp 252-259 https://doi.org/10.1016/j.trpro.2018.12.077
[2] Ahn Y, Kowada T, Tsukaguchi H, Vandebona U 2017 Transportation Research Procedia 25 pp 315–330 https://doi.org/10.1016/j.trpro.2017.05.408
[3] Wang Y, Chen X, Han Y, Guo S 2013 Procedia - Social and Behavioral Sciences 96 pp 136-147 https://doi.org/10.1016/j.sbspro.2013.08.019
[4] Xua G, Liu W, Yang H 2018 Transportation Research Part C: Emerging Technologies 93 pp 501-524 https://doi.org/10.1016/j.trc.2018.06.017
[5] Lingaitis V, Sinkevičius G 2014 Procedia - Social and Behavioral Sciences 110 pp 549-559 https://doi.org/10.1016/j.sbspro.2013.12.899
[6] Dombalyan A, Kecherga V, Semchugova E, Negrov N 2017 Transportation Research Procedia 20 pp 159-165 https://doi.org/10.1016/j.trpro.2017.01.040
[7] Misharin A, Pokusaev O, Namiot D, Katzin D 2018 International Journal of Open Information Technologies 6 5 ISSN: 2307-8162
[8] Liangab X-H, Tana K-H 2019 Case Studies on Transport Policy 7 3 pp 583-597 https://doi.org/10.1016/j.cstp.2019.07.008
[9] Wang L, Duan X 2018 Cities 83 pp 71-82 https://doi.org/10.1016/j.cities.2018.06.010
[10] Bernhoven D, El-Sahlid Z, Kneller R 2016 Journal of International Economics 98 pp 36-50 https://doi.org/10.1016/j.jiinteco.2015.09.001
[11] Bi M, He S, Xu W 2019 Transportation Research Part A: Policy and Practice 120 pp 165-187 https://doi.org/10.1016/j.tra.2018.12.011
[12] Peetawan W, Suthiwatnarueput K 2018 Kasettsart Journal of Social Sciences 39 2 pp 320-327 https://doi.org/10.1016/j.kjss.2018.05.002
[13] Moon D, Kim D, Lee E 2015 The Asian Journal of Shipping and Logistics 31 1 pp 1-20 https://doi.org/10.1016/j.ajsl.2015.03.001
[14] Rodemann H, Templar S 2014 Journal of Rail Transport Planning & Management 4 3 pp 70-86 https://doi.org/10.1016/j.jrtpm.2014.10.001
[15] Fan Y, Behdani B, Bloemhof-Ruwaard J, Zuidwijk R 2019 Transportation Research Part E: Logistics and Transportation Review 130 pp 128-160 https://doi.org/10.1016/j.tre.2019.08.011
[16] Joon SY, Chen F, Roh S 2017 The Asian Journal of Shipping and Logistics 33 3 pp 155-165 https://doi.org/10.1016/j.ajsl.2017.09.005
[17] Reis V, Meier J, Pace G, Palacin R 2013 Research in Transportation Economics 41 1 pp 17-30 https://doi.org/10.1016/j.retrec.2012.10.005