Specific features of high-speed railway construction projects

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Abstract. The most important condition for the integration of the Russian transport infrastructure into the global logistics chain is the design and construction of high-speed railways. In the course of this research, the problems of implementation of high-speed highway "Moscow-Kazan" project by "High-speed Rail Lines" Joint stock Company were considered, and the necessity of large scale projects realization on high-speed railways construction was defined.

Then, the aggregate demand values were determined, and the distribution of traffic between different transportation modes was predicted. Finally, the induced demand value was forecasted. Based on the predicted passenger flow characteristics, the indicators of train traffic were calculated.

The passenger traffic on the road segment between Moscow and Kazan was studied. The methodology for passenger traffic calculation included the calculation of the induced demand, the possibility of passengers choosing the railway over other modes of transportation, and the evaluation of the demand fluctuations dynamics.

The scientific novelty of this study is the application of an improved method of statistical analysis in the calculation of passenger traffic. Along with the theoretical results, the carried out research has an utmost practical importance - its results can be applied in the design of main railways.

Keywords: marketing strategy, large scale project, passenger traffic forecast, high-speed facility, transport infrastructure, statistical analysis, investment, economy, social development, risk analysis.

1 Introduction

The development of the transportation system is one of the most important tasks of the strategic development of the country. The development of high-speed traffic system particularly, in Russia, is one of the most relevant topics, which attracts attention of many senior politicians, large investors, and representatives of the regions. Even at the initial stage of design, the introduction of high-speed road facilities exerts social, political, strategic, and, most importantly, indirect economic effect, which is very important for regions that lag behind in the development.

In Russia it is extremely important to implement largescale projects for the construction of express railways to achieve high results in the field of passenger transportation.

A largescale project (investment project) is a target program, which includes several interconnected projects united by a common goal, timeline and resources, allocated for their implementation [1]. The purpose of large scale projects is the development of domestic and foreign economies, and the creation of the modern infrastructure, both transport and social. Besides, such projects address the most important social and economic problems, the solution of which gives a completely new qualitative development of the economy at both regional and national levels.

Based on the analysis of the available data on the construction of highways, the following characteristic features of the large scale projects in this area were distinguished:

- enormous expenses on the projects, with the implementation cost of more than 1 billion US dollars [1];
- long distance between construction sites, therefore, a large linear extent;
- high complexity and material consumption;
- long implementation periods of 5-7 years or more [2];
- uniqueness. Application of non-standard, individual solutions [3];
- high technological complexity;
- large scale;
- economic, social and political importance.

The development of an alternative railway infrastructure in Russia will ensure safe railway connection with train speeds of up to 400 km/h. [4].

Currently, high-speed systems are at the initial stage of development in the national transportation infrastructure. The main problem that slows down the development of express railways is the lack of financial support.

"High-speed Rail Lines" JSC has developed a large scale project for the construction of a completely new railway, which is necessary for the implementation of the high-speed traffic project on the road segment between Moscow and Kazan. This initiative involves the construction of a new branch passing through the uncovered territories of Tatarstan, Mari El and Chuvashia republics, as well as the Nizhny Novgorod region. Thus, the designed railway line will be divided into sections: the first between Moscow and Vladimir; the second between Vladimir and Nizhny Novgorod; the third between Nizhny Novgorod and Cheboksary; the fourth between Cheboksary and Kazan (figure 1) [5].

![Figure 1. The new highway designed by High-speed Rail Lines JSC.](image_url)

At present, with the existing infrastructure, the transit way from Kazan to Moscow takes 14 hours. According to the project, the new high-speed railway will allow to reduce the travel time to 3 hours 30 minutes. Accordingly, the travel time from Moscow to Nizhny Novgorod will be approximately 2 hours and from Nizhny Novgorod to Kazan - 1 hour 30 minutes [6]. The length of the railway between Moscow and Kazan is 770 kilometers, the train will move at the speed of 440 km/h. This route will be the first step of the creation of high-speed traffic system in the Russian Federation.
2 Methods

Prior to launching this large-scale project of JSC "High-speed Rail Lines", it was necessary to analyze and evaluate the profitability of future investments. To do so, the potential passenger flow was assessed and the transportation cost was calculated. The allocation of traffic by means of transportation was also taken into account.

In order to get the most objective information on these issues, the large-scale marketing research conducted by the specialists of PJSC Lengiprotrans in the course of several months, was assessed.

The results of this study indicated an increase in passenger traffic on the road segment connecting Moscow and Kazan from 2,280,232 people in 2020 to 5,785,551 people in 2050 (optimistic estimate). With a pessimistic forecast for the same route, passenger traffic increases from 2,025,627 people in 2020 to 5,489,404 people in 2050.

Based on the passenger traffic forecast, provided by Lengiprotrans, the indicators of the predicted train traffic were calculated (table 1).

Table 1. Forecast train traffic for the project of High-speed Rail Lines JSC.

| Direction                        | Amount of traffic, train-pairs |
|----------------------------------|-------------------------------|
|                                  | 2020 | 2030 | 2050 |
| Nizhny Novgorod - Kazan          | 2     | 2    | 2    |
| Moscow - Kazan                   | 10    | 15   | 20   |
| Moscow - Nizhny Novgorod         | 11    | 17   | 24   |

The current passenger flow between Kazan and Moscow by railway is 1,500 people per day.

In order to determine the actual values of potential passenger traffic and determine the amount of carriages required, the passenger traffic in the route Moscow - Kazan was thoroughly evaluated. The methodology for passenger traffic calculation included the calculation of the induced demand, the possibility of passengers choosing the railway over other modes of transportation, and the evaluation of the dynamics of demand fluctuations (figure 2).

Figure 2. Methodology for calculating passenger traffic between major cities.

The marketing research was conducted on the basis of various sources of initial information (figure 3).
The distribution of the existing passenger traffic on the road segment between Kazan and Moscow indicates that the railway and aviation are the most loaded modes of transport.

In order to forecast the passenger flow, which will presumably be on high-speed railway, it is necessary to consider the factor of switching passenger traffic from other types of transportation to the new high-speed rail service. In our case the mode choice depends on many factors, including the cost of transportation, travel time, comfort and safety. The share of passenger traffic switched from one mode to another is defined by the coefficient of passenger traffic withdrawal. In this research, the main traffic characteristics are determined using analytical methods. The cost of transportation on the railway is roughly accepted to be 10 % lower. The calculation results on the passenger traffic redistribution to high-speed traffic facilities are presented in table 2.

| Mode of transportation | Number of routes | Number of passengers per year before the introduction of high-speed railway, million | Coefficient of traffic withdrawal | Passenger traffic redistributed to the high-speed facility, million |
|------------------------|-----------------|---------------------------------------------------------------------------------|---------------------------------|-----------------------------------------------------------------|
| Local trains           | 6               | 0.9                                                                              | 0.8                             | 0.72                                                            |
| Long distance trains   | 12              | 0.2                                                                              | 0.6                             | 0.12                                                            |
| Planes                 | 28              | 1.2                                                                              | 0.2                             | 0.24                                                            |
| Buses                  | 8               | 0.15                                                                             | 0.5                             | 0.075                                                           |
| Total on high speed facilities | |                                                                                   |                                 | 1.155                                                           |

3 Results and discussion

In general, in the course of this research, the passenger traffic on the high-speed facility on the road segment between Kazan and Moscow was estimated to be about 1.335 million people, which is almost three times less than the value of passenger traffic adopted by JSC “High-speed Rail Lines” in the design model.

It should be noted that in modern conditions, in order to determine and evaluate the possibility of implementation of such a large scale project, that has a long time base period and a significant estimated cost, it is extremely important to identify the possible risks and the degree of their impact.
Therefore, in order to identify the possible negative situations that can threaten the implementation of the project, it is necessary to determine certain events and cases that fall into different risk categories. Once the possible negative situations are identified, it is important to study and analyze the sources of undesirable events, the causes of their occurrence and possible consequences for the implementation of the project.

Based on this, a thorough identification of all possible risks of the large scale project implementation was carried out. The most probable risks are presented in table 3.

| Table 3. The identified risks of the large scale project of «High-speed Rail Lines» JSC [7]. |
|----------------------------------------|---------------------------------------------------|
| **Risk category** | **Possible risks** |
| Lack of demand | - low passenger flow on different intermediate segments of the route between Kazan and Moscow. |
| Financial | - deterioration in the financial state of project participants; - slowdown of the national economy (rise of inflation, exchange rate changes); - multistage procedure of project financing. |
| Legal regulation of the project | - non-adoption of regulatory legal acts; - rejection of the amendments to the regulatory legal acts necessary for the implementation of the project. |
| Construction stage | - poor preparation of the construction site; - violations of technical specifications during the construction period; - cost overruns (compared to construction estimates). |
| Legal | - significant change in the conditions of the project due to the changes in legislation. |
| Operational stage | - unforeseen expenses for the operation and maintenance of the railway infrastructure. |
| Emergency circumstances | - emergency conditions, leading to negative consequences in the implementation of the project. |

Visual assessment of the risks was completed in the form of risk matrix. In this research, the risk matrix was applied not only to classify and assess the risks of the large scale project, but also to develop recommendations on the distribution, minimization and management of risks. The first column of the risk matrix indicates the probability of risk occurrence, and the second column shows the estimated consequences of the possible event. The probability and consequences of risks in the matrix are evaluated on a five-point scale in order to determine their magnitude more precisely. In the third column of the matrix, general risk assessment is calculated by multiplying the first and second columns (table 4).

| Table 4. Project Risks Matrix. |
|---------------------------------|-----------------|-----------------|-------------|
| **Risk types** | **Possibility** | **Consequences** | **Risk assessment** |
| Legal risks | 3 | 4 | 12 |
| Risks at the stage of project preparation | 3 | 3 | 9 |
| Risks at the stage of construction | 4 | 4 | 16 |
| Risks at the operation stage | 1 | 3 | 3 |
| Risk of the lack of demand | 2 | 3 | 6 |
| Financial risks | 5 | 5 | 25 |
| Compliance risks | 2 | 2 | 4 |
| Risks of the cooperation between project members | 2 | 2 | 4 |
| Emergency risks | 1 | 1 | 1 |

As it is seen in Table 4, the greatest danger is posed by the risks that have higher grades in terms of the probability of occurrence and the expected outcomes. Thus, by analyzing the risk matrix, we can
identify the most crucial risks that have a significant impact on the implementation of a large scale project:
- risk of lack of funding;
- risk at the design stage;
- risk of land acquisition and territory preparation;
- risk of an increase in the estimated cost of construction;
- risk of interfaces;
- risk of the lack of traffic.

Therefore, the most serious problems in the implementation of the high-speed railway construction project of JSC "High-speed Rail Lines" are:
- high cost;
- high material consumption;
- lack of funding;
- legal risks;
- lack of experience in implementing this type of project;
- possibility of low volume of passenger traffic (compared to the planned values at the design stage).

4 Conclusions
To develop and implement a large scale project for the high-speed railway construction, it is important to work out an improved design methodology that will take into account all external and internal factors, and possible implementation risks.

The large scale project for the construction of a new high-speed railway between Moscow and Kazan is characterized by a number of features: management of significant resources consumed; complex subject area of the project; the organizational structure is implemented in the form of "customer - general contractor - pool of subcontractors" relations.

Based on this, a thorough identification of all possible risks was carried out during the implementation of the large scale project. The list of these risks is presented in table 3.

The construction of a high-speed railway is a large-scale and expensive venture therefore it is important to note that its implementation requires significant financial support from investment funds, which includes the support not only from the state and private investors, but also from foreign entrepreneurs.

In case of a large scale project, the development of marketing strategy consists of determining the marketing goals of the project, developing programs for their achievement, as well as logical sequencing of the actions to be carried out. It should be noted that the development of a marketing strategy for a large scale project is the basis for decision making and project resources allocation. In general, for a large scale project, marketing strategies help to obtain the best project output.

The article emphasizes that the construction of a new high-speed railway between Moscow and Kazan poses a wide range of risks. Simultaneous occurrence of a group of such risks could threaten the implementation of the whole project.

The research carried out in order to improve the tools for developing a marketing strategy for a large scale project has both theoretical and practical importance. Some results can be applied in the field of the railway design [8].

The study and analysis of the marketing strategy of JSC “High-speed Rail Lines” can help engineers to come up with recommendations on the improvement of the organizational and technological solutions for the construction of expressways. It can be done through the development of variable projects in order to improve the final technical and economic indicators.

The successful implementation of the large scale project of the construction of the new railway between Moscow and Kazan will not only provide an opportunity for the growth of the state economy, but will also have a significant impact on the development of social well-being of the citizens living in the regions [9-14], and will be a real breakthrough in the Russian railway industry.
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