On The Joint Use Of High-Speed And Conventional Railway Lines

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Abstract. From the moment of commissioning of the first high-speed specialized railways (HSR) in Japan and as a result of more than 50 years of historical development of high-speed passenger railway traffic in different countries, currently, there are several options for its development: first, construction of new highways for the movement of specialized rolling stock, secondly, by reconstructing of the existing railway lines with more technical parameters for higher speed. In scientific publications the issues of justification of the construction of a new HSR are widely covered, as well as reconstruction of existing lines, but at the same time, the problem of definition of efficiency of use of HSR and conventional lines, according to the authors, at least Russian transport science has not been studied enough. In the article some results of the sharing study are presented specialized high-speed railways and reconstructed for more high speeds of passenger trains in existing railway lines of lines'. The question of definition from the economic point of view of costs is considered, depending on parameters such as distance between high-speed trains on the lines reconstructed under high-speed movement, and the cost of passenger-hour, reflecting the duration of passengers on the road.

1. Introduction

More than half a century has passed since the first commercial passenger entered the car of a high-speed train departing from Tokyo to Osaka [1]. The ensuing and ongoing rapid development of high-growth railway traffic in many countries of the world, led to the fact that the length of high-growth highways according to the international Union of Railways (UIC) in April 2018 reached almost 42 thousand. km [2], and the number of passenger-kilometers (according to the MOR as of November 2017) – more than 715 billion [3], and changed the usual before the idea of the possibility of movement of passengers, as well as the world transport system as a whole.

In each country that implements high-speed traffic, based on the features that have historically developed, the network of HSR is developing individually, but in General, the following options: through the construction of new lines, as well as through the reconstruction of existing railway lines at higher speeds of passenger trains. At the same time, the interaction of existing lines and HSR is an important issue.

In Japan, the first option is implemented, since the HSRs are separated from the existing network of Railways due to the difference in gauge, so for transferring passengers from conventional (or high-speed) trains to high-speed ones, the newly constructed VSM stations are combined with the stations of conventional roads on the common territory [4]. An example of such a decision, which later became almost typical for all Japanese HMS, is shown in Figure 1.
Figure 1. The mutual location of the HSR stations (1) and existing line (2).

As it is known, it is the operation of Japanese HSR showed that this type of communication can be, including, economically successful [5], at the same time, even in Japan, which by the way exported its HSR technologies at the end of the XX century [6], came to the understanding that it is necessary to expand the "geography" of high-speed trains at the expense of existing lines and began to develop new rolling stock [7].

World experience shows that the second option is one of the most effective ways to attract passengers to the HSR, thereby expanding the "geography" of circulation of high-growth trains, increasing the level of services provided to passengers using railway transport.

The reconstructed existing lines are closely linked to the HSR and represent a single network in Germany (figure 2), where virtually all types of trains move along the lines of the HSR, and high-speed trains, in turn, go to the existing lines [8].
Similarly, in France, Italy, and some other countries high-speed trains run to existing and reconstructed high-speed sections where considerable distances are covered [9, 10, 11]. As a result, only those separate points that are necessary for the early elimination of failures in the traffic of trains and the organization of the system of maintenance of stationary devices are placed on the European HSR. Passenger operations are performed on operating passenger stations, where on a specially constructed tie lines go high-speed trains.

In Russia, apparently, decided promising lines of HSM to build specialized using partly existing lines, reconstructed at a higher speed [12, 13].

The given brief analysis shows that the issue related to the joint use of existing lines and HSR is relevant.

At the same time, the scientific publications quite widely cover issues related to the prospects of construction of new HSR, including in Russia, and in the most different aspects—construction, economic, etc. [14, 15], as well as the reconstruction of existing lines under higher speeds [16, 17, 18], but at the same time, the problem of determining the efficiency of joint use of HSR and conventional lines, according to the authors, at least Russian transport science, has not been studied enough. Although there are some publications on the establishment and operation of transfer points ("habs") for the transfer of passengers from trains to conventional (and vice versa) [19].

2. Problem statement

As a result of consideration of the experience of foreign countries in the field of interaction of HSR and existing railway lines, three options can be considered [20]:

- option 1—high-speed trains connect to the existing rail network to the first intermediate station and transfer passengers to regular passenger traffic;
- option 2—trains with HSR run on the existing rail network to the large passenger station, and the section needs to be reconstructed to provide a speed of up to 200 km / h on the existing line;
- option 3—train with an ordinary train lines go to the HSR, where is followed up by intermediate HSR station for the passengers’ landing.

We will not dwell on the features of each of the options—details of the technique of technical and economic comparison at a minimum of the reduced costs can be found in an earlier publication of one of the authors of this article [20]. This study examines the impact on the expediency of the exit of trains of the HSR on the existing line of such parameters as the distance of high-speed trains and the cost of pass-fat-hour. These parameters reflect the effect of changing the length of passengers’ travel in relation to the design of the high-speed specialized highway and the existing railway line (Figure 2).
Let us note only some features of the output of high-speed trains on existing lines. First, it is obvious that when organizing the movement of high-speed rides with lower speeds on conventional lines, the turnover time of the HSR trains will increase, which may require the purchase of an additional number of rolling stock to meet the need for such transportation. Secondly, the high-growth rolling stock following the existing line ensures the transportation of passengers without additional time for transfer, which provides greater comfort for passengers and is another factor in favor of high-speed transport, as well as attracting more passenger traffic to the HSR. Thus, these circumstances show that on the one hand, the exit of the HSR trains can attract more passengers, which ultimately will increase the profit of the carrier, and on the other hand it will require additional investment in the rolling stock and infrastructure of the conventional line to increase the speed of the movement.

The following initial data were accepted for the study:
- length of the reconstructed line – from 100 to 600 km;
- the length of the connecting line between the HSR and the reconstructed line – 10 km;
- number of trains in HSR – 1, 3, 5;
- speed of HSR on the usual (reconstructed) line – 160 km/h;
- speed of a regular passenger train – 80 km/h;
- the cost of passenger-hour – 100 rubles.;
- the cost of reconstruction of 1 km – 200 million rubles.;
- high-speed train population – 1000 people.;
- filling the train – 0.7.

To estimate the resulting savings for passengers, expressed in terms of the cost of passenger-hour, from the high-speed train (with their number from 1 to 5) distance on the reconstructed line, the differ-
ence between the speeds between normal and high-speed train for the above conditions can be on the chart (Figure 4).

![Figure 4](image.png)

**Figure 4.** Dependence of the value of the reduced costs (million rubles) on the distance (km) traveled by high-speed ride on the reconstructed line at the cost of passenger-hour, equal to 100 rubles.

From Figure 4 the savings for passengers are seen to increase with the number of high-speed trains and the distance between them on the reconstructed line. At the same time, it is obvious that the increase in the number of high-speed trains gives a much greater effect than the increase in the distance of run.

On the other hand, the implementation of this activity requires investments in high-speed rolling stock, the reconstruction of the existing line, as well as the current operating costs associated with the mileage of trains. For the given conditions these values were determined (Figure 5).

![Figure 5](image.png)

**Figure 5.** Dependence of the value of the reduced costs, million rubles, (capital investments in rolling stock and reconstruction of the line, as well as the current operating costs associated with the mileage of trains) on the number of high-speed trains (1-5) at different distances (100-600 km).

From Figure 5 it can be seen that the costs of rolling stock affect the costs not as much as the length of the HSR on the value of the costs.
3. Summary
The results of the study showed that the greatest costs in the organization of the joint use of HSR and existing lines are capital investments in the reconstruction of lines, although they depend on local conditions, such as: the realized initial speed, the presence of restrictions in the plan, and others. Investments in additional rolling stock are not such a burden, especially with the increase in the mileage of trains. It should be noted that the additional rolling stock allows to get the greatest effect from the output of high-speed trains on the reconstructed line. The cost of a passenger-hour directly affects the resulting effect for passengers, resulting in a reduction in the duration of the trip, which ultimately increases the attractiveness of high-speed rail transport.

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