Sustainable mobility of passenger traffic with the application of the logistics, financial and clients services

1 Introduction

The incorporation of people and territories is facilitated by the freedom of movement, which directly depends on the development of the transport systems. The mobility of the population directly depends on the efficient management of the passenger transportation: work trip, study trips, medical care and recreation. The development of the society and state as a whole also depends on the increasing of the mobility of the population. Country's vast territories and the importance of "reducing" the distances for citizens contributes to the significance of the developing of the passenger traffic in Russia.

The theoretical basis of the research was the work of Chiabaut N., Veve C., Vakulenko S.P., Mamaev E.A., Huang K., Zheng Y., Zelikov V.A. and other studies in the field of passenger transportation, innovative technologies, multimodal transportation and

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The statistical and empirical base of the study was the data from the JSC «Russian Railways», the Ministry of Transport, as well as materials from SNCF and Deutsche Bahn. The objectives of the research is to develop the proposals to improve the quality of the passenger service with the application of the digitalization of the multimodal transportation.

Analyzing the indicators of passenger traffic in a long-distance and suburban traffic at the North Caucasian Railway test site over the past few years (Figs. 1, 2), it can be concluded that, excluding the recession in 2020 due to the coronavirus pandemic, the number of passengers has increased annually.

Source: JSC Russian Railways

Fig. 1. Long-distance passenger traffic in the period of 2015–2020, mln passengers

Fig. 2. Suburban passenger traffic in the period of 2015–2020, mln passengers

Thus, the North Caucasian Railway (Severocaucasian Railway) introduced the passenger trains traffic within the frame of the division of Morozovskaya-Volgogradskaya: №465/466 «Astrakhan-Imeretinsky Resort», №505/506 «Saratov-Imeretinsky Resort» and №215/216 (№113/114) «Adler-St. Petersburg», through passenger is introduced on route of Taganrog-Rostov-Moscow, the route of train №805/806 Novorossiysk-Rostov is extended to Taganrog, passenger trains are assigned to be connected with the Crimea peninsula, retro train №927/928 «Tuapse-Gagra» is introduced, in a number of directions, the tactical traffic of suburban trains was introduced etc. The prospects are as follows: the improving of the transport accessibility of settlements, etc.
It is planned to designate trains «Las» No. 831/832 Vladikavkaz - Tuapse, No. 170/169 «Moscow - Rosa Khutor», No. 99/100 «Nizhny Novgorod - Kislovodsk», it is planned to speed the gearing of the trains «Las» on the route of Mineralnye Vody - Kislovodsk.

A relatively new direction for domestic railways - day trains are gradually becoming a «transport product» in demand among the population. The dimensions of the movement of passenger trains on the North Caucasian railway are shown in Fig. 3.

Source: JSC Russian Railways

Fig. 3. Dimensions of the movement of passenger trains, pairs of trains

Currently, the mobility of the population is increasing every year. Passenger turnover for all types of transport in 2019 amounted to 624.4 billion passenger-kilometers, which is 6.6% higher compared to the data of 2018. Combining services of different types of transport through multimodal passenger transportation with developed logistics is one of the most effective tools for increasing and optimizing the population mobility and strengthening sustainable modes of transport. At the same time, for the passenger himself, this will allow him to optimize the route, reduce losses and costs, and for operating companies it allows to attract additional customers, optimize business processes, increase profits and reduce operational risks.

Historically, railways are considered to be the most important and one of the main parts of the transport system. Rail transport has become especially important in the Russian Federation due to the large distances between settlements. Today, for long-distance passenger transportation in domestic traffic, rail transport mainly competes with road transport (at distances of up to 700–1000 km) and with air transport (at distances over 700–1000 km) [11].

The increase in the competitiveness of railways should be an increase in the section speed of train movement [12, 13], the construction of high-speed and high-speed lines, as well as the development of customer services and services for passengers, among which multimodal transportation occupies an important place.

It is interesting that a peculiar prototype of mixed traffic existed in Russia even before the revolution of 1917: in the city of Novorossiysk, the Russian Society of Shipping and Trade matched the arrival and departure times of the steamers with the arrival and departure times of the Black Sea Express - a fast passenger train No. 1h / 2h via Novorossiysk - St. Petersburg of the Vladikavkaz Railway Society. In the modern sense, multimodal transportation is considered to be the tool for optimizing the transport complex.
contributing to the improvement of the environmental situation and human life. The transportation itself should have a "seamless" character, combining the optimization of the time of docking of different types of transport with each other, a single information and reference system, modern transport hubs and a single travel document.

2 Materials and Methods

The combining of the services of different types of transport through multimodal passenger transportation with developed logistics is one of the most effective tools for increasing and optimizing population mobility, since at present there are a huge number of possibilities for optimal route selection [14, 15]. The key idea should be the statement: "Not the passenger revolves around the transport, but the transport around the passenger" (Fig. 4).

Fig. 4. Principles of modern human mobility

The direction towards the development of railway transportation is facilitated by the important social factors: the process of boarding a train is much easier than boarding an airplane; railway stations are mainly located in the center of settlements, also in some settlements railway transport (mainly suburban) has no alternative at all - these are regions with an underdeveloped network of highways, their absence or these are the territories with a high degree of commuting, which puts an additional burden on urban transport.

According to the definition, multimodal transportation in passenger traffic is the transportation of passengers (development of passenger traffic or its individual segments) on the basis of logistics principles in a particular direction by means of transport. They are distinguished from intermodal passenger transportation by the absence of responsibility of one carrier for the entire trip for different types of vehicles.

International Union of Railway Unions in its action plan until 2022 highlights the importance of improving the multimodal passenger transport, calling for a multimodal vision with public transport and supply chain stakeholders. The UIC World Passenger Forum aims to ensure uninterrupted and sustainable multimodal transportation, taking into account each section of the forum and considering it from different points of view and with different stakeholders.

When organizing multimodal passenger transportation with the efficient use of railway transport, it is necessary to revise the existing concept of this type of communication, taking into account modern trends. Currently, mainly multimodal transportation means the joint use of a train and a bus.
2018 was declared by the European Commission as the «Year of Multimodality». The goal was the Commission's commitment to reduce CO2 emissions, improving transport safety and the competitiveness of its own industry[16]. Key areas included: digitalization, the use of economic incentives, support for infrastructure development and innovation, improving the legal framework to protect passengers, and encouraging «active mobility».

In November 2019, two studies were published on multimodal passenger transport:

1. A study of the remaining challenges for integrated ticketing and payment systems in the EU highlighted the importance of digital solutions that make it easy to book and buy tickets online for door-to-door travel, enabling safe, convenient and efficient passenger transport. The study identified commercial barriers to integrated systems implementation, including low collaboration between companies, unavailability of data, and a wide variety of policies and programs. At the same time, the consultation with interested companies demonstrated a clear interest and potential demand for a single integrated ticket sales system throughout the European Union.

2. A study of passenger rights in a multimodal context discovered that multimodal travel with a single ticket remains a niche market: of the 67 million multimodal transportations per year in the EU, only 5% are based on a single ticket. When traveling in multimodal traffic, passengers cannot be fully protected throughout the entire journey, since the legislation is based on individual modes of transport, and the creation of a new targeted legislative instrument can solve this problem. Thus, despite the existing problems, the high importance of the development of multimodal communication is recognized. According to Deutsche Bahn AG (German Railways), the integration of new mobility services such as sharing, interconnection and on-demand transportation contributes to sustainable mobility in cities and rural areas, making the rail system sustainable and strong.

In terms of multimodal transportation, the Austrian State Railways (OBB Holding) passenger transport regulations only state that in order to travel on trains and buses operated by OBB, a passenger only needs a ticket, which is a proof of a carriage contract. You can buy it both at the box office and in the application and on the company's website. Federal Passenger Company JSC has been organizing multimodal traffic (using motor vehicles) since December 1, 2014. In the suburban sector in 2016, multimodal passenger transportation under the «commuter train + bus» scheme was carried out by 9 suburban passenger companies - subsidiaries of the Russian Railways. In 2018 110 new multimodal routes were introduced, the main of which are: Belgorod-Alekseevka-Rossosh-Adler / Kislovodsk-Anapa-Novorossiysk, Boksity-Serov-Yekaterinburg, Valuiki-Stary Oskol-Moscow, Vologda-Yaroslavl-St. Petersburg, resorts of Abkhazia. The share of JSC Russian Railways in the passenger turnover of the transport system of Russia comprises 26.4%. The company ranks third in the world in terms of the carried passengers. Nowadays, Russian Railways is betting on the development of multimodal transport hubs that meet the needs of all categories of passengers. As a unified information system, Russian Railways plans to use the Innovative Mobility IT platform to sell tickets in multimodal traffic. This system should reduce travel time by choosing the best route, manage the trip through a single interface and provide information on the total cost of the door-to-door trip. The company pays great attention to the development of passenger transportation, experimenting with new business models of services. «Wi-Fi at stations and on trains, mobile applications, new payment methods, electronic tickets, train media portal, bonus programs are becoming a reality today.»

In this section, we consider the digitalization of multimodal transportation services using the example of one of the world's leading railway operators - the French National Railways Society (SNCF).
In 2020, the company set a goal to increase the number of passenger-kilometers by 25% within ten years. For this purpose, SNCF decided to place the client in the «center», combining all sustainable (reducing environmental impact) modes of transport, optimizing mobility and improving travel comfort and accessibility. The development of multimodal passenger services SNCF has also included the new Tech4Rail program in its five main segments. French Railways are betting on their corporate mobile app «Assistant SNCF», calling it «a personal assistant on mobility». This application supports planning an itinerary, book and use the etix on the smartphone. Mobile application supports planning an itinerary combining different kinds of transport. The training interface is presented on the following scheme. (Fig. 5).

Source: mobile applications Russian Railways - Passengers, Assistant SNCF, DB Navigator

Fig. 5. Interfaces for selecting directions in the mobile applications of Russian Railways (Russian Railways - Passengers), SNCF (Assistant SNCF) and DB AG (DB Navigator).
When forming a request in the application, you must enter a choice in the fields «Départ» (departure) and «Arrivée» (arrival): either a train station, or a city, or a place. You can also choose the type of vehicle: train, bus, Taxi, bicycle, Personal car. In this case, the order of a taxi is made separately from the train.

With the introduction of the route «from the address» Paris, avenue des Champs-Élysées, 120 (the representative office of Russian Railways in France) «to the station» route options: «nearest train», «fastest» and «other routes», below a drop-down list with all other routes. When choosing a specific route, the user is taken to the navigator window, then when the «Réserver votre billet» button is pressed, the user is redirected to another mobile application of the company - Oui.sncf. The Oui.sncf app can only purchase a train / bus ticket.

Thus, we can conclude that the Assistant SNCF application is more a navigator, including only the ability to plot a route. In addition to the bus and train, other forms of transport such as taxis or metro cannot be included in a single electronic travel document. In this case, to purchase a train ticket, the client is redirected to another mobile application. This presents a certain inconvenience to the user, since a person on one smartphone must have two different programs to choose a route and purchase a ticket. Optimizing user experience requires seamless integration of application data. Of course, in its assistant, SNCF launched the optimization and simplification of the interaction of passengers with transport, the application itself contains great potential for development. Among the advantages, one can note the high information content, ease of use, design, optimization of the program for smartphones and tablets.

Despite the obvious development of customer services, currently SNCF itself carries out multimodal transportation and ticket sales only using train and bus, like all other companies, as evidenced by the response to our request No. 00445457 in Oui.sncf - a subsidiary of the company selling travel documents.

The interface of the windows for selecting directions and issuing electronic travel documents «from station to station» through corporate mobile applications of Russian Railways, SNCF and DB AG are shown in Fig. 2.

Thus, it is obvious that the most promising direction of multimodal transportation is the combination of trains not only with regional bus routes, but also the integration of urban transport through the digitalization of services and the development of customer services. At the same time, for the passenger himself, this should optimize the travel route, reduce losses and costs, and for operating companies - help attract additional customers, optimize business processes, which in turn will help increase profits and reduce the risks of falling demand.

3 Results

On the basis of domestic and foreign experience, analysis of modern innovative technologies, general digitalization, as well as to increase the comfort of using passenger transportation services, it is proposed to include other types of vehicles in addition to buses, such as urban passenger transport, in the system of organizing multimodal passenger transportation with the effective use of rail transport. (Buses of large and small capacity, trolleybuses, trams, monorails, metro), regional and interregional transport, taxis. In this context, the integration of multimodal transport follows, including interregional and interstate communication with intracity and agglomeration public transport (Fig. 6).
The interaction scheme implies maximum simplicity and transparency of information for all participants in the transportation process. The «key block» represents the core and contains two main segments: long-distance trains and commuter trains. Buses are added in the multimodal block. The system implies the possibility of combining them, including these vehicles in the transportation separately (except for the bus), in pairs or together. This mainly depends on the availability of messages in specific localities.

When issuing a travel document through a smartphone or the website of the operator, the client must plan his route «from door to door», choosing addresses as the starting and ending points, not stations (Fig. 7). Further, the system forms the most optimal route for the passenger, including movement through the settlements. Depending on the choice of the settlement, the passenger should be able to include other types of passenger vehicles in the multimodal route—taxi or city transport: metro, tram, bus, trolleybus (the availability of these types of transport will depend on the existence of agreements signed between the carrier companies; bearing in mind the vast territory of the Russian Federation, not only operating companies, but also regional and local governments should be interested in concluding these agreements).

At the same time, the total time spent on movement should be minimal. The objective function will have the form:

$$F = Q_{ij} \cdot t_{ij}$$

where $Q_{ij}$ – passenger flow of a given direction; $t_{ij}$ – time for passenger moving.
Time spent on a passenger moving:

\[ t = t_{mov1} + k_{mov} \cdot (t_{wait} + t_{mov\ ITPM} + t_{mov2}) + t_{mov2} \]

where

- \( t_{mov1} \) – time spent on moving a passenger from the original location (departure address)
- \( t_{wait} \) – time spent waiting for boarding a vehicle, min;
- \( t_{mov\ ITPM} \) – the cost of terminal passenger movement (ITPM), min;
- \( t_{mov} \) – time spent on movement in a vehicle, min;
- \( t_{mov2} \) – time spent on moving a passenger from a bus stop, metro, taxi, etc. to the final location (destination address);
- \( k_{mov} \) – the interchange coefficient, which depends on the population of a city or megalopolis (Fig. 8).

### 4 Discussion

Railway operators should become aggregators of local transport companies and urban transport systems. At the same time, for the organizations themselves (for example, for carriers of passengers in long-distance and suburban communications (JSC FPC, JSC TC GSE, JSC SKPPK, JSC KEP, LLC UPPK, etc.) this will be a positive factor in the form of business support and the elimination of risks, and for the passenger convenience in the form of a single ticket, reliability and assistance in being in an unfamiliar city: you can often encounter a situation, especially in large settlements where several train stations are located (for example, Socchi) that a person does not know which station to issue a ticket to or does not know about its existence; indeed, navigators, electronic maps can easily solve this problem, but all these are additional actions that complicate the interaction of the client with the operator company's website, but also at ticket offices, while the cashier, in addition to tickets, must issue the client a card generated by the system, and the system should not exclude the standard purchase of a ticket «from station to station». Ticketing through the Internet services of railway stations should be digitalized, among such services, for example, calling an escort for passengers with limited mobility (through the Mobility Assistance Center) or booking long-term rest rooms (smart-hotel). In this case, railway stations act as modern transport interchange hubs (TIH) (Fig. 9), providing transfer of passengers between different modes of transport and servicing passengers with social infrastructure facilities.

![Fig. 8.](image_url)

Intercharge rate

Population, thousand people

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**Fig. 8.** Dependence of the coefficient of the transshipment on the number of the population.
According to studies, the most significant factors for passengers when using TIH, in addition to high quality of service, appears to be comfortable transfer conditions, efficiency and completeness of the vehicle schedule, ease of orientation within the TIH and reducing the time spent on transferring within the TIH. Convenient orientation within the TIH due to the introduction of electronic navigation stands, improvement of passages between TIH points, placement of signs, etc. will reduce the time for transferring passengers and, in general, will increase passenger loyalty.

5 Conclusions

Rail transport, in general, awaits a second rebirth. Its importance as a tool for optimizing the transport systems of settlements is growing in parallel with the increase in the share of motor transport, which has recently increased the load on highways more and more. The results of the study allow us to conclude that the combination of transport through multimodal passenger transportation contributes to increased mobility, erasing the distance for the passenger and providing the client with real freedom of movement.

References

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