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THE SIGNIFICANCE OF PASSENGER TRANSPORT HUBS IN THE TRANSPORT SYSTEM: FACTORS OF THEIR DEVELOPMENT

The modern transport system includes not only the effective functioning of all modes of transport included in it, and the corresponding infrastructure, but also their interaction and complementarity, the purpose of which is to fully satisfy the needs of the client – the cargo owner or passenger. In this regard, today the issue of designing and developing passenger transport hubs – hubs, characterized by all the necessary complex of transport and related services provided to the passenger, is relevant. Therefore, the choice and development of hubs for passenger transportation is an important component of the country's transport and logistics system, which requires special attention, since the subsequent choice for the use of a hub by passengers is based not only on the possibility of obtaining the main transport service, but also on a set of accompanying significant for the passenger services. This determines the set of influencing factors taken into account when designing passenger transport hubs, as well as included in the economic-mathematical model, which makes it possible to evaluate not only the efficiency of the functioning of existing passenger transport hubs and the direction of their development, but also to assess the potential efficiency in the design of passenger hubs.

The significance of the development of passenger transport hubs is determined by the need to improve the quality of passenger service by increasing the level of comfort and services provided, increasing their availability, as well as providing more economical options. Therefore, the development of passenger hubs today is an important aspect not only of passenger logistics, but also a significant factor in improving the efficiency of the country's transport system, increasing its economic stability and transport and economic security, as well as improving the quality of life of the population.

Keywords: *passenger transport hub, influencing factors, accessibility, efficiency, transport system, design and development.*

Introduction

The transport system of any state is a fundamental link in its economy in view of the fact that it provides not only the movement of raw materials and finished products, as well as the transit of goods and raw materials, but also ensures the mobility of the economically active population and satisfies the recreational needs of people. Therefore, the modern transport system is not only the effective functioning of all modes of transport included in it, and the corresponding infrastructure, but, above all, their interaction and complementarity, the purpose of which is to fully satisfy the needs of the client – the cargo owner or passenger.

The transportation industry has long been an essential component of modern civilization, facilitating the mobility of both individuals and enterprises [1]. At the same time, it is relevant to use the so-called «hubs», which are a transport interchange hub, including a comfortable interchange zone that unites all types of public transport at one point. The choice and development of hubs for passenger traffic is an important component of the country's transport and logistics system, which requires special attention, since the subsequent choice for the use of the hub by passengers is based not only on the possibility of obtaining the main transport service, but also on the complex of related services of the passenger logistics complex.

Purpose of the study

The selection of the optimal hub for passenger transportation is of the utmost importance, as it can substantially affect the effectiveness and efficiency of the transportation system [2]. At the same time, from the standpoint of economic efficiency, it can be characterized as a complex economic and mathematical model that includes several variables, the main of which are availability, connectivity, throughput, and efficiency [3]. Their consideration as fundamental factors (in combination with secondary factors that are significant in specific conditions) in the construction and modernization of transport hubs and terminals of various categories will significantly simplify the functioning of the passenger transport system and increase their efficiency.

The purpose of this article is to consider various factors and their combinations that arise in practice and are significant in the design of new passenger transport hubs or in the modernization and improvement of existing ones.

The determining the significance of factors

Accessibility – is one of the primary factors determining a location's suitability as a transportation hub. The hub must be situated in a location that is simple to get to and well-linked to various forms of transportation [4; 5]. Such areas include highways, railroads, and airports. In addition, it should be noted that the proximity of a transport hub to residential areas, shopping areas and tourist sites also significantly affects its accessibility. However, at the same time, when planning large hubs, this factor has an inverse effect on the attractiveness of adjacent residential areas.

The transportation hub must handle many passengers and cargo. This requires the hub to have adequate facilities, such as terminals, parking lots, and baggage handling systems. This factor should take into account that the capacity of the hub must meet the requirements of the transport system to ensure its efficiency.

When designing and subsequently maintaining a hub, an important aspect is its location and the necessary characteristics (throughput, baggage handling volumes, etc.). This includes the initial investment, operating costs, and maintenance expenses [6]. That is why the design should take into account the potential indicators of the economic efficiency of the transport hub in comparison with its potential benefits for the overall transport system.

The hub should provide uninterrupted communication between different modes of transport, their convenient «docking» for passengers [7]. This means that travelers should be able to change from one mode of transport to another without experiencing significant delays or difficulties. Such multi-

modal connectivity of nodes is necessary to improve the efficiency and effectiveness of the transport system, since the lack of passenger logistics has a negative impact on traffic volumes and their final efficiency.

The transport hubs must provide travelers with a comfortable and convenient environment [8]. This implies that it has to include features like dining establishments, retail stores, and lounges. These amenities may greatly enhance the whole travel experience and increase passenger satisfaction. It should be noted that these consumer preferences are not always possible to take into account in full, as they excessively increase the number of influencing factors (variables) taken into account in the economic and mathematical model for calculating the potential efficiency from the operation of a particular passenger hub.

Therefore, in the context of hub selection, factor analysis can uncover the essential aspects influencing the selection reason for passenger transportation hubs [9]. It assists in minimizing the number of variables and summarizing their interrelationships. Using factor analysis to determine the reason for picking passenger transportation hubs, we may identify the most significant decision-making factors. Transportation planners and decision-makers may make informed judgments about the location, design, and development of hubs that best serve the needs of passengers and the transportation system through factor analysis.

It is important to note that modern transportation systems rely heavily on passenger transportation hubs. They play a crucial role in easing the flow of persons and products, fostering mobility, and linking communities. Depending on criteria such as geographic location, population density, economic development, and transportation infrastructure, the experiences of various nations in utilizing passenger transportation hubs can vary significantly. One of the most notable instances of a highly developed passenger transportation hub is the Tokyo Metropolitan Area in Japan. For instance, Haneda Airport is the primary base of Japan's two major domestic airlines, Japan Airlines (JAL) and Skymark Airlines. It handles more domestic flights than Narita Airport, with over 80 million passengers in 2022. For example, Tokyo Station is a central transportation hub with trains and buses connecting it to Haneda Airport. At the same time, free access is also provided directly to Tokyo and back, transfer transport terminals and nearby hotels of various classes. These transportation hubs serve as entry points for people traveling in and out of Japan, linking them to various regions. The Japanese government has invested considerably in developing these transportation hubs, and as a result, they are equipped with cutting-

edge facilities and offer passengers seamless connectivity.

In Europe, the experience of using passenger transportation hubs differs significantly across countries. Several large airports and train stations serve as transportation hubs in the United Kingdom's well-developed transportation network. London Heathrow, London Gatwick, and Manchester Airport are among the busiest airports in the UK, connecting travelers to destinations within and outside the country. Multiple airports and train terminals serve as passenger centers in cities like Paris and Berlin, with well-developed transit networks.

At the same time, in other countries where the transit passenger traffic is not so large, as well as the volumes of incoming and outgoing passenger flows, the experience of effective functioning of passenger hubs is not so great. Passengers in such countries often need logistical support in the implementation of transport services due to long waiting times, poor communication and insufficient comfort of the terminals. The Head of such countries needs not only to implement measures to develop transport infrastructure, but also to make appropriate investments in the development of passenger hubs, as a result of which the experience and efficiency of their use is gradually increasing.

At the same time, the developing nations frequently require assistance in constructing multimodal transportation hubs. However, many developing nations are modernizing their transportation infrastructure, and constructing passenger transit hubs is a significant aspect of their efforts. It should be noted that India, for example, has been enhancing its transportation infrastructure. It has established several multimodal transportation hubs, like the Mumbai Central Terminal, as transfer locations for trains, buses, and taxis. Consequently, the creation of passenger transportation hubs is beneficial both for the individual consumer – the passenger, and for society as a whole. It should be noted that an important element of the logistics of passenger transportation is the quality management of passenger service during the period of initial and final operations, i. e. the complex of station services [12]. First, it enables a seamless transfer between various transportation forms, saving travel time and making it easier for individuals to reach their destination. Secondly, it facilitates public transportation by decreasing traffic congestion and air pollution. As well as well-designed passenger hubs bring economic benefits, including increased jobs and employment opportunities for skilled workers of various categories, and as a result, increased economic activity in the surrounding areas.

Conclusion

Returning to the need for a qualitative selection of factors for factor analysis in the design and development of passenger hubs, it is important to note that in order to provide passengers with a seamless transportation experience, different nations have different selections of criteria that influence the utilization of passenger transportation hubs. Thus, the main factors evaluated and taken into account when building an economic and mathematical model are the following:

- the place where transportation hubs are located greatly affects how they are used [5]. A centrally placed hub with easy access to main thoroughfares, motorways, and airports may attract more travelers and boost use;

- the usage of transportation hubs may be improved by a well-connected transportation network, including an intermodal connection between various forms of transportation [7]. Public transportation services, including buses and trains, may be integrated with the hub to provide a seamless connection to passengers, reducing travel time and enhancing the entire travel experience;

- in terms of the infrastructure component Having enough parking spaces, waiting rooms, and food and retail alternatives may greatly improve the utilization of transit hubs. Having basic amenities like toilets and ticketing areas is another way to enhance the passenger experience;

- the safety and security of transportation hubs are crucial factors that influence their use. Adequate security measures, such as CCTV cameras and security personnel, can provide a secure environment for passengers, increasing their confidence in the hub;

- the cost of using transportation hubs, including parking, ticketing, and other amenities, can impact the frequency of use. The availability of hubs and the cost of alternative modes of transport have a significant impact on passenger choice of hubs.

When compiling an economic and mathematical model that will allow evaluating the efficiency of an existing or designing a new passenger hub, the above factors must be taken into account not in equal shares, since their influence is unequal, but taking into account the coefficients of significance. It is possible to obtain such coefficients by ranking the necessary factors using the method of expert assessments or by questioning passengers. The values obtained in this way make it possible to effectively simulate in practice the results of the functioning of passenger hubs, the transport system and their impact on the main indicators of the socio-economic development of the region (including population mobility, the level and structure of employment, the availability of healthcare, educational and recreational services).

The development of passenger transport hubs also aims to help transport companies and related service providers improve the passenger experience by improving amenities and services, increasing accessibility and connectivity, and providing more economical choices.

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It should also be noted that the development of passenger hubs today is an important aspect not only of passenger logistics, but also a significant factor in improving the efficiency of the country's transport system, increasing its level of economic stability and transport and economic security.

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