Transport and Logistics in a Modern Metropolis: New Opportunities

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Abstract*: The purpose of the present study is to analyze the problem areas in logistics of integrated public transport systems of the metropolis and ways to address them, necessary for the implementation of the tasks required to increase the success of the public transport system. To achieve this goal, the method of an expert survey of specialists was used. Respondents were representatives of the city administration (Transport Department), executives of transport companies, and experts in the field of transport logistics, whose work experience was exceeding 15 years. In consequence of conducted research, the identified problem areas in the logistics of integrated public transport systems concern the harmonization of traffic schedules, transfer hubs, and providing integrated information to passengers. Noted problems can be solved by ensuring public transport adjustment and reducing waiting time, physical integration of interchange stations, accessibility, and multimodality of transfer hubs, integrated planning of stops and stations, determining the information needs of passengers, and wide access to unified information on multimodal transport. It is concluded that the effective management of logistics within the metropolis provides for economic benefits through more efficient use of transport infrastructure and various transport means, improvement of the level of logistics services, and regulation of the transport services for the needs of residents.

***Index Terms*: integrated information for passengers, integrated public transport system, logistics, megapolis, traffic schedule harmonization, transfer hubs, transport logistics.**

I. INTRODUCTION

Contemporary conditions for economic development and functioning contribute to the emergence of new requirements and needs of consumers that has led to structural and functional transformations of cities. In these conditions, logistics becomes a tool that provides the best conditions for business and improves the quality of life for residents through the rational implementation of logistical functions. This leads to providing effective service to the city residents, and its development. Logistics of the city is one of the key elements of the urban economy, which covers the housing and communal services, urban construction, as well as resource and infrastructure facilities management.

In many cities, the lack of reliable and affordable ways to ensure public mobility remains an obstacle to the healthy economic development of the metropolis because new jobs are often created far from places of residence. This deprives many people of access to opportunities for getting income, markets, and education, and therefore greatly limits their participation in public life. Where public transport services are not available, mobility problems are mainly addressed by two-wheeled motorized transport, private cars, and mini-buses. The increase in the number of owners of motorized vehicles without the use of rigid countermeasures leads to the emergence of large traffic jams. The construction of greater number of roads leads neither to the increase in speed nor to a reduction in travel time because each expansion of the infrastructure contributes to the emergence of additional transport units. Short-term improvements quickly come to naught in the medium term due to the fact that new opportunities lead to the emergence of new vehicles. In addition, private motor vehicles carry high direct and indirect (or external) costs, because increased traffic leads to lower air quality, higher accident rates, and noise levels.

To change this trend, it is necessary to strengthen the integration of all modes of transport, up to the point, where this service will be perceived as an attractive alternative to private motorized transport. A major step towards creating an attractive and quality public transport system is an attempt to provide better integration of means of public transport (with physical infrastructure and traffic schedules), as well as their integration with active ways of movement (pedestrian and cycle traffic). Such goals can be reached through carrier alliances, which are a powerful tool.

II. LITERATURE REVIEW

The city logistics concept is defined and interpreted differently. In general terms, the definitions are reduced to a concept that brings together the entire logistics system of the city, with particular emphasis to the transport, which ensures the movement of people as well as goods in order to provide effective and at the same time environmental coordination of all flows in the city [1]. Thus, the concept of urban logistics is becoming widespread in the context of urban processes growth. Savelsberg M. [2] defines the concept of "city logistics" as a system of spatial and temporal transformation of logistics flows (primarily people and goods) through the city center. A number of research publications are dealt with certain aspects of urban logistics development, which analyze the fundamental provisions of urban logistics and international management practices in this area [3], the use of logistics in the passenger and transport flow optimization [4], [5], and the application of information technologies in urban logistics [6], [7].

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Available works indicate the fact that the issue of logistics integration of public transport is not sufficiently covered in Russian-language scientific publications.

At the same time, numerous studies are devoted to the concepts, models, and issues of urban logistics planning [8], peculiarities of urban transport system management and implementation of urban transport [9], modeling of urban logistics systems [10], organization and modernization of transport in megacities [11], transport policy implemented on an urban scale, as well as measures taken on an urban scale to mitigate the adverse effects of freight transport [12], various theoretical and practical aspects of urban logistics management, and the development of urban transport logistics [13], [14].

That is why the study of the features of logistics management of public transport, the issues related to analysis of integrated public transport systems from the standpoint of logistics, and the definition of organizational options for deepening the integration of public transport require further research.

III. PROPOSED METHODOLOGY

A. Algorithm

When solving the set goal, the expert survey method was used to determine the problem areas of logistics of integrated public transport systems of the metropolis, as well as ways to solve them.

Eighteen specialists, namely, representatives of the city administration (Transport Department), executives of transport companies, and experts in the field of transport logistics, whose work experience was exceeding 15 years, were involved in the expert evaluation.

During the application of the expert assessment method, the main emphasis was made on determining the characteristics of integrated public transport systems from the standpoint of logistics and solution opportunities, necessary to implement the tasks of increasing the success of the public transport system operation in the metropolis. At that, experts were invited to indicate the most significant, in their opinion, problem areas of integrated public transport systems, provide their detailed description, and give examples of their solution from global practices.

Processing the survey results consisted of determining the ranks of the most important problem areas of logistics of the integrated public transport system in the metropolis, and qualitative assessment of ways to address them. When processing the results of the survey, the problem areas of integrated public transport systems and their solutions mentioned by more than half of the interviewed experts were taken into account (Fig. 1).

B. Flow chart

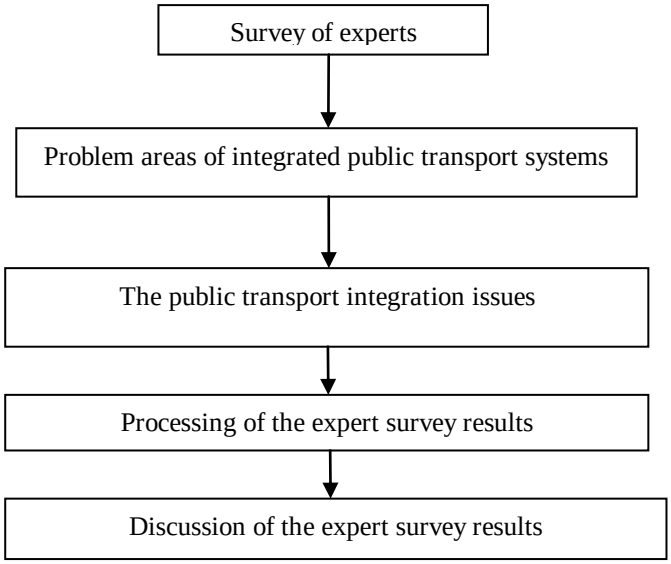

Fig. 1. Research algorithm

IV. RESULTS AND DISCUSSION

The results of the expert assessment allowed determining the most significant problem areas of the integrated public transport systems (more than 50% of references) from the standpoint of logistics (Table I).

Table I. Problem areas of integrated public transport systems (expert assessment)\

Problem areas	Characteristics of the problem solution	Percentage of mentions	Rank
Harmonization of traffic schedules	Providing compatibility and reducing the waiting time	77.6%	1
Transfer hubs	Physical integration of interchange stations; Availability and multimodality; Integrated planning of stops and stations	72.2%	2
Integrated information for passengers	Determining the information needs of passengers; Providing data: wide access to unified information on multimodal transport at stations over the Internet, the phone, and at service points	61.1%	3

Coordination of traffic schedules as a problem area has received the largest number of mentions (77.6% of respondents).

The main purpose of creating any traffic schedule is to provide passengers with the transport of adequate occupancy, which becomes

the most serious problem in today's megacities, especially in densely built-up city centers.

According to experts, traffic schedules are particularly important if services are provided at long time intervals. Most probably, this is outside peak hours, and in less populated areas of megacities. In such cases, it is necessary to harmonize the traffic schedules for public transport. Real-time information on electronic displays and mobile devices notifies passengers of the next vehicle departure time, the possibility of transfers, and vehicles that are approaching the stop. Intelligent transport systems (ITS) have already become an integral part of modern public transport networks.

Traffic schedules have become a problem for buses and trams, which use public roads in mixed mode. In such cases, it is difficult to adhere to the developed traffic schedule. According to experts, the best option will be the arrangement of dedicated lanes for buses and corridors for trams, because this will significantly stabilize the traffic schedule. Another way is to keep the bus routes as short as possible (especially those that bring passengers to the subway lines). This will prevent the accumulation of delays within long time periods.

In the case of a direct trip, waiting time for passengers is easy to plan. When changing transport at transfer hubs, the task of carriers is to adjust the departure time on the transportation routes to reduce the waiting time for passengers as much as possible. At the same time, so-called traffic schedules with fixed intervals, when transfers between modes of transport are optimized in time, are quite effective.

For example, some European countries (primarily Switzerland, the Netherlands, and Germany) have created transport systems with fixed movement intervals. Fixed-interval traffic schedules are particularly important for the suburban areas of megacities, where the service regularity is limited. In such areas, services are provided at fixed intervals between vehicle departures (e.g., every 10-30 minutes). These intervals do not change during the day. Accordingly, passengers know that their bus or train always departs at the same time - for example, every ten minutes. Ideally, traffic intervals are also planned at interchange hubs, for example, at interchange railway stations, which offer convenient connections in all directions with short waiting intervals [15].

More than two-thirds of experts (72.2% of respondents) named transfer hubs as another problem area. In this connection, there is a need for the physical integration of interchange stations.

According to experts, the integrated transport system largely depends on the connections between the routes. This is especially important in cases, where the system of high-capacity express transport (metro, ground rail transport, and express buses) is a basic one. In such cases, it is necessary to pay special attention to the design of transfer hubs.

In order to reduce travel time and improve passenger comfort, it is necessary to minimize interchange distances. According to experts, this should be taken into account at the design stage. In the case of a transfer between the underground and the railway, this can be achieved by organizing multilevel stations, where different lines operate at different levels. Ideally, such stations should be located directly above each other, so that to move from one line to another it was possible to use just one staircase.

Even more convenient, although, as a rule, more demanding in the structural terms, is, as experts believe, the possibility of transport interchanges on the same platform. To do this, the corresponding transport lines must be on the same level. In this regard, direct hubs outside areas of dense settlement can be relatively less complex structurally, for example, bus and commuter train, or bus and urban land rail transport.

At the same time, experts emphasize that after the completion of construction, it is almost impossible to correct such mistakes.

The next solution to the problem of transfer hubs, according to experts, is ensuring their availability and modality.

The availability of public transport depends not only on bus routes but also on other modes of transport. This is especially true with regard to less populated areas of the metropolis. It is necessary to ensure appropriate harmonization for them as well. Drivers of private vehicles and cyclists require parking areas and suitable opportunities for getting off passengers at the stop or station. In addition, there should be appropriate areas for taxis, etc. [16].

In megacities with dense bicycle traffic, as noted by experts, it is important to take into account the possibility of organizing parking areas for bicycles near the junction stations like Mass Rapid Transit (MRT) and the largest bus stations. Another solution to the problem of transfer hubs, according to experts, is integrated planning of stops and stations. Usually, operators are planning only their own stations, often casting aside the issue of the arrangement of transfer hubs involving other routes, the bus or bike transport. Legislative planning and financial considerations limit operators, and thus they cannot influence the development of the territory outside their transport facilities. That is why, according to experts, in megacities, it is necessary to have integrated planning of stations taking into account all modes of transport, and opportunity for the practical implementation of such planning. This can be a very advanced and complex stations integration plan given that the station infrastructure often belongs to different operators with their particular interests, planning cycles, and financial capabilities. In Germany, for example, the government provides investment funds for the establishment of such infrastructure through its modal interconnection programs, if the operator's own funds are insufficient.

Experts also note that currently, public bicycle rental systems are rapidly developing in many cities. Today there are more than 1,000 bicycle rental networks.

Again, it is necessary to have here a suitable access infrastructure and direct connections to public transport. It is also possible to integrate and develop a bicycle exchange system, because the additional offer increases the flexibility of public transport, providing a continuous chain of trips.

Another problem area of integrated public transport systems in megacities is the level of informing potential passengers about provided transport services (61.1% of respondents).

In this connection, there is a need to determine the information needs of passengers.

The passenger's need for information depends on the type of passenger: those, who travel the same route every day, require little information. But the passengers traveling by different routes need more information. Economic development leads to an increase in the proportion of passengers with increased demand for information since the proportion of employees working in different places is increasing.

Passengers need information in two typical cases: first, when planning a trip (for example, from home), and second, directly at the bus stop. Traditionally, passengers usually receive traffic schedules in the form of booklets, which could be used at home, as well as in the form of traffic schedules at stops. Today, these obsolete forms of information are being replaced by advanced technologies.

An important task of carriers, according to experts, is ensuring the ease of information recognition and its availability at the right time in the right place. This includes accounting for the following details:

- standardization of the information provided (traffic schedule, map of the surrounding area, and network map at each station);
- standardization of station names (the same designation for all operators and in all documents, especially for interchange stations).

Advanced technologies are actively developing in the field of information provision. Information in digital format, available via the Internet and smartphone applications, not only informing about stops, but also allowing the search for individual addresses, becomes increasingly important for high-speed passenger services.

Obtaining information in real-time mode and the emergence of information systems about the traffic schedule throughout the metropolis have become the main achievement of recent years. This is a major factor in the development of existing systems.

Information on traffic schedules at stops and stations is increasingly supplemented by real-time information systems that show when the next vehicle arrives, taking into account actual delays or changes [18]. Today, in many countries, stops are equipped with QR-codes (rapid response codes), which allow smartphone users accessing at any time the schedule of transport departures from a particular station.

Although the amount of real-time information can vary, the main considerations to be clarified are as follows: (a) information, which should be provided to users, as well as the point where it is available (details of individual delays, general information on traffic disruptions); and (b) how to communicate complex information to passengers in the most simple and understandable way. One of the main tasks of carriers is developing solutions to provide passengers with the necessary information in a clear and understandable form, provided that the cost of such information will be acceptable.

The technological basis of all advanced information for passenger systems is the electronic traffic schedule, available on the Internet, as well as through user-friendly graphical interfaces. Most information systems in Central European countries, as well as in the growing number of megacities in Asia and South America, currently offer information with respect to specific addresses, including, walking distances to nearby stops [17].

Such systems usually contain detailed information about all transport services that are provided in a particular area, and therefore they can be used to find directions from or to a particular stop, address, or destination. Such systems usually contain detailed fare information and other important data. When entering the appropriate search criteria, one can obtain the main data of the found routes. More detailed information can usually be obtained from individual web pages or through direct links (for example, regarding lines used, transfer hubs, delays and traffic schedule violations, unhampered traffic flow, tickets, and fares).

Thus, in Manchester (UK) an independent company was established, which deals with the information for passengers. Manchester public transport information is very comprehensive and is increasingly being provided and used by a wide range of electronic media. The London Department for Transport, called Transport for London (TfL) also supports a sophisticated user information system. Many actual and potential customers use the TfL call center services every day: about 80% of customers use the recommendations of the information service; about 40% of passengers receive recommendations on how to simplify or reduce their routes; more than 10% of people would not use public transport in case if such information was unavailable [19].

In general, the integration of public transport systems includes many aspects, which are not only related to the above characteristics, but also take into account regional conditions and different modes of transport. Table II shows an approximate assessment of the public transport integration level in the selected cities.

Table II. Simplified assessment of public transport systems in selected metropolitan areas

	Transfer hubs	Integrated information for passengers	Harmonized traffic schedules
Hong Kong	O	O	
Singapore		O	O
IETT Istanbul		O	

STIF Paris	O	+	O
London	+	+	O
Rhine-Main Carriers Alliance (Frankfurt, Germany)	+	+	+
Zurich Region Carriers Alliance (Switzerland)	+	+	+

Notes: + means zones and modes of transport, which are covered in an integrated manner;
O means zones and modes of transport, which are covered just to a certain extent:

V. CONCLUSION

In developing countries, the proportion of private vehicle owners is growing rapidly, while the overall quality of public transport systems is often out of place. The efficiency of the new systems is reduced due to the lack of integration with other public transport services and nonmotorized transport, as well as through operational gaps and street competition between individual operators.

Carriers in Germany, Switzerland, Austria, and the Netherlands, as well as in some other metropolitan areas of the world were able to significantly improve the quality of public transport that had led to an increase in passenger traffic by three to four times, causing significant changes in the choice of mode of movement not in favor of private motorized vehicles. Their success is rooted in the integration of information systems, the harmonization of traffic schedules, as well as in the successful integrated planning of local transport development. Fully integrated public transport systems meet the needs of users for convenience, short duration of travel, comfort, and easy access to various travel modes.

Effective management and coordination of logistics processes within the metropolis, improvement of urban infrastructure management processes can both create conditions for a more comfortable life of residents, increasing the attractiveness of the urban agglomeration, and provide for economic and environmental benefits. This can be achieved through several measures, such as more efficient use of transport infrastructure and vehicles, as well as increasing the level of logistics services by optimal placement of logistics infrastructure, reducing environmental pollution by streamlining traffic flows, regulating transport supply for the needs of residents, and creating a quality transport system for the transport of passengers and goods.

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