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EXPEDIENCY OF MODIFICATION OF CITY TRANSPORT SYSTEM BY IMPLEMENTATION OF PASSENGER WATER TRANSPORT

Об'єктом дослідження є інтеграція місцевого пасажирського водного транспорту у транспортну систему міста. Серед низки проблемних питань можна виділити непідготовленість міської транспортної інфраструктури до впровадження водного транспорту для перевезення пасажирів, хоча цей вид транспорту є вагомою складовою внутрішньоміських і приміських перевезень пасажирів у світових мегаполісах, що розташовані на водних артеріях.

Надано характеристику водного транспорту і проаналізовано пасажирські водні перевезення в Україні. Досліджено дефініцію «транспортна система» в цілому і окремо – в частині міських пасажирських перевезень. Визначено складові транспортної системи міста.

Досліджено структуру міської транспортної системи м. Києва (Україна) і доповнено її новою підсистемою в елементі «міський пасажирський транспорт» – місцевим пасажирським водним транспортом. Така структурна зміна дозволяє якісно покращити наявне транспортне забезпечення міст, що мають водні акваторії, запропонувати місцевим мешканцям альтернативний вид транспорту. Впровадження нового виду міського пасажирського транспорту в транспортну систему міста потребує його детального дослідження. Тому цей вид транспорту структуровано, надано його класифікацію, сформульовано поняття «місцевий пасажирський водний транспорт» і його видів: Water Bus та Water Taxi, що дозволяє запропонувати їх до подальшого використання в науковому середовищі, стосовно місцевих пасажирських водних перевезень.

В межах дослідження запропоновано виділити елементи місцевого пасажирського водного транспорту, а саме: пасажирів, транспорт, підприємства місцевого пасажирського транспорту, суб'єкти нормативного забезпечення, місцеві органи влади. Кожен з елементів запропоновано структурувати за видами.

Завдяки цьому розроблено модифіковану схему системи міського пасажирського транспорту, чим забезпечується підґрунтя для гармонійного впровадження цього виду транспорту. Реалізація запропонованих змін обґрунтована соціально-економічною значимістю вказаного виду транспорту та необхідними якісними структурними змінами в міській транспортній системі.

Ключові слова: транспортна система, пасажирські перевезення, міський водний транспорт, місцевий пасажирський водний транспорт.

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1. Introduction

The innovative processes observed today in the transport sector of the world make it possible to carry out qualitative and structural changes in the transport system as a whole. The transport infrastructure in the cities of Ukraine is in a state of significant moral and physical deterioration, although vehicles are periodically updated in some large cities, but this is not enough to meet the mobility needs of residents and relieve urban transport routes. The transport system of million-plus cities needs to be updated by introducing new types of urban passenger transport (trams, high-speed Bus rapid transit, ultra-compact cars, a network of public cars, unmanned public transport, bike racks over the entire city of Sky Cycle etc.).

These innovative projects require significant investment and can't immediately find supporters among users. But for conglomerates with waterways, it is advisable to offer the implementation of water transport as part of the urban transport system (UTS). Passenger water transport will organically complement UTS, which will allow to qualitatively expand and unload the transport infrastructure of any locality that needs passenger water transportation. There will be an impetus for the further development of transport services for residents of cities and suburbs and tourists, which will contribute to increasing tourist attractiveness and improving the image of the city.

The relevance of the chosen direction of the study is justified by the need to modernize and optimize urban passenger traffic, it is impossible without structural changes in the transport system of the city.

2. The object of research and its technological audit

The object of research is the integration of local passenger water transport (LPWT) into the transport system of the city.

The use of water transport for passenger transportation at the local level (within the city, suburban area) is widely used throughout the world (USA, Canada, Scandinavian countries, the Netherlands, France, Italy, Japan, China, etc.). In cities with lakes, river or sea routes, passengers are transported by water on specific routes or on order. Such transport is on schedule or without it, but always in contact with related modes of transport, which are public and private urban transport. To optimize the activities of the entire UTS, it is necessary to optimize the work of each of its components. When using several adjacent modes of transport, the movement of passengers should be carried out without unnecessary downtime in the transport hubs. Therefore, the main bottleneck in the proposed study is the inclusion of LPWT in the transport system of the city. Overcoming this problem is possible by modifying the UTS and its structural transformation.

The study of water transport as integral UTS is not fully implemented, therefore, it needs concentrated attention from scientists.

3. The aim and objectives of research

The aim of research is development of theoretical provisions for the modification of the urban transport system due to its structural transformation by introducing a new component of the UTS: passenger water transport.

To achieve this aim, the following objectives are defined:

1. To carry out a study of the theoretical aspects of the transport system of the city.
2. To clarify the conceptual apparatus of local passenger water transport.

4. Research of existing solutions of the problem

An increase in the number of vehicles changes the transport system of the city and worsens its transportation capacity. Many scientists consider water transport as an alternative to land transport and suggest its use at the city and local levels.

Thus, the authors of [1] investigate the time series of demand for vehicles (the ferry system between Salvador metro station and Itaparica island (Brazil)) using the non-linear Fokker-Planck equation. Application of the proposed methodology allows to obtain high-quality behavior of demand for a vehicle with the corresponding statistical significance and ensure the logistics of shipping and improve the adaptation of the transport system to local and regional needs. In general, the study points to the need to strengthen efforts to organize the local transport system through coordination between authorities, transport companies and customers.

The study [2] proposes the creation of an urban transport system involving water transport (in the respective settlements). According to the author, such structural changes are necessary to meet the interests of the city, local residents and tourists. These transformations will contribute to the sustainable development of the local economy, because today

there are already effective forms of equivalent networks of the urban transport system.

In [3], a factor analysis of passenger transportation by city water transport in the city of Stockholm (Sweden) is carried out and a model of the structural equation to study the influence of the characteristics of water transport services on the general pleasure of passengers is proposed. The result of the study is the assertion that the «hidden comfort» factor (ship cleanliness, environmental friendliness, picturesque scenery) is more significant in explaining the overall satisfaction of passengers than service problems, such as size and frequency of traffic. So, the widespread use of such non-traditional attributes of services can give a better picture of passenger behavior when choosing a mode of using urban water transport and will help in further planning of the service.

The authors of [4] investigate the operation of micro-ferries for local transportation, focusing on the dependence of the amount of energy consumed on the change in the speed of the ship. The research problem is the planning of boarding, disembarking and delivering passengers, taking into account the amount of energy consumed, depending on the speed of the micro-ferry. As a result, a modeling method is proposed for solving the planning tasks of such a transport, which takes into account the energy consumption.

Most of the scientific works in the field of developing the passenger water transport market pay attention to cruise and entertaining passenger transport by water, bypassing transport. Transportation should be understood as transportation provided in the system of public city or local transport to meet the daily needs of users of these services in movement. In particular, research requires the LPWT operation and the organizational basis for its functioning as a UTS component.

The issues of the functioning of the transport system are constantly investigated and improved by scientists.

Thus, the authors of [5] develop a method for determining municipal expenditures and revenues in the urban transport sector and their distribution into urban transport systems: pedestrian, bicycle, automobile, freight and local public transport. In [6], the concept of a simulation model for assessing the sustainable development of urban transport in the social, economic and environmental dimensions is presented. The authors of the study [7] consider urban transport as a complex system and are exposed to politics. They investigate this effect on the urban transport system with a focus on environmental, economic, and transport indicators.

The theoretical aspects and conceptual apparatus of the transport system are disclosed in many works. So, in [8] it is indicated that the transport system is a territorial combination of interconnected modes of transport, which, interacting, most fully satisfy the needs of the national economy and the population in the transportation of goods and passengers.

The author of the publication [9] believes that a single transport system is a set of internally coordinated, interconnected, socially homogeneous vehicles, with the help of which an organizing and stabilizing effect on the implementation of the main tasks in transportation, reflecting their structure, is provided.

In [10], it is noted that the transport system is a combination of means of transportation, means of communication, means of control and communication, technical facilities that ensure their operation.

And the author of [11] calls the transport system a complex consisting of certain types: railway, sea, river, automobile, pipeline and air. They interact with each other and make up the transport system, developing under the influence of the economy as a whole and its individual industries.

So, based on the research, let's note that the city's transport system, in terms of passenger traffic, is formed by urban passenger transport, consisting of road transport, trolley buses, trams, subway, funicular and local water transport. As it is possible to see, the activity of urban passenger transport is widely studied, but attention is generally paid only to its land-based types, which are divided into passenger, cargo and special purposes. Studies of water transport for urban passenger transport remain outside the field of view of scientists and require theoretical and methodological justification.

5. Methods of research

During the execution of the work, general scientific and special research methods were applied:

- abstract-logical and grouping – with theoretical generalizations, disclosing the essence of concepts and forming conclusions;
- analysis and synthesis – for a preliminary analysis of the problem, the definition of goals and objectives; UTS structuring; development of the LPWT classification and definition of its elements; research of features and analysis of the current state of UTS and LPWT;
- analogies and comparative comparisons – to determine the feasibility of introducing LPWT into the UTS scheme as its component; comparing LPWT with other types of urban passenger transport; systematization of research results;
- decomposition method – for the UTS investigation as a complex system consisting of separate interconnected subsystems that have certain constituent elements.

6. Research results

Transport is a complex system that is divided into subsystems. This branching is due to the need to provide a wide range of transport services. The unified transport system of Ukraine consists of:

- public transport (rail, sea, river, road and aviation, as well as urban electric transport, including the subway);
- industrial railway transport;
- departmental transport;
- pipeline transport;
- public communication lines.

Passenger traffic is provided by all means of transport (except for pipelines). At the same time, there is an incomplete use of the potential of water transport, and in recent years its gradual decline, although transportation is carried out by sea and river routes.

The classification of water passenger transportation is quite wide and is reflected in many works [12, 13]. Both sea and river passenger transportation can be carried out at the local level, that is, within a certain territorial unit (village, country, city, region). Especially such transportations are inherent in river transport (long-distance transit traffic, local, suburban and intracity traffic), however, sea transport also provides bus routes within the port or region.

Passenger transportation by any means of transport is provided by UTS, which is quite complex and is formed from certain subsystems. For example, in [14], three subsystems of urban public passenger transport are identified:

- 1) transport (a business sector of the city that provides transportation services);
- 2) population (potential carriers of need for movement);
- 3) city government (mandatory strategic unit for the development of the city).

Let's believe that these are probably not separate subsystems, but elements of the general system of urban passenger transport, which, interacting, contribute to meeting the demand for transportation.

UTS should be structured using the example of a city with a population of more than 1 million people, in which most types of urban passenger transport are represented and there is an opportunity for the LPWT implementation. For this purpose, let's suggest choosing Kyiv metro station and rely on this in the course of further research.

So, urban passenger transport as a system having an appropriate structure, that is, contains subsystems, which is represented by the following modes of transport: automobile, trolleybus, tram, metro. Let's propose to supplement this list with another subsystem – LPWT, which consists of the following elements:

- passengers (form the demand for transportation and are represented by local residents and tourists);
- transport (LPWT and a set of related types of ground transport integrated into LPWT);
- LPWT enterprises (carrier operators, coastal service base operators, escort entities);
- subjects of regulatory support (organizations and institutions that provide registration and navigation support for the LPWT activities);
- local authorities (carry out normative regulation of activities and management function).

Each of the LPWT elements, in turn, is divided into the following types:

1. Passengers are divided into local residents and tourists. Locals are represented by residents of the city, suburbs and satellite towns; use this type of transportation to meet the daily needs of being moved between place of residence and work and special needs. Tourists use LPWT to move around the city and in the suburban area and for special needs. It should be noted that «special needs» refers to the provision of not only transportation services, but also entertainment and related ones, for example: celebration, relaxation, sightseeing, walking, entertainment, training, corporate events, trainings and the like.

2. Transport is represented by local passenger water and related types of urban land transport, which carry out passenger traffic through the interaction of land and water transport. The LPWT division into types is determined by the existing demand for transport services and can be represented by route and custom-made transportation. Classification of types of urban passenger transport is shown in Fig. 1.

3. The coastal service base provides:
 - fleet operation (dispatch service, so far, moorings, marinas, parking lots (night, inter-navigation, at moorings), repair and maintenance bases, service and technical buildings, other facilities providing LPWT operation);
 - meeting the needs of passengers (stations, stops, shopping and entertainment centers, cultural and educational centers, hotels, parking lots and other facilities that meet the needs of passengers).

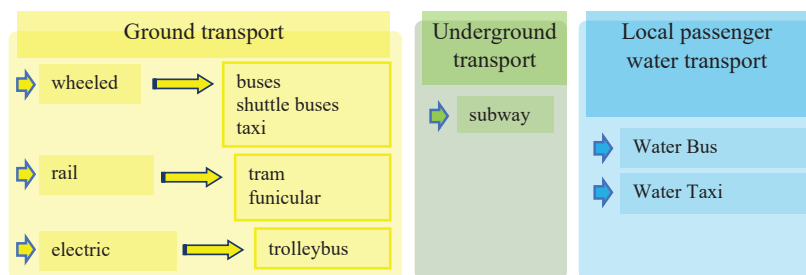


Fig. 1. Classification of types of urban passenger transport [15]

4. LPWT enterprises are represented by shipping companies and operators of the coastal service base, which can be both individuals and legal entities. Carrier operators transport passengers by water at the local level. The operators of the coastal service base provide water transportation services for passengers at the local level and hold the coastal service base, modernizing and/or building it with the aim of ensuring the operation of the LPWT. LPWT enterprises consist of escort entities, which, in turn, are divided into two groups, depending on the functions that are performed, financial and credit and coastal base service entities. Finance and credit are represented by private investors, leasing companies, banks, etc. Coastal base servicing entities provide coastal fleet maintenance (coastal technical service bases, repair and gas stations, etc.) and, separately, passengers (restaurants, shopping centers, shops museums, parks, parking lots, medical support, etc.).

5. The subjects of regulatory support:

- registration (registration of a ship in the Register of Shipping of Ukraine, obtaining a license to carry out economic activities for the transport of passengers by river, issuing a certificate for the right to control a ship, etc.);
- navigation (communication, monitoring compliance with the rules of shipping and passenger traffic, the provision of navigation services, meteorological support, etc.).

6. Local authorities carry out normative and administrative regulation, therefore, it is appropriate to carry out such a separation: the Department of Transport and Passenger Transportation of the City State Administration and the Management Company.

The Department of Transport and Passenger Transportation ensures the organization of the implementation of a certain program, carries out regulatory regulation of the implementation of the partnership conditions. For example, in the city of Kyiv (Ukraine), such functions are performed by the Department for the Organization of Traffic, Parking and Passenger Transport, which is part of the Department of Transport Infrastructure (DTI) of the Kyiv City State Administration.

To establish communication between private business and the city, let's propose creating a Management Company that will provide such mediation. It should include representatives of the LPWT operators and the city government. The management company will carry out the functions of managing the activities of the LPWT, dispatching and information (website) transportation support, infrastructure support and the like.

The functions of the subjects involved in the LPWT implementation program are described in detail in [16].

Studies show that there is no conceptual apparatus of local passenger water transport. Each operator interprets these definitions in their own way. For example, «recreational

vehicles» can be understood as «water taxis», and ships that play the role of public transport and carry passengers along established routes and schedules are called either «river trams», or water buses, or «Water Bus». Therefore, let's consider it necessary to clarify these formulations and offer them for further use in the field of passenger water transport at the local level:

1. Local passenger water transport is a type of transport that provides for:

- provision of services by relevant enterprises for the provision of passenger transport in the water area of the city, suburban and interurban areas (lake, river, sea);
- meeting the needs of the fleet and users within the appropriate coastal service base.

2. Water Bus (WB) is a LPWT type that is operated according to the established schedule and route; stops only at equipped berths.

3. Water Taxi (WT) is a LPWT type that is operated on a custom basis and does not have an established schedule and route of movement; can make stops at un-equipped berths.

So, the study allows to modify the system of urban passenger transport: it will include not only land and underground modes of transport that are currently in operation, but also water passenger transport. The place of LPWT in the UTS in terms of passenger traffic, the composition and classification of its elements is shown in Fig. 2.

Taking into account the research results, let's propose to classify LPWT according to a number of certain signs – Fig. 3.

Organization of transportation by WT LPWT type is carried out through the dispatch service, website and using a mobile application. A ship performing such transportation should have a slight draft and the ability to approach close to the coastline, thereby not requiring the availability of equipped stops.

WB LPWT type to carry out route transportation on different route systems, for example: «round» and «stop-stop». The «round» route connects several stops located on the line of movement of the ship in a single water complex; the movement of the ship is carried out first along one bank of the river (in the forward direction), and then along the other (in the opposite direction).

Usually, two or more ships operate on such a route, depending on the length of the route and passenger traffic. Transportation is carried out according to clear (approved schedule) or flexible (west to intermediate points in the presence of passengers there) schedules. The stop-to-stop route connects two or more stops located on one or opposite shores of the water area. On such a route it can operate from one ship. Transportation is carried out according to the same schedule as on the «circular» route.

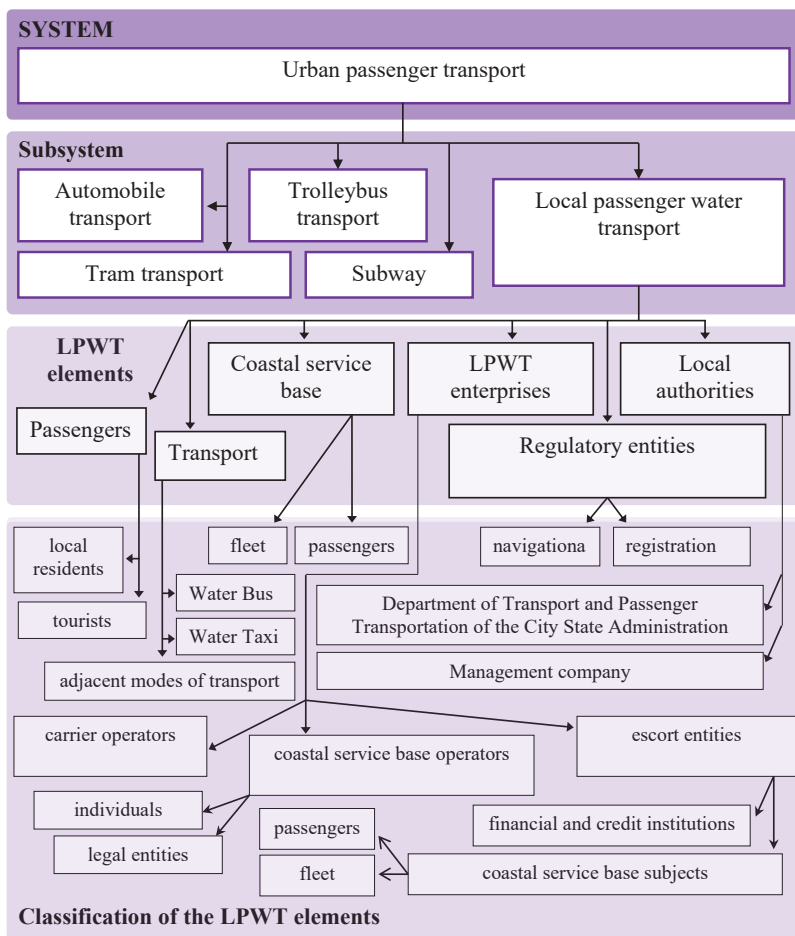


Fig. 2. Modified scheme of the urban transport system in terms of passenger traffic [17]

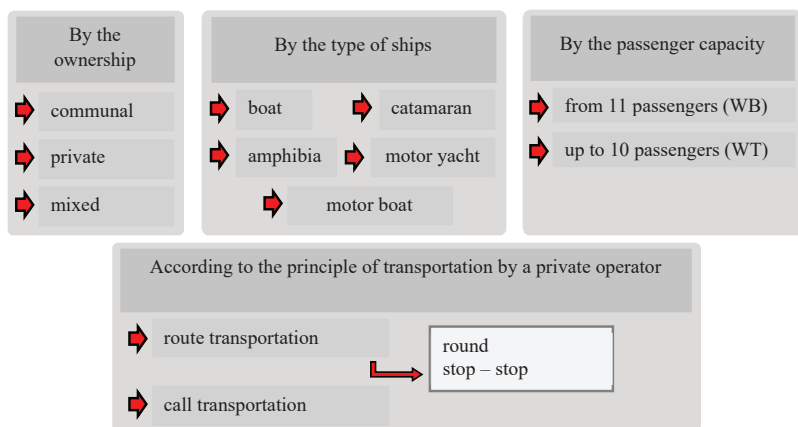


Fig. 3. Classification of local passenger water transport (formed by the authors of [15])

The effective functioning of the LPWT entities will allow for the transportation of passengers at the local level and qualitatively change the UTS structure, but this requires a study of the competitive environment of the LPWT.

7. SWOT analysis of research results

Strengths. The strengths of the proposed UTS structuring study are that passenger transportation services are changing qualitatively due to increased speed, convenience and convenience, safety, environmental friendliness. LPWT ships have various modifications and considerable maneuverability,

which allows to reduce the time for the delivery of passengers in comparison with the corresponding land routes. The organization of LPWT routes will also contribute to this, for example, the integration of one-to-one ring routes. The potential of these shipments is all the more so as there is not always a need for equipped coastal zone, for example, WT can approach an unequipped coastal zone. This feature allows to direct funds for the purchase of new modern ships, they are comfortable, safe and environmentally friendly not only in comparison with land transport, but also with the existing outdated fleet.

Weaknesses. The analysis of the modification of the UTS scheme carried out in the work indicates that the LPWT implementation requires significant financial injections for the high cost of fixed assets and the need to modernize the outdated or missing necessary coastal service base. However, financing of this type of transport will occur thanks to private business, therefore UTS will not be weakened by this. The weakness of the proposed implementation is the limited LPWT in waterways, as well as the seasonality of transportation.

Opportunities. A modification of the UTS scheme is proposed that allows expanding the transport infrastructure of any city in Ukraine, which means that waterways, thanks to the implementation of a new mode of transport, reduce the load on land modes of transport and restructure transport. LPWT services to distinguish actual transport products with high quality service and ship comfort from other similar services of other types of urban passenger transport, will attract users and will allow to quickly increase the LPWT passenger flow. The aesthetics and comfort of the LPWT rolling stock, as well as providing amenities for people with special needs, expand the range of possibilities of the city's transport system itself. LPWT implementation in UTS will contribute to the emergence of new transport hubs, the realization of the tourism potential of the city, and the cooperation of local authorities with private business.

Threats. The threats that accompany the LPWT implementation and, consequently, lead to action on the entire UTS, include:

- priority of expenditures specifically for ground public urban transport in the structure of expenditures of the population, taking into account its low solvency;
 - lack of demand; political and economic instability of the region;
 - lack of funding;
 - high level of corruption in the transport and utilities sectors;
 - natural or man-made threats of violation of the hydrological regime of a river or other waterway.
- It is not always possible to identify potential threats in advance and avoid them. However, an analysis of the

experience of such structural transformations in other cities of the world will allow to develop important methods for their identification and minimization.

8. Conclusions

1. The theoretical aspects of the transport system of the city are investigated. Its subsystems, represented by ground and underground types of urban passenger transport, are highlighted, and additions to this system are proposed by a new subsystem – LPWT. LPWT implementation will relieve ground modes of transport, provide modern and high-quality passenger transportation services and, in general, optimize UTS. The types of urban passenger transport are classified taking into account changes in the UTS structure, namely, the extension of the existing classification due to the LPWT and its types.

2. Clarification of the conceptual apparatus of local passenger water transport by such author's definitions:

- LPWT is a type of transport that provides for the provision of services by appropriate enterprises for the provision of passenger transportation in the water area of the city, suburban and interurban areas (lake, river, sea), meeting the needs of the fleet and users within the corresponding coastal service base;
- WB is a LPWT type that is operated according to the established schedule and route, stops only at equipped berths;
- WT is a LPWT type that is operated on a custom basis and does not have an established schedule and route of movement can make stops on non-equipped berths.

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