URBAN TRANSPORT SYSTEMS AND DEVELOPMENT OF INTERMODAL TRANSPORTATION

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ABSTRACT

The article considers current trends in development of urban passenger transport systems. The emergence of new types and ways of transporting people in megacities (in particular, light rail, high-speed bus), formation of modern transport-interchange hubs are highlighted as the main ones. The practical example shows general principles of arrangement of the latter taking into account the peculiarities of metropolitan public transport and a type (nature) of combined trips.

Keywords: *urban transport, intermodal transport systems, light rail, high-speed bus, interchange hubs.*

Background. *For the conditions of large urban areas, the intermodal transport system ensures integration and coordination of various modes of transport, the fastest and most comfortable transfer of residents to places of settlement, as well as competitive advantages of public transport as compared to the individual, contributing to the comfort of living and development of people's communication links.*

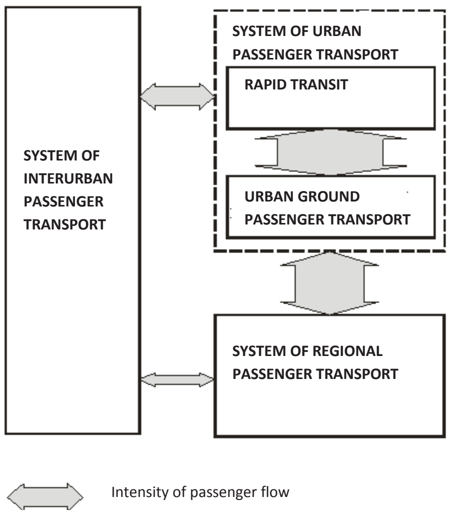
The issues of organization of intermodal passenger transport systems for the largest agglomerations of the metropolitan type are especially relevant, which is important for strengthening the territorial unity of the formations, the length of which can be hundreds of kilometers. In general, the scheme of the intermodal transport system is shown in Pic. 1.

Objective. *The objective of the author is to consider modern urban transport systems and prospects of development of intermodal transportation.*

Methods. *The author uses general scientific methods, economic evaluation, statistical method, comparative analysis, analytical approach.*

Results. *Modern trends in development of urban passenger transport systems include formation of new modes of transport and their separation from «classical» systems, as well as creation of intermodal interchange hubs that integrate various modes of transport.*

Most often, the urban passenger transport system is formed by two main parts –rapid transit (RT) and urban ground passenger transport (UGPT).



Pic. 1. The structure of the intermodal passenger transport system in the metropolitan area.

The structure of the city's high-speed transport system includes: the main system (underground and city railway) and an auxiliary system (various types of «light» subway, monorails, high-speed trams, etc.). In the foreign practice of transport planning they are called – Light Rail Transit (LRT), in Russian domestic practices (due to initial not to accurate translation) – light rail.

Metro and city rail systems provide the maximum performance to ensure carrying capacity and speed of communication, which dictates the need for underground routes and requires significant capital expenditures.

The development of LRT systems is one of the modern trends for passenger transport. According to the International Association of Public Transport (UITP), by 2014, in the world, in addition to 157 metro systems, more than 388 LRT systems operated [1].

If in the largest cities and agglomerations the LRT system provides for transportation of the main system of rapid transit to the stations (in addition to the ground transportation system), in other types of settlements it is the LRT system that becomes the basis for development of the passenger transport system (Pic. 2, 3).

Characteristic features of LRT lines:

– tracing of lines on a separate canvas, mainly in the ground level, at different levels only intersections with the main city highways are solved;

– 3–5 times lower capital costs for the construction of the system in comparison with the conventional subway [2], significantly smaller operating costs;

– the estimated carrying capacity of LRT lines depends on the type of rolling stock used and, according to estimates, is 9–15,0 thousand passengers per peak hour;

– operating speed is less than that of metro lines – about 25–30 km / h.

LRT systems are distinguished by a significant variety of technical solutions. The most frequent of its representatives are a high-speed tram, a high-speed bus, a «light» subway. In Tokyo, a monorail system is actively used.

Another modern trend in development of urban land passenger transport has become its division into two subsystems: high-speed transport, carrying passengers on the main routes, and traditional – consisting of buses, trolleybuses and trams.

Bus Rapid Transit (BRT) systems have similar to LRT principles of organization: movement on a separate canvas, with the maximum priority of vehicles at intersections in one level. The main task of the system is to provide high-speed, routed displacements of citizens along the main lines between the main focuses of gravitation.

Table 1

Comparative characteristics of speed and volume of passenger traffic of buses

№№	Name of the system, city, country	Speed, km/h	Volume of passenger flow (number of passengers in one direction)
1.	Transmilenio, Bogota, Columbia	29	42000
2.	9th July, San Paolo, Brazil	12	34910
3.	Assis, Porto Allegre, Brazil	18	28000
4.	Christiano Machado, Belo Horizonte, Brazil	15	21100
5.	Delhi, India	13	12000
6.	Beijing, China	15	7500
7.	Metrobus, Mexico, Mexica	21	8500
8.	EcoVia, Quito, Ecuador	18	10200
9.	Trans Jakarta, Jakarta, Indonesia	18	4500
10.	Eixo Sul, Curitiba, Brazil	21	10640

Pic. 2. High-speed tram in the old part of Istanbul (Turkey).

Pic. 3. High-speed bus in Istanbul.

In the world practice, a rich experience in creating priority conditions for movement of ground public transport has been accumulated. The materials of the relevant committees of the World Road Association (PIARC) list the main of them [3]:

– separate carriageways allocated by road fences;

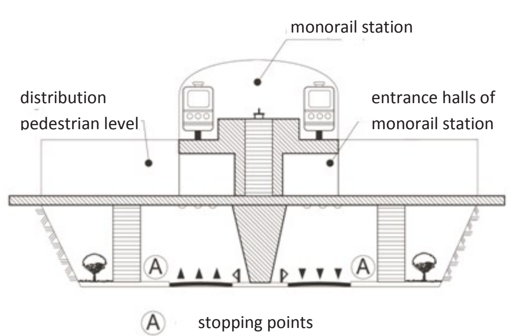
– lanes allocated by marking or fences, on which the direction of movement is opposite to the direction of the transport flow (control-lane lanes);

– allocated by marking or color coverage of the lane only for transport of large capacity;

– priority of public transport at regulated intersections;

– design of high-capacity stop stations.

High-speed bus systems are even cheaper than LRT, and show an attempt to form a high-



Pic. 4. Transverse profile of TIH Odaiba.

Pic. 5. Layout of TIH Odaiba (top view).

Pic. 6. Layout of TIH Odaiba (view from ground level).

Pic. 7. Station of the monorail of TIH Odaiba.

Pic. 8. The entrance to the monorail station of TIH Odaiba.

speed transport system for the settlement. So, according to Iranian experts [4], the cost of building such a system in Tehran (in 2009 prices) was about $3,5 million per kilometer, taking into account the acquisition of vehicles (actually several times less than the cost of building a «conventional» metro).

At the same time, it is obvious that such systems have a number of shortcomings:

– use of the main street-road network for traffic does not always provide the shortest distance between the main focuses of gravitation (as opposed to metro traced underground);

– the need to allocate at least two lanes in the cross-section of the road for organization of continuous traffic with the necessary broadening in the locations of the stopping points;;

– less speed of communication compared to the metro, etc.

Technical and operational indicators of high-speed bus communication systems vary greatly. Table 1 shows the data of foreign researchers [5] on the main indicators of several similar systems.

The world's largest BRT system is Transmilenio in the city of Bogota (Colombia) [6]. The total length of the lines is 85 km, the maximum carrying capacity is comparable with the metro lines and is 42 thousand passengers per hour in one direction.

Among the most well-known systems of this type is the high-speed bus system in Curitiba (Brazil). Within its framework, the planning concept of stopping points is extremely interesting.

The stopping point is a separate structure made of lightly constructed structures, elevated above the ground level by 1,5 m, which ensures the safety of passengers while waiting for transport. The fare is collected at the entrance to it, thereby facilitating the procedure for embarkation and disembarkation of passengers simultaneously through all doors of the vehicle and reducing the delay of the bus at the stopping point. To ensure the right to move people with disabilities facilities are equipped with lifts.

Another worldwide trend is development of transport-interchange hub systems (TIH). They particularly contribute to development of intermodal transport systems. In particular, it provides for the placement of municipal or «interception» parking facilities, designed to support the popularity of combined trips, i.e. those where some displacements are made by individual vehicles, and other by public transport [7–9].

In previous publications of the author, the world experience in development of interchange hubs was considered in detail [10–12]. Taking into account the trends described in the article, we will consider the planning characteristics of the node formed on the basis of the Odaiba station, which is part of the Tokyo Monorail system (LRT system). The node is located on the bulk territories of Tokyo, in the bay, in the Odaiba area. In the pedestrian access area of the *node there are several large shopping complexes, hotels, office and residential buildings. In addition, in the immediate vicinity of the station there is a recreational area that enjoys great popularity among the inhabitants of Tokyo in the warm season (lasting more than 9 months).*

Tokyo monorail is considered to be an effective system of urban rapid transit, providing transport communications of the peripheral areas of the city with the system of the city subway and the railway.

Odaiba TIH has three levels:

– the lower (first) level is intended for traffic of urban transport (individual, cargo, ground passenger);

– the middle (second) level – for pedestrian traffic in the node;

– the monorail station is located at the upper (third) level.

Sufficient representation of the planning solution of the TIH is given by its transverse profile (Pic. 4) and the appearance from different points (Pic. 5 and 6).

The main infrastructure components of the node are:

– monorail station (RT) – see Pic. 7;

– urban ground passenger transport – bus;

– municipal parking.

The planning basis of TIH is the pedestrian platform, which provides pedestrian links of the opposite parts of the node to each other. Through the platform is carried out:

– entrance and exit to the monorail station (i.e. to the upper level of the node) – see Pic. 8;

– descent to the level of the day surface (the lower level), where the stops of urban passenger transport are located;

– pedestrian link of the accommodation zone of recreational and shopping facilities with a zone of accommodation of administrative and business, residential and hotel complexes;

– incidental servicing of passengers by small retail trade objects.

Pedestrian link with municipal parking is provided through the ground level.

It should be noted that, despite the generally compact size, the node contains a full range of devices that create comfort for all groups of passengers. For example, there is a municipal toilet and a luggage room. The concept of «barrier-free space» is fully implemented, allowing passengers with disabilities to move around in the node. In the main directions of pedestrian traffic, special bands are made to help people with poor eyesight, all vertical movements can be carried out not only using stairs, but also elevators.

Conclusions. *The main trend in development of transport systems of large urban settlements is the dominance of public transport, designed to ensure formation of a comfortable environment on the territory of agglomerations. Creation of intermodal transport systems is closely connected to the development of new types of public transport, transport-interchange hubs, real conditions for combined trips. To make these processes sustainable, in our opinion, it is necessary:*

– to conduct scientific research allowing to determine rational areas of application of new and «classical» types of public transport in local conditions;

– to form the regulatory framework for urban planning and design at the federal and regional levels;

– to consider the possibility of using new modes of transport and interchange hubs when developing spatial planning documentation;

– to provide reservation of the territory for the perspective development of the transport infrastructure in the planning projects for territories and line facilities.

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