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Principles of modern route systems planning for urban passenger transport

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Abstract

Principles of route systems planning for urban passenger transport. In order to solve the task of urban transport system economic efficiency improvement it is required to elaborate integrated programs of transport infrastructure development and passenger transportation planning which shall be considered as a part of long-range integrated planning of urban development. Projects of route network development shall ensure achievement of target-oriented technical-economic values, financial and socio-economic indicators of transport infrastructure development including indicators of safety, quality and efficiency of transportation services provision for the population. Thus, planning of transportation and designing of route networks should not only be connected with other strategic planning documentation but should constitute the center of integration being the background for integrated development. At that, most important issues included in transportation planning document shall be: integration of motorized and non-motorized modes of transport, encouraging population to switch to public transport, implementation of "eco" principles, provision of proper quality and access of all users to transport services.

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Keywords: planning document; route network; transport system; integration; infrastructure; urban passenger transport.

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1. Introduction

Transport efficiency is one of the indicators of large cities development. Planning of urban transport route networks promotes improvement of population mobility, growth of labor productivity, productive land use and optimized transport network integration with social, cultural, business and public-service facilities.

Transport is creating favorable conditions for relocation of population, products and services, exchange of knowledge and economic efficiency. Economic and technological development, in its turn, allows different countries to make investments in transport development. However, this interaction is not as cloudless as it may seem. Thus, transport sector development is leading to considerable growth of vehicles and, as a consequence, to companion problems like street-road networks overloading, road accidents and environment contamination (Yin et al., 2002; Gorev and Solodkij, 2013). Aforesaid problems are important all over the world this is why urban transport system planning should be paid great attention (Ceder and Wilson, 1986; Steemers, 2003; Buch et al., 2011). Since transport system management is maintained in condition of resource restrictions (time, finance, land use) it means that basic methods for transport system efficiency improvement shall be: increase of existing street-road network throughput (Braess et al., 2005), development of transport infrastructure in compliance with population demands, creation of priority conditions intended to ensure road users safety (Wu and Hounsell, 1998). In order to solve these tasks it is required to develop integrated programs of transport systems development and passenger transportation planning.

2. Role of transportation planning document in route networks design

Planning of passenger transportation via route networks should not be sporadical and unsystematic; it should be considered as an integral component of long-term integrated city development plan (Schafer and Victor, 2000; Bus Rapid Transit, 2007; Nielsen, 2005).

Therefore, document which is regulating the plan of transportation via the route networks shall be interlinked with documents pertaining to strategic traffic planning, such as: general plan, strategy of socio-economic development, program of transport infrastructure integrated development, integrated scheme of road traffic organization. Place of such planning document stipulating cargo and passenger transportation by automobile transport and urban electrical road transport in the context of the system of territorial traffic planning is shown in Fig. 1.

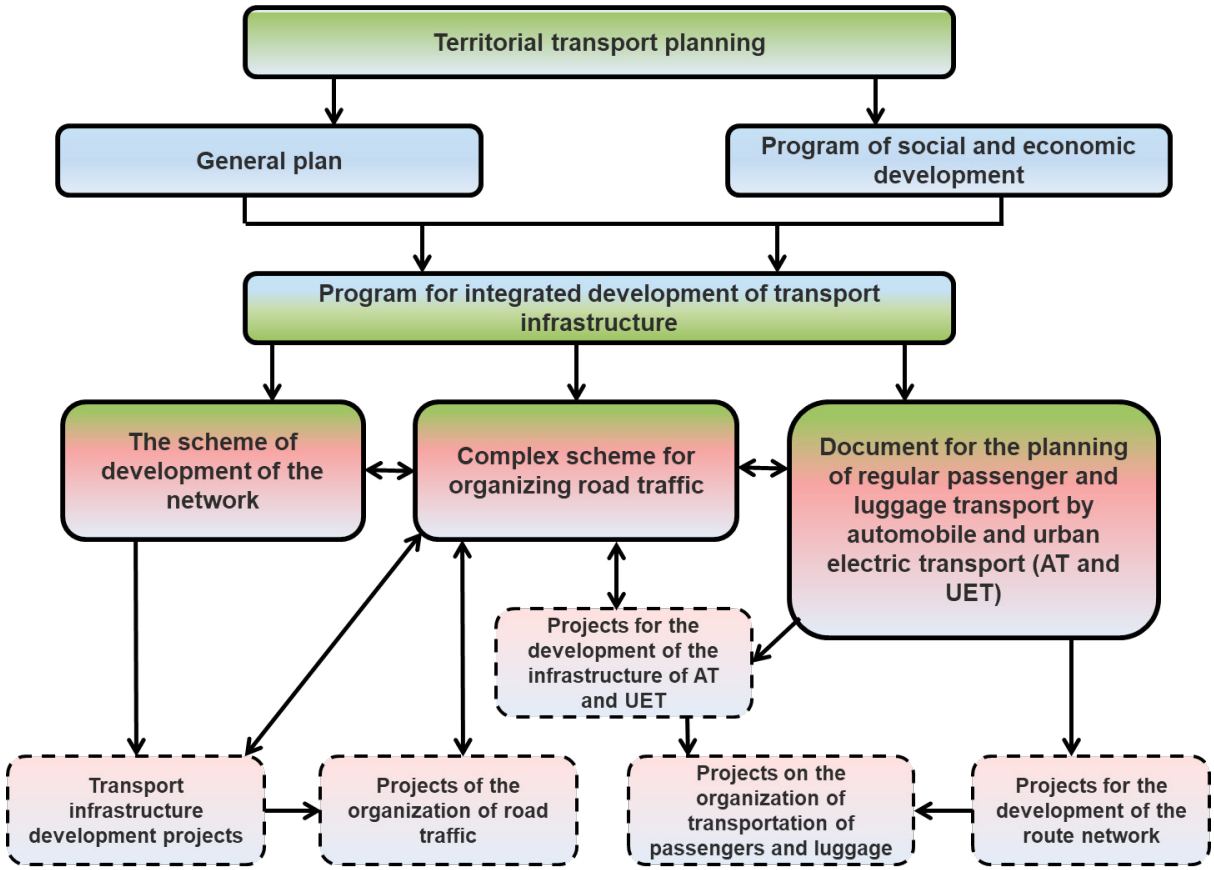

Fig. 1. Place of transportation planning document within the structure of traffic planning documents.

Program of integrated development of transport infrastructure (PIDTI) shall be elaborated on the basis of provisions stipulated by the General plan and by the plan of measures foreseen by the strategy of socio-economic development. Objective of the PIDTI is to ensure long-term well-balanced and well-coordinated development of transport infrastructure of settlements and urban districts aiming to ensure their steady socio-economic development. The PIDTI must ensure due safety, proper quality and efficiency of transport services rendered to the population at the expense of priority given to public transport, transport infrastructure affordability, utilization efficiency and sustainable development meeting the demands of the population. The PIDTI includes complex of measures like design, construction and re-construction of transport infrastructure facilities by types of transport including measures intended to promote development and creation of transfer hubs, integrated parking space, infrastructure intended for pedestrian and bicycle traffic. Besides, PIDTI may foresee road traffic organization activities, activities intended to implement intelligent transport systems, activities intended to reduce negative impact to environment and human health. Therefore, presentation of (i) SRN development procedure, (ii) integrated scheme of traffic organization and (iii) planning document stipulating passenger and cargo transportation procedures shall be tightly linked with the PIDTI.

Also, projects of route network development based on respective [cargo and passenger transportation] planning document shall ensure achievement of target-oriented technical-economic, financial and socio-economic indices of transport infrastructure development including safety, quality indicators and indicators of efficiency of transport services provision for population and economic entities stipulated by the aforementioned PIDTI (Vuchic, 2007).

Integration has strong importance for successful and efficient traffic planning. Planning of the higher order (the General plan, programs of socio-economic development, the PIDTI) is leading to more localized planning (Integrated Traffic Management Scheme, transportation planning Document) which is, in its turn, allows achieving

priorities stipulated by the upline documents. Each local document is unique, therefore, provisions, requirements and decisions contained therein may affect planning and priorities of the higher order (Fig. 1 – two-side arrows).

Since transportation planning and route networks designing are pursuing a two-fold task which includes (i) provision of continuous mobility and, as a consequence, of trouble-free transport-based activities of municipal bodies and urban population and (ii) creation of the base for economic and social development it is expected that such planning must not only correlate with other planning documents (Fig. 1) but stay in the center of integration being the background which is providing integrated development. At that, the planning document shall contain the below listed strategic issues:

- Integrating of motorized and non-motorized modes of transport (Cervero et al., 2009);
- Encouraging population to switch to public transport;
- Implementation of "eco" principles;
- Provision of accessibility and quality of services to all categories of users.

3. Principles of urban passenger transport systems planning

In view of the above, it is possible to formulate the key principles of urban passenger transport systems planning.

1. Stability. Planning of transportation and designing of route networks have long-term socio-economic and ecologic consequences this is why it is necessary to pay particular attention to far-reaching prospects balancing, at the same time, with short-term mobility demands.
2. Integration. Documents pertaining to transportation planning and route systems design require these documents to be integrated with traffic planning documents which integration will allow to provide internal coordination between these documents and to ensure that they will achieve synergy.

Table 1 presents main directions and principles of urban passenger transportation planning.

Table 1. Main directions and principles of urban passenger transportation planning.

Directions	Principles	Principles realization measures
1. Economic social and ecological indices – current and prospective.	Planning solutions shall be taken with consideration of financial capacities.	– Financing shall be provided first of all to spheres which are of primary necessity and economically efficient. – Select the most cost-effective way of achieving the intended effects. – Compare objectives and anticipated financing resources.
	Correlation of effects and costs as of the current moment and for a long term.	– Ensure fair and equitable access to all categories of citizens (including low-mobility persons) by means of pedestrian traffic, bicycle traffic, public transport and automobile. – Analyze various mechanisms of mostly efficient usage of payments.
2. Integration of transport system.	Integration of infrastructure and transport operation modes.	– Analyze all transport operation modes and select the best one. – Ensure interconnection between transport operation modes, public transport stop points, road junctions, parking areas, payment systems, pedestrian and bicycle traffic infrastructure. – Integrate new transport networks with existing ones. – Include missing links into the transport network, for example, most important pedestrian and bicycle routes.
	First of all, use existing infrastructure and existing public transport operation modes.	– Ensure priority to existing public transport operation modes. – Find possibilities to use existing transport infrastructure for the route networks under design.
	Provision of efficient management.	– Introduce amendments into legislation, develop and implement transportation planning documentation and standards. – Take active part in all state policy processes associated with transportation planning. – Ensure transparency of acquisition, analysis and development of transportation planning documentation. – Attract interested parties and inform them in the course of development of

Directions	Principles	Principles realization measures
		transportation planning documentation.
3. Integration of transport and land usage.	Determination of preferable land use areas.	– Models of development shall foresee logical extension of existing transport networks including public transport, bicycle and pedestrian traffic networks. – Determine mostly attractive places and compare them with existing transport network. – Determine areas with good access to public transport, pedestrian and bicycle traffic infrastructure. – Locate land use areas intended for cargo transportation and economic development areas in proximity to main motor roads, railways, sea ports and other transport infrastructure facilities.
	Correlation between land plots and route networks.	– Determine areas requiring high level of transport accessibility and correlate them with existing transport network. – Determine attractive areas intended for pedestrian and bicycle traffic. – Develop infrastructure (centers of attraction) within existing route network, within one district aiming to reduce travel demands. – Ensure proper development of land plots located within existing route network. – Maintain steady demand for trips to areas with well developed transport infrastructure and route network.
	Anticipate and exert influence on transport demands and consequences thereof.	– While planning the route network take into account development of industrial zones aiming to reveal transport maintenance demands. – Envisage probable terms and transport demands which may occur within the framework of potential urban development projects. – Exert influence on territories development plans aiming to locate them in areas most suitable for logical extension of transport and route network.
4. Integration of transport and other planning directions.	Cooperation between transport authorities and authorities of other branches aiming to account plans and priorities associated with their development.	– Cooperate with other state authorities in order to coordinate land use, infrastructure and transport-related issues. – While taking transport planning decisions take into account other types of planning and priorities of other branches development at all levels of state management.
	Cooperation between transport authorities and authorities of other branches aiming to account plans and priorities associated with transport industry development.	– Exert influence on decision taking in the sphere of planning in other branches and at all levels of state management. – Exert influence on attraction centers location planning (hospitals, schools etc.) aiming to improve accessibility thereof. – Cooperate and develop efficient partnership relations aiming to determine plans and priorities of the other branches.
5. Development of efficient partnership relations between transport authorities, other branches' authorities and the society.	Process of elaboration shall be open and transparent.	– Determine methods, means and degree of cooperation with partners within the framework of transport planning task solution. Determine and coordinate (together with partners) the desired planning results. – Elaborate the plan of activities in order to involve interested parties at early stage of transport planning. – When performing analysis in the sphere of transport planning it is necessary to use experience of previous research, including partners' experience.
	Account for concerned parties' opinion.	– Take into account concerned parties opinion in order to improve partner relations efficiency in the course of transport planning. – Maintain flexibility in the course of transport planning and take into account concerned parties opinion. – Inform interested parties and submit information about transport planning process and results thereof.

Optimized planning of the route network is the decisive factor contributing to effective functioning of public transport. Considerable differences may be observed in services quality, scope of transportation and operating expenses depending on the degree of implementation of the following key requirements:

- Route network for all types of transport having different service levels shall be integrated, shall link all transport-attracting centers and cover the entire services-covered territory.
- Type of transport and service provision mode must comply with demand for urban passenger transport (UPT) and efficiency of the UPT operation (Dubois et al., 1979).
- Route network shall have definite structure and shall be easy for understanding and memorizing.
- Routes shall be, if possible, by maximum straightforward and ensure potentially high speed and strict observance of traffic schedule.
- Intensity of traffic by the route shall comply with traffic demand. Routes with maximum intensity shall link city center with suburbs, residential and industrial zones and transportation hubs узлами (Furth and Wilson, 1981; Kocur and Hendrickson, 1982).
- UPT route network shall be stable for long-lasting period of time and have, at the same time, the possibility to be scaled in order to meet transport requirements of the new districts and changing demands of the population.

Modern methods of design are oriented on transport service end users. This ensures transport attractiveness and convenience of its usage by the population (Robertson and Bretherton, 1991; Bell, 1991; Lebedeva and Mikhailov, 2017).

While designing the user-oriented route network it is possible to point out 5 main tasks and to interconnect aforesaid tasks solution results between each other (Pattnaik et al., 1998; Diakaki et al., 2002; Chakroborty et al., 1995). These are:

1. Interests of the user: minimum travel time and number of transfers, high traffic frequency and stop points accessibility, reliability and safety of services, comfort, ecological safety, polite personnel, low tariffs, route network coverage of regional territory coverage by the route network.
2. Regional expediency: low infrastructure expenses, decrease of traffic intensity, ecological improvement, economic development and region reputation.
3. Selection of technological solutions: offers of the producers, preferences and capabilities of transport operators, infrastructural restrictions, level of prospects and innovations.
4. Budget capacities: financial restrictions of investment and operational expenses, ability to raise tariffs and reduce traffic frequency.
5. Decision making: technical and technological solutions based on user preferences with consideration of region's economic capacities.

Aiming to improve services rendered to the population when designing the route network it is expedient to take into account the following indicators:

- Cumulative time spent by the passengers for "from door to door" trip;
- Remoteness of the stop points;
- UPT traffic frequency;
- Number of transfers made during the passenger's trip;
- Traffic safety;
- Degree of motive stock load;
- Cost of travel;
- Transport usage convenience etc.

One of most commonly used transport evaluation criteria – travel time expenditures.

4. Discussion and conclusion

Basic principles affecting transportation planning and route networks design are stability and integration. When planning the route network it is necessary to pay attention to long-term development perspectives, meantime, balancing with short-term mobility demands. Transportation planning document shall be interconnected and integrated with documents relating to strategic traffic planning so as to enable the designer to create the background for integrated development and thus increase documents mutual influencing. In view of the above, basing on

directions and principles of transportation panning it is possible to formulate basic requirements to route networks which should be taken into account during the design phase.

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