MAIN DIRECTIONS OF EFFICIENCY IMPROVEMENT OF TRANSPORT INTERCHANGES FUNCTIONING

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Abstract. The article deals with the areas of study concerning transport interchanges. It has been determined that the most perspective directions for the future research is synchronization of the schedule that allous reducing the waiting time, preventing the public transport congestion at bus stops and stations, and by doing this to ensure their sustainable development.

Key words: transport interchange, efficiency, sustainable development, synchronization.

Introduction

Ensuring sustainable development of social systems is identified as one of the major challenges that covers all aspects of society life and includes economic, social and environmental components. The main problem of ensuring sustainable development is the creation of sustaina-

ble transport systems that can meet needs in mobility of people, goods, while causing minimal damage to the environment. Modern transport system of Ukraine cannot be characterized as one that is sustainable: population of cities suffer of high levels of motorization, congestion and environmental pollution related with it; it is rarely used alternative fuels and «green»
cars and the quality of public transport is not consistent with passengers’ expectations.

The realities of today show that every day thousands of passengers are faced with imperfection of public transport functioning, which is both slow and unreliable. Trips with a transfer are especially problematic ones. The importance of integration and combination of different transport modes is recognized around the world. This fact explains the growing interest in the reorganization of the old and creation of new transport interchanges on the basis of which intermodal and multimodal transportation are carried out, and increasing their efficiency.

Analysis of publications

The conducted literature review shows that there is a tendency to expand the functions of modern transport interchanges: cultural and entertainment, trade etc. functions are added to the main transport one, and the efficiency of functioning should be considered from economic, social and environmental perspectives. Issues that scientists are interested in are ranged from the creation of architectural concepts [1], rational allocation [2-3] to study the movement of passengers, passenger flows formation at transport interchanges [4-5] and problems of interaction between passenger transport modes [6].

The aim and setting the task

The aim of the study is to determine the main directions of the efficiency improvement of transport interchanges functioning. The object of the study is the process of transport interchanges functioning, and the subject is the efficiency of transport interchanges functioning. To achieve the aim, current strategies in the transport sector and existing directions of studies in the area of the efficiency improvement of transport interchanges are analyzed.

Analysis of areas of transport interchanges studies

When solving transport problems that exist in Ukraine, it is necessary to take into account new trends of European transport systems. Key strategic positions towards sustainable mobility and recommendations on decisions in the transport sector are reflected in White Papers. White Paper of the European Commission «Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system» (2011) forms a vector of the transport development by 2050. This White Paper contains 10 main goals, which are underpinned by 40 specific initiatives.

One of the initiatives regarding passenger transport is the twenty-second one entitled «Seamless door-to-door mobility» contains the following provisions:

– Define the measures necessary for further integrating different passenger transport modes to provide seamless multimodal door-to-door travel.

– Create the framework conditions to promote the development and use of intelligent systems for interoperable and multimodal scheduling, information, online reservation systems and smart ticketing. This could include a legislative proposal to ensure access of private service providers to travel and real-time traffic information. [7].

A significant influence on the development of sustainable transport systems has urban mobility. The European Commission has presented a Green Paper «Towards a new culture for urban mobility» [8], which reflects the strategy of making innovative transport decision for guaranteeing mobility, environmental protection and improving the quality of life.

Since a transport interchange is not only a key element of the transport system, but also an important part of the city, different research areas are involved in the study of these objects and solving urgent problems, namely, architectural, urban planning and transport. Nowadays, there is also a growing dependence of transport systems on information technology. The requirements of modern society necessitate the involvement of specialists of this scientific field that can help in the creation of a single database, without which it is impossible to form virtual terminals or search for optimal routes with transfers.

Main directions of studies in the area of the efficiency improvement of transport interchanges functioning are presented in Fig. 1. This variant of division is conditional as some areas are quite related, for example, designing or redesigning of transport interchanges and study of pedestrian flows, forming passenger flows [9]. In most studies it is taken into account the characteristics
of passenger flows or criterion is to minimize the transition distances when transferring.

The improvement of transport and planning decisions of transport interchanges is the first direction of scientific studies. There exist a number of characteristics according to which transport interchanges are classified: combination of transport modes, level of connections which is provided by a transport interchange, allocation of transport interchanges in a city, planning characteristics.

Vlasov D. notes that there exist two types of classifications: urban planning and transport one [10].

![Diagram](image_url)

Fig. 1. Directions of studies in the area of efficiency improvement of the transport interchanges functioning

With the problems of ranking and clustering researches [11, 12] are associated.

Vaira Gromule in the dissertation research systemizes factors which allow introducing the logistics centre concept to the passenger terminals. A particular emphasis is placed on expanding the functionality of information system for further development of the concept of passenger logistics center, namely, its integration into multimodal passenger transportation system on the basis of creation of virtual logistics center («virtual coach terminals») and improvement of the logistics service systems.

For many decades scientists around the world devote their studies to questions of allocation and determination of the required number of transport interchanges. In the scientific paper [2] it is set the problem of finding allocation variants of transport interchanges that maximize the specific quantity of clients per unit of investment in its construction, the main factor that determines the amount of investment is land price.

A similar criterion is used in the mathematical model developed by scientists from China [3], which aims at maximizing served populations per construction cost of transit node. Additionally, an indicator to describe the attraction level of transit node to passengers is introduced.

A separate important research theme is the passenger flows or pedestrian movement. Pedestrian flows are to a certain extent a special phenomenon for science, in the early twentieth century it was generally believed that they cannot be counted.

The paper [4] presents an approach to re-design a passenger interchange node by random utility
models. The authors have calibrated nine discrete choice models based on attributes that are able to explain a passenger behaviour using results of observed flows and generalized least squares technique. The analyses showed which attributes have the greatest influence on the passenger behaviour as the waiting time, the number of pedestrian crossings and the walking running time.

High quality of public service cannot be achieved without perfect help information through which passengers can plan their trip and choose a route of movement. Unfortunately, in Ukraine such information systems do not meet the requirements of the population. In studies [14–15] the problem of the determination of optimum travel rout by public transport is solved, both studies take into account transfers and seats availability. A route selection can be done by a client in online mode via the Internet.

The evaluation of the safety of transport interchanges is a difficult but important task. Authors of research [16] believe that in order to determine the level of safety it is necessary to consider all walking routes in the transport interchange, presenting them as independent linear parts, for each of which it is possible to calculate safety index.

Ensuring the development of multimodal passenger transportation is a complex task in terms of organization. The main problem is to improve the interaction between different transport modes. Economic and legal forms of interaction between passenger transport modes are almost undeveloped; in contrast with freight transportation all legal aspects haven’t been adjusted yet. According to the definition of multimodal transport, one operator organizes transportation of passenger by multiple transport modes; a passenger needs an integrated ticket. Primarily the problem concerns a multimodal transport contract of passenger carriage.

Buhayko D. and Tereshchenko А. in the paper [17] dwell on the harmonization problems of interests of different transport market actors that are engaged in the transportation by air. Airport management should control the level of transport provision by concluding contracts with transport companies, which should ensure convenient routes to transport passengers to the airport from different parts of the city with optimum frequency and high frequency movement of departure in the «peak» hour.

The topical problem is the efficient organization of technological form of interaction between passenger transport modes. This issue requires a separate research as the potential benefits of intermodal transportation can be easily broken down because of poor coordination.

We note that passenger intermodal systems haven’t been developed, studied and disseminated perfectly well compared to freight haulage, where it has been accumulated a huge amount of theoretical developments to improve the efficiency of transportation involving different modes of transport. In order to improve multimodal transportation it is often proposed the schedule harmonization of vehicles movement, the given direction of efficiency improvement is also correct in relation to passenger transportation. The synchronization of schedules can bring up quality of public services to a new level. Only a few studies of Ukrainian scientists are dedicated to the issue of a schedule synchronization of passenger vehicles movement when performing transportation. Most authors in their works only recommend creating coordinated schedules and do not propose particular algorithms for solving this problem. In contrast to the national sources foreign ones present wide range of research papers on the schedule synchronization topic [18, 19].

The main objective of the synchronization is to minimize waiting time when transferring at transport interchanges and prevent accumulation of vehicles at transport interchanges. Simultaneous presence of several vehicles at public transport stops and stations reduces safety of passenger loading and unloading, requires additional time and speed reduction for manoeuvres, while harmful emissions increase and significantly deteriorate ecological situation affecting the rise of additional costs.

**Conclusions**

Among the main directions of studies in the area of efficiency improvement of the transport interchanges functioning it has been highlighted improvement of transport and planning decisions, passenger flow and pedestrians movement study and development of multimodal and intermodal passenger transportation.
It is possible to increase the efficiency of urban transport interchanges by ensuring their sustainable development, in other words, by complex solving economic, social and environmental problems of their functioning. Sustainable development of transport interchanges is ensured by the coordinated organization of passenger transportation, with schedule synchronization as one of the priority problems. This area of research is promising and meets strategy goals of European transport development by 2050 presented in the White Paper.

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