

ТРАНСПОРТНЫЕ СИСТЕМЫ

УДК 656.025.2=111

MAIN DIRECTIONS OF EFFICIENCY IMPROVEMENT OF TRANSPORT INTERCHANGES FUNCTIONING

V. Naumov, Prof., D. Sc. (Eng.), A. Samchuk, P.G.,
Kharkov National Automobile and Highway University

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 allows 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.

ОСНОВНЫЕ НАПРАВЛЕНИЯ ПОВЫШЕНИЯ ЭФФЕКТИВНОСТИ ФУНКЦИОНИРОВАНИЯ ТРАНСПОРТНО-ПЕРЕСАДОЧНЫХ УЗЛОВ

В.С. Наумов, проф., д.т.н., А.А. Самчук, асп.,
Харьковский национальный автомобильно-дорожный университет

Аннотация. Рассмотрены направления исследований транспортно-пересадочных узлов и приведена их систематизация. Выявлено, что наиболее перспективным подходом повышения эффективности является обеспечение их устойчивого развития. Для этого необходимо совершенствовать технологическую форму взаимодействия пассажирского транспорта и синхронизировать расписания его движения.

Ключевые слова: транспортно-пересадочный узел, эффективность, устойчивое развитие, синхронизация.

ОСНОВНІ НАПРЯМИ ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ ФУНКЦІОНУВАННЯ ТРАНСПОРТНО-ПЕРЕСАДОЧНИХ ВУЗЛІВ

В.С. Наумов, проф., д.т.н., Г.О. Самчук, асп.,
Харківський національний автомобільно-дорожній університет

Анотація. Розглянуто напрями досліджень транспортно-пересадочних вузлів та наведено їх систематизацію. Виявлено, що найбільш перспективним підходом підвищення ефективності є забезпечення їх сталого розвитку. Для цього необхідно удосконалювати технологічну форму взаємодії пасажирського транспорту та синхронізувати розклади його руху.

Ключові слова: транспортно-пересадочний вузол, ефективність, сталий розвиток, синхронізація.

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: combina-

tion 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].

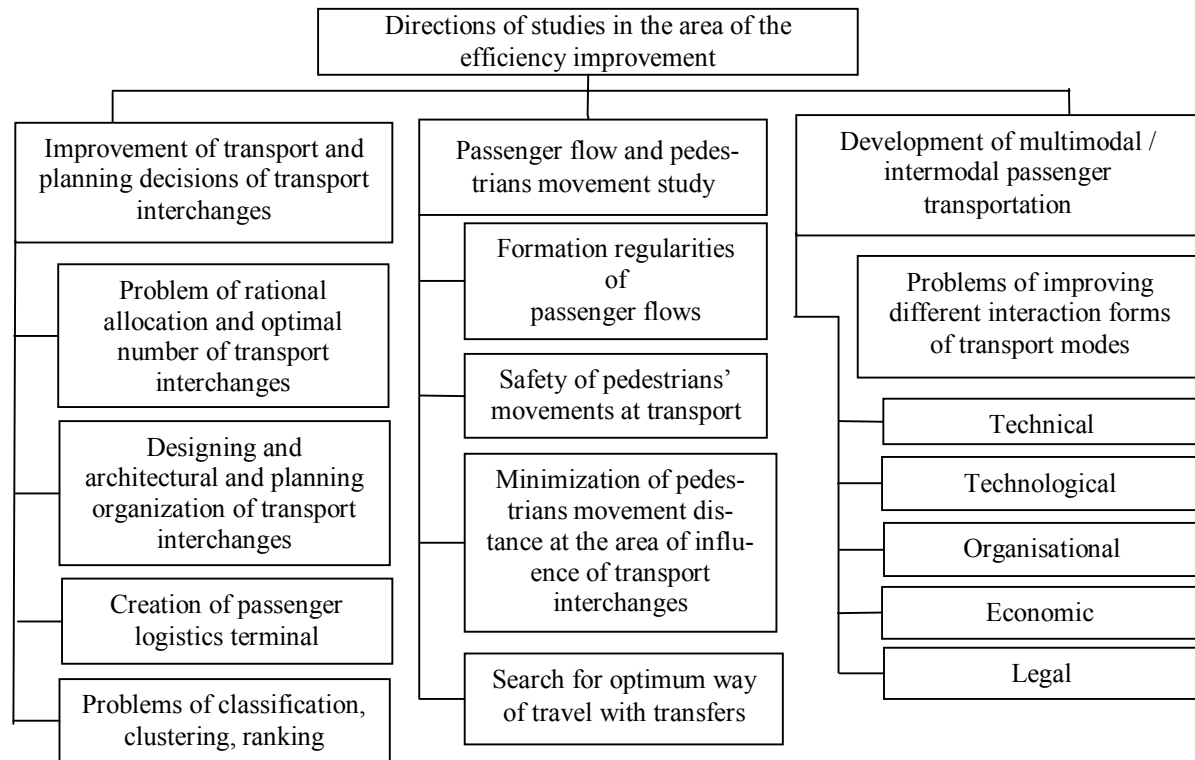


Fig. 1. Directions of studies in the area of efficiency improvement of the transport interchanges functioning

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 terminal») 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 route 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 A. 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 opti-

imum 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.

References

1. Рябова О.В. Методи архітектурного моделювання міських громадсько-транспортних вузлів: автореф. дис. на здобуття наук. ступеня канд. арх. наук : спец. 18.00.01 «Теорія архітектури, реставрація пам'яток архітектури» / О.В. Рябова. – Х., 2007. – 22 с.
2. Горбачев П.Ф. Рациональное размещение транспортно-пересадочных узлов в городах / П.Ф. Горбачев, В.Ф. Далека, И.Г. Гузнецков // Восточно-Европейский журнал передовых технологий. – 2011. – Вып. 4/3 (52). – С. 4–6.
3. Two-phase optimization approach to transit hub location – the case of Dalian / B. Yu, H. Zhu, W. Cai, N. Ma, Q. Kuang, B. Yao // Journal of Transport Geography. – 2013. – Vol. 33. – P. 62–71.
4. Zito P. Random utility approach to re-designing the passengers interchange node / P. Zito, G. Salvo // Urban Transport XV. – 2009. – Vol. 107. – P. 51–62.
5. Торопов Б.І. Розвиток пасажирських комплексів на основі закономірностей формування пасажиропотоків: автореф. дис. на здобуття наук. ступеня канд. техн. наук: 05.22.01 «Транспортні системи» / Б.І. Торопов. – К., 2001. – 21 с.
6. Сай В.М. О моделировании взаимодействия автомобильного, авиационного (малая авиация) и железнодорожного транспорта в области пассажирских перевозок / В.М. Сай, С.В. Сизый // Вестник УрГУПС. – 2012. – №3 (15). – С. 43–53.
7. European Commission: White Paper on transport – Roadmap to a single European transport area – Towards a competitive and resource-efficient transport system. – Luxembourg: Publications Office of the European Union, 2011. – 28 p.
8. European Commission: Green Paper: Towards a new culture for urban mobility COM(2007) 551. – Brussels, 2007.
9. Евреенова Н.Ю. Выбор параметров транспортно-пересадочных узлов, формируемых с участием железнодорожного транспорта: дисс. ... канд. техн. наук : 05.22.08 / Евреенова Надежда Юрьевна. – Москва, 2014. – 197 с. – Режим доступа: http://miit.ru/content/Диссертация.pdf?id_wm=731493.
10. Власов Д.Н. К вопросу о классификации транспортно-пересадочных узлов крупнейшего города / Д.Н. Власов // Вестник МГСУ. – 2009. – Вып. 3. – С. 47–51.
11. Бочаров Ю.П. Ранжирование транспортно-пересадочных узлов городской интермодальной транспортной системы / Ю.П. Бочаров, М.Л. Петрович, А.С. Баранов // Вестник Волгоградского государственного архитектурно-строительного университета. – 2013. – №31(2). – С. 430–436.
12. Овчинникова Е.А. Разработка алгоритмов кластеризации и рекомендаций по модернизации железнодорожных вокзальных комплексов городских транспортных систем: дисс. ... канд. техн. наук: 05.22.01 / Овчинникова Елена Александровна. – Москва, 2014. – 234 с. – Режим доступа: http://www.miit.ru/content/Диссертация.pdf?id_wm=722464.
13. Vaira Gromule. The System of Monitoring the Quality of the Coach Terminal Services for the Realisation of a Conception of a Passenger Logistics Centre in a Multimodal Transport System: Summary of the promotion work Dr. sc. ing. – Riga, 2010. – 48 p.
14. Апатцев В.И. Определение оптимального интермодального маршрута перемещения пассажира / В.И. Апатцев, А.А. Бычкова // Наука и техника транспорта. – 2011. – №4. – С. 76–78.
15. Железов Р.В. Разработка и исследование информационно-справочной системы поиска оптимальных путей проезда на пассажирском транспорте: автореф. дисс. на соискание науч. степени канд. техн. наук: спец. 05.12.13 «Системы, сети и устройства телекоммуникаций» / Р.В. Железов. – М., 2009. – 26 с.
16. Шестернева Н.Н. Транспортно-пересадочные узлы: мониторинг уровня безопасности и комфорта для пешеходов / Н.Н. Шестернева, М.А. Жеблиенок //

- Транспорт Российской Федерации. – 2013. – №5 (48). – С. 29–32.
17. Бугайко Д.О. Взаємодія суб'єктів транспортного ринку в міжнародних аеропортах / Д.О. Бугайко, А.В. Терещенко // Наукоємні технології. – 2009. – №2. – С. 1–5.
 18. Ceder A. Creating bus timetables with maximum synchronization / A. Ceder, B. Golany, O. Tal // Transportation Research Part A: Policy and Practice. – 2001. – Vol. 35 (10). – P. 913–928.
 19. Poorjafari V. A New Mathematical Programming Model for Transit Timetable Synchronization / V. Poorjafari, W.L. Yue, N. Holyoak // The 32nd Conference of Australian Institutes of Transport Research, University of New South Wales, Sydney, Feb 2014. Available at: <http://trid.trb.org/view.aspx?id=1309706>.
 6. Sai V.M., Sizi S.V. O modelirovanii vzaimodeistviya avtomobil'nogo, aviatsionnogo (malaya aviatsiya) i zheleznodorozhnogo transporta v oblasti passazhirskikh perevozok [On modeling the interaction of automotive, aviation (light aircraft) and railway transport in field of passenger transportation]. *Vestnik UrGUPS*, 2012, Vol. 3 (15). pp. 43–53.
 7. European Commission. White Paper on transport – Roadmap to a single European transport area – Towards a competitive and resource-efficient transport system. *Luxembourg: Publications Office of the European Union*, 2011. 28 p.
 8. European Commission. Green Paper: Towards a new culture for urban mobility COM (2007) 551, Brussels, 2007.
 9. Evreenova N.Yu. *Vybor parametrov transportno-peresadochnykh uzlov, formiruemykh s uchastiem zheleznodorozhnogo transporta*. Diss, kand. tekhn. nauk [Parameters choice of transport interchanges formed involving railway transport. Cand. eng. sci. diss.]. Moscow, 2014. 197 p. Available at: http://miit.ru/content/Dissertation.pdf?id_wm=731493 (accessed 24.01.2015).

References

1. Ryabova O.V. *Metody arkhitekturnoho modelyuvannya mis'kykh hromads'ko-transportnykh vuzliv*. Avtoref. dys. na zdobuttya nauk. stupenya kand. arkh. nauk: spets. 18.00.01 «Teoriya arkhitektury, restavratsiya pam'yatok arkhitektury» [Methods for architectural modeling of urban public transport interchanges]. Kharkov, 2007. 22 p.
2. Gorbachev P.F., Daleka V.F., Guznenkov I.G. Ratsional'noe razmeshchenie transportno-peresadochnykh uzlov v gorodakh [Rational placing of bus lining-out knots in cities]. *Vostochno-Evropeiskii zhurnal peredovykh tekhnologii*, 2011, Vol. 4, no. 3(52). pp. 4–6.
3. Yu B., Zhu H., Cai W., Ma N., Kuang Q., Yao B. Two-phase optimization approach to transit hub location – the case of Dalian. *Journal of Transport Geography*, 2013, Vol. 33. pp. 62–71.
4. Zito P., Salvo G. Random utility approach to redesigning the passengers interchange node. *Urban Transport XV*, 2009, Vol. 107. pp. 51–62.
5. Toropov B.I. *Rozvytok pasazhyrs'kykh kompleksiv na osnovi zakonornostey formuvannya pasazhyropotokiv*. Avtoref. dys. na zdobuttya nauk. stupenya kand. tekhn. nauk: spets. 05.22.01 «Transportni systemy» [Development of passenger complexes on the basis of formation regularities of passenger flows]. Kyiv, 2001. 21 p.
10. Vlasov D.N. K voprosu o klassifikatsii transportno-peresadochnykh uzlov krupneishogo goroda [On the classification of transport interchanges of the largest city]. *Vestnik MGSU*, 2009, Vol. 3. pp. 47–51.
11. Bocharov Yu.P., Petrovich M.L., Baranov A.S. Ranzhirovanie transportno-peresadochnykh uzlov gorodskoi intermodal'noi transportnoi sistemy [Ranking of transport interchanges of urban intermodal transport system]. *Vestnik Volgogradskogo gosudarstvennogo arkhitekturno-stroitel'nogo universiteta*. 2013, Vol. 31. pp. 430–436.
12. Ovchinnikova E.A. *Razrabotka algoritmov klasterizatsii i rekomendatsii po modernizatsii zheleznodorozhnykh vokzal'nykh kompleksov gorodskikh transportnykh system*. Diss. kand. tekhn. nauk [Development of clustering algorithms and recommendations on the modernization of railway station complexes of urban transport systems. Cand. eng. sci. diss.]. Moscow, 2014. 234 p. Available at: http://www.miit.ru/content/Dissertation.pdf?id_wm=722464 (accessed 23.01.2015).
13. Vaira Gromule. The System of Monitoring the Quality of the Coach Terminal Services

- for the Realisation of a Conception of a Passenger Logistics Centre in a Multimodal Transport System: Summary of the promotion work Dr. sc. ing. Riga, 2010. 48 p.
14. Apattsev V.I., Bychkova A.A. Opredelenie optimal'nogo intermodal'nogo marshruta peremeshcheniya passazhira [Determination of optimal intermodal passenger travel route]. *Nauka i tekhnika transporta*, 2011, Vol. 4. pp. 76–78.
 15. Zhelezov R.V. *Razrabotka i issledovanie informatsionno-spravochnoy sistemy poiska optimal'nykh putey proezda na passazhirskom transporte*. Avtoref. diss. na soiskanie nauchn. stepeni kand. tekhn. nauk: spets. 05.12.13 «Sistemy, seti i ustroystva telekommunikatsii» [Development and research of Information Inquiry System of search for optimal ways to travel by public transport]. Moscow, 2009. 26 p.
 16. Shesterneva N.N., Zheblienok M.A. Transportno-peresadochnye uzly: monitoring urovnya bezopasnosti i komforta dlya peshekhodov [Transport interchange nodes: monitoring of safety level and comfort for pedestrians]. *Transport Rossiyskoy Federatsii*, 2013, Vol. 5 (48). pp. 29–32.
 17. Buhayko D.O., Tereshchenko A.V. Vzayemodiya sub'yektiv transportnoho rynku v mizhnarodnykh aeroportakh [Interaction of transport market actors at international airports]. *Naukoyemni tekhnolohiyi*, 2009, Vol. 2. pp. 1–5.
 18. Ceder A., Golany B., Tal, O. Creating bus timetables with maximal synchronization. *Transportation Research Part A: Policy and Practice*, 2001, Vol. 35. no. 10. pp. 913–928.
 19. Poorjafari V., Yue W.L., Holyoak N. A New Mathematical Programming Model for Transit Timetable Synchronisation. *The 32nd Conference of Australian Institutes of Transport Research (CAITR)*, University of New South Wales, Sydney, Feb 2014. Available at: <http://trid.trb.org/view.aspx?id=1309706> (accessed 23.01.2015).

Рецензент: П.Ф. Горбачев, профессор, д.т.н., ХНАДУ.

Статья поступила в редакцию 29 апреля 2015 г.
