DOI: https://doi.org/10.30932/1992-3252-2020-18-120-133

Trends in Development of Integrated Transport Schemes for Cities

Mikhail V. NEMCHINOV **Alexander S. KHOLIN**

Nemchinov, Mikhail V., *Moscow Automobile and Road Construction State Technical University, Moscow, Russia.*
Kholin, Alexander S., *Moscow Automobile and Road Construction State Technical University, Moscow, Russia*.*

ABSTRACT

The article discusses the process of planning the work of urban transport operations in the form of an integrated transport scheme (ITS), which is the transport part of the master plan for development of a city, and studies organization of urban transport. The objective of the article is to formulate the main directions of developments in the field of transport planning based on modern domestic and foreign experience and knowledge, and on retrospective analysis of changes in the field of urban transport planning.

The methodology is presented for the conditions prevailing in the Russian Federation, the peculiarity of which comprise a relatively late (compared to European countries and the USA), but rapidly developing motorization of the country, a change in qualifications of specialists working in the field of urban transport planning, a certain loss of experience and skills in development of ITS in recent years.

The suggested conclusions represent a brief description of the concept of a common toolkit, a scheme and the most promising methods for developing approaches to development of integrated transport schemes and require further in-depth research in each specific segment.

Keywords: urban transport, master plan, integrated transport scheme, transport correspondence, modelling, traffic organization, city route capacity, parking, emergency evacuation.

---

*Information about the authors:
Nemchinov, Mikhail V. – D.Sc. (Eng), Professor of the Department of Road Construction and Operation of Moscow Automobile and Road Construction State Technical University, Moscow, Russia, dekanat@da.madi.ru.
Kholin, Alexander S. – Ph.D. (Eng), Associate Professor at the Department of Road Survey and Design of Moscow Automobile and Road Construction State Technical University, Moscow, Russia, holin-as@mail.ru.

Article received 13.04.2020, accepted 20.06.2020.

For the original Russian text of the article please see p. 120.

Background. Retrospective analysis.

Problems of ensuring urban transport traffic have always been and are now a consequence of inconsistency of urban routes with the level of urban transport development and needs. Residents have always moved within settlements (for personal and business purposes). With spatial development of settlements, travel time and amount of goods transported increased, which resulted in emergence and development of transport (personal horse, horse carts, etc.). The transport once emerged, immediately demanded more perfect routes. Gradually, a network of streets emerged, along which vehicles and pedestrians moved. The growth in the number and technical perfection of vehicles was accompanied by development of transport infrastructure, of network of roads and streets, and of their technical improvement.

Domestic transport experts [1–6] divide the entire period of urban development (global process) into several stages:

1. Urban transport is represented by carts. Streets have a narrow carriageway with a wooden or cobblestone pavement for transport vehicles, and without strengthening the carriageway for all the others.

2. Emergence of rail tracks (with horse-drawn traction at the beginning (1853–1854)), then of electrified rail tracks (1881) is witnessed. The streets are narrow, of old construction. The first signs of a transport crisis appeared.

3. There is the emergence of off-street transport and off-street connecting lines (metro: 1863 – London, 1885 – New York, 1892 – Chicago, 1935 – Moscow).

4. There is the decisive reconstruction of street-road and off-street transport network: reconstruction of streets with a change in their geometric parameters, transport profiling of streets, mass construction of transport intersections at different levels, unification of urban and suburban transportation routes into a single transport system (currently).

In all cases, the reason for transition from the previous stage of the state of the urban environment to the next one was linked to oversaturation of settlements with vehicles and occurrence of difficulties in the traffic. At the same time, the system of ensuring traffic of ground (street) transport (including pedestrian flows as a type of urban traffic) was developing and becoming more complex. The development of transportation routes and the system of organizing road traffic is constantly lagging behind development of urban transport, which requires periodically bringing them into line with each other.

In Russia, the issues of better urban transport organization are solved through development of an integrated transport scheme (ITS) of the city, traditionally focused on public passenger transport (street transport, assisted in cities with metro, by underground transport).

In Russia, from the outset, an integrated transport scheme was an integral part of the master urban development plan. True, it was developed after development of the master plan, and urban transport did not actually affect the urban planning. Since the intervals between development of new master plans were rather long, and due to the progress in urban transport, and the difficulties of forecasting for a long time, it was necessary to consider the prospects for transport development for shorter periods of time. Therefore, development of integrated transport schemes is inherently the most important ongoing urban planning task. In the late 1990s (during the famous transition period in Russia), the complex transport scheme was for a short time excluded from the master plan of urban development, and that coincided with the beginning of rapid motorization of the country. Very soon, especially in large cities, acute transport problems declared themselves loudly, and that required resumption of development of integrated transport schemes. Currently, such schemes are being massively developed not only in cities, but also in rural areas[1].

However, the «period of perestroika» did not pass unnoticed for urban construction. The experience and knowledge of development of such schemes has been largely lost, and that happened against the background of a sharp (of «explosive» type) growth of urban transport, increase in the number of vehicles, technical advancement, an increase in transport mobility of the population, a slowdown in reconstruction of the street-road network, emergence of a number of socio-economic changes, changes in acquired qualifications of customers and developers of integrated transport schemes,

[1] That concept is sometimes used locally in several countries, e.g., https://trimis.ec.europa.eu/project/integrated-transport-scheme-rural-area-gloucestershire-hospital-transport-scheme. – *Ed. note.*

mass digitalization of techniques of urban and transport design.

From 1992 to the present, the transport environment in Russia has radically changed in cities, urban agglomerations and, radically, in rural areas. Settlements have changed (they have grown, have been enlarged), and urban agglomerations have emerged. The motorization of population has led to formation of huge car fleets in cities (up to many millions and hundreds of thousands of cars in cities and city agglomerations). As a result, intensive traffic flows appeared in the city streets and roads (up to tens and hundreds of thousands of cars per day). The traffic conditions for urban transport have changed accordingly. The predominant place on streets and city roads was taken by cars, displacing public transport. Speed has decreased and the traffic process has become more complicated. At the same time, due to the large number of private cars, the growth of urban areas, relocation and division of industrial enterprises and organizations, the range of travel of residents has increased. Cars, in addition to places for movement, demanded places for parking (short-term) and storage (long-term). In cities, an acute problem of car parking has arisen. As a result, streets, roads, courtyards were overflown with parked and moving vehicles, often obstructing movement of other vehicles. In this aspect, it should be remembered that any volume has a capacity limit. Do not fill a liter bottle with more than one litre of liquid. The globe also represents a specific capacity. It has long been determined that the resources («capacity») of the globe are quite limited, and it can feed (thus supporting the existence) of only a certain number of people (somewhere no more than 12 billion) [7]. This concerns the cities as well. Their territory is constantly extending due to the increase in the number of inhabitants. But now it is quite difficult to expand the territory of the city. There are no vacant lands. Russian cities generally grow upward. In 1968, the area of the territory of Moscow was only 875 km^2 with population of about 7 million people, in 2019 it was of 2562 km^2 with population of 12,62 million people. The population density was 8000 people/km^2 in 1968 [8], and in 2020 it was of 4980 people/km^2 [9]. But this is the density averaged over the city. In the center of Moscow, the density remained no less than in 1968. The increase in area did not lead to a decrease in the population density of the traditional territory of the city, but to development of a specific huge agglomeration. We use the word «specific» since usually urban agglomerations are formed spontaneously around the entire city, through formation, development and gradual merger of suburban cities and towns. Its geometric shape is usually predefined by local natural conditions (rivers, lakes, mountains, etc.). The modern Moscow urban agglomeration is artificial, not so connected with development of Moscow suburbs.

A simple calculation shows that at present in Moscow almost each family has one or two cars (rounded up calculation shows that with population of 12,5 million people and the average number of people in a family of 3–4 persons, the evaluated number of families will be about 4,17–3,12 million; and the number of cars registered in the city is more than 4,5 million) [9; 10]. And their number grows annually by several hundred thousand. There was a problem where to store them. The overwhelming majority of the «active» vehicle fleet operates only during peak hours. Cars, parked and moving, already occupy the roadway so much that it becomes impossible to drive along many streets. This speaks of overcrowding of the city with cars. In this regard, it is timely to raise the question of assessing the car capacity of the city and its street-road network. Cars are needed, i.e., they should be, they should be driving, i.e. to meet the needs of townspeople, to provide convenience of life. However, to continue to meet that challenge in the future, it is time to assess the permissible limits of filling urban areas – streets, roads, squares, courtyards – with cars, considering environmental damage. The level of air pollution from road transport is well known (it is extremely high). The impact of vehicles on the noise level in the city is great. There is also soil pollution with fuel, oils, wear products of car parts. But there is a limit to everything. Time has come to evaluate it and recommend to the administrations of settlements certain guidelines and methods of managing the process of motorization. The practices of the our life have shown that both market relations and the process of accumulating cars in cities require regulation to ensure favorable living conditions for inhabitants of the settlement.

In recent decades, man-made threats to residents of settlements (of all sizes) have sharply increased in the form of a high road traffic accident rate, an increase in environmental pollution with urban transport waste (exhaust gases, vehicle wear products, etc.). Threats of a natural and man-made nature have become more serious and large-scale: natural and man-made fires and air pollution, flooding of the territory of settlements (as a result of flooding by atmospheric precipitation, during floods) and other natural disasters (dust storms, tornadoes, etc.). Catastrophic situations require the rescue of residents through rapid evacuation (as, for example, it is done in the USA and in a number of other countries).

The administrative and technical conditions for development of integrated transport schemes have also changed. The qualifications of customers of such schemes and of the corps of their developers have changed: in both cases, the number of qualified specialists in the field of urban planning and urban transport has sharply decreased (up to the disappearance), as part of city administrations, that are customers of integrated transport schemes, and as part of contractor organizations, that are scheme developers. In Russia, before the perestroika period, there was a network of urban planning design and research organizations that comprised design institutes (Central research and design institute of urban development and Urban design institute, Giprogor, in Moscow, Lengiprogor in Leningrad), urban planning departments in Moscow (Moscow State Construction Institute (MISI), Moscow State Institute of Architecture (MARKHI)), Leningrad (LISI), Omsk, Rostov-on-Don, and other cities' universities, which had got a huge potential of highly professional specialists in urban planning and transport. During the years of «perestroika» there was a change in the range of organizations who had usually been contractors, and the loss, if not of all, but then of the overwhelming part of the corps of specialists of transport urban planning profile. The digitalization of the project and design process (absolutely necessary for technical reasons) has led to massive emergence of a large number of fairly competent programmers in newly born enterprises, who, however, do not possess urban planning and transport knowledge. This consequently resulted in refocusing of transport solutions on their digitalization at the expense of practical urban planning and transport solutions.

The development and improvement of the legal framework in Russia have resulted in a ban on collection of certain types of information on transport correspondence, necessary and essential for development of integrated transport schemes. If earlier it had been possible to obtain data on the places of residence of employees of enterprises and institutions (e.g., on the locations of the points of departure of passengers of public transport), and from these data it was possible to reliably map job transport correspondences, now the law on personal data protection prohibits collecting that information. Unfortunately, a new system for collecting data on transport and pedestrian mobility of urban residents has not been created in Russia. Besides, a lot of very small enterprises have appeared, which together form significant passenger flows (pedestrians, public and private road transport). In the USA, every ten years, anonymized demographic surveys of population are conducted in the form of censuses, while participation for citizens is mandatory. The list of collected information includes questions about transport and pedestrian mobility. The collected and processed impersonal information can be freely used in development of transport service schemes [11].

Modern tasks

Despite all the changes that have taken place in Russia, the goal and objectives of developing integrated transport schemes have not only been fully preserved but expanded. The goal, in the light of development of cities convenient for life, is to increase the level of transport-friendly life (comfortable conditions for mobility), comprising work and recreation of residents of settlements, technogenic safety of the population, favourable conditions for development of all types of economies in settlements. On the whole, the tasks have been preserved, but have expanded, now they include establishment of a graph of transport correspondence in passenger and freight road transport; development of options for distribution of passenger, car and pedestrian flows along the street-road network and the choice of the optimal one; development of principles for optimal organization of vehicle

Integrated transport scheme. [Electronic resource]: http://900igr.net/up/datai/223319/0008-006.jpg.

traffic and pedestrian motion at the most important transport hubs; development of a set of engineering measures to bring the road network in compliance with the requirements of convenience and safety of transport and pedestrian traffic. The formation of transport and pedestrian correspondence allows extensive mathematical modelling on a city scale (macromodelling) and on a scale of individual transport hubs (micromodelling), using of software for collection and processing of initial data.

The changes that have taken place in Russia have necessitated the inclusion of new transport solutions in the integrated transport scheme, a partial reorientation of traditional developments towards assessing city car capacity, requirement to assess the possibility of ensuring emergency evacuation of population under the conditions of man-made and other disasters. The issue of emergency evacuation of residents of settlements by road has not received much attention before.

Results.

The foregoing makes it possible to formulate the main trends in development and improvement of integrated transport schemes of cities in the interests of making cities convenient for life, to develop the contents of ITS of traffic management, integrating the classic Russian experience and modern requirements, methods, and tools of planning.

Maintaining traditional issues:

- analysis of the street-road network of the considered urban entity;
- analysis of the existing scheme and route system of urban public transport by mode;
- analysis of existing car flows and car parking systems (using mathematical [12–28] and physical [29–35] modelling);
- bringing the transport scheme of urban land public transport and its route system in line with the graph of job transport correspondence of population;
- analysis of pedestrian routes and pedestrian flows;
- analysis of the car parking system.

Development of new issues:

- use of mathematical modelling for optimal distribution of job correspondence referring to public and private road transport, cargo transportation on the existing street-road network of the city;
- development of principles for optimal organization of traffic and pedestrian motion at transport hubs and city streets;
- assessment of car capacity of the city, based on the conditions for ensuring safe traffic, short-term and long-term storage of cars, assessment of the acceptable number of the city car fleet under these conditions;

• assessment of car capacity of storage areas: garages, yard and street parking lots, car storage areas;

• selection of the optimal mode of car movement along the network of city streets (using different criteria: travel speed, volumes of harmful emissions, etc.);

• assessment of the level of environmental impact of road transport on the environmental situation in the city according to the implemented option of traffic organization;

• assessment, organization and engineering equipment of pedestrian paths (sidewalks and paths, ground and underground crossings of streets, lighting, safety fences, road surfaces of pedestrian paths, public transport stops);

• assessment of the possibility of urgent (in a short period of time) evacuation of the population in cases of natural and man-made disasters, designing of urgent evacuation routes, development of principles for optimal organization of traffic during the evacuation period (optimal traffic speed, organization of one-way traffic, maximum use of the width of the carriageway, organization of the possibility of oncoming movement of vehicles of the Ministry of Emergency Situations, traffic police, ambulance and other emergency vehicles, traffic regulation on evacuation routes), identification of modes of transport for evacuation (public and personal vehicles, gathering points for residents close to parking lots of public transport).

The socio-economic circumstances (legal, economic ones) prevailing for the urban environment make it almost impossible to use old methods and techniques for development of integrated transport schemes, assessment of the state of the network and route system of public transport, pedestrian traffic, accounting for road transport, development of passenger and freight graphs (excluding small distributors' vehicles).

New methods need to be developed to suit the new environment. It is necessary to make maximum use of the experience of collecting information on movements of residents, accumulated in foreign countries, where it is believed that transport issues largely determine the level of favorable life and business. Those practices have been largely developed recently in Moscow.

Brief conclusion.

The outlined conclusions represent a brief description of the concept of a common toolkit, a scheme and the most promising methods for developing integrated transport schemes in Russia in the near future and require further in-depth research in each segment.

REFERENCES

1. Butyagin, V. A. Planning and urban improvement: Textbook [*Planirovka i blagoustroistvo gorodov: Uchebnik*]. Moscow, Stroyizdat publ., 1974, 381 p.

2. Fishelson, M. S. Urban ways of communication [*Gorodskie puti soobshcheniya*]. Moscow, Vysshaya shkola publ., 1967, 360 p.

3. Ovechnikov, E. V., Fishelson, M. S. Urban transport: Textbook [*Gorodskoi transport: Uchebnik*]. Moscow, Vysshaya shkola publ., 1976, 352 p.

4. Dubrovin, E. N., Lantsberg, Yu. S., Lyalin, I. M., Turchikhin, E. Ya., Shafran, V. L., Starostin, Yu. V., Mandrikov, A. P. Intersections at different levels on city highways [*Peresecheniya v raznykh urovnyakh na gorodskikh magistralyakh*]. Moscow, Vysshaya shkola publ., 1977, 431 p.

5. Samoilov, D. S. Sociology in urban and regional planning: Study guide [*Sotsiologiya v gorodskom i regionalnom planirovanii: Ucheb. posobie*]. Moscow, MGSU publ., 1998, 97 p.

6. Safronov, E. A. Transport systems of cities and regions: Study guide [*Transportnie sistemy gorodov i regionov: Ucheb. posobie*]. Moscow, ASV Publishing House, 2005, 272 p.

7. The limit of the planet's patience. How many people can the Earth endure? [*Predel terpeniya planet. Skolko lyudei sposobna vynesti Zemlya?*]. [Electronic resource]: https://aif.ru/society/science/predel_terpeniya_planety_skolko_lyudey_sposobna_vynesti_zemlya. Last accessed 17.06.2020.

8. Dynamics of the population of Moscow for 140 years [*Dinamika chislennosri naseleniya Moskvy za 140 let*]. [Electronic resource]: http://www.demoscope.ru/weekly/2016/0689/analit03.php. Last accessed 17.06.2020.

9. Population of Moscow [*Naselenie Moskvy*]. [Electronic resource]: https://ru.wikipedia.org/wiki/Население_Москвы. Last accessed 17.06.2020.

10. How many cars are there in Moscow? Data 2018–2019 [*Skolko mashin v Moskve. Dannie 2018–2019*]. [Electronic resource]: https://yandex.ru/turbo/universeofcars.ru/s/skolko-mashin-v-moskve-v-2018-godu/. Last accessed 17.06.2020.

11. Foreign experience in conducting population censuses [*Zarubezhniy opyt provedeniya perepisei naseleniya*]. [Electronic resource]: https://pandia.ru/text/78/306/7128.php. Last accessed 17.06.2020.

12. Shevtsov, V. I. Mathematical modelling of traffic flows [*Matematicheskoe modelirovanie transportnykh potokov*]. *Avtomatika i telemekhanika*, 2003, Iss. 11, pp. 3–46.

13. Yakimov, M. R., Popov, Yu. A. Transport planning: practical recommendations for creating transport models of cities in PNV VisionRVISUM software systems: Monograph [*Transportnoe planirovanie: prakticheskie rekomendatsii po sozdaniyu transportnykh modelei gorodov v programmnykh kompleksakh PNV VisionRVISUM: Monografiya*]. Moscow, Logos publ., 2014, 200 p.

14. Yakimov, M. R. Transport planning: creating transport models of cities: Monograph [*Transportnoe planirovanie: sozdanie transportnykh modelei gorodov: Monografiya*]. Moscow, Logos publ., 2013, 187 p.

15. Methodological recommendations on the use of software products for mathematical modelling of traffic flows in assessing the effectiveness of design solutions in the field of traffic management [*Metodicheskie rekomendatsii po ispolzovaniyu programmnykh produktov matematicheskogo modelirovaniya transportnykh potokov pri otsenke effektivnosti proektnykh reshenii v sfere organizatsii dorozhnogo dvizheniya*]. Moscow, Mintrans publ., 2017, 72 p.

16. Guidance on application of transport models in transport planning and project evaluation [*Rukovodstvo po primeneniyu transportnykh modelei v transportnom planirovanii i otsenke proektov*]. St. Petersburg, KOSTA Publishing house, 2016, 126 p.

17. Basics of transport modelling [*Osnovy transportnogo modelirovaniya*]. St. Petersburg, KOSTA Publishing house, 2015, 168 p.

18. Rodrigue, J.-P. Urban and Use and Transportation. [Electronic resource]: https://transportgeography.org/?page_id=4613. Last accessed 17.06.2020.

19. Duthie, J., Kockelman, K., Valsary, V., Bin Zhou, B. Applications of Integrated Models of Land Use and Transport: A Comparison of ITLUP and UrbanSim Land Use Models. Presented at the 54th Annual North American Meetings of the Regional Science Association. International, held November 2007 in Savannah, Georgia. [Electronic resource]: https://www.caee.utexas.edu/prof/kockelman/public_html/RSAI07TELUMUrbanSim.pdf. Last accessed 17.06.2020.

20. Rode, Ph. Urban planning and transport policy integration: The role of governance hierarchies and networks in London and Berlin. *Journal of Urban Affairs,* 2019, Vol. 41, Iss. 1, pp. 39–63. [Electronic resource]: https://www.tandfonline.com/doi/full/10.1080/07352166.2016.1271663. Last accessed 17.06.2020. DOI: https://doi.org/10.1080/07352166.2016.1271663.

21. Waddell, P. Integrated Land Use and Transportation Planning and Modelling: Addressing Challenges in Research and Practice. *Transport Reviews*, 2011, Vol. 31, Iss. 3, pp. 209–229. DOI: 10.1080/01441647.2010.525671.

22. Lu, Kai; Han, Baoming; Zhou, Xuesong Simon. Smart Urban Transit Systems: From Integrated Framework to Interdisciplinary Perspective. *Urban Rail Transit,* 2018, Vol. 4, pp. 49–67. [Electronic resource]: https://link.springer.com/article/10.1007/s40864-018-0080-x. Last accessed 17.06.2020. DOI: 10.1007/s40864-018-0080-x.

23. Fierek, S., Zak, J. Planning of an integrated urban transportation system based on macro – simulation and MCDM/A methods. 15th meeting of the EURO Working Group on Transportation Procedia – Social and Behavioral Sciences, 2012, Vol. 54, pp. 567–579. [Electronic resource]: https://link.springer.com/article/10.1007/s40864-018-0080-x. Last accessed 17.06.2020. DOI: 10.1016/j.sbspro.2012.09.774.

24. Yang, L.; van Dam, K. H.; Majumdar, A.; Anvari, B.; Ochieng, W. Y.; Zhang, L. Integrated design of transport infrastructure and public spaces considering human behavior: A review of state-of-the-art methods and tools. *Frontiers of Architectural Research*, 2019. [Electronic resource]: https://discovery.ucl.ac.uk/id/eprint/10085026/1/Integrated%20design%20of%20transport%20infrastructureand%20public%20spaces%20considering%20humanbehavior.pdf. Last accessed 17.06.2020. DOI: https://doi.org/10.1016/j.foar.2019.08.003.

25. Miller, E. J. Integrated urban modeling: Past, present, and future. *The Journal of Land Use,* 2018, Vol. 11, Iss. 1, pp. 387–399. [Electronic resource]: https://www.jtlu.org/index.php/jtlu/article/view/1273/1034. Last accessed 17.06.2020. DOI: https://doi.org/10.5198/jtlu.2018.1273.

26. Mátrai, T., Ábel, M.; Kerényi, L. S. How can a transport model be integrated to the strategic transport planning approach: A case study from Budapest. Models and Technologies for Intelligent Transportation Systems (MT-ITS). *Transport Strategy*, Budapest, Hungary, June 2015, pp. 192–199. [Electronic resource]: http://www.rupprecht-consult.eu/uploads/tx_rupprecht/FLOW_Study_Budapest_-_How_can_a_transport_model_be_integrated_to_the_strategic_transport_planning_approach.pdf. Last accessed 17.06.2020.

27. Haas, A. R. N. Key considerations for integrated multi-modal transport planning. Cities That Work, 2019. [Electronic resource]: https://www.theigc.org/wp-content/uploads/2019/02/Integrated-multi-modal-transport-planning-FINAL-Jan2019.pdf. Last accessed 17.06.2020.

28. Ušpalytė-Vitkūnienė, R., Burinskienė, M. Integration of public transport and urban planning. 7th International Conference on Environmental Engineering, ICEE2008 – Conference Proceedings, 2008. [Electronic resource]: https://www.researchgate.net/profile/Marija_Burinskiene/publication/228716874_Integration_of_public_transport_and_urban_planning/links/543fb6d00cf2fd72f99d19ff/Integration-of-public-transport-and-urban-planning.pdf. Last accessed 17.06.2020.

29. Nemchinov, D. M. Principles and methods of planning road networks: Monograph [*Printsipy i metody planirovaniya setei avtomobilnykh dorog: Monografiya*]. Moscow, TechPoligrafCenter publ., 2014, 305 p.

30. VSN25-86 (Minavtodor of the RSFSR). Guidelines for traffic safety on highways [*VSN25-86 (Minavtodor RSFSR). Ukazaniya po obespecheniyu bezopasnosti dvizheniya na avtomobilnykh dorogakh*]. [Electronic resource]: http://docs.cntd.ru/document/1200006776. Last accessed 17.06.2020.

31. Guidelines for design of ring road intersections [*Metodicheskie rekomendatsii po proektirovaniyu koltsevykh peresechenii avtomobilnykh dorog*]. Moscow, Transport publ., 1980, 76 p.

32. General plan for development of the urban-type settlement Shakhovskaya MO. Main Department of Architecture and Urban Planning of Moscow Region. 2005 [*Generalniy plan razvitiya poselka gorodskogo tipa Shakhovskaya MO. Glavnoe upravlenie arkhitektury i gradostroitelstva Moskovskoi oblasti 2005*]. [Electronic resource]: https://шах-го.рф/ofic-docs/terra/5429-generalnyy-plan-go-shahovskaya-moskovskoy-oblasti.html. Last accessed 17.06.2020.

33. Guidelines for the use of software products for mathematical modelling of traffic flows in assessing the effectiveness of design solutions in the field of traffic management [*Metodicheskie rekomendatsii po ispolzovaniyu programmnykh produktov matematicheskogo modelirovaniya transportnykh potokov pri otsenke effektivnosti proektnykh reshenii v sfere organizatsii dorozhnogo dvizheniya*]. Moscow, Mintrans publ., 2017. [Electronic resource]: http://www.infosait.ru/norma_doc/46/46381/. Last accessed 17.06.2020.

34. Nemchinov, M. V., Kholin, A. S. Transport support of «natural» territories. Methodology for development of a comprehensive scheme for organizing and ensuring safety of vehicles and pedestrians [*Transportnoe obespechenie «prirodnykh» territorii. Metodologiya razrabotki kompleksnoi skhemy organizatsii i obespecheniya bezopasnosti dvizheniya avtomobilei i peshekhodov*]. Moscow, ASV Publishing house, 2019, 169 p.

35. Vlasov, D. N. Transport interchange hubs: Monograph [*Transportno-peresadochnie uzly: Monografiya*]. Moscow, MGSU publ., 2017, 192 p.