

**Lytvynenko T.P.**, PhD, Associate Professor  
ORCID 0000-0002-7229-201X [litta2510@gmail.com](mailto:litta2510@gmail.com)

**Gasenko L.V.**, PhD, senior teacher  
ORCID 0000-0002-1310-914X [lin02011@meta.ua](mailto:lin02011@meta.ua)

**Sharyi G.I.**, DSc, Associate Professor  
ORCID 0000-0001-5098-2661 [sharyi.grigoriy61@gmail.com](mailto:sharyi.grigoriy61@gmail.com)  
Poltava National Technical Yuri Kondratyuk University

## FEATURES OF STREET-ROAD NETWORK MODERN DESIGNING AND RECONSTRUCTION IN CITIES

*The main problems associated with the organization of traffic and pedestrians movement in modern cities are determined. The world experience in designing and reconstruction the street-road network of cities is considered. The factors determining current trends and features of designing and reconstruction of street-road network in Ukraine cities are identified. The priorities of street-road traffic affecting its formation and development are considered. The main goals to adapt urban construction and reconstruction projects to the change of priorities, which took place in the theory of transport planning, are formulated.*

**Keywords:** street-road network, transport planning, priorities of traffic, optimization of city planning structure.

**Литвиненко Т.П.**, к.т.н., доцент  
**Гасенко Л.В.**, к.т.н., старший викладач  
**Шарій Г.І.**, д.е.н., доцент

Полтавський національний технічний університет імені Юрія Кондратюка

## ОСОБЛИВОСТІ СУЧАСНОГО ПРОЕКТУВАННЯ І РЕКОНСТРУКЦІЇ ВУЛИЧНО-ДОРОЖНЬОЇ МЕРЕЖІ МІСТ

*Визначено основні проблеми, пов'язані з організацією руху транспорту і пішоходів у сучасних містах. Розглянуто світовий досвід проектування й реконструкції вулично-дорожньої мережі міст. Виявлені фактори, які визначають сучасні тенденції та особливості проектування і реконструкції вулично-дорожньої мережі населених пунктів України. Розглянуто й обґрунтовано пріоритети вулично-дорожнього руху, що впливають на її формування і розвиток. Сформульовано основні цілі, які мають бути досягнуті при пристосуванні проектів будівництва та реконструкції міських вулиць до зміни пріоритетів, котра відбулась у теорії транспортного планування.*

**Ключові слова:** вулично-дорожня мережа, транспортне планування, пріоритетність руху, оптимізація планувальної структури міста.

**Introduction.** The street-road network of the settlement (SRN) is one of the most stable and important city-building elements, so it must be calculated for a long period of using without expensive major rebuildings and reconstructions.

The current state of urban traffic sets the task to architects, roads designers and workers of transportation sector, which solution depends not only on characteristics of public transport, but also on city development.

**Analysis of recent sources of research and publications.** Nowadays, more and more researchers of transport planning use the term «Automobile Dependency» [1, 2]. During the last decades the international coordination is carried out in the field of transport, roads and urban development. The largest international organization that conducts such coordination is Permanent International Association of Road Congresses (PIARC).

Issues of road infrastructure, urban transport systems development are systematically considered in documents of profile committees PIARC [3, 4]. In 1995 PIARC conducted the specialized XX World Road Congress, devoted exclusively to problems of urban transport planning. In the United States, at the state level, acts were adopted, where special attention was paid to the organization and safety of pedestrian movement: Intermodal Surface Transportation Act of 1991 (ISTEA), Transportation Equality Act of 21th Century.

In the works [5 – 7] the classification of the main geometric structures of the street-road network is given, their influence on the parameters of transport systems functioning of is evaluated and recommendations on the use of the city territory for different planning schemes are given. But such classification based on width and operational qualities cannot fully reflect all the processes taking place on the streets. The street should be not only a city transport artery, but also the place of human interaction. During the organization of street space should be guided by a number of requirements related to activation of social and economic functions: improving the quality of life, mobility and activity of the inhabitants.

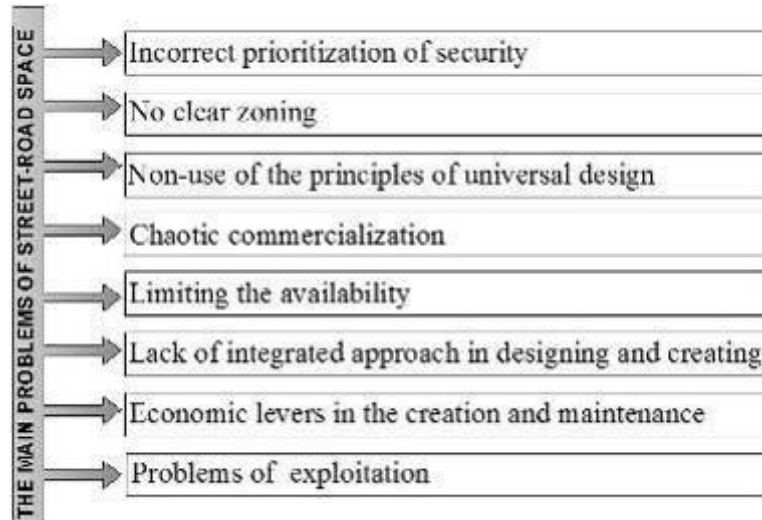
**Identification of general problem parts unsolved before.** The rapid rate of motorization in Ukraine creates a new situation in urban designing. A few years ago, the focus was on improving traffic conditions for road transport (increasing the capacity of SRN and the speed of the connection) and purely technical aspects of resolving this issue. Now problems of providing conditions for pedestrian traffic and especially for the low-mobility groups of the population are getting worse.

**Problem formulation.** The purpose of this study is to summarize the world experience of designing and reconstruction of urban street-road network and to develop proposals for its improvement in accordance with the change of priorities occurred in the theory of transport planning.

**Basic material and results.** The problems of reconstruction of the transport system and the street-road network are very significant. Transportation directly affects labor and cultural-domestic activity of the population, causing technical and social progress of society. Highways and street-road network make up the city framework, forming its planning structure. Moreover, transport communications is the most stable element of this structure, which maintains its functional significance, even with global changes in the organization of urban transport and life of the population. In recent decades the problems of transport in large cities have become much more complicated because of the increasing number of cars and their active using for labor, cultural, domestic and recreational travels.

In Ukraine, for example, the total number of passenger cars approached 2.5 million against 0,55 million in 1991 [8]. The level of car ownership in big and largest cities of Ukraine is 85 – 275 cars per 1,000 inhabitants. The similar rate in urban areas of developed foreign countries is 450 – 700 cars per 1,000 inhabitants. Even with the fact that the level of motorization in Ukrainian cities is low compared with the motorization level of developed Western countries, transport problems in Ukrainian cities are acute and require urgent solution [9].

In the city centers at rush hour the speed of road transport is reduced to 10 – 15 km/h. Time expenditures for travel are increasing, the average time for travel from place of residence to work exceeds 60 minutes at normal rates for 90% of passengers no more than 40 minutes. The study revealed a number of modern cities street-road network problems, the main ones are following (see Fig. 1).



**Figure 1 – The main problems of street-road space**

*Incorrect prioritization of street space security.* Space security depends on many factors: clear and intuitively understandable boundaries of spaces for different activities (walking, moving by bicycle or car, rest in cafes or places for recreation etc.); high concentration of residents on streets, which gives a sense of unity with the city community; good lighting in the dark and so on. Still street lighting is calculated considering the value of traffic. Instead, sidewalk lighting is often relegated to the background, while lighting quality is one of the street safety keys.

*No clear zoning of street space.* The boundaries of private and common spaces in Ukrainian cities are still not clearly defined and there is not any graduation. The boundaries can be both physical (building front, fence, green plantations, etc.), and «mental» (paving, lighting, etc). Because of the lack of clear zoning, pedestrians cannot feel safe even on the sidewalks, car drivers can sometimes both park and ride in pedestrian areas.

*Non-use of the principles of universal design.* The universal design is the design of objects, environment, programs and services appointed to make them as fit for the use of all people without the need for adaptation. Universal design does not exclude auxiliary devices for specific groups with disabilities where they are necessary. Its main principles are equality and accessibility, flexibility for simple and intuitive use, affordable presented information, the right to make mistakes, the need for low physical effort, the presence of the desired size, place, space.

*Chaotic commercialization of street space.* City streets are filled with institutions for business, seasonal and non-sanctioned trade, promotional materials, etc. Thus, the quality of urban space and its visual perception sharply falls. At the same time, it contributes to the reduction of the efficiency of promoting goods and services, the development of the shadow economy, the establishment of «society of consumption» principles and the reduction of mental health of people (irritation due to impossibility of free passage, feeling of imperfection, etc.).

*Limiting the availability of street space.* In the streets of most cities there are no special facilities for people with limited mobility, the design of improvement elements often is not

ergonomic, the crossing of the road often need to use an underground passage, inconvenient for the elderly and low-mobility groups of the population.

*Lack of integrated approach in designing and creating of street space.* A large number of stakeholders in the using of space, variety of landowners create chaotic placement of improvements and other elements of street space. Often there is no street navigation, no signing.

*Economic levers in the creation and maintenance of street space.* In market conditions, the city is not able to maintain a high quality of free space, based in Soviet times. It is necessary to introduce new scenarios for the development of such places using investments from different business structures.

*Problems of street space exploitation.* When operating the streets, normative acts regulating the maintenance of street space are often violated. Garbage disposal system is ineffective, poorly performed work on the current paving repair, etc.

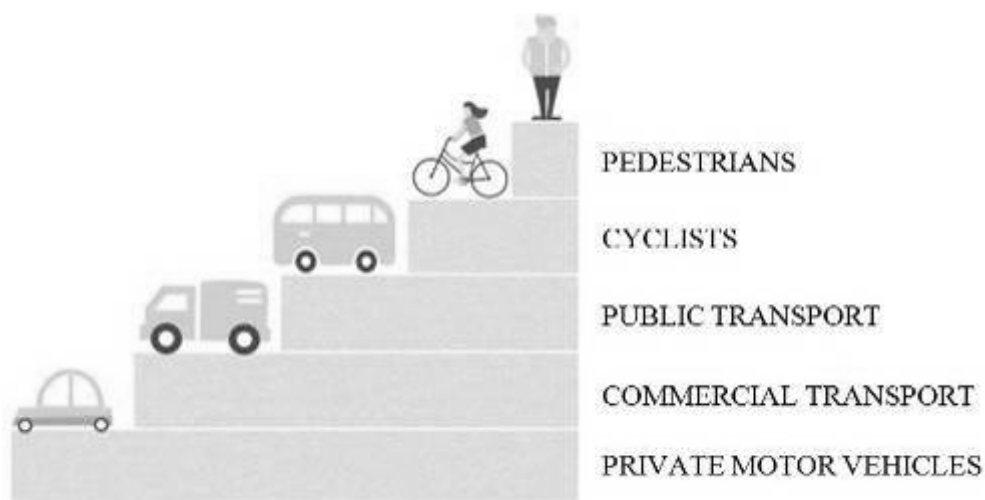
On the second step there is cycling transport, which has the same advantages and problems as the pedestrian, but occupies a separate place in the pyramid because it allows to overcome much larger distances (effective radius of bicycle use is 5 – 7 km) and needs parking spaces and, on separate streets, a separate infrastructure.

Also, with the development of urban traffic, the task of environmental protection revolts especially sharply. Protection from noise, vibration, air pollution of the city by harmful impurities, contained in the exhaust gases of the car are the most acute problems of modern cities.

High growth of city motorization, increasing traffic volumes on the streets, creating a network of high-speed roads and highways of continuous motion, rational organization and traffic management with the creation of the best conditions for its safety are the problems of transport in a modern city, without them the normal functioning of the city life is impossible [10, 11].

In recent years, the views on designing and reconstruction of the street- road network have undergone revolutionary are changed. The term «Automobile Dependency» got the following definition: automobile dependency is the total effect of a number of factors, which leads to a high level of car using and limits the possibility of using transport alternative modes. Another definition is automobile oriented transportation and land use patterns.

World experience shows that even investing heavily in the development of the road network, the solution of road transport services problems is complex; it is impossible to solve the problem of transportation in large cities by providing comfortable movement of cars. The best in terms of transport cities in the world (Copenhagen, Berlin and others) use the so-called pyramid of priority (see Fig. 2), which is advised to apply when making decisions in streets designing and reconstruction [12].



**Figure 2 – The transport pyramid of the city**

Considering the mass of the pedestrian movement and its safety for the environment, on the highest step of this pyramid pedestrian should be set. The long-term global experience proves that the city cannot be comfortable and attractive if it is not convenient for pedestrian traffic (the most vulnerable are low-mobility groups of population).

The third step of transport pyramid is public transportation, which carries far more people than private cars, produces considerably fewer emissions (especially trolleybuses), takes much less space on the road and is not parked for a long time in the central part of the city. The social role of public transport, which is much more affordable for private cars, is also great.

To commercial vehicles, delivering consumer goods, in cities with an efficient transport system have priority above private transport, since convenient conditions for this kind of transport stimulate business development and prevent the shortage of goods. Standard is the permission of commercial vehicles in certain hours, usually in the morning.

The last step in the pyramid of priorities are private vehicles, which, although provide high mobility, comfort and unlimited travel range, have low efficiency (large expenditure of energy efficiency relative to the weight they carry), causing noise and chemical pollution and occupies large areas.

The PIARC methodical documents of recent years and the works of 20th Congress highlight the following important directions of the development of road traffic organization: decreasing the intensity of traffic in city centers; searching for alternative, environmentally friendly modes of transport; the priority of public passenger transport and cars used by several passengers (HOV – high occupancy vehicles); parking regulation; the interaction between the street-road network and the urban environment.

The most radical means of reducing the intensity of traffic in urban centers are car-free zones. They are characterized by a total ban on traffic, with the exception of special types (ambulance, police, fire and communal services, shop maintenance). Such zones are arranged on small, usually guarded territories. As an example, the historical center of Tallinn (Old Town) and the ancient quarters of Little France (Strasbourg).

Currently, a common measure of traffic management is «traffic calming», which combines technical and architectural-planning solutions. According to the definition of the Institute of Transport Engineers (ITE) traffic calming is «a combination of physical measures that reduce the negative effect of cars using and improve the conditions for other street users» [13]. The main objectives of these measures are: improving living conditions; considering priority of the requirements that are put forward by the user of the city territory (work, recreation); creating safe and aesthetically attractive streets; reducing the negative effects of road transport (especially noise and pollution); creating favorable conditions for pedestrians, cyclists and people with limited mobility.

Among the main results achieved by the calm of the movement, the following items are indicated: decreasing of vehicles speed; reducing the number and severity of accidents; provision of conditions for various types of movement (by public transport, by bicycle, by foot); reduction of transit traffic of motor transport.

Traffic calming is achieved by technical measures and laws. First of all, creating calming zones they eliminate the transit movement, where within the zones through-streets turn into dead-end, loop, ring, etc. In addition, the speed limit is introduced, which can sharply reduce the number of conflicts between pedestrians and transport, and regulate parking. It should be emphasized that when designing zones of calming the improvement of the streets and the design of their space play very important role and they are considered as a means of influencing the mode of vehicles movement.

Service of areas often relies on public transport, which is in priority. Therefore, the combinations are possible, for example, of pedestrian traffic and tram lines

(Strasbourg, Saint-Etienne) or pedestrian traffic and bus routes (Dijon). The organization of street space, their landscaping and design ensure the priority of pedestrians and cyclists movement and stimulate the reduction of vehicles speed; in particular, it is supposed the reducing of SRN bandwidth or some its sections.

In the USA and Canada, where practice of parkway design is used, measures of calming the movement are combined with landscape design. For example, part of sustainable development programs in the great Vancouver area was the creation of so-called «green streets», «green ways». Designing of this street type involves reducing the coverage areas, increasing the areas of landing and lawns within the streets, turning them into boulevards, creation of separating strips with landings, application for sidewalk paving and construction from natural materials instead of standard asphalt.

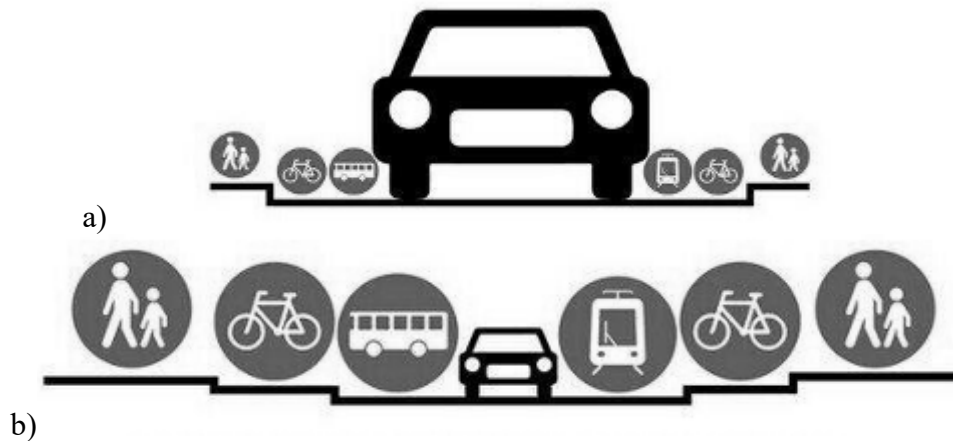
As an example, there should be considered the problems arising during the substantiation of the SRN development in disigning the plan of Poltava.

From the beginning of the XXI century, the city officials of Poltava faced the acute problems of organizing transport, cycling and pedestrian traffic and parking areas in the central part of the city, caused by a number of reasons. The level of motorization in Poltava region in 2003, 2005 – 2009 and 2011 was higher than the nationwide and in 2008 reached the maximum number – 164 cars per 1,000 inhabitants [14]. During the last decade, the so-called tertiary sector (trade, domestic services and various forms of commerce) has been rapidly developed in the settlement. Thus, the «trading core» – a functionally rich territory with an area of approximately 15 hectares, which became the focus of mass attraction of pedestrian and transport flows, has been created. The territory of the «trading core» is gradually expanding and is increasingly saturated with new objects. In fact, there is the process called in foreign urban planning literature as «urban regeneration». The organization of transport services of «trading core» requires the reconstruction of the SRN, but is in disagreement with the requirements of Poltava cultural and historical center preservation.

The city area needs the development of cycling, as the city is compact, most of the streets have a fairly wide passageway, sidewalks are often separated from the roadway with greenery, there are many parks, squares in the city, which promotes the development of recreational cycling. But the results of survey conducted in October 2014 – January 2015 by public organizations «SITI-LAB» and «VeloPoltava» give an idea of the obstacles that prevent Poltava residents from crossing the bike. Among the factors that influence cycling in Poltava are: low quality of roads and sidewalks (this factor is very important for 75.3% of the respondents, important, but not critical for 20.4% and not important for 4.3%); disrespect from drivers/pedestrians, discrimination on the road, violation of the road rules (48.1, 41.3 and 10.6% respectively); lack of bicycle paths (45.1, 46.8 and 8.1%), lack of bicycle parking (44.7, 41.3 and 14.0%), lack of bike parkings at work (38.7, 29.4 and 31.9%).

Therefore, the development and improvement of master plan will have to solve new problems, including the area of ensuring the availability of Poltava SRN to the needs of cyclists and people with disabilities. For execution and addition the transport section of the new master plan and, in particular, the justification of the SRN development, a number of initial indicators should be given. Among them are the projected level of motorization, population mobility (including owners of individual motor transport), distribution of passenger flows between public passenger transport and individual automobile, cycling and needs of people with disabilities.

Thus, Ukraine, like other countries of the world, has faced the problem of adapting the projects of city streets construction and reconstruction projects to changes of priorities, which took place in the theory of transport planning (see Fig. 3).



**Figure 3 – The change of priorities, which took place in the theory of transport planning:**

a) the priority of private car; b) the priority of pedestrian movement [15]

**Conclusions.** Considering the world experience in designing and reconstruction the street-road network of cities, the main goals to achieve adapting urban construction and reconstruction projects to the change of priorities, taking place in the theory of transport planning can be formulated:

- conducting constant researches as the basis for further design work;
- differentiation of the road network by type of prevailing types of transport and organization of movement;
- minimizing the mileage of traffic when traveling between any two points in the city;
- the maximum possible restriction of transit traffic within the city;
- reduction of the harmful effects of traffic flows on residential quarters, recreation areas, areas of historic buildings, which have architectural and artistic value;
- preparation of settlement for the future progress in the sphere of vehicles;
- creation of one-way streets and pedestrian streets;
- increasing mobility of people with disabilities, construction of main bicycle paths;
- clear zoning of streets, separation of pedestrians space and automobile streams, arrangement of parking places, etc.

To achieve these goals, it is necessary to make changes in transverse profiles of city streets (to change the distribution of width of the street, design slopes, types of coverage), to consider the priority when designing roads interconnections, to provide measures to improve the environmental situation in the urban environment. The competent implementation of these actions requires clear orientation in diversity of space organization elements.

#### **References**

1. Рейцен Є. О. *Організація і безпека міського руху* / Є. О. Рейцен. – К. : ТОВ «СІК ГРУП УКРАЇНА», 2014. – 454 с.  
ISBN 978-617-709-243-7.
2. Barton H. *Healthy Urban Planning in practice: experience of European cities*/ H. Barton, C. Mitcham, C. Tsourou // *Report of the WHO City Action Group on Healthy Urban Planning*. – Copenhagen: WHO Regional Office for Europe, 2003. – 57 p.
3. *Central Coordinating Committee for the Promotion of Accessibility for the Disabled (CCPT). Accessibility of Buildings and the Outdoor Environment*. – Delft: Dutch Standard Institute, 1988. – 67 p.
4. *Dansk Ingeniørforning (Danish Engineering Association). Planning of Open Spaces as regards Access for Disabled People*. Translated by Eva Eriksen. – Copenhagen: Forlag Normstyrelsen Publicationer, 1984. – 51 p.

5. Лобанов Е. М. Транспортная планировка городов / Е. М. Лобанов. – М. : Транспорт, 1990. – 240 с.
6. Moughtin C. *Urban Design: Street and Square* / C. Moughtin. – Architectural Press, 2003. – 320 p.
7. Marshall S. *Streets and Patterns: The Structure of Urban Geometry* / S. Marshall. – Spon Press, 2005. – 318 p.
8. Айлікова Г. В. *Методологічні основи планування території регіонів України: автореф. дис. на здобуття наук. ступеня канд. техн. наук: спец. 05.23.20 «Містобудування та територіальне планування»* / Айлікова Ганна Вітольдівна. – К., 2015. – 23 с.
9. Бурко Д. Л. *Порівняльний аналіз рівня автомобілізації в Україні та країнах Євросоюзу* / Д. Л. Бурко // *Матеріали Міжн. наук.-практ. конф. «Транспортні проблеми найбільших міст»*. – Х., 2012. – С. 60 – 61.
10. Lytvynenko T. *Peculiarities of infrastructure designing for the movement of individual environmental friendly vehicles* / T. Lytvynenko, L. Gasenko // *Periodica Polytechnica Transportation Engineering*. – Budapest: University of Technology and Economics, 2015. – Vol. 43. – No. 2. – P. 81 – 86.  
DOI: 10.3311/PPtr.7593
11. Lytvynenko T. *Principles of the road beautification elements placing* / T. Lytvynenko, I. Tkachenko, L. Gasenko // *Periodica Polytechnica Transportation Engineering*. – Budapest: University of Technology and Economics, 2017. – Vol. 45. – No. 2. – P. 94 – 100.  
DOI: 10.3311/PPtr.8592.
12. *Комфортне місто. Як спланувати велоінфраструктуру: довідник* / Громадська організація «Асоціація велосипедистів Києва». – К. : АВК, 2014. – 64 с.
13. Ivasenko V. *Analysis of the regulatory provisions for engineering construction and traffic management course for projecting public transport to the needs of people with limited mobility* / V. Ivasenko // *Сучасні технології в машинобудуванні та транспорті*. – Луцьк: Луцький НТУ, 2016. – № 1 (5). – С. 17 – 21.  
ISSN 2313–5425
14. Шевченко І. Ю. *Регіональна диференціація автомобілізації населення України* / І. Ю. Шевченко // *Економіка: реалії часу*. – 2015. – № 3. – С. 41 – 46.
15. Гершман А. *Как вернуть город людям? [Электронный ресурс]* / А. Гершман. – Режим доступа: <http://gre4ark.livejournal.com/127476.html>.

© Lytvynenko T.P., Gasenko L.V., Sharyi G.I.