Planning of passenger transportation in the cities of Russia on the basis of sustainable development

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Abstract. In cities, transport is the leader in the use of the sustainable development – SD concept. The article describes the features of SD of the urban transport in countries with a high level of economic development. In Russia SD of transport is carried out in accordance with national legislation. Urban transport plans should be developed in all regions and municipalities. The analysis shows that the development of transport plans should be preceded by the solution of a number of problems. The main problems are: the inability of administrations of territories and cities to solve new issues of transport planning; lack of methodological developments for designers of transport systems; a fragmentary information base of transport planning; lack of qualified developers of transport plans. The main ways of solving these problems are proposed. Attention is drawn to the need to take into account not only the internal results (they are received by investors and carriers), but also external results obtained by other persons. The formation of civil society institutions is a prerequisite for SD implementation. Training for environmentally and socially oriented professionals should be changed.

1. Introduction
Sustainable Development (SD) is now a globally recognized general direction of transformation of society and economy including urban passenger transport [1, 2]. The concept of SD was developed in the course of conferences under the auspices of the United Nations (main conferences: Rio de Janeiro - 1992 and 2012; Johannesburg 2002). SD is a dynamic form of materialization of noospheric ideas formulated a century ago by renowned scientists Edouard Louis Emmanuel Julien Le Roy (1870-1954), Pierre Teilhard de Chardin (1881-1955), and continued by academician V. I. Vernadsky (1863-1945) and by many of their followers. The main idea of the SD concept is an integrated approach to assessing the effectiveness of various projects for the development of the urban environment and urban transport. We use a multi-criteria approach that takes into account not only economic results, but also environmental, social, urban planning, policy and other implications of the proposed innovations. SD is aimed at achieving a high quality of life for present and future generations [1, 3].

Urban Public Transport (UPT) leads in the implementation of the SD concept due to environmental, social, demographic and economic factors: localization of UPT work in cities and suburban areas, where the main part of passengers is transported – more than 80-90%;
(a) high density of urban population, which in developed countries is 70 % or more than all citizens (in Russia – 74 %);
(b) concentration of industrial activities in cities including those carried out on a large scale;
(c) considerable time that residents of cities spend to make daily trips. Transport movements in the total balance of free time of a resident of a large city according to our research are about 20 % [4].
(d) urban concentrations of road traffic accidents;
(e) the generation of the bulk of all municipal and industrial waste in cities.

Road transport supplies around 88 % greenhouse gas (GHG) emissions to the atmosphere. Transport consumes 19-25 % of energy and gives 23-25 % of CO2 emissions into the atmosphere [5, 6]. By 2030 the state programs will provide the reduction of transport GHG emissions from 1.8 to 5.5 %. A detailed analysis of the state of GHG emissions is carried out in the article written by Trofimenko Yu. Komkov V and Donchenko V [7]. In large cities, about 85 % of GHG are produced by passenger cars, while buses produce less than 1 % of these gases. About 70 % of the population use buses. Passenger transportation by bus requires 40 times less urban space than the passenger car does [2, 4]. UPT has a significant impact on the quality of life of the majority of the population, its mobility, transport and environmental safety, the level of social tension in society.

The negative consequences of motorization and increased mobility of people should be compensated by a change in the attitude to the preservation of the environment. Transport policy should provide for the development of the infrastructure and stimulate the greening of citizens' consciousness. Sociological studies have shown that people are willing to pay for environmentally friendly transport [6].

In the EU countries SD transport policy is harmonized taking into account the national characteristics of SD UPT. Among the most interesting works on the problem of SD UPT you can point to the article of A. May [9, 10], G. Cohen-Blankshtain [11], P. Miller [12], M. Lowson [13] and their co-authors.

A comparative study of SD plan models was conducted in 84 European cities. Gross domestic product, population density and climatic conditions were taken into account. It is established that by 2050 there is a potential for significant decarbonization of greenhouse gas emissions and mitigation of other environmental consequences [14].

Experts of the European Commission's attitude to urban transport (ECAUT) prepared an analysis of the features of transport planning in 28 European countries [10]. The main differences between the approaches to SD UPTO in different EU countries are political and legal aspects, the state of the methodology of project work, the formulation of goals, the level of public participation in decision-making. Implementation of the SD concept on UPT is carried out by means of transport planning, which provides multi-variant problem solving, computer simulation of situations, achievement of certain goals. ECAUT recommended the development of Sustainable Urban Plans (SUMPs) [3, 15].

The purpose of the article is to summarize the experience of development and use of UPT development planning in Russia, to identify the main problems on the way of successful use of UPT transport planning, to develop a common approach to accounting for the externality of transport systems development projects in cities.

2. Methodology of research
In Russia transport planning based on the experience of developed countries. Integrated transport planning is beginning to be applied, which in the world practice has been named Sustainable Transport Planning (STP).

In Russia UPT transport planning is carried out on the basis of the Federal Law from 13.07.2015 N 220-FL "About the organization of regular transportation of passengers and baggage by road and city land electric transport..." (further – the FL N 220). FL N 220 the law provides for the development of a passenger transportation planning document, which should contain:
- list of measures for the development of passenger transportation, indicating the executors of projects and sources of their financing;
- newly organized routes and routes on which the movement of vehicles will be stopped, the number of vehicles and their passenger capacity on each route, the schedule;
list of routes with regulated and non-regulated tariffs; regulated fares.

The tariff policy on UPT should be aimed at encouraging a reduction in the use of cars. Due to the increase in transport tariffs in Russia in recent years, the demand for passengers transportation has decreased 3.6 times, and the number of cars has increased by 12%. It is necessary not only to set transport tariffs taking into account the possibilities of budget financing, but also to provide the quality of UPT services, which will allow competing with the use of cars by residents of cities [4, 16].

Transport development plans should take into account:
- development plans for the relevant territories;
- state and municipal programs of social and economic development of regions and municipalities;
- programs for the integrated development of transport infrastructure;
- a comprehensive scheme of traffic organization in cities;
- social standards that establish requirements for the level of transport provision of the population and other plans of the authorities.

The methodology of research and development UPT in accordance with the SD concept is based on the use of theoretical developments and the results of the analysis of the production experience of Russian and foreign transport companies and UPT management bodies. The research uses scientific knowledge in the field of passenger transportation, engineering, urban planning, economics and management, demography, applied mathematics, systems modeling, ecology, sociology and psychology, law, qualimetry and standardization, political science, etc.

3. Research and development of the draft transport planning document

JSC "NIIAT" by order of the Ministry of Transport of the Russian Federation developed guidelines for sustainable transport planning of urban transport systems. Currently, the project is being discussed in public authorities, municipalities, scientific and design organizations. In accordance with FL N 220 the project provides guidelines for developing planning documents scheduled traffic on routes UPT. The objectives of the development of the UPT regular routes transport planning document are:

- meeting the needs of citizens in transportation UPT. The level of quality of transport and availability of tariffs should be determined taking into account the possibilities of the city budget (subventions to carriers). The transportation plan should ensure the availability of UPT for mobility of the passengers. In this regard, a comparative analysis of various indicators of mobility assessment is of interest [17];
- improving the competitiveness of UPT and creating conditions to encourage the minimization of the use of cars for daily trips in cities.

The main principles of UPT scheduled transportation planning are:
- guaranteed provision of transport services to the population with the implementation of established quality standards;
- transportation planning in accordance with urban planning and territorial-economic planning;
- integration of transport in all modes of transport, non-motorized movement of people into a single system of multi-modal communication;
- ensuring a high level of safety of transport services;
- choice of the type of transportation (at regulated or non-regulated tariff);
- providing a "barrier-free environment" in the transport service of the population;
- achieving a balance between the guaranteed level of quality of transportation, the solvency of the population, and the ability of budgets to finance UPT;
- variant development of transport plans and selection of the best one with the participation of a wide range of specialists and representatives of the public.

The main tasks of planning transportation on regular routes are:
- UPT route network structure and topology optimization;
• coordination of schedules on different routes;
• ensuring the availability of transfers, including trunk transport;
• increasing the speed of communication in the transport of passengers;
• implementation of "soft" measures to encourage the reduction of the frequency of use of cars;
• ensuring priority in the movement of UPT vehicles;
• raising public awareness of transport;
• ensuring the availability of transport for passengers with limited mobility.

The draft contains recommendations for the authorities and carriers of UPT (procedure for the development of the transport plan, implementation of the transport plan, control of work). The project focuses on the use of the latest achievements of IT and technical means, organizational innovations.

Researchers in Europe, Japan and China are exploring the use of IT to create reasonable alternatives to the quantitative expansion of transport systems. The use of the latest technologies allows one to obtain significant results at acceptable costs for their implementation. Promising technologies are Smart City, satellite navigation and its practical applications, self-adjusting intelligent search and orientation systems, Internet of Things (IoT), creating jobs at home, improving urban logistics, the use of the concept of "transport without transport", etc. [18-23].

The challenge is to obtain information on the need for movement. Geospatial data on the movements (Geospatial Big Data) should be collected on the condition of anonymity. This requires the involvement of lawyers and IT specialists in solving the problem. By the example of Tokyo, recommendations have been developed for the implementation of intelligent statistical analysis of the characteristics of mass movements of people in cities with respect to the confidentiality of personal data [24].

The concept of Smart City is a synthesis of information technologies and ideas of their use to solve various problems, including transport. The transport component of this concept is based on the integration of various information resources, technical means and the organization of rational management of traffic flows, traffic, logistics and the use of transportation capabilities of vehicles. A group of researchers from Finland, studying the complex and dynamic flow processes in cities, concludes that spatial planning of these processes in cities and suburbs should be decentralized. Transport and logistics networks in Smart City should be built as systems with distributed intelligence [21]. This gave us grounds to use neural network construction algorithms to model such systems. Neural networks allow one to implement network configuration based on the principles of self-learning and self-organization [2].

In Europe, the concept of Smart City is used to develop long-term plans for the development of transport and energy policy to achieve the indicators provided for in the White Paper 2011 and the European strategy 2020 (COM 2020). Smart mobility of information technology, used in 22 cities of Italy, since 2005, has allowed achieving significant results and returning on investment [22]. Based on the UN-recommended model of For FITS (Future Internal Transport), a stable relationship between the reduction of CO₂ concentration in the atmosphere of the city and the implementation of Smart City policy is shown [20, 25].

The successful use of Smart City technologies is impossible without the creation of modern information and transport infrastructure, as functioning autonomously IT cannot bring the desired results [23]. For Russian cities, the creation of infrastructure to ensure smart mobility of the population is particularly relevant due to the lack of funding and infrastructure renewal.

The development of the city and its passenger transport under a sustainable scenario has a significant impact on road safety. Russia in terms of road safety significantly lags behind the countries with developed economies. Traditionally, the number of road accidents and the number of deaths and injuries in these accidents have been used as indicators to assess the level of road safety. A more detailed analysis allows us to carry out the technique used in the cities of Spain. This methodology provides for a differentiated assessment of the share of different road users and road infrastructure in the occurrence of road accidents. The evaluation is carried out according to a multidimensional criterion, including economic, demographic, road, technical and other factors, taking into account SD tasks [26]. This allows you to
rank regions and cities, to determine the composition of measures for the prevention of road accidents.

To improve the safety of vehicles, European legislators provide for the introduction of new requirements for vehicles manufactured by the industry. These requirements are based on the use of smart technologies: automatic braking systems, car retention systems on the road, Parking assistance, automatic driving, etc. In Europe, it has been decided to exclude the death of people in road accidents by 2050.

4. Problems in the implementation of transport planning in Russian cities

Studying the experience of application of FL N 220 shows that everywhere instead of full plans of transport development of the relevant territories only tables in which the list of routes of UPT with indication of the type of the tariff applied on these routes (regulated or unregulated) is prepared. Such tables cannot serve as the plans for transport development. This situation is explained by:

– inability of state and municipal employees to manage UPT development strategy on new principles;

– absence of scientifically grounded methodological support for calculation and analytical activity on development and assessment of transport plans quality;

– lack of specialists in transport planning;

– fragmented information monitoring system required for UPT transport planning;

– low quality of UPT infrastructure.

The inability of officials to manage UPT on the basis of the SD concept should be eliminated by professional development and staff renewal.

The creation of modern methodological support is an urgent task for representatives of applied transport science. 20-30 years ago, there were a total of about 70 documents containing a methodology for solving the problems of technological support of passenger transportation [4]. These documents are largely outdated and do not meet modern requirements. The fastest solution to the problem of methodological support of planning is possible due to increased efforts on the part of graduate students of transport universities of Russia.

Training qualified professionals is an inertia task. It takes at least five to ten years to solve it. Particular attention should be paid to the development of students’ innovative environmentally-oriented consciousness. In this article, due to its limited scope, it is not possible to dwell on the relevant issues, so we refer readers to our developments [2, 27].

The creation of an information monitoring system for the purposes of transport planning should be based on the use of existing and newly created information systems in various fields of activity (cadaster, urban planning, social accounting, traffic management, positioning using GPS/GLONASS, etc.). Modeling transport demand requires the use of information available to various authorities and business structures. The reliability of this information is not always high. In the article, Polish researcher J. Chmielewski made proposals to create an information monitoring system for SD UPT [28].

It is necessary to prepare software to perform the necessary multivariate calculations and transport forecasts.

The poor quality of UPT infrastructure is due to insufficient financing for its development. Sometimes it is believed that the development of a sustainable scenario can oppress the economy of the city. This opinion is not justified. The development of transport infrastructure creates prerequisites for the growth of business activity. Therefore, infrastructure financing can be profitable and should be based on public-private partnership [29].

5. Comprehensive assessment of transport planning results

The theoretical basis for a comprehensive assessment of the results of sustainable transport planning is the development of A. C. Pigou (1877-1959), which divided the results into internal and external, that is, external, non-systemic effects [30]. External results are obtained by stakeholders other than the first persons of the project (investors, passenger carriers and their affiliates). The results obtained by the first
persons are mainly monetary (profit) and are called internals. The authors develop guidelines for assessing the various external effects of improving the work of UPT. In particular, the external effects are the reduction of time spent by passengers on travel (the cost estimate of time lost is used), the damage caused to life and health of people in road accidents, the environmental consequences of transport projects.

Let us consider the example of internals and externalities. The company UPT, which has invested in the implementation of the project to improve the quality of transport services for passengers, receives a travel fee from them. Passengers receive socially significant results – reducing the time spent on travel. At the same time, an environmentally significant result is obtained – the reduction of harmful emissions into the atmosphere due to the rationalization of routes and schedules of vehicles.

Figure 1 graphically shows that the flows of internals and externals exist in parallel and are not summed. The horizontal dashed line models the barrier between internals and externalities.

![Figure 1](image)

**Figure 1.** Cash flows and external results currently do not integrate. 1, 2, 3 ... N – conditional numbers of years of implementation of the project; I, II ... M – conditional numbers of years of obtaining internal results.

Cash flow over time is formed as the algebraic sum distributed by year of investment (shown in Figure 1, for example, investment in the project envisaged in the years with reference numbers from 1 to N) and the internal results for the year (these results are for example obtained in the years from number of conditional I, II ... (M).

Cash flow reflects the commercial interests of passenger carriers and investors. The flow of external results has nothing to do with the interests of passenger carriers and investors. Therefore, external goals can be declared by commercial structures, for example, as the "mission of the enterprise". But this is a formal slogan. At present, the mission remains only good wishes.

Internals and externalities can be both positive and negative. Therefore, they should be considered with a plus or minus sign.

Currently, the methodology of complex economic, social and environmental analysis of SD indicators of organizations is being developed. In order to carry out a comprehensive accounting and analysis of all results in assessing the effectiveness of implemented projects and activities, it is necessary to provide a single measure of expression of various results obtained by different stakeholders.
As such, it is advisable to use the value expression of the results. The choice of such measure is due to the economic nature of production and economic activity and the presence of some experience in the valuation of non-economic results obtained in the implementation.

Typical examples of this approach are the valuation of time spent on travel [4] and the valuation of environmental or social damage, damage to life, health and property in the event of road accidents.

To be able to implement an integrated approach, it is necessary to:

- carry out research and development of methods of valuation of various positive and negative internals and externalities;
- legally legitimize the mandatory use of appropriate techniques in the analysis and accounting of innovations.

Determining the effectiveness of innovations should include the formation of a total cash flow, the components of which should be calculated according to these methods. Regulatory and legal regulation of the procedure for such calculations should be based on legally established rules for calculating costs and results, the size of sanctions for violations of environmental legislation (currently such sanctions are established, but the mechanisms for their application do not provide for a sufficiently severe impact on persons who caused environmental damage), the size of sanctions for harmful social consequences of projects, the size of incentives from budgetary sources and in the form of state preferences to persons providing positive externalities. Then the first persons will stop thinking only about their profits, and will pay attention to increasing the capitalization of the business (in a broad sense).

The relationships of different stakeholders arising in the process of implementing the sustainable development strategy are structurally reflected in Figure 2.

![Figure 2. Economic relations with sustainable transport development. Designations: 1 – UPT companies; 2 – Investors; 3 - Current transport expenditure; 4 - Investment in transport development projects; 5 - Implementation of projects of transport development and transport of passengers; 6 - Internal Ny results; 7 - External results; 8 - Means of different stakeholders; 9 - The budgets of authorities; 10 - Economic incentives for obtaining external results (+/-).](image)

The end result of the transition to the proposed procedure for determining the effectiveness of innovations will be the development of socio-economic progress in a sustainable scenario. In the future, instead of economic assessments (cost – income – profit), an innovative model should be created, in which various positive and negative internal and external effects from the implementation of measures should directly affect the total tax burden of the person using the appropriate solution: additional deductions in the presence of negative effects (the so-called Pigou Tax), and additional incentive remuneration of this person with positive effects.

6. Result and discussion

The considered draft guidelines for the development of transport plans is intended for use by public authorities and municipalities, carriers, transport infrastructure enterprises in order to solve the important social problem of passenger transportation on UPT routes.
The draft guidelines set out only the main organizational issues of transport planning. Transport development projects of certain regions and municipalities, developed in accordance with the guidelines, are used to solve the main tasks:

(a) competitive selection of passenger carriers for transfer to them of the state or municipal order for service of routes UPT;

(b) the formation of an information base for the implementation of transport planning on the basis of the requirements contained in the guidelines for the procedure for collecting information, data details, means of collecting information. In particular, it is mandatory to maintain a passport for each route of passenger transportation with the indication in the passport of information used for planning and organization of transportation;

(c) how routes are divided according to the type of fare used (regulated or unregulated fares).

Methodical recommendations do not contain calculation algorithms for evaluation of design decisions. A set of such algorithms should be developed in the near future.

7. Conclusion

Transport planning due to its statutory obligation is the main method of strategic management of UPT, implemented in Russia by joint efforts of state and municipal employees, carriers, designers of transport systems, urban workers, road authorities, specialists and various institutions of the emerging civil society.

The transition to sustainable development of UPT on the basis of transport planning should be innovative and should be based on the transformation of the economic system in the direction of integrated accounting and assessment of the consequences of the implementation of technical solutions that is, taking into account the positive and negative internal and external results of UPT activities. In order to ensure the interest of UPT carriers and investors in achieving external results, tax and civil legislation should be reorganized. In intractable conflict situations, decisions must be made from environmental and social considerations in order to ensure a decent quality of life for present and future generations.

Actual problems among various aspects of UPT activity are development of methodological support of transport planning, monitoring system of initial data, and training of specialists of new formation, advancing development of transport infrastructure.

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