Rubric 4. ECONOMIC TRANSPORT

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ASSESSMENT OF PUBLIC EFFICIENCY OF RAPID URBAN TRANSPORT DEVELOPMENT STRATEGY

Abstract. Assessment of public efficiency of rapid urban transport development strategy is the final stage in the formation of a strategy for the development of rapid transport.
The rapid urban transport development strategy is distinguished by the following main characteristics:

- significant initial investment, which in some cases is considered as an objective obstacle to adoption and implementation of the strategy;
- long timeframes for implementation of the strategy;
- timing of the achievement of the goals;
- use of financial resources.

These characteristics enhance the current cost of the project. The process of measuring the results a new transport project implementation is complicated, because a significant part of the results is of external character and is not subject to cost measuring.

The peculiarities listed above prove the relevance of determination of public efficiency rapid urban transport development strategy. Considering the specifics of the object of the research, the comparison of costs and results of innovative transport product implementation should be carried out within assessment of its public efficiency.

The aim of this work is to develop a system of indicators for assessment of public efficiency of rapid urban transport development strategy; study of existing public efficiency assessment methods, search for their advantages and disadvantages, and research into maglev technology advantages.

The system of indicators proposed to assess public efficiency of rapid urban transport development strategy, considers all advantages of maglev technology and prioritises it in selecting rapid urban transport.

Keywords: public efficiency, rapid urban transport, magnetic levitation.

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ОЦЕНКА ОБЩЕСТВЕННОЙ ЭФФЕКТИВНОСТИ СТРАТЕГИИ РАЗВИТИЯ СКОРОСТНОГО ГОРОДСКОГО ТРАНСПОРТА

Аннотация: Оценка общественной эффективности стратегии скоростного городского транспорта является заключительным этапом формирования стратегии развития скоростного транспорта.

Стратегия развития скоростного городского транспорта отличается следующими основными характеристиками:

- значительные первоначальные инвестиции, которые в ряде случаев рассматриваются как объективное препятствие к принятию и реализации стратегии;
- длительные сроки реализации стратегии;
- разнесение во времени достижения поставленных целей;
- использования финансовых ресурсов.

Эти характеристики увеличивают текущую стоимость проекта. Сложен процесс измерения результатов внедрения нового транспортного продукта, т.к. значительная часть результатов, носит внешний характер и зачастую не поддается стоимостному измерению.

Перечисленные особенности доказывают актуальность определения общественной эффективности стратегии развития скоростного транспорта. Учитывая специфику объекта исследования, сопоставление затрат и результатов внедрения инновационного транспортного продукта должно происходить в рамках оценки его общественной эффективности.

Целью работы является разработка системы показателей для оценки общественной эффективности стратегии развития скоростного городского транспорта. Изучение существующих методик оценки общественной эффективности, поиск недостатков и преимуществ, исследование преимуществ магнитолевитационной технологии.

Предлагаемая система показателей для оценки общественной эффективности стратегии развития скоростного городского транспорта учитывает все преимущества магнитолевитационной технологии и делает её приоритетной при выборе скоростного городского транспорта.

Ключевые слова: общественная эффективность, скоростной городской транспорт, магнитная левитация.

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INTRODUCTION

The magnetic levitation transport meets the requirements of innovativeness because it ensures breakthrough solutions in urban transportation organisation: safety of passengers, environmental safety, high speed, energy efficiency, low life cycle costs as compared to existing transport modes [1].

The Table 1 below represents competitiveness factors of rapid urban maglev transport [2].

Table 1. Rapid urban transport competitiveness factors

№	Competitiveness factors
1	Safety of passengers
2	Average ride time
3	Optimisation of costs for construction and passengers transportation
4	Environmental friendliness
5	Energy efficiency

In transport systems of metropolises, there is certain community interested in transportation processes. Each of them has its own purposes and priorities:

- for city and local authority bodies it is development of promising plans to increase the share of public transport in urban transit;
- for investors it is investing into innovative urban transport system and return of the capital;
- for industry it is production of innovative products for urban transport.

Let us highlight the priorities of choosing urban transport form the standpoint of members of the transport system, that is passenger, state and investor, considering the research [3]. In Fig. 1, the priorities of each of the system's members are given.

The economic literature underlines that maglev transport development can become a real answer to growth of public requirements for quality and speed of passenger transportation in the time of digitalisation of the economy. Due to new tendencies in transport systems evolution, the necessity is substantiated to use fundamentally new modes of transport, and the limitations were identified which are applied to further improvement of the wheel-rail technology [4].

Development of transport systems in metropolitan areas should be happening with outpacing tempo as compared to other economy branches. This is explained by the transport system's special role in the economies of metropolitan areas, that is building of infrastructure for development of other branches, realisation of large investment projects of transport infrastructure, new rolling

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stock, and it is greatly dependent on possibility to attract private investment apart from governmental support [5].

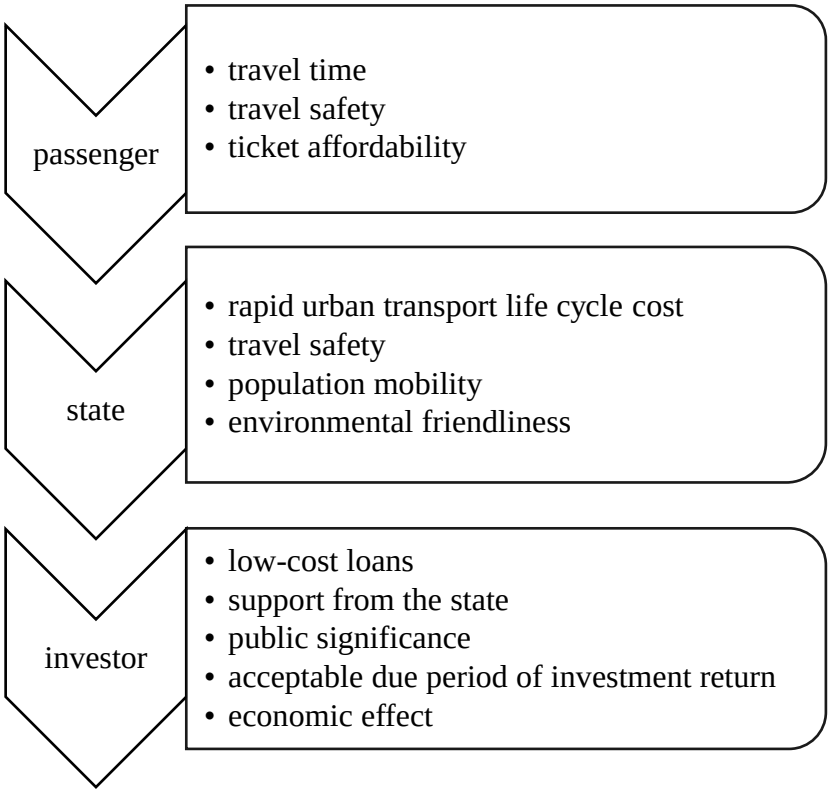

Fig. 1. Priorities governing choosing of urban transport mode

These moments are exclusively of long-term nature, they considerably influence development of urban passenger transport and therefore belong to strategic sphere of management decisions. Thus, this explains the necessity to develop an urban rapid passenger transport development strategy for metropolises, which will ensure increase of transportations speed.

RAPID URBAN MAGLEV TRANSPORT DEVELOPMENT STRATEGY

The strategy represents a combination of management decisions, aimed at achieving rapid urban transport development to fully meet the population's demand for rapid transportation, based on competitive advantages of the technology: higher route speed compared to metro, low operational costs, impossibility of derailment, absence of noise and dust, lower power consumption due to absence of friction, high throughput, provided that there is due transport infrastructure.

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Basing on the analysis of the existing approaches to development of urban transport, we have suggested a conceptual approach to forming of rapid urban transport development strategy, considering specifics of maglev technology, which includes major stages of its development and realisation mechanism: determination of mission, strategic priorities and objectives, purpose indicators, setting of tasks of rapid urban transport development, assessment of investment cost of the project, assessment of public efficiency of the strategy. Fig. 2 represents it on the example of Saint Petersburg agglomeration.

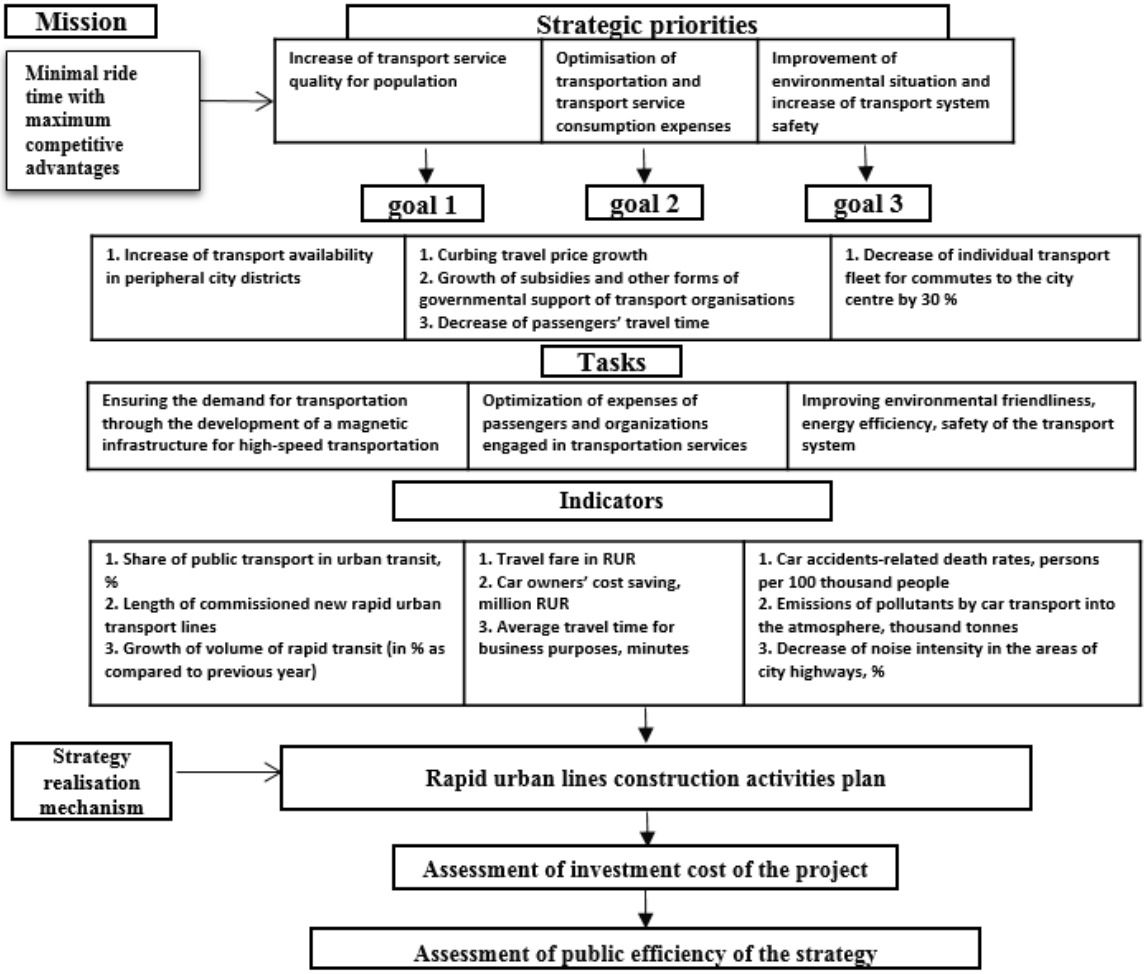

Fig. 2. Conceptual approach to strategy forming
for development of rapid urban transport

The process of formation and realisation of rapid urban transport development strategy comprises five stages:

1. Shaping the strategic vision of the future rapid urban transport; determination of long-term perspective of development, formulation of purposes of

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rapid urban transport, identification of priorities of rapid urban transport;

2. Setting the purposes; transition from strategic vision to actions;
3. Development of the strategy;
4. Realisation of the strategy;
5. Assessment of results and update of the strategic vision, purposes, strategy and their realisation considering experience gained, changing conditions, and emergence of new ideas and opportunities.

Selecting a strategy is a key to success of performance and development of rapid urban transport. First of all, formation of strategy is determined by the mission and vision of rapid urban transport.

Vision is the perspectives and strategic vectors of rapid urban transport development, the plans that may be achieved in the future. The vision encompasses not only rapid urban transport and its development, but the entire transport industry, technologies chosen as well, and the position that the rapid urban transport hopes to take in the competition. The vision is what the rapid urban transport will be in 5−10 years, it is its perspective capabilities and target consumers.

If the vision determines the future, then the task shows the performance of the industry at the present moment. The task is explained by high social and economic role of rapid urban transport in the present day society. The situation in the passenger transportation branch provides a great number of competitive advantages to rapid urban transport in fulfilling its task.

The task of the rapid urban transport is determined by its interested groups, whose demands it strives to meet. Forming the task of the rapid urban transport, we forecast the volume of passenger transportation to be provided by rapid urban transport.

Forming the task of the rapid urban transport, we need to precisely describe the present situation of passenger transportation market and technologies. Clearly formulated task enables the following:

- setting leading, prioritised tasks before the rapid urban transport;
- determining development of the rapid urban transport for long-term perspective;
- decreasing the risk of making inefficient decisions.
-

The strategic priorities provide answers to:

- what does development of the rapid urban transport give to metropolises?
- what does business community, economy of metropolises expect from this development?
- what should transport acquire in the process of realisation of the strategy, so that to ensure efficient performance of the rapid urban transit?

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Thus, the main strategic priorities of the rapid urban transport development describe the target guides of the rapid urban transport development from the standpoint of meeting demands of population, business and representatives of the rapid urban transport.

At the second stage of formation of the rapid urban transport strategy, the stage of purposes setting, the mission of the rapid urban transport turns into certain results and outcomes, which strive to achieve within certain period. The purposes will have management value only in the case they are determined in the qualitative and measured indicators, and will contain maximal figures, that should be achieved.

Determination of purposes sets benchmarks which enable assessment of performance of the rapid urban transport.

The purposes of the strategic development of the rapid urban transport should comply with the Russian Federation's 2030 Transport Strategy [6], but not necessarily coincide with it. The recommended purposes of the strategy of development of the rapid urban transport are:

Purpose 1.

Ensuring demand for transportation by virtue of development of maglev infrastructure of high-speed transportation.

Purpose 2.

Optimisation of passengers' and transportation services organisations' costs.

Purpose 3.

Increase of environmentability, energy efficiency and safety of transport system.

In realisation of the Purpose 1, the strategy should include formation of optimal routes of rapid transport network to meet the demands for rapid transport in various groups of population, considering local conditions, as well as increase of transport availability of peripheral city districts.

The tasks of the Purpose 2 are to curb growth of travel fares, subsidies and other forms of governmental support of transport organisations, and decrease of travel time of passengers.

The role of agglomeration in the Purpose 3 consists in providing safety at the level set by strategy indicators. And transport strategies should identify in detail the activities aimed at increasing transport system's safety considering local conditions. The most important activities from the standpoint of safety are the activities to liquidate dangerous parts of transport system.

The realisation of the Purpose 3 of the strategy to decrease impact of transport system on environment is included in the sphere of strategic interests on social and economic development of the agglomeration and is directly dependent on regional authorities' work. In this regard, regional transport strategies should include a set of tasks and measures to achieve the strategy indicators, connected

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with transport impact on regional environment, as well as to enhance transport energy efficiency. The decrease of transport impact on environment is achieved through decrease of emissions and discharges of hazardous substances into environment, decrease of impact on natural landscapes. Development of public car transport with efficient motors using alternative fuel, is a considerable factor of impact on environment in urban areas.

The task in the Purpose 3, decrease of individual transport fleet for commutes to the city centre by 30 % was identified.

For each purpose of the rapid urban transport strategy, a short clarification should be provided, disclosing, what exactly achievement of this purpose will give to economy and social sphere of the region, and at the expense of what major measures achievement of this purpose will be. The form and stylistics of this clarification is set by designer. For each purpose of the strategy, the target indicators should be described.

At the stage of the strategy development, the questions should be answered as to how to achieve the set purposes. The strategy is means of achievement of the purpose.

The mechanism of realisation of the strategy if applied to Saint Petersburg agglomeration includes a set of measures to be undertaken by state procurement clients and Saint Petersburg and Leningrad Oblast Transport Systems Development Coordination Council, in order to increase efficiency of realisation of activities (projects) and achievement of the planned indicators, specified by the Strategy.

The strategy is the basis for consideration of especially important large investment projects aimed at developing transport system of Saint Petersburg and Leningrad Oblast, in the documents of strategic planning of the Russian Federation, Saint Petersburg and Leningrad Oblast, in accordance with the Federal Law of June 28, 2014 № 172FZ (Rev. of July 3, 2016) “On Strategic Planning in the Russian Federation” [7].

ASSESSMENT OF PUBLIC EFFICIENCY OF RAPID URBAN TRANSPORT DEVELOPMENT STRATEGY

The assessment of public efficiency of rapid urban transport development strategy is the finalisation of development of the strategy of rapid urban transport development. Let us detail it.

As the analysis showed, the process of development of transport systems of both regional and federal levels contains determination of purposes, that should be achieved at each stage of its realisation, and substantiation of necessary resources for their achievement as well.

The strategy of development of rapid urban transport is distinguished by the following characteristics:

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- significant investment, which in a number of cases are viewed as an objective hindrance to adoption and realisation of the strategy;
- long period of realisation of the strategy and large spacing between achievement of the set purposes and use of financial resources make it more considerable to determine current price of the results and compare them to initial investment [8].

The difficulty is made up my process of measuring the results (effects) of implementation of a new transport product. Significant part of these results are of external nature and are frequently to subject to price measuring.

The peculiarities listed confirm the relevance of determination of public efficiency of urban transport development strategy. Considering specifics of the object of research, comparison of costs and results of implementation of innovative transport product should be done within its public efficiency.

For *"publicly significant"* projects, in the first place, their *public (social and economic, and "economic", in accordance with the western terminology)* efficiency is assessed. With unsatisfactory public efficiency, these projects cannot rely on state support. If, on the contrary, their public efficiency is sufficient, their commercial efficiency is calculated [9].

The indicators of social and economic efficiency consider social and economic outcomes of implementation of investment project both for society in general, including direct results and costs of the project, and "external" costs and results in associated economy sectors, ecological and other extra-economic effects. We are talking about existence of the so-called external effects (externalia), i.e. costs and results of the project, which could not be adequately reflected in the indicators of economic activity of the subjects of the economy, involved in the project.

All external effects of the project are divided into effects that can be estimated in terms of price, and effects that cannot be expressed in monetary units. In turn, the latter ones are divided into effects that have a quantitative expression and effects that are described only at a qualitative level. External effects that can be estimated in monetary expression are directly included in the calculations of the social and economic efficiency of the project in the form of additional cash inflows and outflows.

In the most general form, the external effects can be divided into environmental, social and public welfare, that cannot be measured in terms of money.

The *environmental externalia* include: change of soil pollution, emissions into the atmosphere and water; disturbance of ecological balance of the territory;

The social externalia are those directly connected with life standards in population (unlike the technological ones, the influence of which can be considered as indirect). The indicators of social effect achieved as a result of

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realisation of regional investment project, are: increase of working age population employment level; increase of level of provision of population with comfortable housing; increase of affordability and quality of transport service, medical care, education, sports, culture, public utilities; change of population incomes, level of unemployment, price of goods and services, quality of food products, quality and price of housing, provision with housing, household and utility services, cultural and sports institutions, transport services, education and health care levels, employment conditions, number of working places with severe, harmful and hazardous conditions.

The economic externalia are reflected in the expenditures and incomes of companies and organisations, which are not involved in the project. They may encompass: establishment and development of new production (by virtue of transport, raw materials and innovative developments provision); saving on transport expenditures of health care and culture institutions by virtue of construction of new roads, etc.

Let us consider experience in calculation of external effects of the Moscow–Saint Petersburg and the Moscow–Kazan high-speed railway lines. In calculation of economic efficiency of construction of HSR 1 Moscow–Saint Petersburg, in accordance with JSC "RZD" methodology of August 29, 2009, cash inflows and outflows were taken into account, which characterise external economic effects of the project. Among them there are: additional income for industrial enterprises and construction industry as the result of construction of HSR; additional revenues for enterprises of various industrial branches, energy generating companies, formed in operation of HSR; revenue increments to all level budgets through taxes from JSC "RZD" and indirect participants realising the project; decrease of air carriers' revenues due to transition of part of passenger flow to HSR; decrease of budget expenses aimed at realisation of state policy of assisting population employment; cash inflows formed through price evaluation of reduction of time of passengers to travel by HSR from Moscow to Saint Petersburg and back; additional revenues of construction companies, building residential and commercial real estates in the areas of close proximity to a new railway line, caused by increase of population revenues and demand for housing.

Considering the scale of construction of the Moscow–Kazan HSR 2, the social and economic effects are underlined: effect from demand, induced by HSR 2, increase of regional employment and commutes, and effect from HSR lines influence on tourism development.

In the work [10] the authors underline the following external effects anticipated from maglev technology implementation: additional growth of GDP of both local and regional scale, agglomeration effects, expansion of opportunities for population for efficient realisation of their skills.

We have substantiated a system of indicators of assessment of public efficiency from rapid urban transport, which includes methods of calculation of

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the following effects: decrease of passengers' travel time, reduction of impact on the environment, and safety increase in realisation of maglev transport (MLT) project.

It is especially important to design a system of such indicators for maglev transport, because it is distinguished by such advantages as impossibility of derailment, high route speed and, consequently, less time spent for the ride, lower levels of noise and vibration than those in metro and light railway, and complete absence of dust [11–14].

The system of indicators has been developed considering specifics of innovative transport projects, namely maglev transport.

CHANGES OF PASSENGERS' RIDE TIME

The calculation of ride time for passengers who changed to maglev transport from other modes of transport. The price evaluation of time saving is carried out using cost of time depending on travel purpose, whether it is work or leisure.

$$\sum \mathrm{ESTT}_i^t = \sum \left({P_{ijk}^t}^0 \times Vot_{ik}^t \times TC_{ij}^t \right) - \sum \left(P_{ik}^{t\,MLT} \times Vot_k^t \times {TC_i^t}^{MLT} \right) \quad (1)$$

where i – connection;
j – transport mode;
k – ride purpose;
ESTT_i^t – effect from ride time saving per one year t for passengers of all types of transport in realisation of MLT project;
${P_{ijk}^t}^0$ – amount of passenger flow in i-th connection on j-th transport mode with leisure purposes k per one year t;
Vot_{ik}^t – cost of time of passenger in i-th connection with travel purposes k per one year t;
TC_{ij}^t – passenger time expenses en route in i-th connection on j-th transport per one year t;
$P_{ik}^{t\,MLT}$ – volume of passenger flow in i-th connection with travel purposes k per one year t, in realisation of MTL project;
${TC_i^t}^{MLT}$ – cost of time of passenger in i-th connection on j-th transport per one year t in realisation of MLT project.

The basis for evaluation of cost of time is the average-weighted *hourly labour rate* in the cities in question. Discrepancies in costs of time, depending on purpose of travel, was set on the basis of world developments in this sphere, results of social surveys and experts' assessments.

Effect of decrease of harmful impact on environment in realisation of MLT project was calculated as follows:

$$\mathrm{EED} = \mathrm{VED}^0 - \mathrm{VED}^{\mathrm{MLT}}, \quad (2)$$

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where VED^0 – cost assessment of environmental impact in "zero" option; VED^{MLT} – cost assessment of environmental impact in realisation of MLT.

With the approach considered, the impact on environment is formed by three components:

$$VED = VEmis + VCli + VN, \quad (3)$$

where VEmis – cost assessment of emission of pollutants into the atmosphere;
VCli – cost assessment of harmful impact on climate;
VN – cost assessment of noise impact on environment.

The cost assessment of noise impact on environment is of special importance, because maglev transport has a lower noise level, namely 65 decibels, unlike other modes of transport with over 70 decibels.

The cost assessment of noise impact on environment is determined by the following formula:

$$\sum VN_i = Pkm_{ij} \times r_j^N, \quad (4)$$

where Pkm_{ij} – passenger flow in i-th connection on j-th transport mode;
r_j^N – cost assessment of noise impact on environment per 1 passenger kilometre.

The cost assessment of emission of pollutants and harmful impact on environment is calculated likewise.

Re-distribution of passenger flows as a result of implementation of MLT will lead to change of load on environment due to change of emissions of pollutants and noise loads.

Environmental damage is assessed on the basis of specific indicators of environmental impact for one passenger kilometre by transport modes. The environmental impact made while constructing MLT is considered within capital costs. The effect from decrease of environmental impact is determined for "zero" option and in realisation of MLT.

The cost assessments of emissions of pollutants into atmosphere, harmful impact on climate and noise impact on environment are presented in the Table 2 [15].

Table 2. Cost assessment of damage to environment by types of transport

Transport mode	**Units of measurement**	**Figures**
Emissions into the atmosphere		
Bus	euro ct/pkm	0.64
Car	euro ct/pkm	0.58
HSR	euro ct/pkm	0.28
Maglev	***euro ct/pkm***	***0.13***
Harmful impact on climate		
Bus	euro ct/pkm	0.96

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Transport mode	**Units of measurement**	**Figures**
Car	euro ct/pkm	1.83
HSR	euro ct/pkm	0.16
Maglev	***euro ct/pkm***	***0.08***
Noise impact on environment		
Bus	euro ct/pkm	0.17
Car	euro ct/pkm	0.18
HSR	euro ct/pkm	0.13
Maglev	***euro ct/pkm***	***0.06***

Source: CE Delft Study (Handbook on Estimation of External Costs in the Transport Sector, 2008 г.); INFRAS, CE Delft и Fraunhofer ISI (External Costs of Transport in Europe, 2011 г.)

Effect of safety increase in realisation of MLT was calculated as follows:

$$\sum ES_i = \sum \left(Pkm_{ij}{}^{0} \times r_j^S \right) - \sum \left(Pkm_i{}^{HSR} \times r_i^{SHSR} \right), \qquad (5)$$

where i – connection;
j – mode of transport;
ES – effect of ride safety increase for passengers of all transport in realisation of MLT project;
$Pkm_{ij}{}^{0}$ – passenger flow in i-th on j-th transport in "zero" option;
r_j^S – cost assessment of fault-related expenses on j-th transport mode;
$Pkm_i{}^{MLT}$ – passenger flow in i-th connection with the purpose of ride k in realisation of MLT project;
r_j^S – cost assessment of fault-related expenses in realisation of MLT projects.

The assessment of effect from increase of passenger transportation safety is determined on the basis of specific indicators of damage from faults per passenger kilometre by modes of transport, and distribution of passenger flows by modes of transport in "zero" option, and with realisation MLT project. Specific indicators of damage for MLT are assessed by international equivalents.

The cost assessment of expenses for faults are given in Table 3.

Table 3. Cost assessment of expenses for faults by modes of transport

Modes of transport	**Units of measurement**	**Figure**
Bus	euro ct/pkm	1.3
Car	euro ct/pkm	3.42
HSR	euro ct/pkm	0.06
Maglev	***euro ct/pkm***	***0.01***

Source: CE Delft Study (Handbook on Estimation of External Costs in the Transport Sector, 2008 г.); INFRAS, CE Delft и Fraunhofer ISI (External Costs of Transport in Europe, 2011 г.)

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CONCLUSION

Thus, the system of indicators of public efficiency assessment for rapid urban maglev transport development strategy has been show.

The suggested system of indicators for assessment of social and economic efficiency of rapid urban transport development strategy considers all advantages of maglev technology and prioritises it when choosing rapid urban transport.

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