Economic and functional efficiency of the digital platform of urban traffic control

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Abstract. The paper is devoted to the development of urban planning activities in the field of urban traffic control via the expedient economic methods for solving the problems of road congestion, in particular, using the tax on congestion. The present study includes a comprehensive analysis of economic factors and methods of economic regulation to address the issues related to traffic congestion in a modern city. It has been found that the total costs of the trip affect the individual decision concerning the method, time and route of the trip. The economic regulation of this allows the optimal value of traffic density to be achieved. The application of this approach in combination with other economic and urban-planning methods in the field of urban-planning regulation and transport planning enables to significantly reduce or completely eliminate the problem of traffic congestion on the main streets of the city. Consequently, a comprehensive economic approach to elimination of traffic congestion in Irkutsk has been developed. The effectiveness of investments in an IP video surveillance system and transport fixation is justified. The choice of time periods and sections of city roads for levying tax for maintaining good city roads is analyzed.

1. Introduction

The growth and development of cities is accompanied by increasing role of economic effects and social factors. However, this process is not free from some negative trends. The high population density in cities, without proper regulation of living conditions by the authorities, leads to the rise in crime, environmental crisis, transport standstill, as well as other negative consequences. All this inevitably affects the comfort of social life in the city, the economy of which suffers multi-million losses. These phenomena stimulate the migration of the economically active population to territories with more comfortable living conditions. Therefore, the economic and social development of cities, as well as conceptual urban-planning activities, cannot today ignore the modern challenges imposed by urbanization. The efficient economic addressing of these challenges, in turn, can bring beneficial results for the whole society, improve the quality of life of population, and also give the impetus to the development of local solutions and the entire urban territory.

Among the pressing challenges of a modern large city is the so-called traffic jams occurring on the most important sections of city roads. Almost every day, in the morning and evening rush hours, the big cities suffer from traffic jams. The central "transport arteries" of metropolitan areas are paralyzed during
these hours, the average driving speed being dramatically lower than the normal one (sometimes five or more times slower). Meanwhile, the number of vehicles per capita is growing at an astonishing rate every year. However, the road capacity is drastically inferior as compared to the traffic growth. As a result, road congestion is booming. The sitting traffic jams results in waste of time (hundreds of thousands of hours daily for total traffic), unnecessary fuel consumption, etc. In addition, traffic jams create serious environmental problems (concentrated air pollution), interfere with health of drivers and passengers (many hours long sitting in the car, pollution of the ambient air with exhaust gases, etc.). All this worsens attractiveness of the city, in which the issue of traffic jams becomes acute. Also, due to the traffic jams, the transport costs for firms and individuals increase significantly.

The problem of traffic jams is also hot for Irkutsk, the nearest city to Lake Baikal. Historic buildings adjacent to the most popular traffic routes limit the road capacity. An acute shortage of parking space in the downtown area even more significantly narrows the city roads. However, the demand for these roads is highly flexible. According to statistical data, each city dweller has more than 1.3 registered cars and this number is growing steadily every year. At the same time, not every city dweller has personal transport. It is impossible to ignore the circular migrants from the suburbs and the Irkutsk agglomeration, as well as the transit traffic. Two federal highways pass through Irkutsk, while lateral cannot take all additional traffic. All this, together with the low quality of the road surface and the weak level of development of public transport, aggravate the problems of traffic jams in the regional center.

2. Theory
The topic of the present paper is poorly understood in the works of Russian researchers. The literature survey has shown that the foundations of theory and methodology of traffic control were the objects of research of such world-renowned scientists as Bruce Greenshield, Vukan R. Vuchic, William D. Eggers, Peter Samuel, Rune Munk, Fritz Sollner, etc.

The Greenshield’s basic diagram, reported in 1933, still remains a fundamental classic. He has proposed a relationship between speed, density and intensity of interrupted traffic flow, which predicts and explains the trends that are observed in real traffic flows [1].

Vukan R. Vuchic, in his famous book [2] offered to reconcile the character of the city with the types of livable vehicles: such symbiotic transport systems should be economically efficient, socially sound and environmentally friendly. The author discussed the consequences of excessive automobile dependence and demonstrates that the most livable cities worldwide have intermodal systems that balance highway and public transit modes while providing for pedestrians, cyclists and others.

A collective monograph by William D. Eggers et al. deals with the urgent and most disputable (since introduction of the first toll road in the United States in 1911) problem of road user pricing both for individual state and Europe as a whole. The goals are to regulate the overall distance driven within the network and institute a more advanced charging structure than traditional vehicle and fuel taxes. To reach these goals it is proposed 10 strategies of the transition to road user pricing including the most important Strategy #4. Cover all the Bases: Make It Part of an Integrated Transport Strategy The first part of getting the design right is ensuring that it is part of an integrated transport strategy. Strategy #5. Counter the “Just another Tax” Charge: Make the Use of Funds Acceptable to the Public One sure killer of any pricing project is the notion that it is “just another tax.” Most people are fatalistic about what “the government” is already taking from them, but except perhaps in times of national emergency, they are viscerally antagonistic to new or higher taxes [3].

Fritz Sollner argued that the road traffic taxation should follow certain basic principles, such as fairness, efficiency or practicability. He stated that the reform of road traffic taxation should be made also in terms of political acceptability and of compatibility with European law [4].

The Russian scientists have developed the simplest dynamic model of bimodal splitting of the demand for urban transit modes. The model takes into account the evolutionary component in the splitting mechanism [5], and employs the Braess’s paradox, which arises from the inefficiency of the Nash-Wardrop equilibrium in terms of a public good, that is, due to the selfishness of the drivers, the total costs of all drivers in equilibrium are higher than they generally could be with some other
distribution [6]. Toll roads are proposed as measure to overcome this problem. A.Yu. Krylatov studies the problem of optimal management strategies for distribution of the traffic flows on a network of parallel channels. This approach is based on the findings that a network of arbitrary topology should be represented as a number of pairs departure-arrival interconnected by a set of parallel routes. The application of a linear BPR delay function in the formulated problem allows competitive equilibrium and systemic optimum to be found in an explicit form [7].

The works of S.I. Kuzmich, T.O. Fedina, A.B. Kupriyanov, A.Yu. Mikhailov are devoted to transport flow control in a big city. In particular, they deal with the application of Intelligent Transportation Systems (ITS). The latter are understood as the modern technologies of communication, control, computer equipment and software to improve the efficiency and safety of urban land transport. ITS are employed to simulate urban traffic [8]. They are also applied in the known methods of traffic calming such as sleeping policemen, mini-ring intersections, road reducing, diagonal deviations at intersections, etc. [9]. The relations of government authorities and public transport operators in terms of legislation and evolution of organizational practices are studied in the work of A. Ryzhkov "Local public transport in Russia: Regulation, ownership and competition" [10]. Muleyev E.Yu., Bazavluk V.A., Useinova E.S. have analyzed more local problems concerning the assessment of public transport quality and planning of the pedestrian-transport network of new microdistricts [11].

Economic aspects, such as, for example, a possible increase in the cost of a territory with developed systems of transport control are considered by I.N. Ilyina and E.O. Koncheva [12]. The expenses of population associated with the time of public transit are evaluated in the works of E.M. Reshetov, R.V. Filippova and others [13].

However, the available research potential still do not allow solving the most pressing problems and tasks related to efficient control of transport flows in modern cities and to the costs associated with this process. This should stimulate further investigations in this field. The most promising seems to be the digitalization of transport control, the introduction of Smart City systems, where transport sections are mandatory, which, according to N. Krupenskiy, K. Trofimenko, make urban spaces and transport networks smarter [14]. In the present paper, the practical aspects of digitalization of transport control on the example of Irkutsk city are discussed and economic effects and consequences of this process are calculated.

3. Methods of investigations
According to the statistics, "the automobilization of Western Europe, which began in the fifties of the last century, occurred following almost the same pattern for all countries: a linear increase in the number of cars to the level of 300-350 vehicles/1000 people, then a slowdown in growth and stabilization at a level of 550 cars/1000 people. The rate of automobilization in Russia was somewhat higher than in Western Europe at the level of 300 cars/1000 people, but the decrease in the rate was also observed at the level of 250-300 cars/1000 people. It is expected that maximum level of the automobilization in Russia (about 550 vehicles/1000 people) will be reached by 2020 – 2025, which is one and a half times more than the level achieved today in most cities of Russia" [8, p. 159-160].

The above data and forecast require a revision of the entire strategy for the development of cities and urban transport.

Traditionally, this problem is solved via purely technical routes, i.e. by expanding the transport hubs, organizing new road interchanges, banning the parking and other traffic routes, calibrating traffic lights, etc. Also, some economic measures are applied such as the organization of chargeable parking facilities on city streets suffering from congestion or the subsidizing of public transport. Generally, these measures give a certain positive effect. However, this effect is insignificant in comparison with the costs of these measures. Consequently, the problem remains unsolved, and society continues to bear a loss. Obviously, the problem requires a comprehensive urban planning and economic solution [15, 16].

Congestion tax seems to be especially urgent challenge. It is quite complex and multifaceted problem that requires serious theoretical conceptualization and comprehensive analysis of various regulations and scientific works of leading experts in this field.
Professor Vukan Vuchic, one of the most famous American experts in the field of transportation, states that the private motor vehicle with its unique ability to provide superior personal mobility is a fundamental element of our civilization. Owning and using a vehicle is the most important advantage and the most important element of our living standards [2, p. 12]. In this regard, the economic management of the demand for traffic transit, in particular, the introduction of congestion tax, does not discriminate the population. On the contrary, this measure will contribute to the development of urban transport infrastructure as well as to even distribution of traffic flows in terms of time intervals and available directions that, ultimately, will provide for beneficial social situation.

The experience of many developed countries shows that the most promising and optimal measure to improve the road traffic is the versatile development of integrated systems of transportation control using economic methods of demand management. It should be noted that there are all the necessary prerequisites for this. First of all, these measures can be implemented in the shortest time with minimal costs compared to road construction. Secondly, the introduction of such systems will allow using the existing road network taking into account the needs of road users as much as possible. Thirdly, the development of adaptive tools of economic management is one of the most expedient and efficient methods for the improvement of the traffic control in modern city highways and in the streets of cities [3].

To maintain the optimal traffic density, the local authorities can use such a tool as a congestion tax. The tax in the amount of external costs enables to transform external effects into internal ones that results in the balanced number of drivers.

Since the congestion tax eliminates the gap between private and public costs, the driver has to take into account the public costs before trip. Consequently, the road can be used more rationally. However, to function effectively, the congestion tax should be variable over time and space. The tax should be higher on the most congested roads, usually these are the central "transport arteries" of metropolitan areas connecting the public and business zone with the residential area and the suburbs [2, p. 421].

There are following approaches to levying the congestion tax by local authorities. First, it is the traditional manual method. At the entrance to the road, special booths are installed, and the hired employees independently collect the tax amount. This is a highly ineffective approach, since it significantly slows down the traffic thus exacerbating the congestion problem. Second, these are technological approaches. Surveillance cameras installed on the roads can record the time, place and number of the vehicle. A monthly payment receipt for the total tax amount is sent to the vehicle owner, or this sum can be debited automatically from the driver's bank account. It is also possible to equip each vehicle with a transponder, which is identified by sensors installed on the road. Other technological methods can also be employed.

Thus, economic methods of management of demand for urban road transport hubs are quite effective. The congestion tax mechanism aims to transform the external costs of a travel into the internal ones, thus ensuring the balanced number of drivers on each route. The individual road users may lose their benefits associated with free usage of congested roads. However, society as a whole is approaching the optimal state of supply and demand. For population, the costs of travel during rush hours are insignificant in comparison with the benefits acquired.

### 4. Results

The primary objective of the congestion tax in the metropolitan area is to achieve the optimum state of society in terms of access to urban road networks [17]. At the same time, the achievement of such a socially-oriented goal is associated with financial chargers, potential risks and economic effects. No less important is the question what dynamics of changes in the traffic is predicted in the conditions of a particular municipality? This section of the paper is devoted to the calculation of chargers and released funds within the framework of the project. The intermediate and final conclusions are based on the inductive method of logical research.

To efficiently implement the above goal as well as to calculate the econometric indicators, the local authorities should determine the method for taxing a section of the city road network. As a traditional
option, it can be proposed to install specialized points (booths) with barriers at entrance to the "congestion zone" to levy the taxes directly from traffic users. Of course, this measure solution is impractical, since the levying procedure (calculation, delivery of change) will further aggravate the congestion. It should be noted that this approach requires the construction of many buildings (booths), their maintenance, and a fairly large staff. As a result, even a preliminary examination of the traditional options shows that it is economically and functionally inefficient.

A more expedient alternative solution is the use of IP systems of video surveillance and fixation. This approach has a number of unique competitive advantages. First, this system does not slow down the city traffic; transport moves within the permissible speed, and no additional stop and delay are required to enter the regulated section.

The second advantage is in the fact that most of such processes are automated and do not require human intervention. Consequently, there is no need for a large staff. The third benefit is the "easy" and less expensive process of improvement, updating and adaptation of this system. Its individual elements can be easily replaced, reprogrammed or retuned. Moreover, this system permits to record and process the data on almost unlimited number of traffic users. If necessary, it is possible to generate a report on the date and times of entry to the road for any traffic user. Also, a significant benefit of this approach is that it is employed on the market in various areas for some time. This testifies to the reliability and efficiency of this digital system, as well as to the fact that its use for the solution of congestion problems requires minor refinement and technical approbation.

The operation of such a system can be represented as follows. A vehicle, which enters a certain section of the road, is fixed by a video camera. The vehicle registration plate is recorded and the corresponding information on the vehicle is processed by special software. The algorithm of the software eliminates the duplicate registrations of one vehicle within one trip, since one access to the road provides for the usage along its entire length. Further, the congestion charge can be debited instantly from the bank card or account of the vehicle owner or the tax can be paid by the invoice sent to the driver by the end of the month. For example, if the congestion tax is 157 rubles, and the driver uses the congested road 20 times per month, total tax will be 3,149 rubles.

It should be emphasized that this measure provokes traffic participant to use their personal vehicles more "compactly". Consequently, if three persons simultaneously use one vehicle (the "vehicle pool" is especially popular in the United States), then the amount of congestion tax per one person will be 52.3 rubles. For a route taxi with an average capacity of 12 passengers, the amount will be about 13 rubles per person, and for a large bus with a capacity of more than 50 people it will be less than 3 rubles per person. It should also take into account a possibility of subsidizing public transport in order to increase its attractiveness and to control the travel prices.

The next step involves the determination of the time intervals for the congestion tax. This decision defines how long the access of any vehicle to central road junctions will be associated with additional costs. The excessive use of this approach can result in negative economic effects. Organizations and enterprises located along these roads will incur lost profit costs, as the number of traffic users (customers) will noticeably decrease. Therefore, the congestion tax can be constantly applied using a diversification of the amount in terms of time and date, and on different sections of the road network. Due to the fact that traffic congestion in Irkutsk city happens exclusively on week days and only during rush hours, the choice of this option looks unfair in relation to the local population.

Therefore, the regularities and trends observed in this filed allow one to conclude that the congestion tax should be levied 20 days a month (week days in accordance with the production calendar), excluding public holidays, and also exclusively in the morning and evening rush hours. This time for Irkutsk can be from 8:00 to 10:00 in the morning and from 17:00 to 20:00 in the evening. This period includes the most of the trips made by the circular migrants of the Irkutsk agglomeration. In total, congestion tax will cover averagely 100 out of 720 hours per month. It seems that this approach enables to achieve a more balanced and efficient distribution of urban traffic in terms of time and routes.

To calculate the costs of creating an IP video surveillance and fixing system, a specific section of the road network should be taken as a basis. Baikalskaya Street is located in the October district of Irkutsk.
city and is one of the main transport routes of the city, connecting the downtown with a number of districts and suburbs. The length of the street from the dam of the hydroelectric power station to Sovetskaya Street is about 3,730 meters. Despite the fair width of this road, which includes from 2 to 4 lanes in each direction, the relatively high quality of the roadway, and underground pedestrian crossings, this street is traditionally the center of road congestion. During rush peak hours, travel along this road can take up to 50-70 minutes. This road has 31 adjoins, including crossroads and courtyards with a through passage.

The traffic capacity of this road has been calculated based on the traffic methodological document of the Federal Road Agency (Rosavtodor) and the standard of the state company "Russian Highways. Taking into account the coefficient of traffic light regulation of crossroads and pedestrian crossings, as well as the coefficient of urban public traffic, the above capacity is about 1,400 vehicles per hour for one direction. For this level of traffic density, the average traffic speed is 60 km/h. Even an insignificant increase of the capacity essentially slows down the traffic speed, which is about 40 km/h for traffic capacity of 1,600 and 20 km/h for 1,800.

The indicated dynamics is clearly shown in Figure 1. Therefore, this road requires insignificant reduction in the level of congestion. For usual traffic density in Irkutsk, the reduction by 10-15% of the total traffic will be sufficient that allows reaching the optimal traffic capacity of the street.

![Figure 1](image)

**Figure 1.** Dynamics of average speed of traffic flow at different traffic density on Baikalskaya street.

Taking into account 31 junctions, 44 IP-cameras, which can record the vehicles moving at a speed of at least 80 km/h, are required to control the entrance to this section of the road. These devices are located on both sides of the road at major junctions and crossroads in order to eliminate no-zones and the hiding of one vehicle by another. The devices are located from above at a direct (linear) entrance to a road section, as well as at small exits and crossroads.

According to the open data of the Russian representative of Hikvision, as well as other partners of the company, the retail price of flagship model of the device with the maximum available functionality DS-2CD4026FWD/P-HIRA is 119,890 rubles. This camera has highest digital record extension, infrared illumination at a distance of 120 meters, recognition functions under low light conditions, as well as protection from all types of precipitation and harsh climatic conditions, which is very important for Eastern Siberia. Competitive models from other manufacturers are significantly more expensive. Also, if necessary, more affordable devices can be used. It should be noted that the manufacturer gives a 15% discount for a batch of more than 30 devices.

The modern market offers diverse relevant software for systematization and uploading of the digital information from the streets into a single database. The cost of such software is from 10 to 50 thousand
rubles. The aforementioned manufacturer can provide its software free of charge in case of purchase of more than 30 cameras. Nevertheless, any software should be tested before installation of the device. However, the available software on the domestic market has typical drawbacks: the lack of Russian versions, poor functionality, and the lack of technical support service from the manufacturer. These shortcomings are circumvented in the PTV ITS product of the domestic companies SISTeMA and PTV Group. The cost of the software package is 129,500 rubles, while the manufacturer takes care of its configuration and technical support. Also, this software permits to tune the traffic lights, and ensure a dynamic forecast and control of traffic flows.

Also, the warning signs with retroreflection characteristics (Russian state standard GOST R 52290-2004) should be installed at all crossroads and road entrances. The price of such signs varies from 480 to 500 rubles. To organize full information for traffic users, at least 40 signs are required.

**Table 1.** Estimated capital expenditures for the creation of a digital system of urban traffic control.

| Entry | Expenditure item                                      | Cost, RUB, in thousands | Number, units | Total, RUB, in thousands |
|-------|-------------------------------------------------------|--------------------------|---------------|--------------------------|
| 1.    | IP-camera Hikvision DS-2CD4026FWD/P-HIRA              | 101,9                    | 44            | 4483,6                   |
| 2.    | Software                                              | 129,5                    | 1             | 129,5                    |
| 3.    | Warning metal sign, retroreflection (Type A), 350x700 mm. | 0,5                      | 40            | 20,0                     |
| 4.    | Logistical costs                                      | 13,1                     | -             | 13,1                     |
| 5.    | Installation costs                                    | 10,0                     | 44            | 44,0                     |
| 6.    | Contingency costs, 10%                                | -                        | -             | 46,9                     |

Total: 4 737,1

Tables 1 and 2 present the preliminary estimated costs for creation of digital system of traffic monitoring as well as current (monthly) expenditures for the maintenance of this system.

**Table 2.** Estimated current (monthly) expenditures for the digital system.

| Entry | Expenditure item                                      | Cost, RUB, in thousands | Number, units | Total, RUB, in thousands |
|-------|-------------------------------------------------------|--------------------------|---------------|--------------------------|
| 1.    | Scheduled maintenance                                 | 25,0                     | -             | 25,0                     |
| 2.    | Amortization chargers                                 | 56,1                     | -             | 56,1                     |
| 3.    | Salary including taxes                                | 42,6                     | 5             | 213,0                    |
| 4.    | Rental of premises, utility expenses                  | 30,0                     | -             | 30,0                     |
| 5.    | Postal costs for notification on congestion taxes     | 0,015                    | 10 000        | 150,0                    |
| 6.    | Office expenses                                       | 5,5                      | -             | 5,5                      |
| 7.    | Contingency costs, 10%                                | -                        | -             | 47,9                     |

Total: 527,5

The current expenditures include a salary fund for the city center of traffic control (5 staff units), as well as postal costs for the mailing of payment receipts to the congested road users.

**Table 3.** Dynamics of traffic density and congestion tax revenue.
Table 3 shows the dependence of traffic intensity in the area where the congestion tax applies on the daily revenue from this tax. It is revealed that the higher the tax amount, the less demand is demonstrated by the traffic users. The fee is charged on weekdays within 5 hours. So, when the optimal traffic density intensity is reached (1,400 vehicles per hour) and the congestion tax (157 rubles) is valid during five hours, the total daily tax revenue is 1,099 thousand rubles. This is the maximum revenue that local governments is able to obtain within the framework of this measure.

![Dependence of traffic intensity on amount of congestion tax](image)

**Figure 2.** Dependence of traffic intensity on amount of congestion tax.

Figures 2 and 3 clearly illustrate how the amount of congestion tax affects the overall traffic density and the tax revenue. The highest amounts of daily revenue are reached in the point of optimal traffic intensity (1400 users) and at the tax of 157 rubles. The data of the intersection of the curves of public demand and supply will help the authorities to make an effective decision concerning the tax amount.
So, the total amount of capital expenditures will be 4,737.1 thousand rubles, while the current expenses will reach 527.5 thousand rubles per month. With daily revenues (on weekdays) of 1,099 thousand rubles, the month revenue can be 21,980.0 thousand rubles. Consequently, even after only the first month of this system introduction, after covering all investments and costs, up to 16,715.4 thousand rubles can be obtained. These funds are directed to a specialized fund and are used to maintain the quality of the road surface.

5. Discussion
It should be emphasized that if a city has only one toll road with congestion tax, then the traffic will be completely redirected to the neighboring roads with free traffic, thus aggravating dramatically the congestion problem. In this regard, it is necessary to create a system of congestion taxing that would include a number of main transport arteries in the downtown. However, for the presented calculation, only data from one road will be used, which significantly reduces the accuracy of the final results, but is often used in inductive studies.

Traditional "congestion zone", formed during rush hours in Irkutsk, covers the historical center of the city (Pravoberezhny administrative district) and part of large city streets of the Oktyabrsky administrative district such as Baikalskaya, Sovietskaya, Dekabrskikh sobytii, Karla Liebknechta, Deputatskaya and others. From the west, the historical center is bounded by the Angara River. Accordingly, the perimeter of the urban “congestion zone”, which requires fixation of the vehicles, is about 10 kilometers including bridges, road junctions and crossroads. This is the reference area of the traffic congestion zone of Irkutsk city, where economic measures of urban traffic control should be tested.

The budget of the main capital expenditures will increase 5-8 times, depending on the method for controlling the traffic in the city center and, taking into account courtyards, etc., it can range from 23,500 to 37,900 thousand rubles. At the same time, the budget of current (monthly) expenses will not grow so significantly (no more than 2-2.5 times). This is explained by the “scale” effect. For example, the operation of a large system requires the maximum number of staff of 10 units. The main expenditures will cover amortization and scheduled maintenance. Thus, current expenses should be no more than 1,318 thousand rubles/month.

The total revenue from the congestion tax should be augmented several times, since the “operating zone” of the economic measure covers all the most popular (and therefore problematic) traffic routes.

There is also an opportunity to reduce the initial expenses related to the purchase of expensive video cameras. This function can be partially performed by available systems of video surveillance (city

![Figure 3. Dependence of congestion tax revenue on the tax amount.](image-url)
cameras) and video recording of traffic safety rules violation (car radars), which are located at control points of vehicles entry into the congestion tax area.

6. Conclusions
In conclusion it has been shown that the formation of highly effective integrated solutions in the field of organization and control of road traffic in Irkutsk city comprises three main tools.

Urban-planning regulation should be focused on the decentralization of residential areas, industry, business, office centers, universities and other centers of gravity, and their transfer to suburbs or satellite cities.

Traffic planning in Irkutsk should be based on methods of mathematical simulation and forecasting using the correspondence matrices, cartograms of passenger flows and estimation of traffic density. These methods are employed to comprehensively revise the program for the overall development of the transport infrastructure in Irkutsk city, as well as to elaborate an effective integrated system of traffic control using digital technologies. In addition to strategic measures for long-term development, the tools of operational management of demand should be applied.

The congestion tax should be the flagship of this system, but it needs to be supplemented with satellite measures.

The center of city traffic management could play a role of the operator of traffic digital control. The initial investment and current expenses for maintenance of the system infrastructure are compensated within the first months after its implementation. The functional efficiency from reduction of the congestion level is also quite high. However, this economic solution should not be considered as a commercial project, since its purpose is not a profit-making. Therefore, the total revenue obtained from the congestion tax should be directed to a specialized fund to maintain a high level of road surface in the “congestion zone”. The tax should only be valid on weekdays and in rush hours. The final decision on its introduction should be made after public hearings.

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