Georgian Scientists

ქართველი მეცნიერები

Vol. 5 Issue 4, 2023

https://doi.org/10.52340/gs.2023.05.04.22


# Determining priority implemented measure of intelligent transport systems in order to improve urban mobility in accordance with the requirements of the population

**Aleksandre Lomidze**

Associate Professor, Akaki Tsereteli State University, https://orcid.org/0009-0005-7737-0821

**Abstract**

In recent years, intelligent transportation systems (ITS) have made it possible to solve many problems related to urban mobility in a number of cities around the world. However, as practice has shown, the direct transfer of respective measures from other cities to a given city often does not provide the desired results for the population there. In order to solve such an issue, as it is known, the whole problem of urban mobility in a specific city should be presented as a sum of individual (standard) typical problems. Then, taking into account the opinion of the population, one or more typical problems to be solved urgently should be selected from them (for example, the indicator of urban mobility to be urgently improved) and the priority typical measure of the ITS should be defined, which would best solve this problem. Despite the existing researches in the mentioned direction, there is still no established methodology for unequivocally determining the priority measure of the ITS in order to purposefully improve urban mobility in accordance with the requirements of the population. In order to evaluate the priority of a typical measure, the paper introduces a parameter - the total stimulus expected as a result of the realization of a typical measure according to the (desired) indicators chosen by the population. A formula for its calculation has been developed. This parameter is calculated for each typical measure. Among them, the measure for which this parameter will take the maximum value is considered to be the priority. In this way, the presented methodology allows to easily and quickly determine the measure to be implemented as a priority of intelligent transport systems in order to improve urban mobility in accordance with the requirements of the population.

**Keywords**: urban mobility, typical indicator, priority measure.

In modern conditions, the demand for high-level mobility from the city population is increasing, which leads to an increase in the number of vehicles needed for movement. And existing street-road networks in large cities can no longer handle the increased number of vehicles. As a result, traffic

delays increase, queues and traffic jams arise, which leads to a decrease in traffic speed, and, therefore, road capacity. In addition, unjustified consumption of fuel and excessive wear and tear of nodes and aggregates of vehicles, high pollution of the city with traffic noise and products of incomplete combustion of fuel occur. Finally, an increase in the intensity of transport and pedestrian flows directly affects the travel time of the population and road safety.

In recent years, the development of information and digital communication technologies and the integration of these technologies with the field of transport has given rise to a new direction - intelligent transport systems (ITS), which has made it possible to solve many accumulated problems related to the perfection of urban mobility in a number of cities around the world without building new roads. There are examples of this in many big cities of Japan, USA and Europe [1].

It should be noted that each city is unique and has its own characteristics in terms of mobility [2]. Therefore, as practice has shown, the direct transfer of decisions and measures (even successful ones) taken in other cities in this direction to a given city often does not give the desired results for the local population. This places greater responsibility on urban mobility planners and decision-makers.

The experience of advanced countries has shown that in order to improve urban mobility in a specific city, first of all, the existing general problem should be presented as a sum of individual typical (standard) problems. Then one or more of the most acute components should be identified and optimal measures should be taken immediately to eliminate them (to improve one or more indicators of urban mobility). In the works [2, 3], which are dedicated to determining the priority measure of ITS in order to improve urban mobility indicators, a list of such typical problems (of goals - of indicators urban mobility) is provided. as well as a list of typical measures of ITS, that to one degree or another, will contribute improving one or another indicator of urban mobility. Selecting the best of these standard measures requires the development of an appropriate methodology.

It is known that the same measure carried out in this direction affects not one, but generally all indicators of urban mobility. At the same time, this influence is significant on some indicators, while on others it is insignificant or absent altogether. Table 1 presents the results of relevant studies, which show the degree of expected impact of each typical measure of ITS on a specific urban mobility indicator (in some sources, this impact is indicated by the corresponding number of stars [2, 3]). Applying the currently available recommendations to determine the priority ITS measure requires additional judgment and analysis, which may ultimately lead to a subjective decision.

We've added an-other row to the table 1 below that sums up the scores listed in the corresponding column of each typical measure. These scores reflect the total stimulation of this measure for all indicators of mobility simultaneously. Their values practically does not depend on the characteristics of the city and, accordingly, the wishes of its population.

This final row of the table will help us choose a priority ITS measure only if the city needs to maximally improve mobility as a whole (without taking into account the requirements of the

population, and therefore without indicating mobility indicators). At the same time, priority will be given to the implementation that typical measure of ITS that will best contribute to the simultaneous improvement of all indicators of urban mobility. For example, the measure “Traveler information” to one degree or another improves all mobility indicators, and the total incentive for them is a maximum - 26 points. Accordingly, with this approach, priority will be given to the last typical ITS measure. However, in this case, it should be taken into account that the mobility indicator, which the population demanded to improve, can be improved only slightly. And vice versa, it is possible to more improve that indicator, the need for improvement of which was not urgently faced by this city.

When it comes to improving any particular indicator of mobility, then the issue should be solved with a different approach. In the bottom row of table 1, the total score given in the corresponding column of each tipical measure, which shows the total stimulus of this tipical measure on all indicators at the same time, can be conditionally presented in the form of two term. One of depicts the incentive from the measure to be implemented on the indicators of mobility, requested (and supported) by the population, and the other part - on all other indicators of mobility. In a private case, when the entire population of the city unanimously requests the improvement of only one specific indicator of urban mobility, then the total stimulus resulting from the implementation of any typical measure on the indicators requested by the population is directly equal to the score, which is given in the cross-section of the column of a typical measure under consideration and of the row of the indicator subject to improvement at the request of the population. For example, if the population unanimously demands only “Reduce congestion”, then, as a result of the implementation of the measure “Fleet Management Systems”, the total incentive will be 2 points.

Table 1

The degree of stimulation expected as a result of the implementation of a typical ITS measure according to a separate indicator of urban mobility, in points

| ITS measures / Urban mobility indicators | 1. Reactive traffic management and control | 2. Predictive Traffic management and control | 3. Public Transport and emergency vehicle Priority | 4. Traveler information | 5. Parking management and information | 6. Red light & parking enforcement | 7. Maps and location referencing | 8. Dynamic route guidance | 9. Floating vehicle data | 10. Road user charging | 11. Fleet Management Systems | 12. demand-responsive transport | 13. Electronic ticketing | 14. Electronic payment | 15. Mobility as a Service |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Improve city liveability | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 0 | 1 | 1 | 1 | 3 | 3 | 3 |
| 2. Reduce $CO_2$ and improve air quality | 1 | 2 | 0 | 2 | 1 | 1 | 0 | 1 | 0 | 3 | 2 | 1 | 0 | 3 | 1 |
| 3. Reduce noise emissions | 1 | 2 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 3 | 2 | 1 | 0 | 0 | 2 |
| 4. Improve transport accessibility | 0 | 2 | 1 | 1 | 1 | 0 | 3 | 0 | 1 | 1 | 0 | 3 | 2 | 2 | 3 |
| 5. Improve safety | 1 | 2 | 2 | 2 | 0 | 3 | 0 | 1 | 0 | 2 | 0 | 0 | 2 | 3 | 0 |
| 6. Reduce congestion | 1 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 3 | 2 | 2 | 1 | 2 | 2 |
| 7. Boost economic growth | 1 | 2 | 1 | 1 | 2 | 2 | 0 | 0 | 0 | 2 | 1 | 1 | 2 | 2 | 2 |
| 8. Unlock spatial opportunities | 0 | 0 | 3 | 2 | 3 | 2 | 1 | 0 | 0 | 3 | 0 | 1 | 0 | 2 | 3 |
| 9. Smoother seamless journeys | 2 | 2 | 2 | 3 | 1 | 1 | 2 | 2 | 1 | 1 | 0 | 2 | 3 | 3 | 0 |
| 10. Boost public transport | 1 | 2 | 3 | 2 | 1 | 0 | 2 | 0 | 1 | 1 | 3 | 3 | 2 | 2 | 1 |
| 11. Boost active travel | 0 | 0 | 0 | 2 | 0 | 2 | 2 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 1 |
| 12. Boost electromobility | 0 | 0 | 0 | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 0 | 0 | 0 | 2 |
| 13. Better transport data | 1 | 2 | 1 | 3 | 1 | 1 | 2 | 2 | 3 | 2 | 2 | 1 | 1 | 1 | 2 |
| Improvement of all indicators at the same time | 10 | 20 | 17 | 26 | 15 | 16 | 17 | 11 | 8 | 25 | 14 | 16 | 19 | 23 | 22 |

When the population unanimously requests the improvement of only one indicator, then decision-making is relatively easy using Table 1. In this case, the priority can be given to the measure of the ITS that gives the greatest stimulus to the improvement of the indicator requested. If there are several such typical measures, then of them can be chosen une that in total more improves all mobility indicators (or indicators that the city may need to improve in the near future).

Selection of the event to be carried out as a priority becomes somewhat difficult in the case when the opinion of the population is not uniform, i.e. One certain part of it demands improvement of one indicator, another part - another, and so on. The decision of this issue by the majority of the population's votes is incorrect, since as can be seen from Table 1, the degree of stimulation of different typical measures on this or that indicator of mobility is different.

How should we act in cases where a specific city is faced with the issue of urgent improvement of several indicators of urban mobility?

As can be seen from Table 1, carrying out any typical j-th measure along with the indicators demanded by the population, more or less leads to the improvement of the indicators that are not demanded by them. Our goal is to select such a typical measure, which in total will maximally improve not all, (or any one), but several indicators of urban mobility demanded by the population of a given city in proportion to the votes given to them (for example, when one resident has the right to demand urban mobility only improvement of one indicator).

In order to determine which typical measure can be priority for a given city in such a case, first, using Table 1, in case of carrying out all j-th typical measures separately, let's calculate the expected total stimulus according to the indicators, in accordance with their support. And then, from the typical

measures, let's select the one, in case of implementation of which, as a result of improvement of indicators at the request of the population, the expected total stimulus will be maximum.

Since the opinion of the city population is not uniform, and is divided in favor of several indicators of urban mobility. Therefore, when summing up the points along the mobility indicators in the measure column, we should not take them as 100%, but in proportion to their support by the population. For example, if " Boost economic growth" is desired by 40% of the population, and " Reduce $CO_2$ and improve air quality" by 60% of the population, then the measure - " Traveler information" in favor of these indicators will give us $1 \times 40\ \% + 2 \times 60\% = 1.6$ scores the total incentive. Hence, before summing up, each scores given in the measure column must be multiplied by the share of the population supporting the corresponding indicator to be improved.

Taking this into account, in the case of implementing a given standard j-th measure, the total score $Q_j$ of incentives expected as a result **of improving mobility indicators at the request of the city population** can be calculated using the following formula:

$$Q_j = \sum_{i=1}^{m} (q_{ij} \cdot p_i), \quad (1)$$

where m is the number of urban mobility indicators; $q_{ij}$ - a score indicating the degree of impact (stimulation) of the j-th typical measure on the i-th mobility indicator; $p_i$ - the specific share of the population that supports the improvement of the i-th mobility indicator.

If the population's support for improving any i-th mobility indicator is zero, then the corresponding $p_i = 0$ and, therefore, the product $q_{ij} \times p_i$ will also be equal to 0, that is, when carrying out a typical measure j the incentive for this indicator of mobility will be equal to zero.

Below, in table 2 provides an example of definition of priority typical measure of intelligent transport systems to improve urban mobility based on public demand in Microsoft Excel. Here we are considering the case where 40% of the population demands "Improve transport accessibility", 60% of the population demands "Boost economic growth" and 0% of the population demands improvement of all other indicators.

In the cells of the last lower row of this table, in the column of each typical j-th measure, the total score $Q_j$ of the incentives expected as a result of the improvement of the indicators demanded by the city population is calculated using the image (1) (The cell with the maximum value in this row is colored differently). In the given example, the maximum value of the total incentive score $Q_j$ is 2.4. It corresponds to a typical "Mobility as a Service" measure. Therefore, in this case, this measure will be a priority.

In case of a request to improve other indicators of urban mobility, only the data to be entered in the column "Population demand for indicator improvement (%)" should be changed in the Microsoft Excel table to determine the priority measure (obviously, the sum of these data in percentages should be 100). This will automatically change the data in the bottom row of this table, and therefore the

priority measure as well. If necessary, it is possible to add other mobility indicators as well as a typical measure to the table.

It can be seen that the total scores given in the bottom line of the table "Total score of incentives expected as a result of improving indicators demanded by the population" are significantly lower than in its top line "Improving all indicators at the same time." This is because the top line shows the total score of incentives received as a result of the event in the case of improving all indicators at the same time, and the bottom line shows only the indicators requested by the population (when each resident selects only one indicator for improvement). The scores in these columns would be the same if the entire population were 100% in favor of simultaneously improving all indicators of urban mobility.

Table 2

Determining priority implemented measure of intelligent transport systems in order to improve urban mobility in accordance with the requirements of the population in Microsoft Excel

| ITS measures / Urban mobility indicators | Demand of the population to improve the indicator, % | 1. Reactive traffic management and control | 2. Predictive Traffic management and control | 3. Public Transport and emergency vehicle Priority | 4. Traveler information | 5. Parking management and information | 6. Red light & parking enforcement | 7. Maps and location referencing | 8. Dynamic route guidance | 9. Floating vehicle data | 10. Road user charging | 11. Fleet Management Systems | 12. demand-responsive transport | 13. Electronic ticketing | 14. Electronic payment | 15. Mobility as a Service |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Improve city liveability | 0 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 0 | 1 | 1 | 1 | 3 | 3 | 3 |
| 2. Reduce $CO_2$ and improve air quality | 0 | 1 | 2 | 0 | 2 | 1 | 1 | 0 | 1 | 0 | 3 | 2 | 1 | 0 | 3 | 1 |
| 3. Reduce noise emissions | 0 | 1 | 2 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 3 | 2 | 1 | 0 | 0 | 2 |
| 4. Improve transport accessibility | 40 | 0 | 2 | 1 | 1 | 1 | 0 | 3 | 0 | 1 | 1 | 0 | 3 | 2 | 2 | 3 |
| 5. Improve safety | 0 | 1 | 2 | 2 | 2 | 0 | 3 | 0 | 1 | 0 | 2 | 0 | 0 | 2 | 3 | 0 |
| 6. Reduce congestion | 0 | 1 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 3 | 2 | 2 | 1 | 2 | 2 |
| 7. Boost economic growth | 60 | 1 | 2 | 1 | 1 | 2 | 2 | 0 | 0 | 0 | 2 | 1 | 1 | 2 | 2 | 2 |
| 8. Unlock spatial opportunities | 0 | 0 | 0 | 3 | 2 | 3 | 2 | 1 | 0 | 0 | 3 | 0 | 1 | 0 | 2 | 3 |
| 9. Smoother seamless journeys | 0 | 2 | 2 | 2 | 3 | 1 | 1 | 2 | 2 | 1 | 1 | 0 | 2 | 3 | 3 | 0 |
| 10. Boost public transport | 0 | 1 | 2 | 3 | 2 | 1 | 0 | 2 | 0 | 1 | 1 | 3 | 3 | 2 | 2 | 1 |
| 11. Boost active travel | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 2 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 1 |
| 12. Boost electromobility | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 0 | 0 | 0 | 2 |
| 13. Better transport data | 0 | 1 | 2 | 1 | 3 | 1 | 1 | 2 | 2 | 3 | 2 | 2 | 1 | 1 | 1 | 2 |
| Improvement of all indicators at the same time | 100 | 10 | 20 | 17 | 26 | 15 | 16 | 17 | 11 | 8 | 25 | 14 | 16 | 19 | 23 | 22 |
| The total stimulus expected as a result of improving the indicators demanded by the population | | 0.6 | 2 | 1 | 1 | 1.6 | 1.2 | 1.2 | 0 | 0.4 | 1.6 | 0.6 | 1.8 | 2 | 2 | 2.4 |

Thus, the presented methodology will allow us to easily and quickly determine the priority typical measure of intelligent transport systems in order to improve urban mobility in accordance with the population's demand. Such an approach can be used to solve similar issues in other fields of activity as well (for example, in health care - when prescribing medicines for a patient).

## References

1. ლომიძე ა. ინტელექტუალური სატრანსპორტო სისტემების პრიორიტეტულად გასატარებელი ღონისძიებების განსაზღვრა ურბანული მობილობის კონკრეტული მაჩვენებლობის გაუმჯობესების მიზნით // პერიოდული სამეცნიერო ჟურნალი ”გონი”, №9. - ქუთაისი, 2023. - გვ. 36-46.
2. The role of Intelligent Transport Systems (ITS) in Sustainable Urban Mobility Planning: Make smarter integrated mobility plans and policies. https://www.eltis.org/sites/default/files/the_role_of_intelligent_transport_systems_its_in_sumps.pdf (accessed 3/24/23)
3. Guidelines for Developing and Implementing a Sustainable Urban Mobility Plan (Second Edition) Final Draft for SUMP Conference, 12 June 2019. – 149 p. https://www.eltis.org/sites/default/files/guidelines_for_developing_and_implementing_a_sustainable_urban_mobility_plan_2nd_edition.pdf (accessed 6/17/22)


## ინტელექტუალური სატრანსპორტო სისტემის პრიორიტეტულად გასატარებელი ღონისძიების განსაზღვრა ურბანული მობილობის გაუმჯობესების მიზნით მოსახლეობის მოთხოვნების შესაბამისად


**ალექსანდრე ლომიძე**

ასოცირებული პროფესორი, აკაკი წერეთლის სახელმწიფო უნივერსიტეტი
https://orcid.org/0009-0005-7737-0821



## აბსტრაქტი

ბოლო წლებში ინტელექტუალურმა სატრანსპორტო სისტემებმა **(ისს)** მსოფლიოს რიგ ქალაქებში შესაძლებელი გახადა ურბანულ მობილობასთან დაკავშირებული მრავალი პრობლემის მოგვარება. თუმცა, როგორც პრაქტიკამ აჩვენა, შესაბამისი ღონისძიებების პირდაპირი გადმოტანა სხვა ქალაქებიდან მოცემულ ქალაქში ხშირად არ იძლევა სასურველ შედეგებს იქაური მოსახლეობისთვის.

ასეთი საკითხის გადაჭრისათვის, როგორც ცნობილია, კონკრეტულ ქალაქში არსებული ურბანული მობილობის მთლიანი პრობლემა წარმოდგენილი უნდა იქნას ცალკეულ ტიპიური (სტანდარტული) პრობლემების ჯამის სახით. შემდეგ, მოსახლეობის აზრის გათვალისწინებით, მათგან უნდა შეირჩეს ერთი ან რამდენიმე სასწრაფოდ გადასაჭრელი ტიპიური პრობლემა (მაგალითად, ურბანული მობილობის სასწრაფოდ გასაუმჯობესებელი მაჩვენებელი) და განისაზღვროს **ისს**-ის ის პრიორიტეტული ტიპიური ღონისძიება, რომელიც

საუკეთესოდ გადაჭრის ამ პრობლემას. აღნიშნული მიმართულებით არსებული კვლევების მიუხედავად, ჯერ კიდევ არ არსებობს **ისს**-ის პრიორიტეტული ღონისძიების ცალსახად განსაზღვრის ჩამოყალიბებული მეთოდიკა ურბანული მობილობის მიზანმიმართულად გაუმჯობესების მიზნით მოსახლეობის მოთხოვნების შესაბამისად.

ტიპური ღონისძიების პრიორიტეტულობის შეფასების მიზნით, ნაშრომში შემოტანილია პარამეტრი - ტიპური ღონისძიების რეალიზების შედეგად მოსალოდნელი ჯამური სტიმული მოსახლეობის მიერ არჩეული (სასურველი) მაჩვენებლების მიხედვით. შემუშავებულია მისი გამოსათვლელი ფორმულა. აღნიშნული პარამეტრის გამოთვლა ხდება თითოეული ტიპიური ღონისძიებისათვის. მათგან პრიორიტეტულად ითვლება ის ღონისძიება, რომლისთვისაც ეს პარამეტრი მიიღებს მაქსიმალურ მნიშვნელობას.

ამგვარად, წარმოდგენილი მეთოდოლოგია იძლევა მოსახლეობის მოთხოვნების შესაბამისად ურბანული მობილობის გაუმჯობესების მიზნით ინტელექტუალური სატრანსპორტო სისტემების პრიორიტეტულად გასატარებელი ღონისძიების მარტივად და სწრაფად განსაზღვრის საშუალებას.

**საკვანძო სიტყვები:** ურბანული მობილობა, ტიპიური მაჩვენებელი, პრიორიტეტული ღონისძიება.