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ANALYSIS OF SYNERGISTIC PROPERTIES OF INTELLIGENT TRANSPORT SYSTEMS WITH ROAD INFRASTRUCTURE ELEMENTS

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Аннотация. Ушбу мақолада ҳаракат қатнови зич бўлган шаҳарларда тирбандлик вақтларда автомобиль двигателининг энергия тежамкорлик хусусиятларини таъминлаш масаласи кўрилган. Автомобиль ва инфратузилма элементи билан “Интеллектуал старт-стоп тизими”ни Тошкент ва Андижон шаҳарларда ҳаракат циклини қўллаш орқали энергия тежамкорлик хусусиятлари ўрганилган. Олиб борилган тадқиқот натижалари бўйича интеллектуал транспорт тизимиларининг инфратузилмасини ривожлантириш харажатлари интеллектуал транспорт тизимлари технологиясини мослаштириш билан мутаносиб бўлишини кўрсатди.

Тадқиқот ишининг амалий натижалари двигателнинг ишчи ҳажми 1,5 литр бўлган енгил автомобилларда ИТТ элементларини қўллаб, уни ишлаб чиқаришга жорий этилиши мавжуд автомобилларга нисбатан бир йилда 20 000 км масофа юрганда аккумулятор батареяси, стартёр ва генераторларни хизмат қилиш муддати инобатга олинган ҳолда, эксплуатация харажатлардан ташқари битта автомобиль учун 424281 сўмлик йиллик иқтисодий самара олиниши аниқланди.

Калит сўзлар: интеллектуал транспорт тизими, стар-стоп, тиғизлик, микроконтроллер, режим, синергия, сигма, вариацион қатор, экспериментал, статистик.

Аннотация. В данной статье рассмотрен вопрос обеспечения энергосберегающих характеристик двигателя транспортного средства в условиях транспортных заторов в мегаполисах с плотным движением транспорта. Исследованы характеристики энергосбережения с использованием «Интеллектуальной системы старт-стоп» с элементом транспортного средства и инфраструктуры в ездовом цикле в городах Ташкент и Андижан. Результаты исследования показали, что стоимость разработки инфраструктуры интеллектуальных транспортных систем должна быть пропорциональна адаптации технологии интеллектуальных транспортных систем.

Практический результат исследования на примере «Интеллектуальной системы старт-стоп» как пример обоснования синергии инновационной интеллектуальной транспортной системы в местных условиях с объемом двигателя автомобиля 1,5 л с учетом эксплуатационных затрат. , годовой экономический эффект в расчете на одно транспортное средство составляет 424 281 сум. Кроме того, учитывался срок службы аккумуляторной батареи, стартеров и генераторов при пробеге автомобиля с ИССС 20 000 км в год.

Ключевые слова: интеллектуальная транспортная система, старт-стоп, плотность, микроконтроллер, режим, синергия, сигма, вариационный ряд, экспериментальный, статистический.

Annotation. In this article, the issue of ensuring the energy-saving features of the vehicle engine during traffic congestions in mega-cities where traffic is dense. The characteristics of energy saving were researched by using the "Intelligent start-stop system" with the vehicle and infrastructure element in the drive cycle in Tashkent and Andijan cities. The results of the research have shown that the cost of developing intelligent transport systems infrastructure should be proportional to the adaptation of intelligent transport systems technology.

As a practical result of the research, using the “Intelligent start-stop system” as an example of justification of the synergy of innovative intelligent transport system in local conditions with vehicle engine`s capacity in 1,5-liter taking into account exploitation costs, the annual economic efficiency per vehicle has 424,281 soums. Forthmore, the service life of the battery, starters and alternators was taken into account when the vehicle with ISSS traveled 20,000 km per year.

Keywords: intelligent transport system, start-stop, density, microcontroller, mode, synergy, sigma, variation series, experimental, statistical.

Introduction. The day-to-day development of the transport network in our country is faced with the need to solve certain problems related to it in the future. Tashkent's population and vehicles have increased during the last 10 years, the number of vehicles in Tashkent has doubled from 250,000 to 510,000. Accordingly, the transport infrastructure is being developed. Additional new roads, bridges and subways are under construction. However, there is a lot of traffic on the streets of the capital city, and there are enough problems in traffic regulation. The research the densityof traffic and flow passengers through the geoinformation system revealed the presence of more than 500 major intersections in Tashkent. Of these, about 200 intersections have traffic signal control problem. This situation can lead to traffic jams or restrictions on movement. On the basis of such a complex analysis, a preliminary draft master plan for the improvement of road infrastructure and public transport in Tashkent has been developed. In particular, it was calculated that the optimizing 24 major traffic intersections in the capital might reduce the average number of stops by 71% and time by 48%, congestion by 64% and fuel consumption by 34% [1].

In the experience of developed countries, by applying innovative ideas into the road transport network, intelligent transport systems (ITS) are created, which are efficient in solving modern transport problems [2]. Today, all vehicles manufactured on the basis of electronically controlled systems. Intelligent transport systems allow vehicles to communicate with everything related to these technologies. This is why, the communication with each other of innovative technologies of the 21st century determines the relevance of today.

ITS are necessary to ensure the following:

- For the development of roads and infrastructure;
- To limit and control speed;
- To reduce congestion and industrial costs;
- To reduce traffic accidents;
- To make the transport system more efficient, safe and reliable using information, communication and management technologies;
- To increase the mobility of public transport;
- Reducing the negative impact of transport on the environment, etc.

Advantages of ITS:

- Reduction of stops and delays at intersections;
- Speed control and improve movement;
- Save time and energy;
- Ensuring interoperability in mechatron and neural systems in the vehicle;
- Accident management and so on.

Modern engineers emphasize that all types of technology should be not only single-functional, but also multifunctional.

Although research in the field of ITS is increasing, the field itself is still new and its potential has not been fully explored. Based on this, there is a volume of application of appropriate ITS technologies in our country, which leads to the effective solution of road safety problems [3].

The technology is available and offers many different options for solving future problems, and in that respect, ITS comes first [4-5].

Methods. The research of indicators that characterize traffic in the organization of safe traffic on the roads depends in the fist place on the quantity of traffic, composition, density, flow rate, and so on.

Traffic composition is an indicator that determines the ratio of different vehicles in the traffic flow, which is measured in percent. This indicator has a major impact on the speed and density of traffic flow [6]. For instance: the change in traffic on the streets of the city of Tashkent cars are 75-80%, buses 10-15% and trucks make 7-10%. The traffic flow in the city of Tashkent is one million vehicles a day.

Traffic congestion is a decrease in the speed of cars on the road compared to the nominal speed. It can be detected in m/ s or km/ h, and also in seconds. For example, the time of duration of traffic lights at intersections (t_r=60 s; t_g=30 s, t_y=3 s). This creates traffic light cycles and the sum of all periods represents one of its operating cycles ($t_r + t_g + t_y$).

Traffic congestion depends on the quantity of movement and the throughput of intersections. The quantity of movement is a variable indicator to years, months, days of the week, and hours of the day, as well as road sections. The change in the quantity of movement on automobile roads during the day often depends on the direction of driving, the days of the week, and the importance of the road. It is mainly observed rising three times a day (morning, lunch and evening). The quantity of movement during such hours is called “**tight / rush**”. Correct organisation of traffic at these times is an essential factor to ensure safety.

Congestion increases traffic time, fuel consumption, air pollution and reducing efficiency or exploitation of transportation infrastructure [7].

The movement of vehicles on city streets always requires the synergy of infrastructure with vehicles. This is because infrastructure is a set of key facilities and systems that serve a country, city, or other region and cover the services and facilities needed for the economy [8-9]. Synergy of vehicle-to-Infrastructure (V2I) helps vehicles to establish a wireless connection and optimize traffic between the environment’s static infrastructure joints, road signs, traffic lights, and others. V2I technology enables the exchange of data wirelessly between vehicles and road infrastructure (Fig. 1). For example, if we take a traffic light as an infrastructure, its signals need to be controlled automatically during tight hours. In this mode, the time of the green signal can decrease or increase based on the amount of movement of the vehicles. There are two approaches to this process: 1) modeling using software PTV VISSIM (PTV-Planung Transport Verkehr AG, VISSIM – “Verkehr In Städten – SIMulationsmodell” from the German “Traffic in cities - simulation model”) that simulates the flow of traffic through surveillance cameras at intersections [10]; 2) optimization of traffic light cycles using a special detector. Vehicle detection loops, called inductive-loop traffic detectors, can detect vehicles passing or arriving at a certain point, for instance approaching a traffic light or in motorway traffic [11-12].

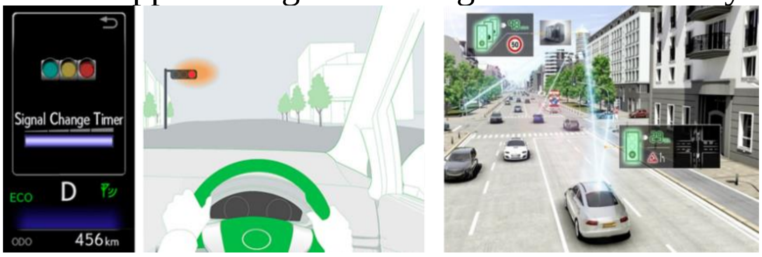


Fig.1. Communication technology of V2I in ITS

Spending time idling at traffic lights can really feel like a waste of fuel and, with an ever-increasing focus on economy and emissions, it makes sense to switch your engine off.

According to experts, about 30% of the fuel is consumed in the idle mode of the engine. In the world experience, car drivers and passengers in cities lose an average of 30 minutes a day by stopping at a red traffic light. If we calculate their annual stop or loss times at traffic lights, it is 250 ... 365 days * 30 minutes = 125 ... 182.5 hours [13].

We consider that it is necessary to ensure the fuel economy and environmental performance of vehicles in its driving modes by analyzing the component V2I of ITS.

The driving modes of vehicles are following (Fig.2):

1. Idle speed engine or stop mode ($V_a=0$; $\omega_e=\omega_{ise}>0$; $S=0$; $t>0$);
2. Acceleration mode ($j_a>0$; $V_k>V_n$; $S>0$; $t>0$);
3. Constant speed driving mode ($j_a=0$; $V_k=V_n$; $S>0$; $t>0$);
4. Deceleration mode ($j_a<0$; $V_k<V_n$; $S>0$; $t>0$).

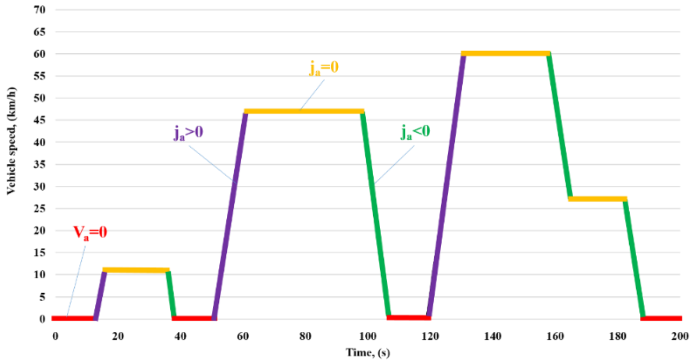


Fig.2. Drive cycle of Tashkent city [14]

During the testing process, we analyzed the idle engine mode in driving modes of vehicle. There are several methods to reduce fuel consumption. One of these methods is to use the “Intelligent start-stop system” in the synergy of V2I. The “Intelligent start-stop system” considerably improves its fuel efficiency by shutting off the engine during idling. This helps when the car halts at the traffic signal or in traffic jams. Because, saving fuel consumption in this mode has not been researched in our country. A mathematical model for the detection of this system on the basis of vehicle with on (V_h) 1.5-liter engine will be developed.

“Intelligent start-stop system” technology improves the fuel economy by about 5 to 10 percent as well as CO2 emissions [15].

The efficiency of this system is determined by turning off the car engine at the red light of the traffic lights depending on time, and saving fuel consumed during this time. In addition, this system reduces the idle time of the engine and increases its efficiency and resource.

To do this, the data transmission and reception processes between the vehicle and the traffic light are performed via the ESP8266 microcontroller. One of the main functions of the microcontroller is that it has the ability to send and receive information wirelessly. The distance of wireless information exchange is up to 300 meters (Fig.3).

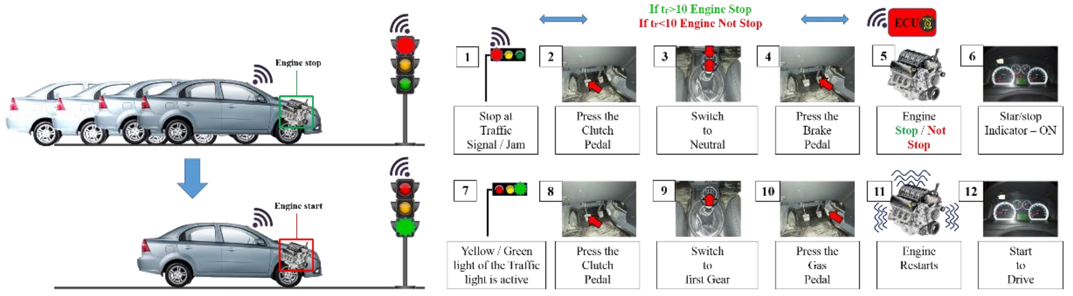
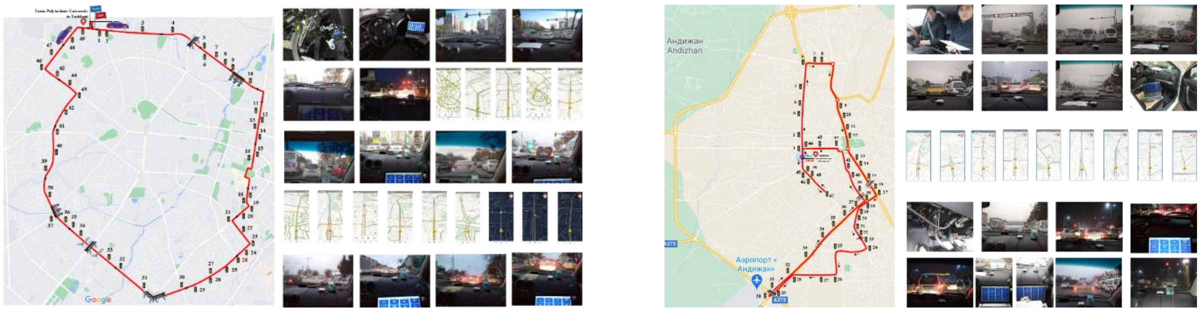


Fig.3. The mode of operation of the “Intelligent start-stop system” in V2I sinergy

Analyzing the conditions of exploitation of vehicles, and taking into account the density of traffic, the city of Tashkent and Andijan were selected as the object of research. We used a Chevrolet Nexia to drive mode in both of cities. The statistics datas were collected using the experimental method in a small ring road with a high traffic intensity on the central streets of the cities in the tight time, which is distance of 25-30 km long and passing 45-50 traffic lights (Fig.4). Given that the operation of the system depends on a microcontroller setted on the traffic light, during the test, when the vehicle stopped at the red light, by using simulation its engine was stopped and started.



a) b)

Fig.4. Research processes by using "Intelligent start-stop system" at the traffic lights to determine the lost times

a) Tashkent city rive mode, b) Andijan city rive mode.

During the test, the main parameters of movement of the vehicle in the specified direction in urban conditions by using Scanmatic diagnostic device to receive about 90 exploitation parameters were obtained through OBD-II CAN on board the electronic control unit of the engine. These include vehicle speed, engine speed, torque, load engine (in, percent), temperature, ignition timing (in, grades), detonation (in, voltage), fuel injection pulse duration, fuel tank reserve (in *l*, % position), λ-zond sensor voltage, such as the discharge and charge voltage of the battery when starting the engine on the electrical supply, as well as the voltage generated by the alternator and so on (Fig.5).

Fig.5. Recording the parameters of the vehicle in the driving mode through the scanmatic diagnostic device

Results. In the urban driving cycle, the idle engine phase of the vehicle's driving modes was separately analyzed and synthesized. We analyzed at this process in detail because as we aim to reduce engine idling to reduce fuel consumption.

If the instantaneous speed of the vehicle is $V_{a_i} \quad 0$ or $V_{a_i} \quad 1, \; V_{a_{i\ 1}} \quad V_{a_{i\ 1}} \quad 0$ it is assumed to be a engine idling or stop mode and is equal to $V_{a_i} \quad V_c^n \quad 0$.

$$1 \quad \overset{x}{\underset{i\ 1}{}} V_{a_i} \quad V_{a_i} \quad V_c^n \quad 0; \quad \text{or} \quad 0 \quad \overset{x}{\underset{i\ 1}{}} V_{a_i} \quad V_{a_i} \quad V_c^n \quad 0; \quad (1)$$

here: $x - n$- the last limit determined in the period.

The period of the idle engine mode lasts until the next mode arrives, and its total time is determined as follows [14]:

$$t_{iem}^n \quad t_{et}^n \quad t_{bt}^n \, ; \; (2)$$

here: t_{bt}^{n} – *n*-beginning time of idle engine mode in test process, s; t_{et}^{n} – *n*- ending time of idle engine mode in test process, s.

Total driving time of the vehicle:

$$\mathrm{T}_{tdt} = \mathrm{T}_{ie.m} + \mathrm{T}_{ac.m} + \mathrm{T}_{cd.m} + \mathrm{T}_{d.m}; \quad (3)$$

here: $\mathrm{T}_{ie.m}$- total time in idle engine mode, $T_{ie.m} \ \overset{1}{\underset{n}{\ }} \ t_{ie.m}^{n}, (s)$; $\mathrm{T}_{ac.m}$- total time in acceleration mode, $T_{ac.m} \ \overset{1}{\underset{n}{\ }} \ t_{ac.m}^{n}, (s)$; $\mathrm{T}_{cd.m}$- total time in constant speed driving mode, $T_{cd.m} \ \overset{1}{\underset{n}{\ }} \ t_{cd.m}^{n}, (s)$; $\mathrm{T}_{d.m}$- total time in deceleration mode, $T_{d.m} \ \overset{1}{\underset{n}{\ }} \ t_{d.m}^{n}, (s)$.

The main parameters were calculated on the idle engine mode of the vehicle in the city driving cycle (Table 1).

Table 1.

The idle engine time parameters in the city driving mode of Tashkent.

№	**Test parameters**	**Without ISSS**	**With ISSS**
1.	Total test distance - S_t, (m)	$S_t \ \overset{3}{\underset{n}{\ }} \ S_t^n \ \ 75000$	$S_t \ \overset{3}{\underset{n}{\ }} \ S_t^n \ \ 75000$
2.	Total time for test - T_{tdt}, (s)	$T_{tdt} \ \overset{3}{\underset{n}{\ }} \ T_{tdt}^n \ \ 11580$	$T_{tdt} \ \overset{3}{\underset{n}{\ }} \ T_{tdt}^n \ \ 11760$
3.	Average speed of vehicle - V_{av}^{T}, (m/s)	$V_{av}^{T} \ \overset{3}{\underset{n}{\ }} \ V_{av}^{T} \ \ 6,47$	$V_{av}^{T} \ \overset{3}{\underset{n}{\ }} \ V_{av}^{T} \ \ 6,37$
4.	Idle engine time of vehicle - $T_{ie.m}$, (s)	$T_{ie.m} \ \overset{3}{\underset{n}{\ }} \ t_{ie.m}^{n} \ \ 2825$	$T_{ie.m} \ \overset{3}{\underset{n}{\ }} \ t_{ie.m}^{n} \ \ 2848$
5.	Share of the idel engine time over the total time - $T_{iet}^{\%}$, (%)	$T_{iet}^{\%} \ \dfrac{T_{ie.m}}{T_{tdt}} \ \ 24,39$	$T_{iet}^{\%} \ \dfrac{T_{ie.m}}{T_{tdt}} \ \ 24,22$

Using the scanmatic diagnostic device were obtained vehicle speed on driving mode of the vehicle through OBD-II CAN on board the electronic control system of the engine. In this case, $t_1^{tr}, t_2^{tr}, \dots, t_n^{tr}$ are represented by the stopping times at traffic lights (Fig.6).

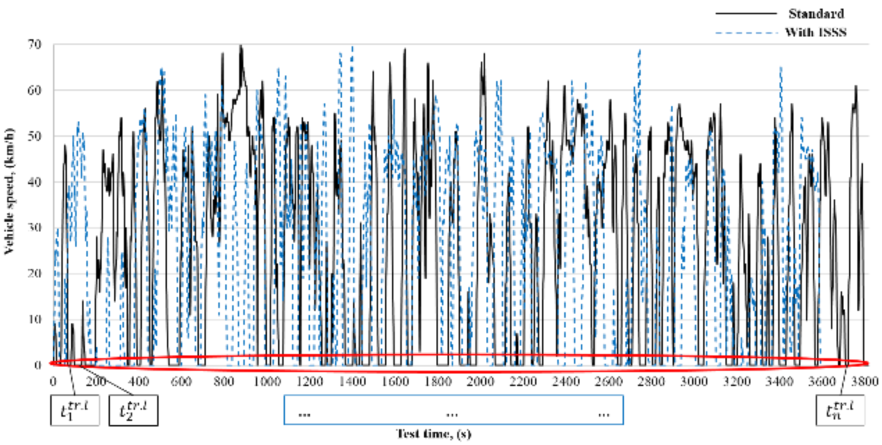


Fig.6. Changing in vehicle speed in the city driving cycle of Tashkent

In the test experiments, in the driving cycle “Intelligent start-stop system” was used on the idle engine mode $(t_1^i, t_2^i, \ldots, t_n^i)$ and engine stopped times $(t_1^{en.s}, t_2^{en.s}, \ldots, t_n^{en.s})$ were calculated (Fig. 7). These calculated times are statistically summed by random quantities of stopping times at a traffic light in the direction of test travel.

We define the statistical data obtained as a result of observations in the random state of $x_1^*, x_2^*, \ldots, x_n^*$ as a sample. The statistical data was disorder.

To statistically verify this information we do these:

1) make the variation series;

$$x_1 \leq x_2 \leq \cdots \leq x_n.$$

This sequence can be called the values of a variable (variation) series. To process the statistics, you first have to put a set of random numbers in ascending order. The values of the variation series of the sample were constructed. The minimum value of the variation series was 3-5 s and the maximum value was 59-81 s. These values were randomly determined in the example of the city of Tashkent in the framework of a cycle of variability t_r = 25 ÷ 90 seconds at the standard minimum and maximum illumination period (tact) of the red light of traffic lights.

2) composing the law of distribution of sample.

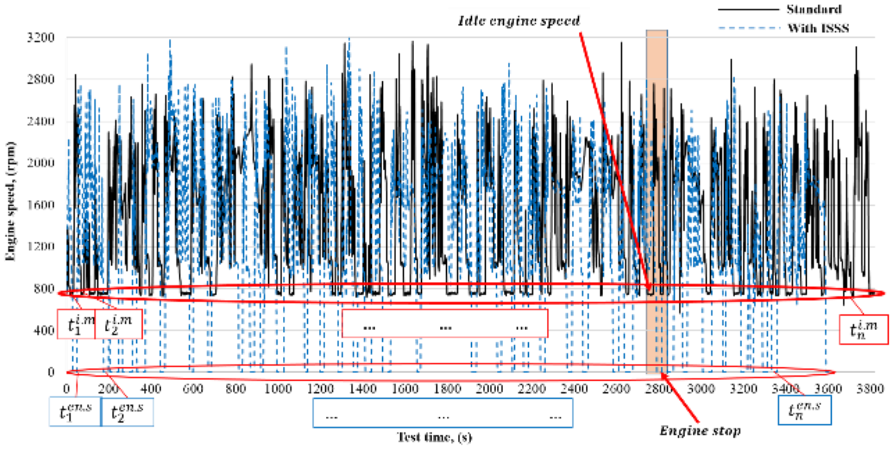


Fig.7. Changing in engine speed in the city driving cycle of Tashkent

For this, we used the following formula because the sample size is large [16].

$$h = \frac{x_{max} - x_{min}}{k} = \frac{x_{max} - x_{min}}{1 + 3{,}31 \cdot lgn}; \quad (4)$$

here: x_{max}, x_{min} - maximum and minimum waiting time at the red light of the traffic light, s; k is the number of intervals divided into variational series (determined using the Starjess formula and taken in the range k=8-12 (Table 2.)); n is the number of experimental data.

Table 2.

Values of the number and width of intervals of data obtained in the city driving cycle.

№	**Parameters of variation series**	**Without ISSS**	**With ISSS**
1.	Number of intervals - k	$k = 8$	$k = 8$
2.	Wirth of intervals - h	$h = 7$	$h = 6{,}75$

In the next processing stage a number of private around the calculated average value or the variance value of the reliability index and the mean quadratic deviation changes were calculated (Table 3-4.).

Table 3.

Average value and average quadratic deviation value in Tashkent city

№	**Parameters of variation series**	**Formula**	**Without ISSS**	**With ISSS**
1.	Average value - $\overline{X}$	$\bar{X} = \frac{1}{n}\sum_{i=1}^{k} m_i \cdot x_i$	$\bar{X} = 23$	$\bar{X} = 24$
2.	The value of the second-order moment - $\overline{x^2}$	$\overline{x^2} = \frac{1}{n}\sum_{i=1}^{k} m_i \cdot x_i^2$	$\overline{x^2} = 693$	$\overline{x^2} = 731$
3.	The variance of the sample - $\overline{\sigma^2}$	$\overline{\sigma^2} = \frac{1}{n-1}\sum_{i=1}^{k}(x_i - \bar{X})^2 \cdot m_i$	$\overline{\sigma^2} = 173$	$\overline{\sigma^2} = 141$
4.	Average quadratic deviation - $\bar{\sigma}$	$\bar{\sigma} = \sqrt{\overline{\sigma^2}}$	$\bar{\sigma} = 13{,}15$	$\bar{\sigma} = 11{,}87$

Table 4.

Average value and average quadratic deviation value in Andijan city

№	**Parameters of variation series**	**Formula**	**Without ISSS**	**With ISSS**
1.	Average value - $\overline{X}$	$\bar{X} = \frac{1}{n}\sum_{i=1}^{k} m_i \cdot x_i$	$\bar{X} = 26$	$\bar{X} = 25$
2.	The value of the second-order moment - $\overline{x^2}$	$\overline{x^2} = \frac{1}{n}\sum_{i=1}^{k} m_i \cdot x_i^2$	$\overline{x^2} = 1012$	$\overline{x^2} = 931$
3.	The variance of the sample - $\overline{\sigma^2}$	$\overline{\sigma^2} = \frac{1}{n-1}\sum_{i=1}^{k}(x_i - \bar{X})^2 \cdot m_i$	$\overline{\sigma^2} = 317$	$\overline{\sigma^2} = 316$
4.	Average quadratic deviation - $\bar{\sigma}$	$\bar{\sigma} = \sqrt{\overline{\sigma^2}}$	$\bar{\sigma} = 17{,}8$	$\bar{\sigma} = 17{,}77$

Discussions. The results of the research have shown that the cost of developing ITS infrastructure should be proportional to the adaptation of ITS technology.

Statistical processing of experimental data was performed to determine lost time at traffic lights and congestion. During the calculations, it was found that the minimum value of the interval limit is $x_{min} = 3; 5$, the maximum value is $x_{max} = 58;\ 59$, the average value of the variation series is $\bar{X} = 23; 24$, and the average quadratic deviation is $\bar{\sigma} = 13{,}15; 11{,}87$.

It found that the 3σ rule was appropriate for the random quantity being tested in determining the time lost at traffic lights and congestion. The time of standby at the red light of the traffic light without “Intelligent start-stop system” of the vehicle on the rule of 3σ is equal to:

$$\bar{X} + 3\sigma = 23 + 3 \cdot 13{,}15 = 62{,}45;$$
$$\bar{X} - 3\sigma = 23 - 3 \cdot 13{,}15 = -16{,}45.$$

And with the “Intelligent start-stop system” of the vehicle is:

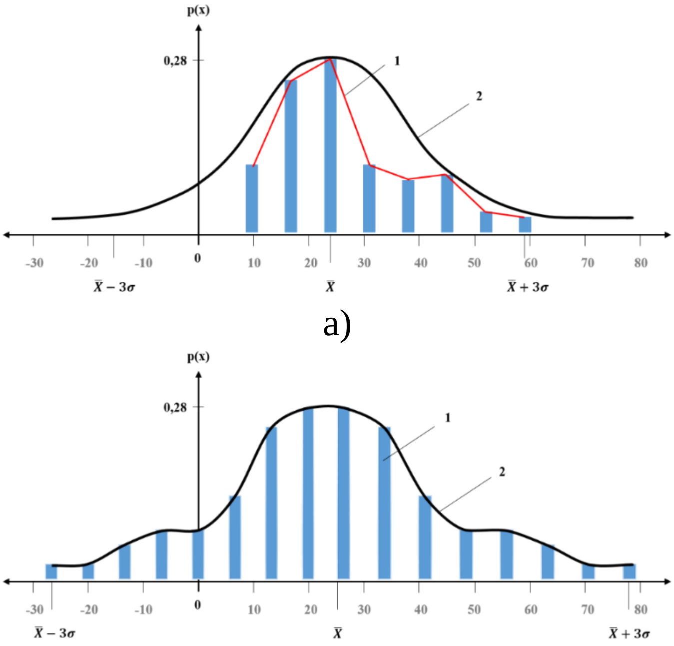
$$\bar{X} + 3\sigma = 24 + 3 \cdot 11{,}87 = 59{,}61;$$
$$\bar{X} - 3\sigma = 24 - 3 \cdot 11{,}87 = -11{,}61.$$

Based on the conclusion of three sigma (3σ), the time lost (random quantity) at the traffic lights proved to be subject to the Normal distribution (Fig.8). The Normal distribution function is written as follows:

$$\Phi(x) = \frac{1}{\sigma\sqrt{2\pi}} \int_{0}^{\infty} e^{-\frac{(x-\bar{X})^2}{2\sigma^2}} dx; \quad (2)$$

The density function is written as follows:

$$\mathrm{p}(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\bar{X})^2}{2\sigma^2}}; \quad (3)$$



a)

b)

Fig.8. Histogram

1-experimental polygon of distribution, 2-curve of the regulatory axis.
a) Tashkent city rive mode, b) Andijan city rive mode.

Conclusion. The time of stopping at a red traffic light of a vehicle with the “Intelligent start-stop system” was calculated in Tashkent and Andijan cities conditions. According to theoretical and practical analysis, the time limit before the red traffic light turns off in the engine start-stop mode was fixed by at least 10 seconds. In order to ensure the resource of components', it was determined that if the time is less than the limited time, the engine will not be switched off or otherwise switched off.

The vehicle with an “Intelligent start-stop system” saved 8.25 percent of fuel when traveling 100 km in urban modes. By using practical and analytical methods, when we assume that one vehicle travels 20,000 km per year, it saved an average of 132 liters of fuel and emissions of toxic gases (CO - 8060 g, CH - 700 g, and NOx - 520 g) and their release of this amount into the environment has been minimized. So, through the use of the “Intelligent start-stop system”, the engine idling times were reduced by 28-32% in 100 km [17].

In Technical and economic efficiency of research were discussed the technical and economical effectiveness of the use of ITS in the field of national road transport in the local condition on the example of ISSS. The dependencies that characterize the determination of the basic order parameter of ISSS or its utilization factor have an empirical origin. The tests were determined by the ability to save time, resources, and relative costs of technical systems on the basis of the vehicle (Table 5).

Table 5.

Technical and economic indicators of justification of synergy of innovative ITS in local conditions on the example of "Intelligent start-stop system"

№	Parameters	Unit	Quantity		Difference, +/-
			Standard vehicle	ISSS vehicle	
1.	Coefficient of ISSS use in the test (Order parameter)	-	0	0,69 (0,31)	- 0,69 (0,31)
2.	Comparison fuel consumption	l/100 km	7,98	7,32	+ 0,68
		l/20000 km	1 596	1 464	+ 132
3.	Exploitation costs	sum/year	375 850	763 719	- 387 869
4.	Annual cost-effectiveness for a single vehicle	sum/year	$((1596-1464)\cdot 9000)-763719 = 424281$		

In this article, we considered in a vehicle as a special case. In the next scientific research works, taking into account the flow of all vehicles on the roads, the synergistic properties of the vehicle - to infrastructure elements and their optimization will be considered.

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