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# MODELING OF INTELLIGENT TRANSPORT SYSTEM FOR POWER SUPPLY CONTROL IN PUBLIC TRANSPORT SYSTEM

# INTELEKTUĀLĀS TRANSPORTA SISTĒMAS MODELĒŠANA ELEKTROENERĢIJAS PIEGĀDES KONTROLEI SABIEDRISKĀ TRANSPORTA SISTĒMĀS

**Nadezda Kunicina,** Dr.sc.ing.,
Riga Technical University,
1, Kalku Street, LV –1658 Riga, Latvia,
Phone: + 371 7089051
e-mail: kunicina@latnet.lv

**Alina Galkina,**
*Riga Technical University,*
*1, Kalku Street, LV –1658 Riga, Latvia,*
*Phone: + 371 7089051*
*e-mail: alina.galkina@rtu.lv*

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## 1. Introduction

The structure of transport intelligent system for power supply control is described in the article. The Intelligent Transport Systems (ITS) [2] program is a worldwide initiative to add information and communications technology to transport infrastructure and vehicles. It aims to manage factors that are typically at odds with each other such as vehicles, loads, and routes to improve safety and reduce vehicle wear, transportation times and fuel consumption. For intelligent transport system modeling for power supply control in public transport system, is also actual the problem of cooperative decision making, and system approach.
The main goals of transport intelligent system are traffic control, traffic information, vehicle safety, vehicle guidance and navigation, drivers' assistance utilization and maintenance of the infrastructure, cooperative systems and other. For the development and investigation of intelligent agent models for control of electric power consumption [5] a complex of interconnected models is analyzed: model of transport system functioning for the supply of electric energy to public transport; model of the supply of electric energy to public transport;

control model of the public transport that can provide passengers with the most acceptable service of the public transport, its schedule, and make the most effective use of electric energy. The potential decreasing of the consumed electric energy in transport is demonstrated in Table 1 [5].

Table 1. Major Consumers of electrical energy – savings potential (fragment)

| Energy Split: | | | Energy saving potential | Key technology |
|---|---|---|---|---|
| Factory autom.<br>Process engineering, Heavy industry, Lighting industry, ... | Motor control 55% | Variable Speed Drive (VSD) | >30% | IGBT modules<br>CiPOS<br>EMCON<br>CoolMOS CT<br>optimized μC<br>8 bit/16bit/32bit |
| Transportation: Train, Bus, Car | | VSD + Bi – directional energy flow | >25% | |
| Home appliance:<br>Fridge, WM, HVAC, .. | | VSD | >40% | |

The article states the changes which are necessary in the structure of transport in order to provide such Intelligent Transport Systems functions: advanced traffic management systems; advanced traveler information systems; advanced public transport systems; advanced vehicle control systems; advanced rural transportation systems; commercial vehicle operations. An intelligent electric vehicle model is suggested. This research was supported by Ministry of education and science republic of Latvia grants "Science Development in Universities" „Optimization process of power supply for intelligent transport systems".

## 2. Problem statement

Energy saving power electronic and drive technologies, energy saving drive applications and energy system management, user applications experiences [5] require presence of intelligent devices in the vehicles. It provides operation of the intelligent transport systems for the control of electric energy supply. Intelligent power electronics is realized by a focused research activity [5]. The authors suggest application of intelligent agent networks in transport intelligent systems, which with the help of intelligent devices fully provide system integration, to describe present control scheme of electric transport, to describe GPRS and GPS [3] application possibilities for transport control. The article considers development of a control system and analysis of its elements.
The most important problem of control could be formulized in the following way [7], using Intelligent agent demonstrated in Fig.1.

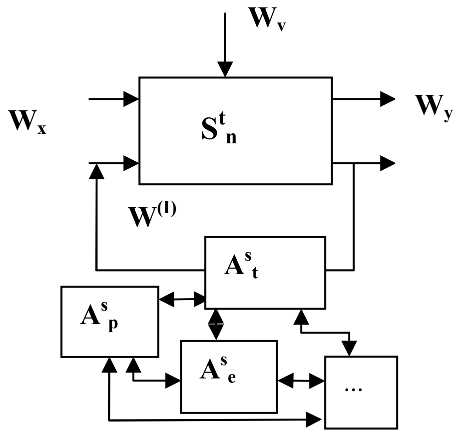


Fig 1. Model of the control task for public transport vehicle

Figure 1 demonstrates control scheme of transport system, St – is transport system; where $W^{(I)}$ - feedback (transport control system); $W_x$ – input of the transport system (resources, passengers, signals), $W_y$ – output of the transport system (resources, passengers, signals), $W_v$ – influence of environment.

The operation of the transport control system is provided according to the priorities of passengers (Z°p) Wy→Z°p, taking into account its interaction with other systems according to logic criteria. Modeling of intelligent transport systems for the control of supplied energy is analyzed in the connection of public transport with other systems and intelligent agents [4, 6] structures.

**3. Research method**

There will be the following designations used in this work:

Se – power system;

Sp – set of passengers with subsets $S^p{}_1, S^p{}_2, ..., S^p{}_k \in Sp$; k=1,2, ...,

St – transport system with vehicles $S^t{}_1, S^t{}_2, ..., S^t{}_n \in St$;

Ste – total consumption of energy with the vehicles energy resources consumptions $S^{te}{}_1, S^{te}{}_2, ..., S^{te}{}_n \in Ste$; n=1,2, ...,

t – time, $t_1, t_2$, .. ti – moments of time;

$Z°_p$ – priorities of passengers;

W - environment

$W_v$ – influence of environment;

$W^{(I)}$- feedback (control system of transport);

$W_x$ – input of transport system (resources, passengers);

$W_y$ – output of transport system (resources, passengers);

$A^s$ – set of intelligent agents (intelligent agent network) with subsets $A^{st}{}_1, A^{st}{}_2, ..., A^{st}{}_{m,}$ $A^{sp}{}_1, A^{sp}{}_2, ..., A^{sp}{}_{m, ..} \in A^s$ ; m=1,2, ...,

$A^{supra}$ – Supra intelligent agent

$\exists\, S^t{}_n\ \forall\, S^p{}_k\, S^{te}{}_j\, (S^t{}_n, S^p{}_k)$ -> min, (exists when $S^t{}_{n,}$ when for each $S^p$ exist $S^{te}{}_j\,(S^t{}_n, S^p{}_k)$.

Target function $S^{te}{}_j$ -> min, $S^t{}_n \geq S^t{}_{direkt}$

By the means of logistics Supra intelligent agent provides the development of electro energy consumption efficiency increasing procedure for public transport system and takes the task of optimum in dynamic $S^{te}{}_j\,(t) \rightarrow \min,\ S^t{}_n \geq S^t{}_{direkt}$ .

The purpose of the work is to formalize functions of a vehicle taking into account objectives of the passengers according to one of the logistic criteria (expenses, time, quality of service), for performance it by the intelligent agent system and equipment.
Optimization of power regimes of public transport demands an active influence on the power equipment of the vehicle [8] it self as well as on the infrastructure of the transport. In this connection electric transport especially city rail transport is the most acceptable, because of two reasons:
1) an electric drive has its own electronic block that in its turn simplifies acceptance and performance of commands as well as 2) city rail transport has its own infrastructure (light signals, ways, etc.).

## 4. Example of control electric circuit of tram

For driving trams DC as well as AC electric motors with semiconductor converters [9] for rotational frequency control are used. Historically DC motors are more applied in these drives. Control devices with contactors and rheostats widely used earlier have been changed for semiconductor regulators which control voltage value supplied to motors. Control of motors according to the mentioned algorithms can allow improving of the consumed energy efficiency.
During the last decades the pulse converters are produced on the base of power transistors (IGBT), as they have a lot of advantages:

1) With pulse converters on the base of simple IGBT transistors a cheaper and safe tram drive can be realized;
2) IGBT transistors do not need additional safety devices as the modules are produced with that built-in;

The sizes and weight of IGBT transistor circuits are considerably lower that that of thirstier circuits. The control of transistors [10] provides a necessary tram speed and its use with intelligent agents improves efficiency of electric energy consumption.

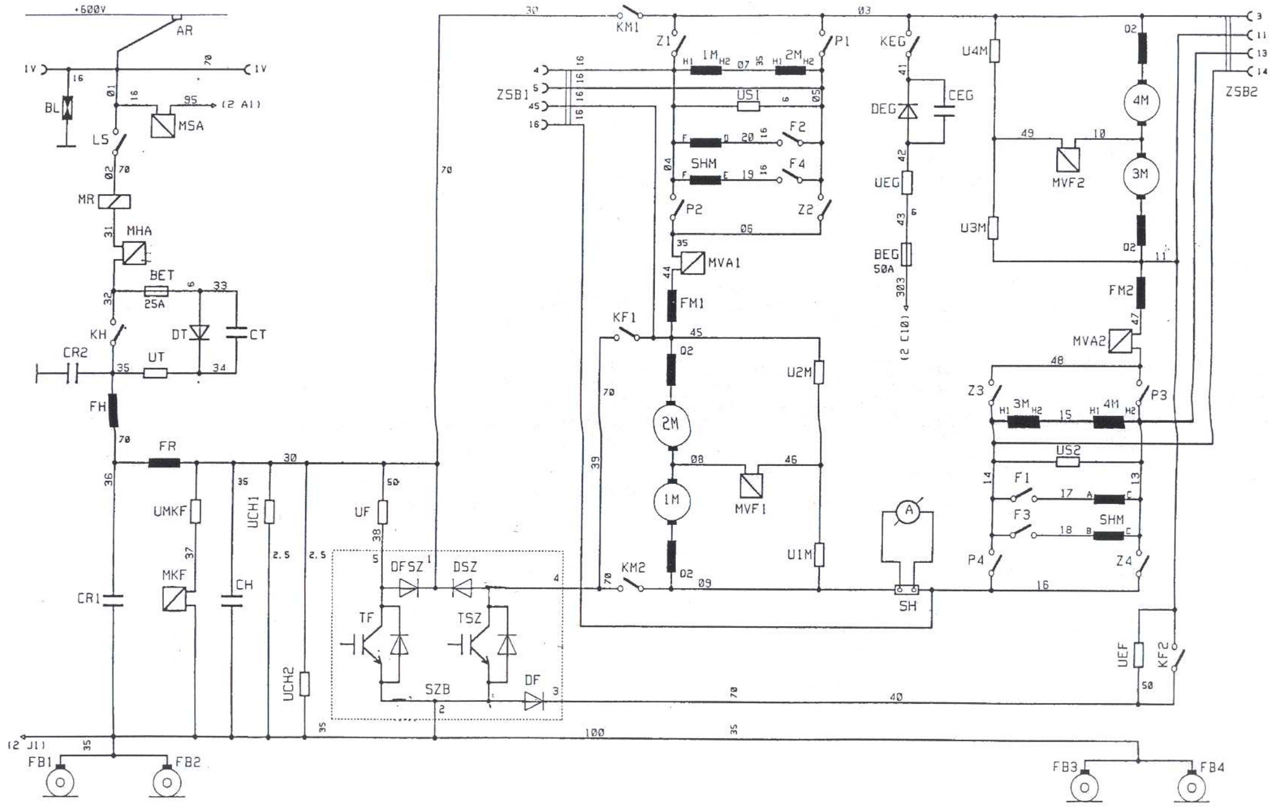


Fig. 2. Electric circuit of tram

Investigation of the pulse converter and its control block of the tram power circuit allows to conclude that the pulse converter itself is simple but the control block is a complex device on which the effective operation of the converter depends. Applying it to the starting and braking of trams allows saving of 20% of the consumed energy. The regenerating braking of the trams allows saving up to 30% of the energy consumed by the tram with resistive starting equipment.

With the development of industrial electronic technologies the control blocks and tram drives power circuits' possibilities are improved but their sizes and weight decreased. This in its turn gives possibility to transport more passengers consuming less energy.

In Riga the trams are modernized with pulse regulators of the firm Ansaldo. The tram drive basic scheme is shown in fig. 2. In this scheme power transistor TSZ completes pulse regulation of four motors drive 1M…4M in its starting as well as braking regimes. Contactors KM1 and KM2 are coming into operation in the starting regime contacting two parallel motor circuits with the starting current 240A each. In the braking regime contactors KM1 and KM2 are open and KF1 is operating.

As a result the transistor switch is in parallel to the electro motors operating in generator modes and provides pulse-type regenerative braking periodically switching the generator circuit and regenerating the accumulated energy to the network through diodes DSZ, DF. The control block of the tram is given in figure 3. The operating frequency of the pulse regulator is 1kHz.

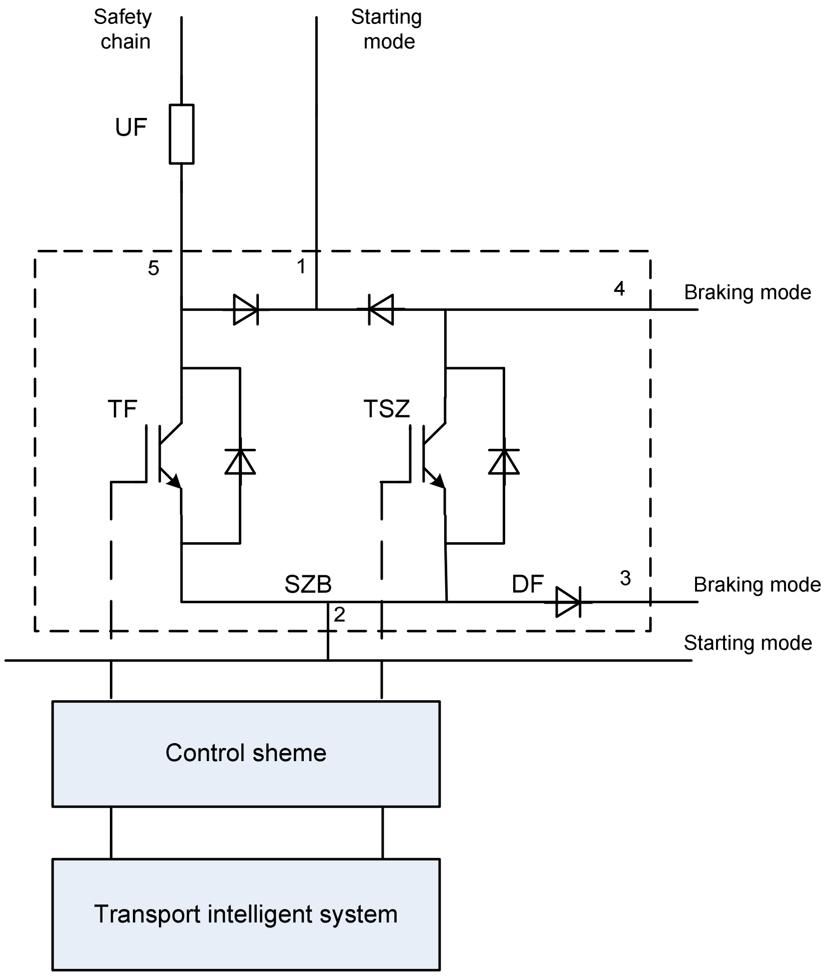


Fig. 3. Functional model of the intelligent transport system equipment for the control of electric energy supply

As a total EMF of the generator in regenerative braking mode can not exceed supplying voltage, but at high rotation speed and full excitation currents it can take place, then for such case with speed over 30km/h energy reducing resistor UEF rated with 1Ω is connected to the generator circuit. At low speeds this resistor is by-passed by contactor KF2. If in the braking mode there are no other similar consumers then in the case of pulse recuperation voltage of input filters capacitors CR1 and CH to increase. If this voltage is higher than 750 V, then for regenerated energy decreasing with transistor TF energy reducing resistor UF is connected, i.e., a rheostat braking takes place instead of regenerative one. In an engine mode the transistor pulse regulator TSZ by-passed with reverse diode DSZ is connected in series with both parallel motor circuits. Contacts KM1 and KM2 are in operating condition. The circuit of the contacts is connected through LC filter with chokes FM + FR and capacitors CR1 and CH. For the increasing of the speed at the end of pulse regulation, the excitation windings are step-wise by-passed with power contactors F1, F2, F3, F4 reducing excitation magnetic field. In the braking mode the contactors KM1, KM2 are disabled, but KF1 operates connecting in parallel the transistor pulse regulator TSZ to the parallel circuit of motors 1M, 2M and excitation windings 3M, 4M, as well as motors 3M, 4M and excitation windings 1M, 2M. This connection provides the operation of the motor in generator regime without the reversing of motor elements.
The model of the control circuit considered in the example of the tram public transport system is given in fig. 4 and 5.

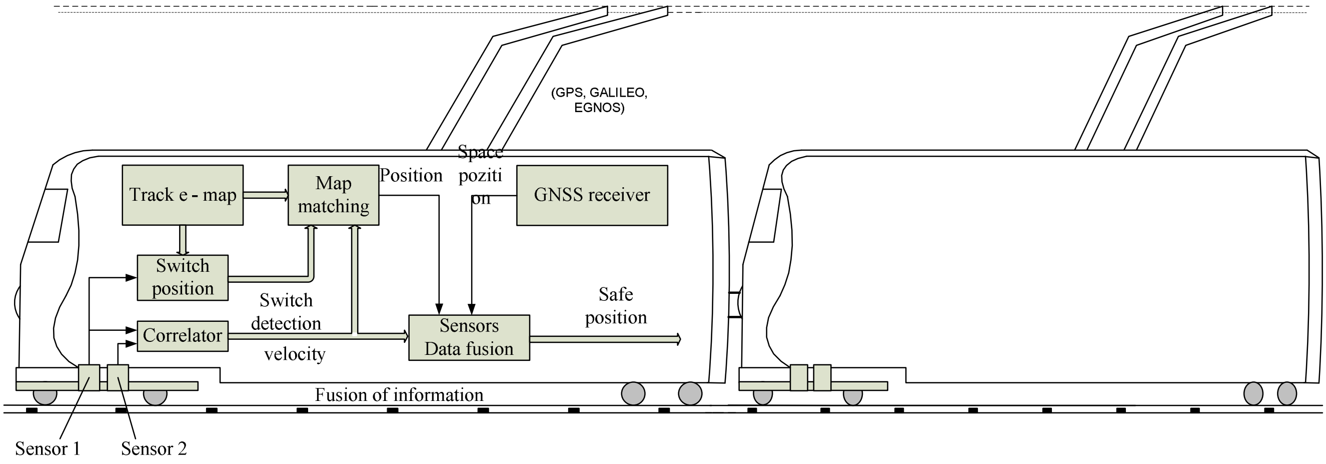


Fig. 4. Model of public tram system control

Model of public tram (fig. 4.) system control shoves application of GPS for signals, all of which utilize of three basic components of the GPS; absolute location, relative movement, time transfer.

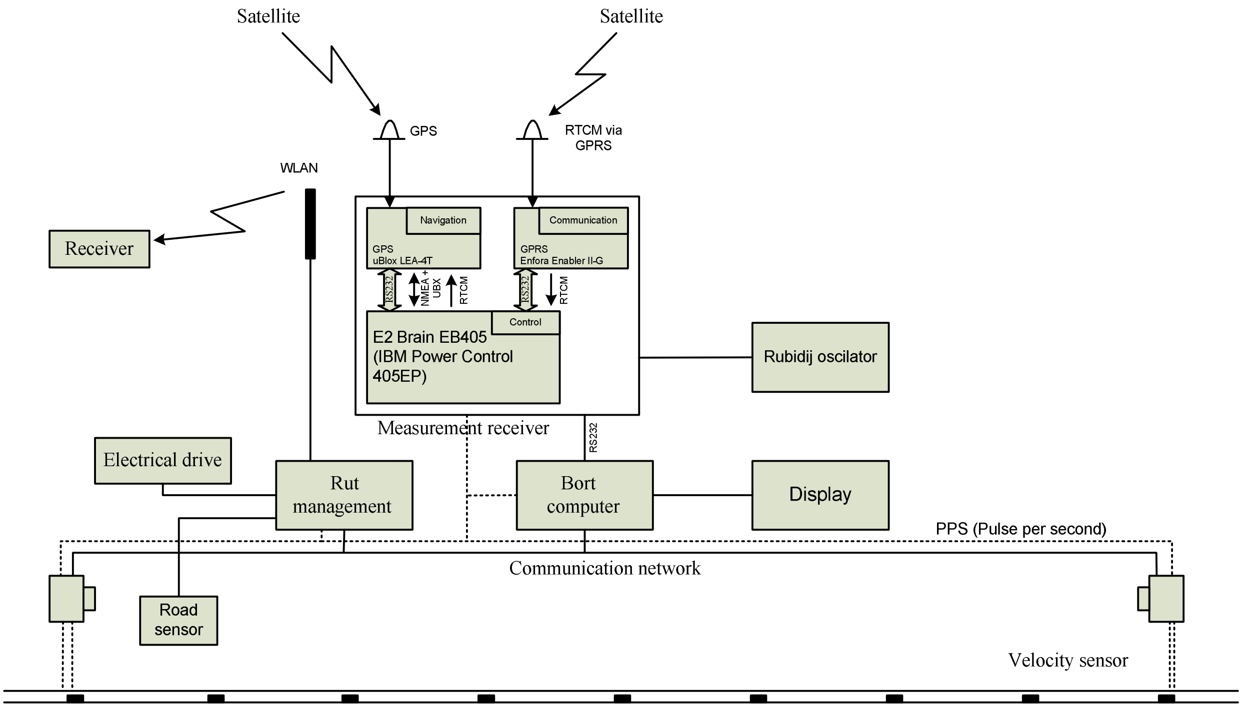


Fig. 5. Model of tram control with the application of GPRS signals

Model of tram control with the application of packet-switched GPRS signals (fig. 5.) system control shoves application of GPRS for intelligent agent system functioning and other application. This block is used for the intelligent transport system functioning and energy consumption control.

## 5.Conclusions

The task of procedure development for the improvement of electric energy efficiency is stated as a task of formalized model investigation that can provide efficiency of the present transport system investigation that has a high economic importance including the situations of city traffic congestions. The procedure for intelligent transport system of the improvement of consumed electric energy use efficiency is formalized. The role of Supra intelligent agent was defined. Analysis of the present electric transport control system shows that it is't provided energy consumption control by transports intelligent system, using intelligent agents. Analyzing the results of transportation system technical equipment can concluded that GPS and GPRS application has a considerable influence on environment, speed of motion, maintenance conditions and GPS is one of technology, which could be useful for transport intelligent system to dedicate absolute location and relative movement. GPRS application in the control of electric transport is a perspective direction of intelligent transport systems development, as intelligent agent realizing technology.

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***Kuņicina N., Galkina A. Intelektuālās transporta sistēmas modelēšana elektroenerģijas piegādes kontrolei sabiedriskā transporta sistēmās.***

*Galvenie transporta intelektuālo sistēmu pielietošanas mērķi ir transporta sistēmas kontrole, informācija, transporta līdzekļa drošība, vadība un navigācija. Rakstā ir risināts elektroenerģijas izlietošanas efektivitātes paaugstināšanas procedūras izstrādes uzdevums, kas tika risināts, pielietojot sistēmu analīzes pieeju, tika veikta transporta sistēmas un ar to saistīto sistēmu modeļu formalizāciju. Transporta intelektuālo sistēmu modelēšana, tika veikta ņemot vērā transporta sistēmas ekonomisko nozīmi un sarežģītu transporta situāciju. Rakstā tika formulēta elektroenerģijas lietošanas efektivitātes paaugstināšanas procedūra sabiedriskam transportam. Esošās elektriskā transporta vadības procedūras analīzes rezultātā tika identificētas transporta intelektuālo sistēmu pielietošanas lietderībā, kura tiek izmantotas kā pamats intelektuālo aģentu darbībai. Analizējot transporta sistēmas tehnisko aprīkojumu var secināt, ka GPS un GPRS pielietošana ir nepieciešama, lai uzskaitītu būtisku apkārtējās vides ietekmi, kustības ātrumu, aprīkojuma tehnisko stāvokli. GPS ir tehnoloģija,*

*kura ļauj transporta intelektuālām sistēmām precīzi noteikt transporta līdzekļa ģeogrāfiskās koordinātes un nosacīto nobraukumu. GPRS izmantošana elektriskā transporta vadībai ir perspektīvs intelektuālo transporta sistēmu attīstības virziens, kas tiek izmantots kā platforma intelektuālo aģentu realizācijai.*

***Kunicina N., Galkina A. Modeling of intelligent transport system for power supply control in public transport system.***

*The main transport intelligent system application aim are traffic control, traffic information, vehicle safety, vehicle guidance and navigation, drivers' assistance utilization and maintenance of the infrastructure, cooperative systems. The task of procedure development for the improvement of electric energy efficiency is stated as a task of formalized model investigation that can provide efficiency of the present transport system investigation that has a high economic importance including the situations of city traffic congestions. The procedure for intelligent transport system of the improvement of consumed electric energy use efficiency is formalized. Analysis of the present electric transport control system shows that it isn't provided energy consumption control by transports intelligent system, using intelligent agents. Analyzing the results of transportation system technical equipment can be concluded that GPS and GPRS application has a considerable influence on environment, speed of motion, maintenance conditions and GPS is one of technology, which could be useful for transport intelligent system to dedicate absolute location and relative movement. GPRS application in the control of electric transport is a perspective direction of intelligent transport systems development, as intelligent agent realizing technology.*

***Куницына Н., Галкина А. Моделирование интеллектуальной транспортной системы для контроля подачи электроэнергии в общественной транспортной системе.***

*Главные задачи использования транспортной интеллектуальной системы это контроль системы транспорта, информации, охраны устройств защиты, управление и навигация. В статье решается проблема повышения эффективности использования процедур производительности электроэнергии, которое решается путем использования системы анализа транспортной системы и связанной с этой системой модели формализации. В системе транспортного интеллектуального моделирования берется с расчетом экономического значения и сложной ситуации транспортной системы. В статье формулируется модель интеллектуальной транспортной системы с целью повышения энергоэффективности. Анализ результатов в существующей системе управления транспортом применяя интеллектуальную транспортную систему, которая используется как основа работы интеллектуальных агентов. Анализируя техническое обеспечение транспортных систем, можно сделать вывод, что GPS и GPRS использование необходимо, чтобы вычислить существенное влияние окружающей среды, скорость движения, техническое состояние устройств. GPS это технология, которая позволяет интеллектуальным системам точно вычислить географические координаты транспорта и условный пробег. Использование в управлении электротранспорта GPRS это перспективное направления в развитии транспортной системы, которое используется как платформа реализации интеллектуальных агентов.*