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DEVELOPMENT PASSENGERS TRANSFER PROCEDURE FOR CITY TRANSPORT IN RIGA

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ABSTRACT

The integration of railway transport in Riga city public transport control is important for passenger's service, using existing recourses. However the integration of transport control systems has just started to be developed. The first implemented system was bus control system – ASOS. The three levels of integration in vehicle control, transport mode control and all city transportation system control in one system are described. The decision making procedures for predefined conditions, using decision trees, takes into account risky conditions by definition of possibility to choosing one of alternatives. The dynamic control for transport modes in pre - defined time interval and composite the final control procedure for each transport mode and harmonize the motion with the aim to arrive transport in time and

harmonize railway and public transport motion. An effective tool of research of problems of optimum control is the principle of dynamic system control, representing a necessary condition of optimality in such problems. The example of Riga city transport system is described.

INTRODUCTION

In Latvia the tendency to reduction of railway routes of the suburban and long-distance message with partial replacement with their bus service recently is observed. And nevertheless time from time speech about necessity of integration of railway transportation into a network of city passenger transport of a city of Riga appears. It is rational improvement, because it allows transporting passengers more efficiently. In Riga the railways have separate infrastructure, they are not crossing motorways and roads in city centre, railway was built on viaducts at it allows to transport passengers faster and cheaper. However no parking places or city transport connections are available to transport passengers from regions nearby railways to railway station. This is complex and strategically transport network replanting task, with aim of integration of separate transport modes in one city transport system. Decision of this problem is not simple; it requires making a detailed planning and simulation experiments. It requires using decision making tools, simulation, economical calculations and also developing new passenger's transportation routes and control tools for managing all transport modes as one system. The introducing intelligent transport system, using intelligent agent concept [1] for control of passenger's service in tree levels: vehicle level, transport mode level and complex transportation level are required.

Use of modern technologies of monitoring and the transport control integrated in intelligent transport system have received wide popularity all over the world. Such systems are means of considerable reduction of non-productive expenses for transport and increases of an overall performance of transport system as a whole. The first step in Riga city is bus control system ASOS. Systems of satellite monitoring of motor transport now are widely used in the transport, however the strategic development in city and implementation in tree levels of control is not just engineering issue, it is also an issue for decision makers. In article the usage of such system for passenger's transportation are discussed.

Necessity of working out of the centralized system of wireless dispatching management of city passenger transport in Riga is obvious. The centralized management of city passenger transport presumes to use more effectively transport resources and to provide higher level of service for passengers. It will be promoted also by integration of railway transportation into system of passenger transport of the city of Riga, with including into the general control system.

Analyzing world experience in working out and use of control systems of city passenger transport, it is possible to assume that introduction of similar system in the city of Riga will have a positive effect. Considering experience of other countries, it is possible also to assume

approximately-necessary functionality of system.

DESCRIPTION OF EXISTING SITUATION

There are the following types of public transport in Riga: trams, trolleybuses, buses, route taxi and railway. Analysis of the present situation in Riga states that railway transport integration into public transport system of Riga could be cheaper and simplest way to optimize passengers transportation, instead of building new infrastructure. The greatest part of the railway transportations is provided by the only market participant - concern Latvian Railway Ltd. [2]

The development of public roads foresees new highways but in Riga the transportations are realized with public as well as with private transport. The optimization of transportation of passengers in Riga can effectively use railway (the idea of its integration into public transport is included into the general plan of Riga transport development).

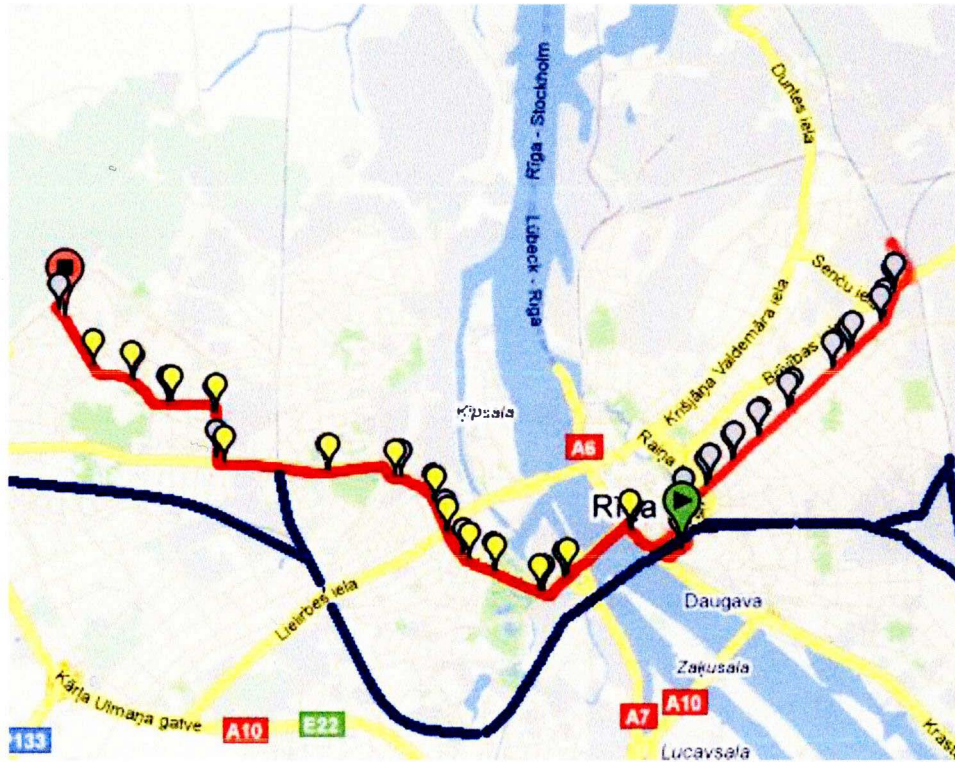

Fig. 1. 4 th trams route and railway track in parallel in the center of Riga

The analyses of route of transportation shows, that there are a lot of duplications (figure 1) and possibilities to transfer passengers transport from private transport to public transport, but it also requires to have better quality of service for passengers transportation. The potential of transferring is at least 1/3 of daily traffic. The type of the passenger transport should meet the requirements of transportation policy of Riga and should answer to the questions whether the transport system is sustainable if an alternative is implemented, what trends are unsustainable,

how much mobility is sustainable, and the others. A particular activity or option seems desirable and successful when one way is measured, but undesirable and ineffective when another one is measured. Therefore the understandable assumptions and implications and its evaluation method are described in the article.

For the improvement of the present situation a passenger's transfer procedure is developed.

PROBLEM MATHEMATICAL DEFINITION

Let's define graph of transport network (fig.2.):

N nodes of graph – transport stops $N=n_1, n_2, \ldots, n_k$;

K carrying capacity of branches of graph - roads $K'=k_1, k_2, \ldots, k_i$;

T transportation time from one node to another node $T= t^{n1nk}_1, t^{n2nk}_2, \ldots, t_j$;

C transportation cost from one node to another node $C= c^{n1nk}_1, c^{n2nk}_2, \ldots, c_m$;

Q transportation quality of service from one node to another node $Q'= q^{n1nk}_1, q^{n2nk}_2, \ldots, q_n$;

V passengers amount, using public transport, passengers amount is changeable in time V(t) ;

W passengers amount, using private transport, passengers amount is changeable in time W(t);

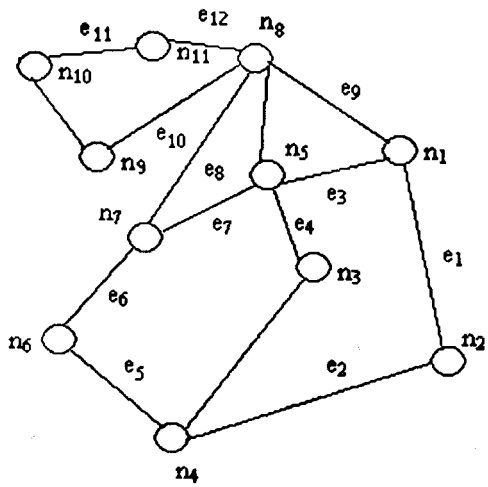

Fig. 2. An example of transport network

The transport system improvement could be in the cases, when new node building $N=n_1, n_2, \ldots, n_k, n_{k+1}$, when carrying capacity of branches of graph are not enough to transport all the goods and passengers $k_i \leq k_i^d$, when T transportation time is not acceptable for transport goods and passengers $t_i \leq t_i^d$, when Q′ transportation quality of service from one node to another node $Q'= q^{n1nk}_1, q^{n2nk}_2, \ldots, q_n$ transportation time is not acceptable for transport passengers $q_n \leq q_n^d$, in this cases we have to control usually maximize carrying capacity of branches of graph, when transportation time is minimizing. Decision making about transport system development alternatives allows defining as $A= a_1, a_2, \ldots, a_w$,

$$A=K'xCxTxQ' \qquad (1)$$

the best alternative is

$$A' \supset A\ k, q \rightarrow \max, t, c \rightarrow \min. \qquad (2)$$

Let's introduce also passengers preferences, and build passengers transportation procedures, based on passengers preferences. Let's define N as a set of alternatives of passengers transportation by city transport, and set of alternatives M, when passengers use private transport. The Q′ quality of service lets define, as difference on the amount of passengers, who use public transport and private transport in peak hours (working days mornings and evenings). Let's define the existing passengers habits within time ϑ as $V(\vartheta)$ and $W(\vartheta)$, and optimal passengers habits within time $V(\Theta)$ and $W(\Theta)$. The optimal procedure for passengers transportation will be assumed under the condition when $V(\Theta)/W(\Theta) > V(\vartheta) / W(\vartheta)$.

Let's introduce such symbols $z = V(\Theta)/W(\Theta)$, and $h = V(\vartheta) / W(\vartheta)$,

Let's include expression for quality of service in formula (2)

$$A' \supset A\ k, z \rightarrow \max, t, c, h \rightarrow \min. \qquad (3)$$

The passengers preferences could be defined, using multi criteria decision making. [3]. According to [4] the relation and situations are consolidated for modeling preferences relative to two potential actions (alternatives) a_1 and a_2.

Table 1

Situation	Definition	Binary relations
Nonpreference	Corresponds to an absence of clear and positive reason that justify strict or weak preference in favor of either of the two actions and thus consolidates situation of indifference and incomparability without being able to differentiate between them	~: $a_1 \sim a_2$. ⇔(in and only if) a_1 I a_2 or a_1 R a_2.
Preference	Corresponds to the existence of clear and positive reasons that justify strict or weak preference in favor of one (identified) of the two actions and thus consolidates situations of strict and weak preference without being able to differentiate between them	➢ : a_1 ➢ a_2⇔ a_1 P a_2 or a_1 Q a_2.
J - preference	Corresponds to the existence of clear and positive reasons that justify weak preference, no matter how weak, in favor of one (identified) of the two actions or at the limit, indifference between the two actions, but with significant division established between the situations of weak preference and indifference	J: a_1 J a_2.⇒ (only if) a_1 Q a_2. or a_1 I a_2.
K - preference	Corresponds to the existence of clear and positive reasons that justify strict preference in favor of one (identified) of the two actions or incompatibility between two actions, but with no significant division established between the situations of strict preference and incomparability	K: a_1 K a_2⇒ (only if) a_1 P a_2 or a_1 R a_2
Outranking	Corresponds to the existence of clear and positive reasons that justify strict preference or J – preference in favor of one (identified) of the two actions but with	S: a_1 S a_2⇒ (only if) a_1 P a_2 or a_1 Q a_2 or

	no significant division being established among the situations of strict preference, weak preference and indifference	a_1 I a_2

Roy notes, that a_1 outranks a_2 if a_1 is considered to be at least as good as a_2.
It table 1 I – indifference; P – strict preference, Q- weak preference, R - incomparability

Purpose, set of criteria (impacts), factor of its importance can be specified for each particular case. The selection procedure can be realized within the help of information technologies and intelligent transport networks. We will add the criterion of electric energy consumption to the set of criteria of decision making procedure modelling for the consumed energy decreasing, therefore A=ExCxTxQ′, the best alternative is A'⊃A k, z →max, e, t, c, h →min,

$$A=ExCxTxQ' \qquad (4)$$

To build the best alternative, such as A', which is in fact route of each passenger in time t, let's apply the maximum of Pontrjagins principle. Method giving a necessary condition for the solution of optimal control problems: let $\theta(\tau)$, $t_0 \leq t \leq T'$ be a piecewise continuous vector function satisfying certain constraints; in order that the scalar function $S = \sum c'_i x_i(T')$ be minimum for a process described by the equation $\partial x_i/\partial\tau = (\partial H/\partial z_i)[z'(\tau), x(\tau), \theta(\tau)]$ with the given initial conditions $x(\tau_0) = x^0$ it is necessary that there exist a nonzero continuous vector function $z(\tau)$ satisfying $dz_i/d\tau = -(\partial H/\partial x_i)$. $[z(\tau), x(\tau), \theta(\tau)]$, $z_i(T) = -c_i$, and that the vector $\theta(\tau)$ be so chosen that $H[z'(\tau), x(\tau), \theta(\tau)]$ is maximum for all τ, $\tau_0 \leq \tau \leq T'$, such H is the best alternative A' in this case.
So the best alternative is:

A'⊃A k, z →max, e, t, c, h →min, and A'$[z'(\tau), x(\tau), \theta(\tau)]$ →max for all t, $t_0 \leq t \leq T'$ (5).

THE CONTROL SYSTEM

The public transport system control in additional requires on board equipment with application of GPS, all of which utilizes three basic components of the GPS; absolute location, relative movement, time transfer. There is bus control system, which is first component of intelligent transport system [5] figure 3.

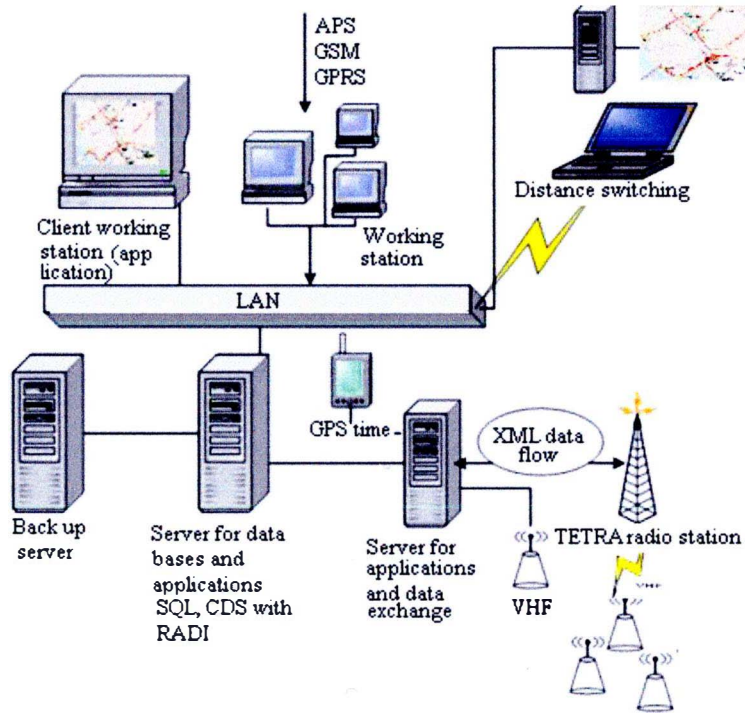

Fig. 3. Structure of bus management system ASOS

The intelligent transport system requires having control procedures, which should:

- carry out the control over movement of passenger transport of a city with possibility of the operative control of movement

- provide possibility of carrying out of vocal communication sessions between dispatchers and mobile objects in certain places of a city, for example on movement terminal points. The given function allows to regulate an exchange order in an air manually, in case of any non standard situation.

- provide support of an emergency communication in case of breakage of vehicles on all city territory. The driver of the Vehicle receives a direct communication channel with emergency services or communicates through dispatching knot. The emergency communication can be made active in any point of a city the driver.

- give possibility at any moment to carry out a call of any subscriber of system from dispatching service.

- provide protection against offenders in case of an attack, and also security system of a rolling stock of vehicles on all city territory. The driver of the Vehicle receives the direct channel on Services "Ambulance" and "Militias" for transfer of the vocal message. Alarm signal giving by "the Latent button" is possible.

- provide gathering of the information from onboard equipment (gauges, the measuring equipment, buttons) and fixing of gauging on the base equipment.

- provide an information transfer on stationary equipment of display (for example digital boards at stops).

- support the possibility of the emergency notification of the population through a complex infrastructure. The notification through onboard completes set (a circular call on all vehicles) and stationary equipment (a board at stops).

- support the possibility of regulation by movement by public transport. Regulations can be carried out in an automatic mode with display of amendments to movement to the display of the onboard complete set.

- give uniform time for all system objects which is displayed on onboard complete sets and it is corrected automatically from the dispatching centre.

- provide possibilities of self-diagnostics and visualization of a condition of devices and a component.

POSSIBLE FUNCTIONALITY OF SYSTEM

Co-ordinate positioning (definition of the place) of systems objects:

Mobile objects, moving on a city, form on the board item marks. Formation is carried out in two ways:

A) beacon- positioning. The algorithm of action of such method consists in the following. The beacon settles down near to road (on a building, on a column etc.) Radius of action of a beacon is about 50-100 meters. The beacon radiates in the special way the number. Vehicles, coming into a beacon operative range, receive a registration mark. On the basis of beacon number mobile means receives the information on the site in a city. This data together with current time is transferred in a dispatching office and used for the further calculations of movement on a route.

B) GPS - navigation. The algorithm of action of such method consists of the following. Onboard a vehicle the additional equipment (GPS - the receiver) is established and the vehicle defines the site by data from this receiver. Further the receiver data (current geographical co-ordinates) are transferred in dispatching knot and used for the further calculations of movement on a route.

Independent work of onboard equipment.

The equipment of mobile object allows conducting work in a usual mode (to register marks to show an advancing, backlog from the schedule etc.) within days without dispatching service. Such situations can arise, for example, at failure of dispatching service or when the board has considerably left from a city (suburban transportations). Thus the board accumulates the information on the equipment, and after restoration of communication with dispatching service pumps over the information from a board in the centre.

Transfer of the alphanumeric information from the dispatcher on mobile object and from mobile object on dispatching knot.

The mobile objects having onboard the display (for example, special dispatchers bus), can receive different alphanumeric information (for example, reports on a brigade for a present day, a planned target etc.). The Alphanumeric information aboard can arrive at the

initiative of the dispatcher or on demand from a board. The Alphanumeric information can be transferred from a board to a dispatching office.

Voice communication with the dispatcher in an operative range of the beacons resolving a vocal mark.

Certain beacons on a route can be planned in such a manner that a vehicle, being in radius of its action, has possibility to spend a session of a voice communication with the dispatcher. Thus the dispatcher himself registers a mark for the given board only after the spent vocal session. This factor allows achieving from the driver of an obligatory exit on a voice communication in an operative range of such beacons.

Voice communication (emergency) in any point of a city on demand from a board.

In extreme conditions the driver can contact special services (first aid, militia, fire service etc.) in any point of a city and to inform on the created situation. The exit is carried out on concrete service individually. Thus registration of such voice communication is carried out on the dispatching computer.

Voice communication (emergency) in any point of a city on demand from a board.

In case of failure the driver from any point of a city can cause auxiliary services in a vocal session with emergency service.

Latent button "Alarm".

In case of an attack the driver has possibility to transfer an alarm signal pressing of one button from any point of a city.

Voice communication of the dispatcher with group of mobile objects.

The dispatcher has possibility to spend a vocal session individually (with a concrete board) or with group (with several boards). Thus the initiator of a call is the dispatcher.

Voice communication of the dispatcher with group of mobile objects.

The dispatcher has possibility to realize a vocal session individually (with a concrete board) or with group (with several boards). Thus the initiator of a call is the dispatcher.

On vehicles, the modules of monitoring containing GPS-receiver, microcontroller, flesh-memory and GSM GPRS modem are established. Except GPS and GSM aerials, to monitoring module GPS probably connection of gauges of the control of level of fuel, gauges of the expense of fuel, gauges of work of mechanisms, gauges of temperature, gauges of a volume of passenger traffic, ignition, pressure of oil and other gauges. It allows to collect in a real-time mode the major information for further analysis.

PASSENGERS TRANSFER PROCEDURE

The procedure structure for decision making of transportation system, included such elements [6]: decision maker DM, administrator A, decision maker interface I(DM), reactor of knowledge base R(KB), general knowledge base (KB), the particular cases (KBp) (figure 4.). The user interface could be developed as questionnaire, menu, and native language or table of symbols.

The decision maker goal (figure 4) is with the use of decision support system to get optimal sustainability of transportation in innovation process Im – impact Kr – criteria, coefficient –Kf.

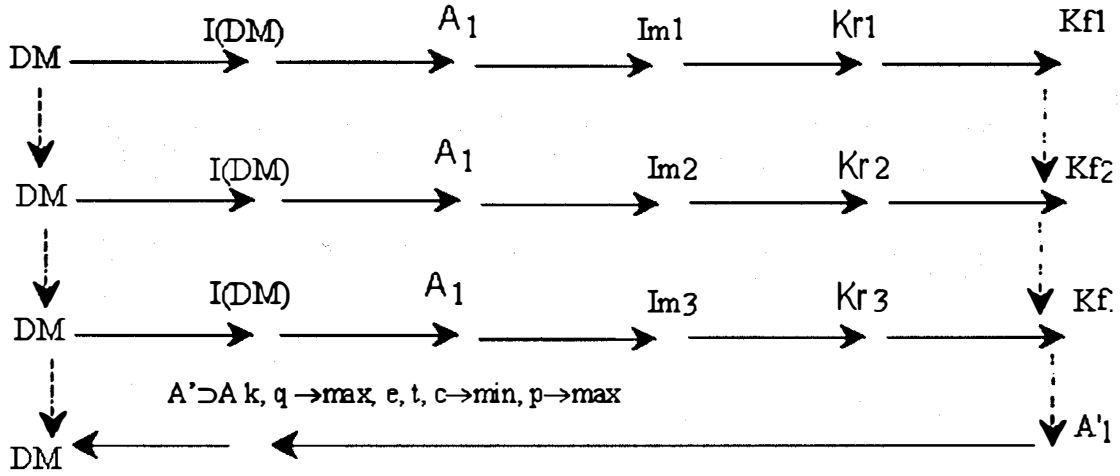

Fig.4. Interaction between decision maker and decision support system

APPLICATION EXAMPLE

It is offered to create the two-level centralised control system of passenger transport of the city of Riga (fig.5.).

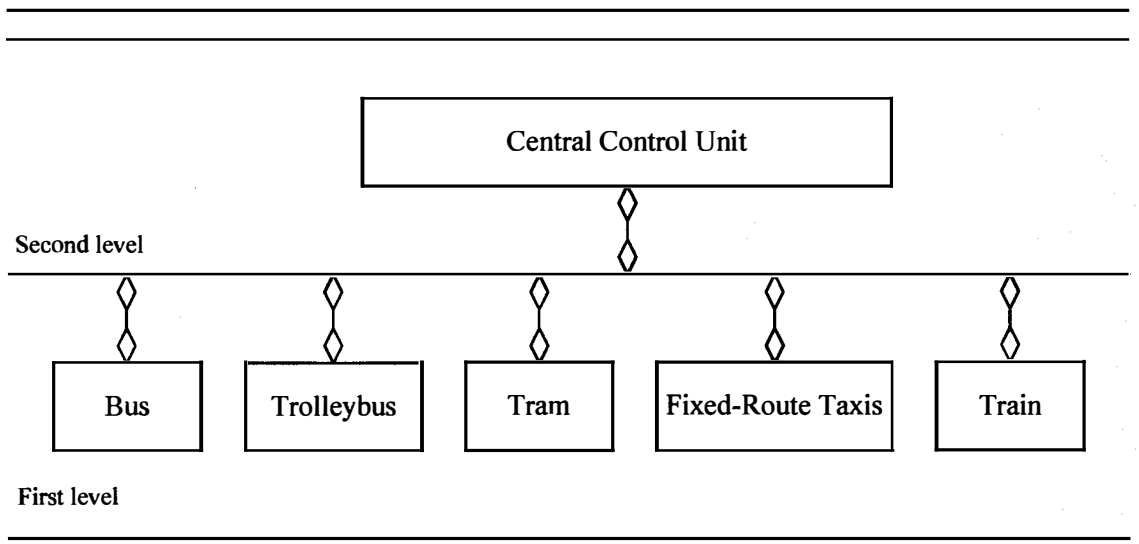

Fig.5. Two-level centralised control system of passenger transport of a city of Riga

At the first level the control of each type of transport separately (something similar now well only for the Riga buses) will be carried out (ASOS system). The second level will allow supervision system as a whole. It will allow to plan more competently work of transport system using corresponding methods of the theory of management, more effectively to

transport passengers. Thereby the system of passenger transport will work more in coordination, in the best way carrying out the main function - timely delivery of passengers in the place of a city necessary to them.

CONCLUSIONS AND RECOMMENDATIONS

The authors of the article offer to develop a centralized control system of public transport of the city of Riga. Analyzing world experience it is possible to tell that it can essentially improve system of passenger transport of the city of Riga. The authors suggest to continue researches in this area and as a result to consider possibility of introduction of a two-level control system of city passenger transport. The authors recommend except traditional buses, trolley buses and trams, to include into the system taxi and trains as well fixed-routes. In this case also it makes sense to equip all these vehicles with devices of reading of e-tickets. It will allow more competently, conveniently and precisely to trace and analyze volumes of passenger traffic in a city. That, in turn, will allow planning work of system of public transport more competently.

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