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Integrated Control Tools Development for Sustainable City Transport System

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ABSTRACT
Sustainable development of City Transport System is described in the article. Control tools relating to planning, and management of Public Transport System are described. 3-levels Integrated Control Tools system usage is offered which allows carrying out the control of vehicles, to supervise work of each type of transport separately and to co-ordinate work of all passenger transport system in the city.

KEYWORDS: Sustainable City Transport System, Control Tools, passengers, consumption of fuel and electric energy

1. Introduction

Transportation of the passengers in large cities is of great importance for the urban and economic development of those. But the public transport is not the only type of it running in the cities, people use also private transport that increases traffic congestions increasing in their turn the consumption of fuel and electric energy.

Therefore the actual investigation under the present transport situation is selection of that type of transport meeting the requirements of the passenger transportation optimization. Particularly important it is under the conditions of transport network renovation. The renovation process is realized usually with the optimization of transportations according to the time parameter without reducing the comfort and costs. As the base of decision making procedure of the transport network development alternative selection co-modal transportation principle is suggested to use in optimization of the city transport. The elaboration of decision making procedure is important for intelligent transport systems and services development.

In this article transport sustainability means, that transport provides safe, economically viable and socially acceptable access for people, places and services while meeting objectives for health and environmental quality, protecting ecosystems and minimizing adverse impacts on global phenomena such as climate change [1]. Transport routes and vehicles should be convenient, safe and simple to use.

The purpose of this research: Increase of an overall performance of system of a City Transport, by development of Integrated Control Tools for Sustainable City Transport System.

Tasks of research:

- Definition of measured parameters for evaluation of Sustainability of City Transport System.
- Reduction of time of a trip of one passenger from point „A" to point „B" in comparison with an existing situation.
- Optimization of quantity of vehicles in system of city public transport to minimum quantity of vehicles in

the considered system, capable to execute demanded number of inquiries of passengers.
- Increase in an overall performance of each vehicle.
- A problem of assignments. Appointment to a route of vehicles of different capacity.
- Scientific novelty - working out of three-level models of management of transport system.

The first level provides the control of a vehicle and traffic lights. In other words, at this level the control of transport system at level of objects of system is made: vehicles, traffic lights and inquiries about service of passengers.

The second level: integration and realization of management by transport system within one mode of transport.

The third level: work coordination, transport modes coordination and quality of inquiries about service of passengers (quality of service).

2. Sustainable Transportation Principles and City Transport System

Serious challenge for engineers and designers, and also for policy makers is observance balance between mobility and sustainability.

The principles of sustainability and environmental indicators evaluation [2] should be analyzed according basic transportation activities, which affecting the environment:

1. Infrastructure construction, maintenance, and abandonment (e.g., building roads);
2. Vehicle and parts manufacture;
3. Vehicle travel;
4. Vehicle maintenance and support;
5. Disposal of used vehicles and parts

The World Commission on Environment and Development is usually credited with the first definition of sustainable development. In [10] the Commission defined the sustainable development as the „development that meets the needs of the present without compromising the ability of future generations to meet their own needs". The report continues: „It contains within it two key concepts:
- The concept of "needs" in particular the essential needs of the world's poor, to which overriding priority should be given, and
- The idea of limitations imposed by the state of technology and social organisation on the environment's ability to meet present and future needs".

As it is mentioned in COST 356 [9], - hierarchy of objectives in the environmental field according to [11] Master the environment;
- At global scale;
- Preserve an environment in favor of the human life;
- Limit the greenhouse effect;
- Limit the climate change;
- Protect the ozone layer;
- Preserve the natural resources;
- Limit the extinction of natural species;
- Limit the extinction of natural environment;
- Limit the energy consumptions;
- Limit the maritime pollution;
- Limit the production of non-recyclable waste;
- Concerning the human environment;
- Respect the areas «villages»;
- Preserve habitats from soiling.

3. Integrated Control Tools technical platform

The intelligent transportation system (ITS) by it salves is used as bases for Integrated Control Tools technical solution development. The typical structure of ITS [3] is given in figure 1.

According to [4], such principles of sustainable transportation could be implemented, using ITS:
- Intergenerational equity
- Multi dimensional
- Dynamic
- Continuum

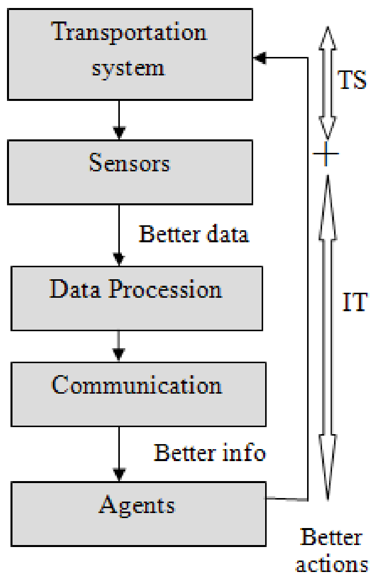

Fig. 1. Modeling and simulation process flow in TRANSIMS
Source: [own work]

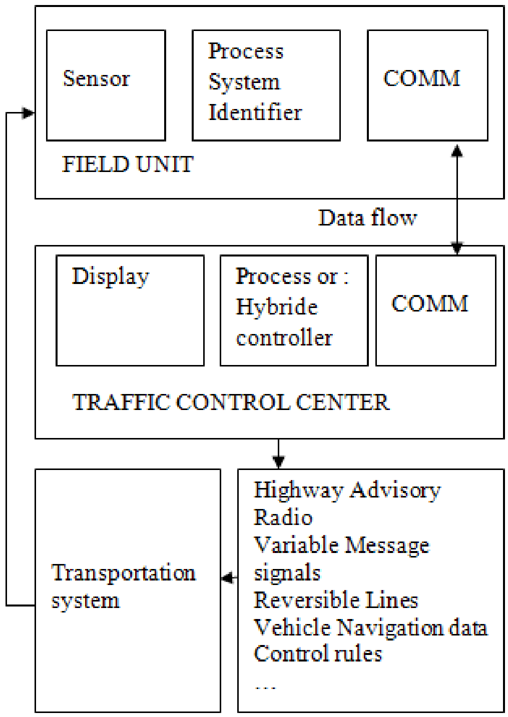

Fig. 2. Functional structure of transport control tool
Source: [3]

Properties of the agent should provide necessary functions of ITS. The main properties of agents:

- Independent execution and interaction with other agents and/or applications, supervision over environment;
- Ability to use abstraction;
- Ability to use knowledge of a subject;
- Ability to adaptability for purpose achievement;
- Ability to be trained at environment;
- Stability to errors and wrong signals;
- Functioning in real time;
- Interaction with Supra agent.

Constraints of ITS implementation are: environment, ecology, resource, technology.

Examples of Technologies and functions which are now integrated with ITS:

Automatic number plate recognition;

- Cellular Phone Tracking;
- Global Positioning System;
- Loop Detectors;
- Video Imaging;
- Automatic Vehicle Location;
- Automatic Vehicle Identification;
- Micro Simulation.

ITS system is a powerful tool for traffic flow organization, ITS system application could be different. However, the priority of Riga transport network development is to co - control railway transport in city transport network [5].

Regional rail [5] can carry considerable number of passengers without overloading transport infrastructure, more particularly Riga road network.

Railway transport is very important to the mobility of people and it is based on the well-developed infrastructure. There are 6 railway lines, including 4 electric lines (Riga-Skulte; Riga-Aizkraukle; Riga-Jelgava; Riga-Tukums) crossing Riga region. These lines are provided with 16 railway stations as well as 26 passengers` stops within Riga district.

In despite of the enormous loses of passengers during the 90-ties it still plays a considerable role to the traffic in Riga metropolitan area in particular for regional towns Jurmala, Ogre, Olaine, Salaspils, Saulkrasti as well as for dense populated recreation areas namely Jurmala, Carnikava, Saulkrasti, Sigulda.

Interest in ITS comes from the problems caused by traffic congestion and a synergy of new information technology for simulation, real-time control, and communications networks.

Traffic congestion has been increasing worldwide as a result of increased motorization, urbanization, population growth, and changes in population density. Congestion reduces efficiency of transportation infrastructure and increases travel time, air pollution, and fuel consumption.

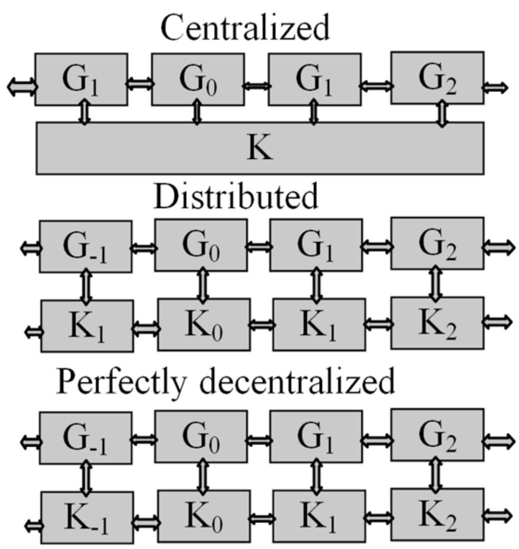

Fig. 3. Three – levels Integrated Control Tools system Control Strategies
Source: [3]

3.1. Three-levels Integrated Control Tools system

Three-levels Integrated Control Tools system usage is offered which allows to carry out the control of vehicles, to supervise work of each type of transport separately and to co-ordinate work of all transport system in city boundaries

Supra software agent(Supra agent) in this article is software agent with coordination function. Supra software agent coordinates task realization, in distributed level coordination made by subsystem, in centralized level several coordination agents are used.

Scheme of interaction of Supra software agent is given in Fig.4.

The development of control tool was done in three level:

- Control tool of vehicle;
- Control tool of transport mode;
- Control tool of transport modes co- modality.

The control methodology application depends on control level. In vehicle control (fig. 5.) based on regulation theory approach are used mainly.

Continuous programming methods usage requires to use computer based network, information technologies, based on possibility to realise on line control of systems, such as intelligent transport systems (ITS). ITS allows to make predefined decisions in emergency case, in heavy traffic situations, during repairing works and in other situations. Applying ITS allows to control traffic online and to make decisions immediately, when it is needed. ITS can be used as a data source for existing situations in view of long term decision making.

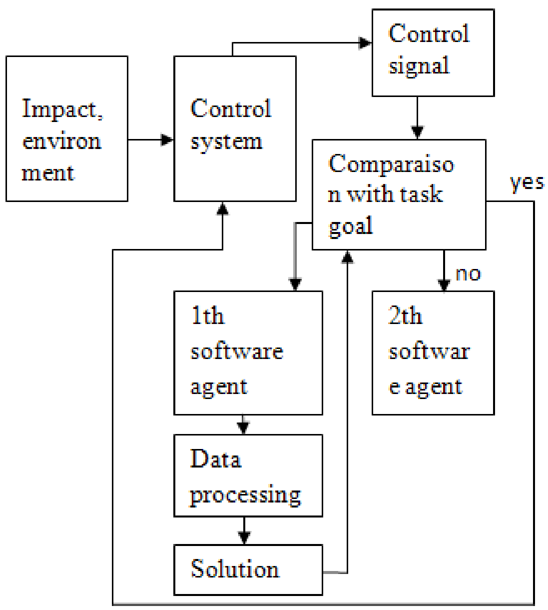

Fig. 4. Scheme of interaction of supra software agent
Source: [own work]

4. The mathematical formulation of the task

The important problem of control could be formulized in the following way, using intelligent agent demonstrated in Fig.5.

Figure 5. 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 logistic criteria. Modeling of intelligent transport systems for the control of all the system is analyzed in the connection of public transport with other systems and intelligent agents structures.

Following variables have been named:

Se – system of resources;

Sp – set of passengers with subsets $Sp_1, Sp_2, ..., Sp_k \in Sp$; k=1,2, ...,

St^m – transport system mode with vehicles $St_1, St_2, ..., St_n \in St$;

St – transport system ;

Ste – total consumption of recourses by vehicles $Ste_1, Ste_2, ..., Ste_n \in Ste$ n=1,2, ...,

t – time, t1, t2, .. ti – moments of time;

Z°p – priorities of passengers;

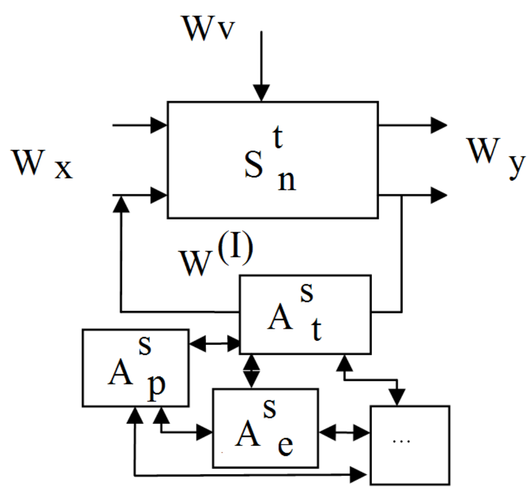

Fig. 5. Model of the control task for public transport vehicle
Source: [own work]

W - environment

W_v – influence of environment;

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

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

Wy – 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, ..єA^s ; m=1,2, ...,

A^{supra} – Supra intelligent agent

Stn $\forall$ 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>=S^t_{direkt}

By the means of Supra intelligent agent provides the development of resources consumption

efficiency increasing procedure for public transport system and takes the task of optimum in dynamic:

S^{te}_j (t)→ min, S^t_n>=S^t_{direkt}

The target of 3 th level in co – modal transportation could be formulate as:

St^{m1}x St^{m2} x …x St^{mi} x Sp -->Z°p, and

St^{m1} (W_x) -->min.

5. System integration issue

Requirements for transport modes development require integration of all transport modes, including its specific automation systems and existing equipment.

In railway domain, where European CENELEC Standards such as EN 50126, 50128 and 50129, European Research Projects and Networks and finally the establishment the European Railway Agency have helped and are still helping to streamline and normalize the safety and interoperability sector.

At the present stage of development, in Latvia it is impossible to use the European control system of movement of railway transportation ETCS. The main reason of it is incompatibility of railway on – field devices and control systems. Now, carrying out passenger and freight traffic in the countries of Europe, on border the mobile structure on such which meets both width of railroad tracks, and other requirements varies, but, it is obvious that it requires a lot of time and leads to a long delay of cargo on border. In this connection the railway transportation becomes slower, than motor transport. Historically the situation has developed so that in each European state there was a railway standard.

Therefore, to co-ordinate all requirements to railway systems of Europe and to realize functionally compatible system, the unified control system of railway transportation ETCS has been developed. In this system the uniform

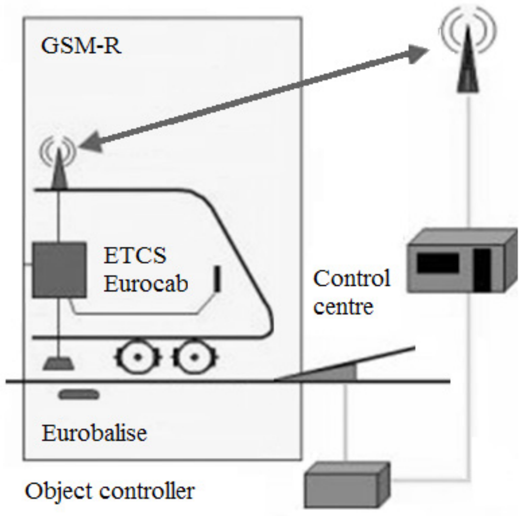

Fig. 6. Signal transmission structure in ETCS
Source: [own work]

standard of the railway equipment and used equipment which is considered is provided, making modernization of railway system of the European states. In the given research the using of existing equipment Eurobalises and communication via GSM-R for railway transport (Fig. 6) control of safe movement of trains are used.

The functional model for public transport – tram as control tool of vehicle level is shown at figure 7.

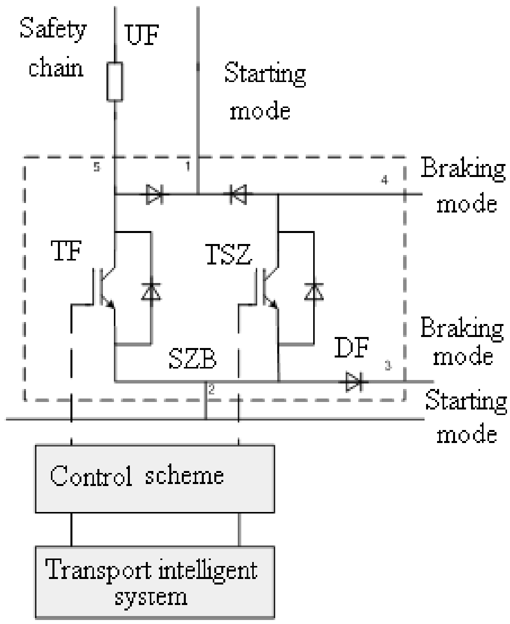

Fig. 7 Functional model of the intelligent transport system equipment for the control of electric energy supply
Source: [own work]

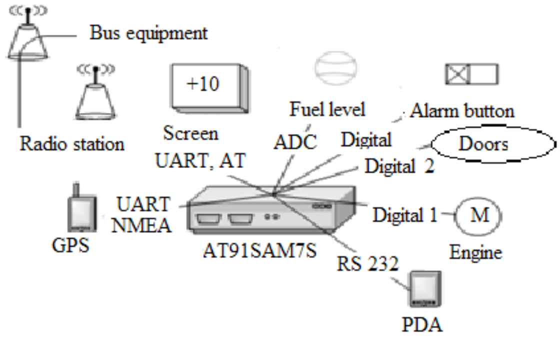

Fig. 8. On bus equipment with integration in ASOS bus management system
Source: [own work]

In Riga city mostly trams TATRA and TATRA 3M are used. For driving such DC trams as well as AC electric motors with semiconductor converters [8] for rotational frequency control are used.

Control devices with contactors and rheostats widely used earlier have been changed for semiconductor regulators which control voltage value supplied to motors.

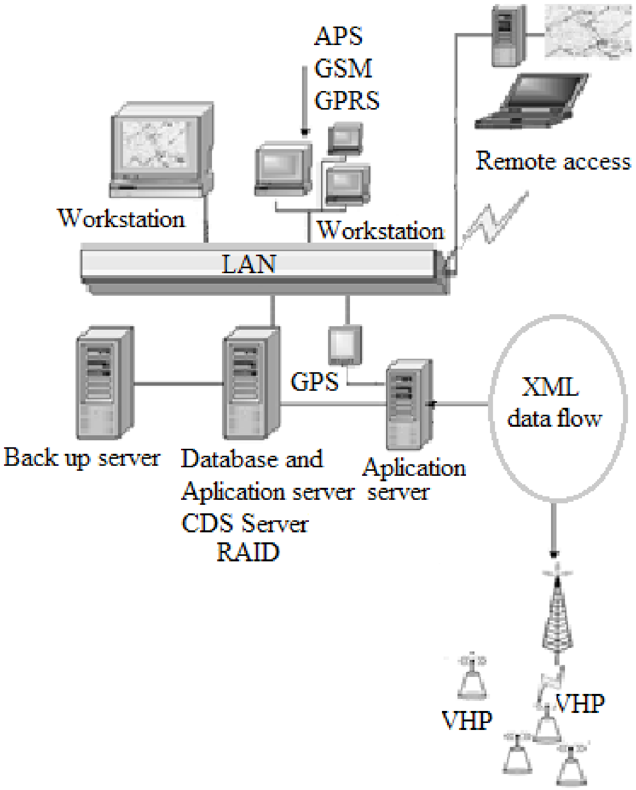

Fig. 9. Structure of bus control system ASOS
Source: [own work]

Control of motors according to the requirements has to include tram control possibilities as well as traffic light control, as well as passengers flow control. The tram control equipment scheme is shown at figure 7.

The another transport mode, which are currently equipped with distance tracking equipment in Riga are buses.

Bus control system are developed on Control tool of transport mode level.

The bus control system could track of bus route, using GPS receivers, but currently bus movement are not optimized in on – line mode.

Currently public bus system control in additional requires on board equipment with application of GPS, all of which utilize of three basic components of the GPS; absolute location, relative movement, time transfer.

On bus equipment for Riga bus control system (ASOS) are shown at figure 8.

The structure of such control system are shown at figure 9. The ASOS system are first implemented control system in Riga.

The next stages of co – modal passenger transportation requires introduce Control tool of transport modes co- modality. Such tool in Rigacity are useful to develop for all passengers transport modes: buses, trolleybuses, trams and railway.

6. Conclusions

There is various possibilities and tools to increase of an overall performance of system of a city passenger transport have been described in the article. There is 3-levels Integrated Control Tools system usage is offered which allows carrying out the control of vehicles, to supervise work of each type of transport separately and to co-ordinate work of all transport system in city boundaries.

The current transport control systems, it´s components on vehicle, transport mode and transport modes co- modality issues are analyzed for Riga city transports.

Bibliography

[1] MEAL J.: Public transport in GB – 'Policy context and practice' illustrated with reference to smart card deployment and the ITSO specification" ITS 2007 Austria Conference proceedings pp 84-90, ITS Austria, Wien, 2007.

[2] USEPA (1996): Indicators of environmental impacts of transportation - Highway, Rail, aviation and maritime transport. USEPA report, 230-R-96-009, Washington, USA, 268 p.

[3] Toward Resilient, Self-healing and Smart Interdependent Infrastructure Systems. S. Massoud Amin, D.Sc.

[4] ZIETSMAN, J.: Using sustainable transportation performance measures in corridor decision making COST 356 Seminar, Oslo, Norway, February 2008
[5] VIRCAVS, I.: Development issues of transport infrastructure in Riga region. Final Regional Report. Action group II. Transport Corridors Network.
[6] GALKINA A., KUŅICINA N. Modeling of intelligent transport system for power supply control in public transport system// RTU scientific articles. 4. vol., Enerģētika un elektrotehnika. - 22. issue. (2008), pp. 86.-93.
[7] MEZITIS, M.: Microprocessor centralization systems reaction time reduction, Vilnius: VGTU 2005
[8] BIEZBĀRDIS L., RIBICKIS, L.: Tramvaja vilces piedziņas impulsu pārveidotāju spēka shēmas izpēte, 40 RTU konference, Rīga, 1999.g.
[9] COST 356. EST - Towards the definition of a measurable environmentally sustainable transport.
[10] Our Common Future (WCED, 1987).
[11] Rousval and Maurin (2008).