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AUTOMATED SUPERVISORY CONTROL SYSTEM OF URBAN PASSENGER TRANSPORT

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ABSTRACT

The article presents scientific and technical aspects of improvement of the effectiveness of the Automated System of Urban Passenger Transport Supervisory Control (ASUPTSC) that are the most crucial elements of modern city passenger transportation management. It is proposed to establish the ASUPTSC on the basis of development of software and technological solutions designed to improve the quality of headways monitoring that ultimately improves the quality of supervisory control and management. The article includes the overview of domestic and international experience of using the automated systems of urban passenger transport supervisory control. The article provides the analysis of the informational support structure for ASUPTSC. The analysis includes the main components of any automated system of supervisory control (ASSC), the basic roles of participants of transport management process. The article provides the analysis of tasks, solved via ASUPTSC, requirements to it, and ASUPTSC architecture.

Keywords: urban passenger transport, supervisory control, motor transportation, automated system, software.

1. INTRODUCTION

An important indicator of the social and economic stability in Russia is a reliable, safe and efficient performance of urban passenger transport (UPT) with a leading position of bus passenger transportation.

Ensuring efficient and reliable operation of UPT is a complex, systemic problem. However, it is obvious today that it cannot be solved without modern control systems designed on the basis of the latest achievements of science, with widespread application of computer technology, mobile communications and navigation aids.

With development of satellite navigation systems, emerging of marketed satellite navigation devices for location identification, adapted for automobile and passenger transport, now it is possible to implement the conceptually innovative supervisory control systems, ensuring the satisfaction of ever-increasing requirements for reliability, safety and quality of passenger transportation by urban transport.

Currently the specialists in different towns and regions of Russia are developing the automated systems of urban passenger transport supervisory control that are based on the satellite navigation. The essential part of works is performed under the supervision of RF Ministry of Transportation as the part of the federal purpose-oriented program of application of global navigation satellite system GLONASS for the benefit of commercial customer. [1, 2, 6, 7, 9].

2. OVERVIEW OF DOMESTIC AND INTERNATIONAL EXPERIENCE OF APPLICATION OF ASUPTSC

One of the leading life-support systems of any town is passenger transport, the main role of which is the ability to remove barriers to mobility of people by providing the access to key services and opportunities. Quick and uninterrupted performance of passenger transport is a major task of transport Vehicle Park. Therefore the automated systems of supervisory control (ASSC) became widespread globally. These systems gained immense popularity wide spreading throughout the world, including the vast territories of Russia.

Among different types of ASSC, that are used globally, one can stand out the following as the most modern and proven on the positive side: COMFORT (Germany), Opticon (Italy), JUPITER (Florence), Bus Tracker (United Kingdom), ROMANSE (England), PROMISI (Germany, France, Finland, Sweden, Scotland), SCADA-systems (U.S.) [1 - 23].

The idea of development of automated systems of urban passenger transport supervisory control in Russia appeared in the 70s of the last century. The first projects were developed in the cities of Omsk, Moscow, Nalchik, etc. A characteristic feature of all systems of the first generation was using the local navigation for instrumental fact and time fixing of urban passenger transport (UPS) driving alone the route with help of physical checkpoints devices that were installed and used on the route network of urban transport [6, 12, 21, 23].

Automated systems of route urban passenger transport supervisory control of different types have been implemented in more than 500 towns and cities. [1, 2, 7, 8] Table-1 provides a brief list of the most widespread ASUPTSC [1-6].

Table-1. The list of common systems of supervisory control.

No.	System class	Type codes	Developer	Development closure
1	Semi-automated systems (reporting at reporting point by means of voice message of the driver via induction coupling)	Diston	Production engineering consultancy, Chelyabinsk	1968
		Sadko	Special design bureau, Kaliningrad,	1970
		Nalmas	Special design bureau “Transavtomatica”, Dnepropetrovsk	1979
2	Automated flashing systems with automated reporting at reporting point by means of radio (the closest radio link)	NEZHAN-P	Special design bureau “Transavtomatica”, Dnepropetrovsk	1964
		NEZHAN-50		1981
		NEZHAN-D		1983
		NEZHAN 300		1983
		NEZHAN 300 M		1988
3	Automated systems of passenger transportation control without “driver-operator” voice communication, with automated reporting via induction coupling	ASDU-A	Special project design bureau “Promavtomatica”, Vitebsk	1979
		ASDU-E		1980
		ASDU-T		1981
		ASU-Interval-1		1976
		ASU-Interval-2		1979
		ASOU AP	Departmental standards of production engineering, St. Petersburg	1986
4	Automated flashing systems of passenger’s transportation supervisory control with “driver-operator” voice VHF radio communication and automated reporting at reporting points via VHF radio communication.	ASU-Rejs	MOSGORTRANSNIIPROEKT (Moscow)	1988

3. ANALYSIS OF THE STRUCTURE INFORMATIONAL SUPPORT OF ASUPTSC

The most crucial tasks of automobile transport are prompt on-line supervisory control of rolling stock (RS) and actual transportation service performance record. The main tools for solving the tasks are navigation systems used for prompts traffic control and actual transportation service performance record [1, 4, 13, 17, 18, 23]. These tasks are linked to performance of Automated Systems of Supervisory Control (ASSC). The implementation of navigation systems at transport enterprises is aimed to solve the following basic tasks:

- informational support of transportations: implementation of routes passports, running times estimation, development of digital map of the city, making up of urgent shifts-daily targets (assignments);
- prompt traffic control;
- producing and output of prompt references and output reporting forms at the end of the shift.

Prompt control consists in the solving of the following tasks:

- automated control of the process of placing the passenger transport in operation on the line and its returning to the park;
- automated control of vehicles traffic, preparation of the messages and signaling about the failure of timetable by some RS;
- implementation of managing tasks of the operator (timetable adjustment, reserve vehicles placing in operation, timetable changes, etc.).

Foreign and domestic experience of ASSC operation based on satellite navigation system shows that implementation of such systems reduces the number of vehicles required for the specific transport operation. Meanwhile the dependence of the efficiency of the system on its scale is not linear. This is achieved by obtaining the possibility of centralized management of the entire vehicle fleet, taking into account the real on-line situation [4].

Distributed computer network of ASSC includes the head computer system at Central Control Unit (CCU)

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or central control station of auto-transport enterprise and also certain automatized workplaces for specialists, participating in traffic management process [4, 10, 19, 20].

Computing machinery, operating at ASSC must solve the following tasks:

- making up planned performances of the vehicles on a line;
- obtaining real data of performance of vehicles on a line and storing in database;
- ensuring the access to databases for some users and groups of users from their workplaces;
- data exchange between groups of users, system components, and other information systems.

The general scheme of information network is shown on Figure-1.

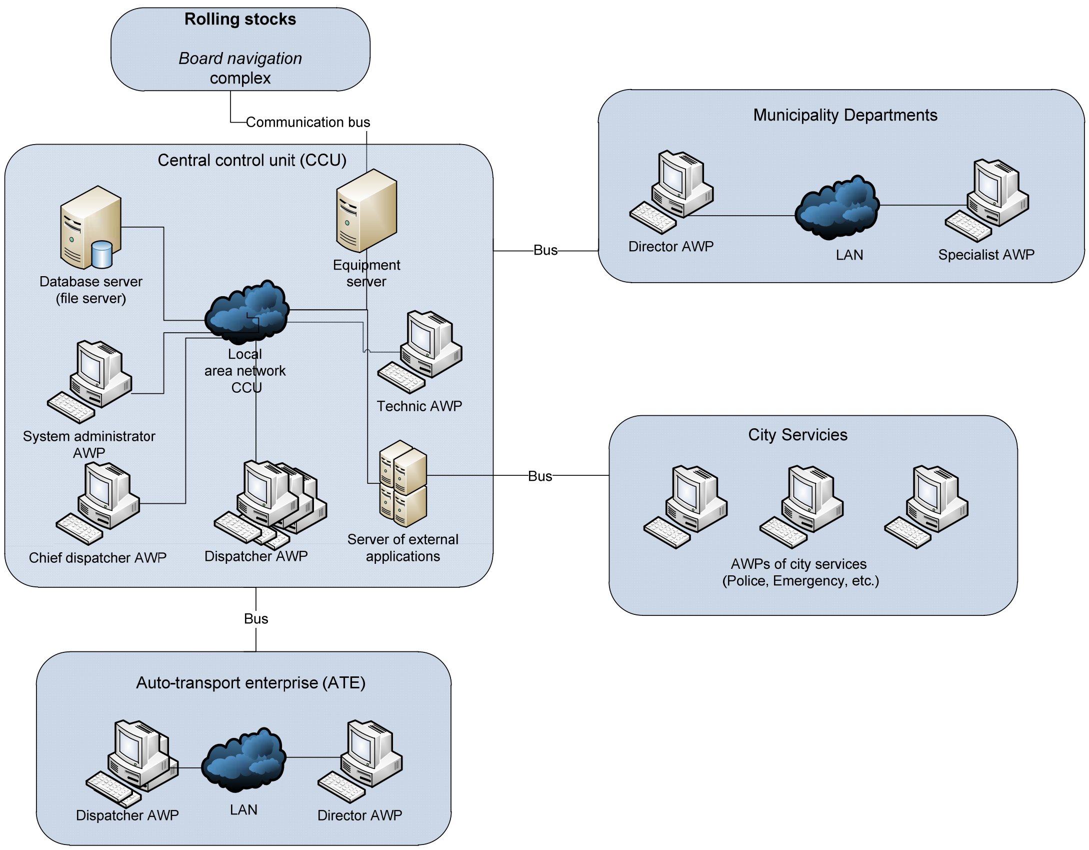

Figure-1. General scheme of information-computer network of ASSC.

This scheme can be applied to passengers transportation management in the cities, when governing bodies (the representatives of municipal administration) take part in the process of transportation management.

Structure of hardware and technological tools of computer system usually includes the following components.

A. On the level of municipality, transport and communications departments

- chief automatized working place;
- specialist automatized working place.

B. On CCU level

Database server, providing operation of local area computer network of the system and remote data base access;

- server of the equipment to ensure the operation of radio equipment;
- server of external applications to ensure the interaction of field services;
- computers to organize the automated working places (operator AWP, technic AWP, analyzer AWP, system administrator AWP);
- data archiving device;
- network and communication equipment.

C. On auto-transport enterprise (ATE) level

- director AWP;

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- computer to organize park operator AWP;
- network and communication equipment.

From the viewpoint of prompt supervisory control, the main working place of ASSC is the operator Automatized Working Place (AWP) [4, 13, 17, 18, 23]. The operator AWP must provide:

- on-line generating and output (continuous or on request) of text and graphic information about passenger transport (being on the line, scheduled and actual performance of trips, passing reporting points, regularity of trips, headways, etc.);
- monitor display of vehicles deviations from the schedule on special "hot windows" (no-show, frequency failure, route failure, scheduled communication failure, unscheduled operation, etc.);
- monitor display of vehicle location on the route map;
- voice communication with drivers on operator demand and drivers request;
- monitor display of «hot messages» from a RS (“SOS” signal, driver communication requests, etc.);
- management impact on RS operations correction (RS shift to another timetable, route, operational timetables generation, headways increase, vehicles replacement, drivers replacement, operations analysis, new vehicles implementation, new transportation modes implementation, such as "off-road", etc.);
- system performance high points registration;

ASSC performance analysis

General informational support of urban passenger’s transportation includes the following elements [4, 9, 10, 21, 23]:

- subsystem of passenger transport supervisory control and gathering of raw data about operation of transport vehicles on the line;
- subsystem of auto-transport enterprise level (raw data operating, generating of internal reporting analytical forms);
- subsystem of territorial department of motor vehicles level (gathering information about regional motor transport subdivisions, generating of analytical reporting forms broken down by regional subdivision);
- subsystem of municipal administration, district, region level (generating of analytical reporting forms about regional motor-transport subdivisions performance and informational interaction with other state bodies);
- cooperative regional network (dedicated and dial-up channels for data and voice messages transmission).

Technology of transport supervisory control on the base of systems of transport telematics can be performed schematically as follows (Figure-2) [19, 20].

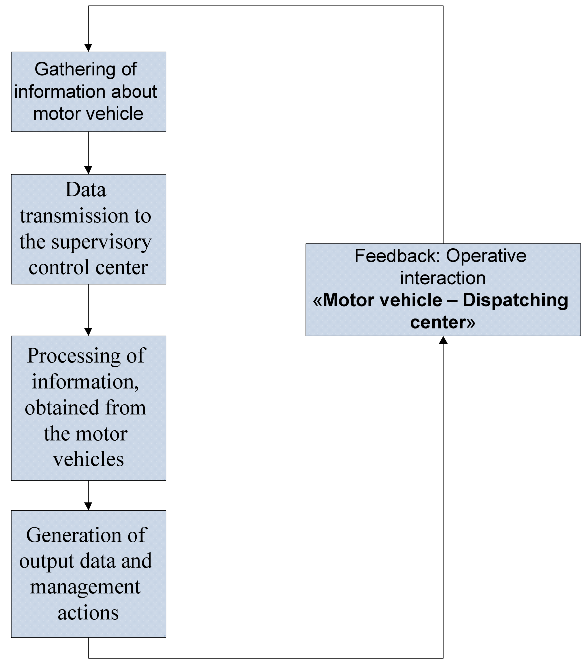

Figure-1. Consolidated scheme of technology of automated transport supervisory control.

Let’s consider each element of the presented scheme in detail.

a) Gathering of information about motor vehicle

Depending on the tasks of the supervisory control system for this or that vehicle, the list of parameters of motor vehicle may vary, and this fact must be considered when generating the output data, management actions, etc.

Basically, the information obtained from the vehicle can be divided into two blocks:

- information about location of the motor vehicle (coordinates, reporting point, и т. д.);
- information describing the motor-vehicle performance (such indicators as fuel consumption, major units and aggregates condition may be taken into account additionally).

In both cases the motor vehicles must be equipped with devices that gather information, coming from transducers, installed on motor vehicles, and from navigation blocks.

b) Data transmission to the supervisory control center

On-line transmission of prompt and reliable information from vehicles to the supervisory control station to improve the efficiency of transportation process and its management.

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c) Processing of information, obtained from the motor vehicles

Information about vehicles, obtained by supervisory control center, is processed with help of specialized software.

d) Generation of output data and management actions

Generation of output data allows analyzing the performed transportation service during particular period of time.

4. ASUPTSC ARCHITECTURE DEVELOPMENT

The main technological functions that are automated during the supervision control development are the following:

- **current planning of transportation** - automated generating and maintenance of routes passports databases and routes timetables, preparation and issuance of timetables, the creation and maintenance of digital map (scheme) of the city and suburban areas, drawing and correction of route network on the map; generating the prompt shifts- daily tasks; formation of city (municipal) orders for transportations;
- **management of placing in operation and returning of vehicle to the enterprise** - fixing of departure and arrival of the vehicle out/to the park; automated generation of the messages about all violations while placing in operation; on-line entering correction information on actual data while placing vehicle in operation; generating and output of prompt references about putting in operation and returning processes;
- **management of performed route transportation services** - transport unit (TU) location determining, fixing of reporting points (RP) TU passing, determining of route and timetable failures; fixing of putting in operation, vehicle idle time, arrivals, automated generation of messages and prompt references output about all violations on route; monitor display of motor vehicles movements on the route network with help of digital maps or schemes;
- **prompt supervision planning and control of vehicles movements alone the routes** - quick solving of the problems, connected with route and timetable failures, quick redistribution of vehicles according to the quantity and directions in case of any troubles of scheduled transportation; liquidation of consequences of emergency and extreme situations for public transport, including solving the problems related to traffic safety, safety of drivers and passengers;
- **analysis of performed transport services** - creation and management of data archives related to performed transport services, generation and monitor display or printing of the results of performed transport services on a route, analysis of effectiveness of the routes.

A simplified scheme of a distributed computer network system is shown on Figure-3.

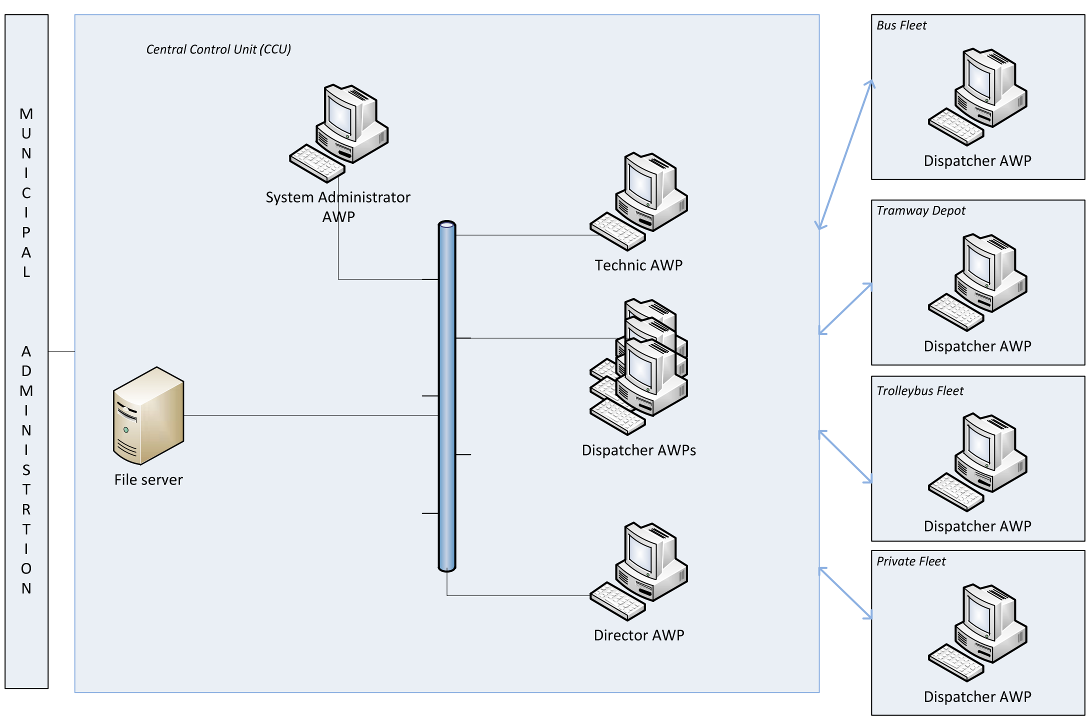

Figure-3. A simplified scheme of a distributed computer network system of ASSC-TU.

Different data must be generated and displayed at automatized working places according to the their location: background information about TU performance, mileage, deviation from the timetable, location of each TU, idle time, route videogram, performance of the drivers according to the shifts and many others.

Accumulation of date about each TU location is performed minutely, that meets the requirements, designed for public transport supervisory control systems.

ASSC-TU data contents must be optimized to minimize the volume of data processed and stored at each level. It is necessary to provide duplication of the most frequently used and important information that will let to rehabilitate the system in the cheapest and the fastest way in case of failures or accidents.

5. CONCLUSIONS

Overview of domestic and international experience in using automated systems of urban passenger transport supervisory control showed that ASUPTSC are crucial elements for management of passenger transportation in modern city.

The main components of any modern ASSC, the basic roles performed by the participants of transport management process were contemplated during the analyzing the structure of informational support of ASUPTSC.

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