

Issues of application of the results of space activities of the Glonass/GPS satellite positioning systems in transport logistics (as exemplified by the Chechen Republic)

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Abstract. The article deals with the issues of application in practice of a transport logistics management system using the technology of the Global Navigation Satellite System (GLONASS) and the Global Positioning System (GPS), on-line transaction processing, planning, traffic control, accounting of route deviations, and decisions support systems.

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Introduction

In logistics, transport plays an important role as it connects separate economic areas, companies, and enterprises with each other [1]. Transport moves material resources, ready products from the production sphere to the consumption sphere. Transport is a branch of material production and its main product is transportation. This product is sold and purchased, thus acting as a commodity, i.e. it has the consumer value. The consumer value of the transportation product is its ability to meet the need in transportation of various cargoes. It can be expressed as delivery of a cargo to a consumer on time and in certain quantity with the increasing number of logistic operations and decreasing costs [2].

For years, the most popular cargo and passenger transportation mode has been the road transport. This sphere grows and develops in high gear. Motor trucking in the Chechen Republic (CR) is the most popular mode of cargo delivery to consignees [3]. The road industry in the CR has been intensively developing during recent years, and this process started in 2008, when the Federal Dedicated Program "The Social Development of the Chechen Republic in 2008-2012" was adopted. However, due to the 2009 world financial crisis, financing of development of the road network by routes was reduced. Consequently, the planned results have not been achieved. Currently, 70% of 3016 kilometers of roads that are assigned to the budget of the Ministry are overloaded. Despite the listed and other obstacles, the republic takes measures on development of additional road network to ensure approaches to all settlements. It requires consideration and practical application of the transport logistics management system using new technology, which includes the GLONASS/GPS technologies allowing to provide

online transport monitoring, choosing and controlling routes, monitoring fuel consumption, precise mileage accounting, etc.

Usage of the GLONASS navigation system for monitoring vehicles becomes an integral part of proper arrangement of operation of the transport service of any enterprise. Owners of enterprises, which have several dozens and hundreds of vehicles, buses, and other transport means, can appreciate the advantages of the GLONASS/GPS system as an economically efficient and beneficial solution for a wide range of tasks. The GLONASS system can ensure high level of safety at monitoring the municipal transport, which is an essential condition of passenger transportation and fulfillment of any works carried out under a municipal order. For example, a school bus equipped with a GLONASS/GPS receiver can ensure several times better safety of motion due to the continuous monitoring of the vehicle motion [4].

2. Methods

Usage of the results of space activity for the benefit of socio-economic development of the CR (Chechen Republic) and in execution of the Decree of the President of the Russian Federation "On the Long-Term State Economic Policy" dated 07.05.2012 No. 596, the Ministry of Transport and Communications of the CR developed and the Ministry of Economic and Territory Development of the CR and the Ministry of Finance of the CR approved the draft State Program "Development of the Transport System and Communications in the Chechen Republic in 2014-2020".

The State Program includes:

The Sub-Program "Implementation of the State Program "Development of the Transport

System in the CR" in the sphere of transport and communications";

The Sub-Program "Development of the System of Supporting Calling Emergency Services by the Phone Number 112";

The Sub-Program "The Complex Program of Ensuring Safety of Population in Transport";

The Sub-Program "Improvement of Traffic Safety in the CR in 2013-2020";

The Sub-Program "Use of the Results of Space Activity for the Benefit of the Socio-Economic and Innovative Development of the Chechen Republic in 2014-2018".

In developed countries, the results of space activity (hereinafter – RSA) are widely used in various spheres of socio-economic activity [5]. For example, the navigation technology has become a standard of everyday life not only for the population, but also for public authorities. The market of navigation and geoinformation technology shows rather good financial and economic growth rate. According to forecasts, the volume of the world market of navigation systems will reach 300 billion US Dollars by 2015.

The scale of use of the results of space activity considerably grows in the Russian Federation, as well. However, in the CR, certain elements that are required for efficient use of the RSA have been developing at an insufficient rate. Those, first of all, include elements of the base infrastructure, which ensure receiving and storing the satellite information, and the information technology developed based on the navigation and geoinformation systems [6].

The above-mentioned issues related to using the results of space activity are of systematic and interdependent nature and are common for the majority of Russian regions. Their solution is possible only through a target program approach, which will be implemented by the Sub-Program "Use of the Results of Space Activity for the Benefit of the Socio-Economic and Innovative Development of the Chechen Republic in 2014-2018" of the State Program of the Chechen Republic "Development of the Transport System and Communications in 2014-2020".

In the course of the Sub-Program implementation, the events on deployment of the base informational-navigational and geoinformational infrastructure, which will ensure efficient use of the RSA, will be carried out.

3. Solution and the results

GLONASS, the Russian Global Navigation Satellite System, along with GPS (the Global Positioning System) are the base for navigation

equipment, which is widely used in various industries (Figure 1). The GLONASS system allows real-time plotting of the geographical position of an object located anywhere in the world with the accuracy of few meters (the latest models of GLONASS satellites allow the accuracy of 2.5-2.8 meters), track motion and obtain other additional information on the object. This function of the system is currently in demand of various spheres of activity, from space research to agriculture, and is especially important for the sphere of monitoring and dispatching of vehicles [7].

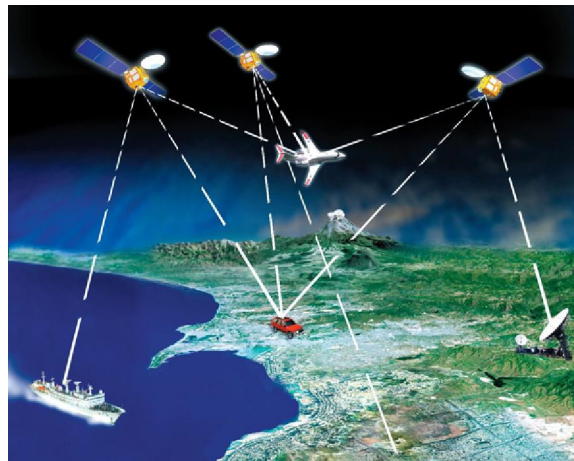


Figure 1. The component scheme of the GLONASS/GPS system of satellite positioning

Lately, many companies operating in the sphere of production of communication and navigation equipment offer on-board terminals and navigation devices, which use the satellite global positioning system [8]. The functions range of various navigation devices varies rather much. However, the offered software and hardware solutions do not always meet the requirements of the republic in the sphere of application of such class devices.

For solution of the tasks of implementation of the Sub-Program "Use of the Results of Space Activity for the Benefit of the Socio-Economic and Innovative Development of the Chechen Republic in 2014-2018" and the State Program of the CR "Development of the Transport System and Communications in 2014-2020" requires development of an information graphical system (IGS) [9]. The IGS will also require arranging a certain number of dispatcher positions, implementation of the Order No. 285 of the Ministry of Transport of Russia, as well as creation of transparent working conditions comprehensible for all market players. An analysis of the order with account of further prospects of development of the navigation industry demonstrates the obviousness of

formation of a civilized market of transport telematics and satellite navigation GLONASS and GPS [10], which a priori includes rendering high quality services to the population by carriers. It will allow solving the main tasks of management associated with arrangement of cargo and passenger transportation with common transport more efficiently, promptly, and with better quality. The main tasks of those are selection of the type and mode of a transport means, optimization of the transportation process during intermodal transportation, determination of optimal routes of delivery, and, of course, the onboard navigation and communication equipment itself [11].

Solution of so difficult tasks can be achieved in several stages

The first stage is the task of plotting the geographical position of a vehicle. Use of the IGS at this stage will allow being prompt at registering an order for transportation services and obtaining full and valid information on the vehicle, which will be used for rendering the transportation service [12]. The information can be either of the reference or graphic type, where the latter one assumes showing the operator a local map of preset scale on the monitor of the dispatcher as he enters the address. Further, the software will allow to record, finalize and store orders as well as receive various statistics from the archive (mileage, fuel consumption, downtime, etc.).

The second stage is the solution of the tasks of rational route building. However, in the circumstances of the republic, there are objective factors related to branching and condition of motor ways, weather conditions, and intensity of traffic, which increases during rush hours and can result in traffic jams.

The third stage is the solution of the tasks of rational route building. However, at operation in the circumstances of the republic, there are objective factors related to branching and condition of motor ways, weather conditions, as well as intensity of traffic, which increases during rush hours and can result in traffic jams [13].

Maintaining a structure like the transport system of the republic requires existence of an efficient dispatching service, which would contain the data on condition and position of the vehicles, which we are interested in, on a real-time basis [14].

The software and hardware module of plotting the position of vehicles

The project of such a dispatching system should be reasonably developed for the three state-owned passenger transportation enterprises: SUE

Chechentransagentstvo, SUE Chechenavtotrans, and SUE Avtopassazhirservis. The number of routes covered by them for the period between 2001 and 2013 has reached 204. The rolling stock as of the beginning of 2014 numbers 553 buses. In 2013, the state-owned transport companies carried 17,300.3 thousand passengers. The IGS can serve as the basis of the graphic display of the vehicles' position.

The functions of control and accounting of the vehicles' motion along the routes must be implemented based on regular detection of the position of the vehicles using the signals of the global satellite navigation system GLONASS or GLONASS/GPS (a method of satellite navigation).

Visual control of the location and motion of the vehicles should be implemented based on use of an electronic map. The electronic map should provide (when used for in-process monitoring and management) for efficient visual representation of the en route situation both generally and for each vehicle in the course of taking decisions and implementing the control actions by the dispatcher, as well as when emergency situations take place [15].

Representation of the actual movement of the vehicles using retrospective data (the history of motion) for any working day on the electronic map must be provided for.

The technical support of the automated dispatching navigation system of control of vehicles' motion includes (Figure 2):

- technical elements and management automation means, including the navigation and communication equipment of the vehicles, the computing hardware installed in the central dispatching service and at transport enterprises;
- channels and means of cellular communication (GSM, GPRS) and technical equipment for coupling in order to support the system of operative dispatching communication of the system;
- communication channels of data transmission of the wired corporate network of the operating enterprise and technical means of coupling with them;
- channels and communication means of the data transmission cellular network (GPRS);

The navigation of vehicles is carried out using the hardware and software system built by the client-server technology using WEB technology in certain cases.

The system includes:

- a telematics server;
- software of the telematics server;

- a database server;
- user software;
- electronic vector maps;
- subscriber terminals (ST);

The figure contains a general scheme of the system operation.

Development and implementation of these technologies will allow improving efficiency of transport logistics management – to improve the stability of operation, to reduce operational costs, and to improve the service quality [16].

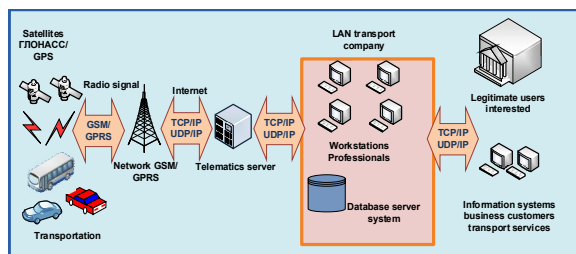


Figure 2. The general scheme of the GLONASS/GPS satellite positioning system operation

Table 1. Effect of implementation of the system in public transport

Function	Description of the effect	Importance of the effect
Optimization of the transportation plan (logistics), compilation of optimal schedules with account of speed modes and streets/roads permitted for passage	Improvement of performance of vehicles at fulfillment of the transportation plan.	Growth of the volumes of chartered carriages by 15-20%. Reduction of the total mileage of vehicles by 8.0-10.0% . Reduction of the demand in investments in the rolling stock by 1.0-3.0% .
Continuous monitoring of location and motion of vehicles	Reduction of empty and unproductive mileage. Prevention of using vehicles by drivers for non-production needs.	Reduction of the total mileage of vehicles by 0.5-1.5% .
Control over strict abidance by the assigned schedule (timetable) of carriages by the vehicles.	Improvement of attractiveness of a transport enterprise for customers, prevention of customers churn in favor of other carriers.	Growth of income of the carrier enterprises by 2.0-4.0% .
Monitoring of the motion speed of the vehicles.	Improvement of safety of hazardous cargo transportation.	Reduction of the prime cost of carriages by 0.5-1.0% .
Continuous navigation monitoring of fuel consumption using special sensors.	Reduction of fuel consumption.	Reduction of the prime cost of carriages by 5.0-10.0% .

Summary

With regard to various types of transport (municipal transport, a taxi company vehicle, a school bus, etc.), the GPS/GLONASS system can help optimize costs for their maintenance and service, decrease the labor input of the personnel, and ensure high safety and prompt actions at emergency situations. The carried out research confirms reduction of the costs for the ownership of a fleet, in which each vehicle is equipped with GLONASS/GPS, by 20-30% on the average. Thus, the GLONASS/GPS system installed in a vehicle, a school or municipal bus can pay off within a very short period at any cost of the equipment. It brings real profit to the vehicle fleet owners and improves safety on roads of the whole republic.

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