

# Aerospace Navigation Technologies in Logistics

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The work examines the technical aspects of the solution of logistics tasks in the automobile transport domain that are based on satellite navigation technologies, communications and geoinformation systems. Present-day international requirements to the hardware and software of the AVL class are provided.

**Keywords:** logistics, navigation, satellite technologies, control systems.

## 1. INTRODUCTION

Transport development is an inalienable part of the economic development of every state. Transport is a link between different regions, cities and towns, branches of industry and agriculture, enterprises and simply between people. The unique significance of transport in the structure of a state and a society demands special requirements to it, the main ones being controllability and safety. In accordance with modern requirements to the levels of the general hierarchy of automated transport control systems (ATCS), it is common to bring the controllability of a business transport complex down to the level of a transport unit as a key and executive element of the ATCS, whereas it is at this level that the formation of data flow commences which are further utilized to achieve logistics targets. The use of satellite navigation and communications systems and geoinformation systems (GIS) in the transport sector to achieve established targets is gaining ever more significance.

The intensification of road traffic in all developed countries aggravated the issues of transport highways capacity, traffic participants' safety, and environment protection, which also adds to the acuteness of economic problems. The acquired experience of resolving the said issues testifies to the fact that informational provision, which allows timely and efficient decision making, is becoming the most important constituent of the

present-day cargo and passenger traffic control complex. Modern information provision of transport systems incorporate respective hardware and software that provide the ATCS system with information on the location and travel speed of road traffic participants, and the radio communications and telecommunications aids secure the delivery of data about the actual situation on the roads and the localization of such data on digital maps.

Over the past years, the market of transport, and primarily automobile transport electronics, is thriving on the automobile market development, which is one of the basic branches of economy in most industrially developed countries. Along with conventional devices, such as engine and drive mode control processors, automobile electronics encompasses electronic navigation equipment, mobile radio communications and data exchange. State-of-the-art ATCS are capable of improving passenger safety level, securing cargo transportation control and adherence to traffic timetables, which allows urban transport users to enjoy better service quality. Comprehensive application of satellite navigation and mobile communications aids in automobile transport opened unique opportunities for complete computerization of all transport control levels, which introduces a totally new level of control quality and increases transport complex operation safety. [1,2]

In view of modern international requirements, each transport unit as a “civilized carrier” included in the ATCS that features “transport management” software must contain autonomous position finding and bidirectional communications aids. Such a vehicle is made into an “intelligent” automobile potent to inform, in a time-effective manner, about its own location on digital maps, to be included in mass service systems, such as control, anti-theft, insurance, cargo and passenger transportation.

Cargo processing technology during transportation and warehouse storage, including the information provision of these operations, is generally defined as “logistics”. The term of “telematics” designates technical solutions connected with the development of navigation, communication and traffic control aids as well as geographic (cartographic) information provision of all these objectives with the help of the GIS – geographic information systems. The widely applied term of AVL – Automatic Vehicle Location – generally stands for modern telematic control systems equipped with location and communication means. According to EU standards, in cases of highway transportation, for the purpose of automatic control and movement parameters logging, a special electronic terminal must be employed – a tachograph, or, otherwise, a logger.

In respect of transport tasks, the “AVL/logistics/telematics” complex means, in the first place, modern computerized high technologies for vehicle and transportation servicing, featuring traffic control, on-line location and voice communication, as well as off-line data communication with a driver or a forwarding agent.

## 2. MODERN SATELLITE NAVIGATION SYSTEM USER EQUIPMENT OF THE “AVL/LOGISTICS/TELEMATICS” CLASS

Groundbreaking information aids for AVL, as a rule, make maximum use of satellite technologies. Satellite technologies secure radio navigation, localization and trip planning by virtue of utilizing global navigation satellite systems (GNSS) – GPS (USA) and Glonass (Russia), separately by each format or jointly [3]. According to data provided by the GPS Industry Council, the market of GPS terminals sales for automobile transport worldwide exceeds the sales volume for any other purposes that the satellite technology is

used, including military, aviation, seagoing transport, geodesy and GIS taken together. Every month, more than a million of GNSS terminals of various types are produced worldwide, including in the form of boards and OEM (Original Equipment Manufacturer) modules to be integrated into communications and signal processing equipment. The European Space Agency (ESA) commenced the implementation of the Galileo European satellite navigation system in order to break the established dependence of navigation service users on the GPS (USA) and Glonass (Russia) systems.

The necessity of using two-system GNSS receivers for AVL will provide responsible navigation service users with increased reliability and precision, especially in the complicated observation conditions in cities, mountains, and woods. However, it can be stated that, in the near future, only two-system GNSS receivers will be used in AVL systems; these receivers will be supplemented with inertial sensors built under the MEMS technology, or with the so-called integrated inertial-satellite navigation systems (ISNS), which, in conditions of temporary unavailability of GNSS satellite observation, will secure the output of data on the transport unit movement trajectory.

For successful development of transport informatization, a relevant task of current interest is the production of own terminals and software development within the country, towards which a number of companies started working successfully. At the foundation of this production and development lies the use of the existing element base of microelectronics and the realization of navigation data and GIS data processing algorithms developed to date by scientific and academic institutions.

The National Aviation University possesses ample experience in the development of automated control systems, including movable objects control [4,5]; Figure 1 presents the structure of the automobile transport traffic control system of the “AVL/logistics/telematics” class, whereby

**CC** – Control Center

**DS** – Database Subsystem

**MDCS** – Multichannel Data Communication Subsystem

**AWP** – Automated Working Position

**AFS** – Accessibility Forecast Subsystem

**Logger** – a mobile terminal

**MCU** – Monitor and Control Unit

**GNSS Receiver** – a GPS receiver

**FDL** – Fast Data Link

### 3. AVL-CLASS ON-BOARD EQUIPMENT

The on-board equipment of vehicles performing highways transportations via international transport corridors or EU autobahns must comply with international requirements to automobile electronics based on a distribution architecture and which uses the CAN cable area network standard and a digital TTL main. Under the CAN standard, each function of an automobile on-board logger is provided with a module that serves within the on-board system as an independent device and possesses a general interface in the automobile network [6].

The logger must be compliant with the European technical regulations – the Normal [7], as well as the ISO-9141 interface for the connection of an automobile diagnostics system along with the RS-232 interface for the connection of standard portable or industrial computers. In terms of vibrations, shock and environment conditions, automobile electronic equipment must comply with the MIL-STD 810E standard, Category 8 (Ground Module).

As a rule, for the localization of automobile transport, it suffices to have planned two-dimensional (latitude and longitude) 2D coordinates. The required coordinate determination precision varies depending on the sphere of use and designation of transport objects and is divided into three grades: I – existing, II – necessary, III – boundary.

The logger performs the following obligatory functions:

- GNSS-based navigation;
- logging of geographical coordinates in the relative or global system of coordinates WGS-84;
- logging of the elapsed distance;
- logging of speed at a set rate, for instance every 1-5 seconds in real-time or at a set rate throughout the week or the month;
- logging of the engine rotation (revolution) rate or other vehicle modes;
- monitoring of crew operation modes (driving, other work, readiness, rest);
- logging of breaches (speed limit excess, non-stop driving time excess etc.).

According to private requirements, implementation and programming of other supplementary functions is possible. For all these functions, a link to current time – national, UTC global or Greenwich – is secured.

### 4. COMMUNICATIONS SUBSYSTEM

The modern concept of the development of information subsystems within ATCS presupposes their communication role with the help of external hardware and software and radio communication channels – private, corporate or leased. Apart from voice message communication, necessary for the functioning of an information subsystem are data links through which digital information is transferred in the volumes needed for ATCS and at a needed speed.

In the ATCS, the communication subsystem unites MDCS and FDL, depending on traffic volumes and service areas; a few types of radio communication are employed, such as the regular personal, trunking, cellular mobile and satellite mobile radio communications. The effective radio communications cellular network projects in the areas of major European transport corridors allow to secure 99.5-percent accessibility of data communication with a high authenticity rate.

The use of satellite mobile communications systems allows to have real-time bilateral communication of a controller with a driver and a forwarding agent, and drivers, with other drivers likewise, as well as to enter local fixed communication networks on the European continent and beyond it. Satellite access to mobile objects differs from the access to fixed satellite long-haul communication and radio-tele-broadcasting, primarily due to radio frequencies range and uses different types of terminals depending on necessary speeds and exchange modes. Movable object terminals, primarily covered by AVL traffic control systems, are divided into two classes: data communication systems with satellite radio telephone communication and systems without the radio telephone function.

The most popular international global mobile satellite communications system that develops stably, INMARSAT, now uses the fourth generation of space devices and services movable objects of all types – naval, aviation and ground. Essentially, it possesses a large number of modes (A, B, C, M, E, mini M, M4, Aero, D i D+) and specialized transport terminals. Most types of INMARSAT terminals feature an inbuilt GPS-based radio navigation mode. In the case of AVL systems that use a low-orbit satellite communication system of the Globalstar type, here the user is also offered a single (satellite ground) terminal [8].

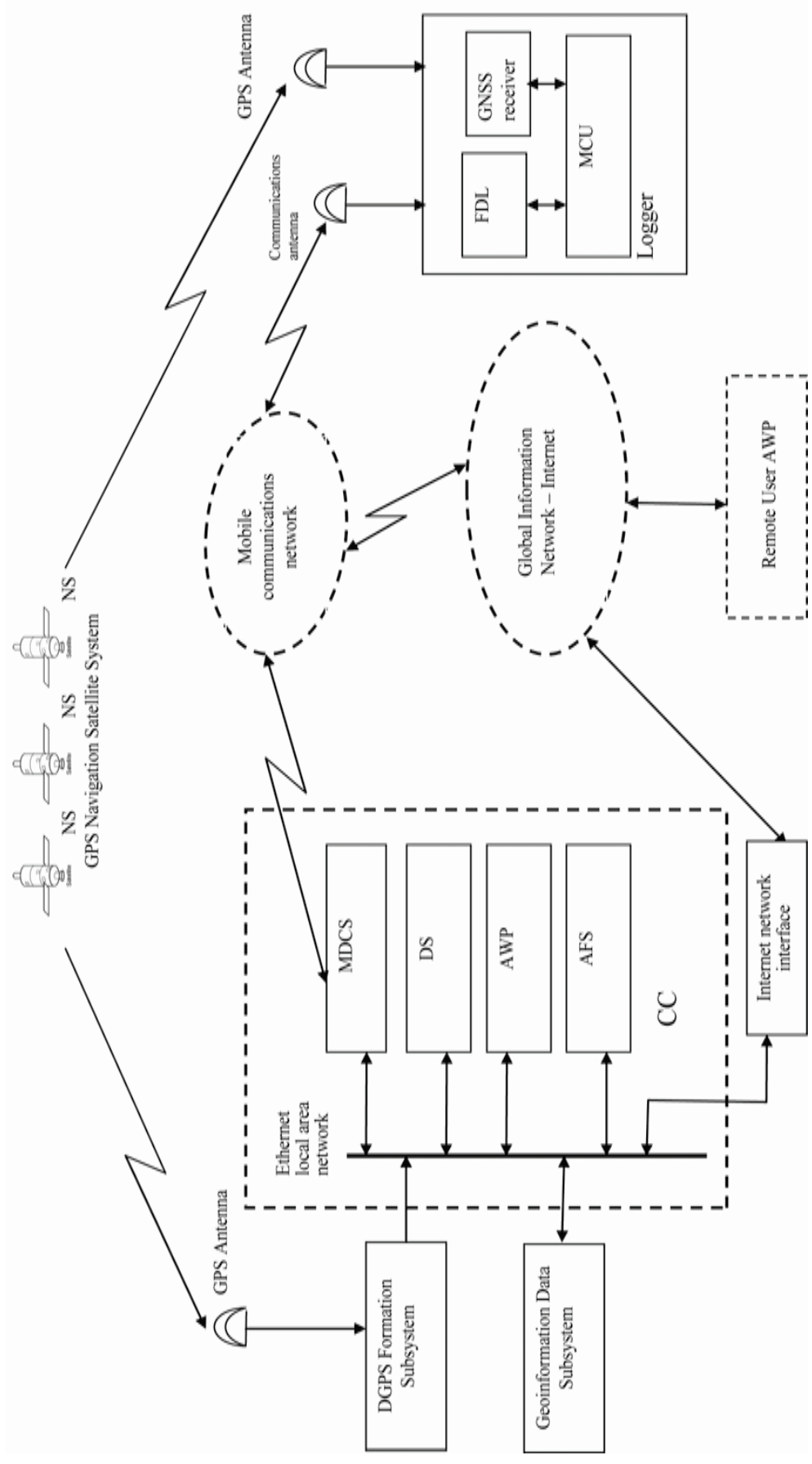


Fig. 1. ATCS Structure Scheme.

Since recently, GSM cellular communications (3G and 4G development) have been competing with satellite mobile communications; in case of the former, digital information is transferred along with voice at a speed sufficient for transport tasks.

## 5. CONTROL CENTER

A GPS/AVL auto transport traffic control system must feature mass service software of the trance-management class and electronic GIS cartography and receive necessary information on the location of tracked objects via mobile ground or satellite corporate radio communications with package network protocols or via a cellular general-use communications network, or via the Internet. Information receipt may be performed both based on a schedule and in the polling mode. Another variant of system features presupposes the possibility of providing the services of surveillance over a small quantity of objects of a designated transport company presupposing the receipt of information about the location of its objects via the Internet without the need to arrange a separate control center and a remote user AWP, when using the display equipment on one of the vehicles of the manager.

GPS/AVL auto transport traffic control systems that service highway transportations via transport corridors must be additionally furnished with hardware and software for on-hand and after-route analysis of driving on the electronic map of

Europe.

In the National Aviation University, works on the creation of a CC with software and cartographic provision were performed; the CC structure is delineated on Figure 1, and it was used as a basis in the process of the development of an experimental NAU complex for large-scale testing of a GPS/AVL-class system in Kyiv. A characteristic feature of this structural scheme is the use of the Internet network.

Widespread implementation of Internet-oriented technologies in all spheres of human activity creates unique possibilities for utilizing them in the development of control systems. The development of software with the use of Internet technologies, where communications issues are resolved as a whole, databases are accumulated, cartographic provision and vehicle coordinates display on a digital map is performed along with accomplishing of a number of service targets, including result processing. As a result of works performed, a hardware and software complex was built that is able to perform any monitoring and vehicle control tasks.

Figure 2 shows a typical route record received in the process of complex testing of all integrated equipment included in the on-board equipment (logger) on a vehicle, the communications subsystem and the CC hardware and software complex.

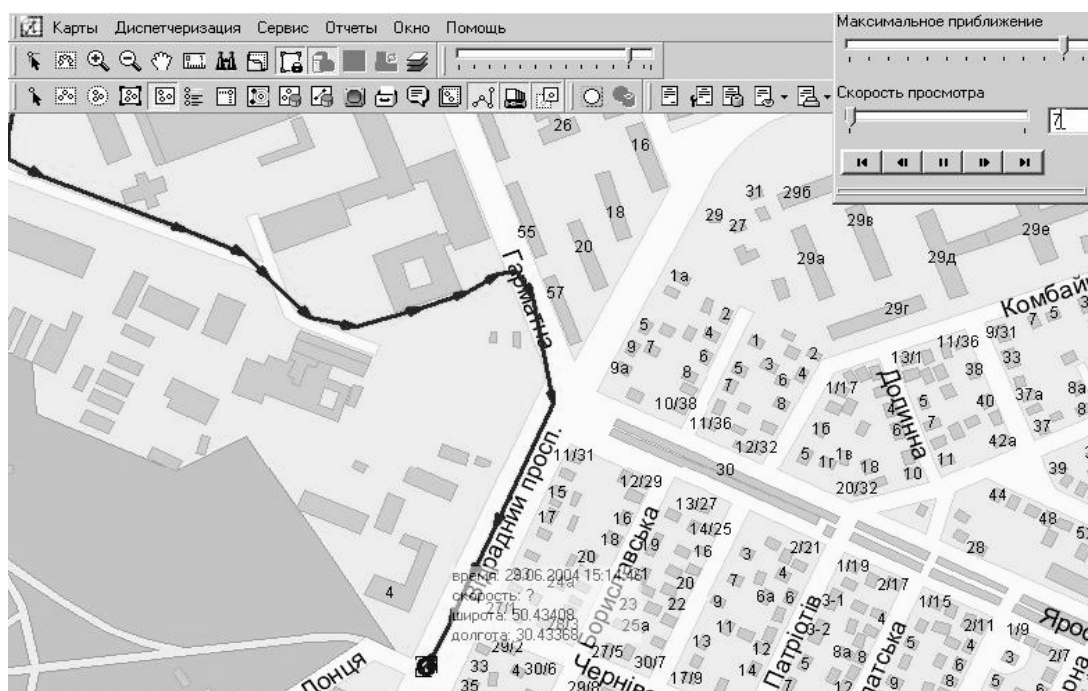


Fig. 2. Vehicle localization on an electronic map.

## 6. CONCLUSIONS

Both large transport corporations that manage thousands of vehicles – trailers, truck tractors, container trucks etc. – and hundreds of small automobile transport companies that operate only up to twenty automobiles use a complex of AVL/GPS services. A need in utilizing such services is manifest in the case of such agencies and institutions as the customs, reinforcement authorities, special-purpose transport, ambulance, cash messengers and separate public officials, businessmen and persons using discreet personal security and accompaniment services.

The use of satellite navigation and communications in the auto transport domain considerably improves its complex maintenance, which changes essentially the quality of service provision, secures management and increases the safety of vehicles of civilized carriers.

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