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Application of GIS in automobile-road sector

Using the ArcGIS example

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***Abstract*—This article is dedicated using geo informational system in the transport-road sectors. The purpose of this article is to find those directions in the transport-road sector, where it is possible to effectively use geo informational system. Given specific direction and examples of using geo informational system such area as, road construction, traffic safety, logistics, and environment protection. Data using in ArcGIS was obtained from nature experimentations and polygon works in the Jizzakh city.**

Keywords—GIS; road sector; traffic accidents; noise; traffic congestion

I. INTRODUCTION

The development of telecommunications and information technologies has made it possible to use them in all spheres of our life [1]. We can observe this from jurisprudence to archeology, from engineering to construction, or from management to monitoring. Many fields in science, through influence with each other, made it possible to open new directions [2]. The new directions created also began to influence other areas of science. This gave impetus to the formation of new disciplines in science and education [3].

One of this area in science is the merger of two disciplines, such as geography and information technology, creating a new direction as a geographic information system (GIS), or a geoinformation system that provides the collection, storage, processing, access, display and dissemination of spatially coordinated data (spatial data).

GIS contains data on spatial objects in the form of their digital representations (vector, raster, quadrotomic and others) and includes a set of functional capabilities corresponding to the tasks in which geoinformation technology operations are implemented supported by software, hardware, information, regulatory, personnel and organizational support [4].

Geoinformation technologies are closely related to cartography. Therefore, topographic and thematic maps, aerial photographs and space imagery are the main sources of information. To coordinate all other data in the GIS, coordinate systems adopted in cartography are used. One of the main ways of processing is the analysis and synthesis of data [5]. GIS is a mathematical-cartographic simulation and the delivery of information to the user, which is most often carried out in the form of maps, cartograms or block diagrams.

The purpose of this article is to find those directions in the automobile-road sector, where it is possible to effectively use geographic information systems.

II. APPLICATION OF GIS IN TRANSPORT

Transport as a human activity and process that enables territorial articulation and integration, the exchange of goods and ideas and the access of basic services to the population is, by its nature, a geographical issue, given its unobjectionable spatial expression [6]. Geographical dimension of transport is fundamental in planning processes, in the formulation of investment projects and also should be used as a basic criterion in decision making [7-9].

Transportation is undoubtedly a complex activity [10] that involves multiple actors (operators, users, authorities, etc.), performs diverse functions (among others communication, integration, transfer of goods and people) and requires various tasks for its execution (planning, organization, design, infrastructure construction, maintenance, operation, etc.).

Organization and planning of the transport must understand, among many other aspects, needs and requirements of different transport participants, feasibility and convenience of transport modes integration, geographical characteristics of the territory that crosses and communicates, weight, volume, type and economic density of transported goods, itineraries, timeliness and safety of the transfers [11-14]. Systematic vision of transport allows delineating the framework of action of Geographic Information Systems, that is full of opportunities and challenges according to the particular problems of each mode or means of transport and the territorial scale addressed.

In road transport GIS are the axis for application of many technologies and tools, such as for example automated sensors on roads, video cameras at intersections or along highways to detect speed, flows and adjust the operation of traffic control devices or signals, global positioning systems for route monitoring, vehicles location, etc. These applications were

investigated in different researchers that are mentioned in paper´s references [15-26].

Source [27] reports review of more than 100 references from the international database of the Transportation Research International Documentation (TRID) and databases recognized on the Internet, such as the Federal Highway Administration (FHWA), related to the practical applications of GIS in the management of road infrastructure.

Based on the study of listed sources the main advantages of GIS application in road transport can be summarized as the following ones:

- GIS functions allow that the occurrence of different events on different road sections (deterioration of pavements, traffic volume, etc.) can be combined for subsequent analysis; that means integrate and manage information collected by different systems in a common database;
- GIS makes possible simultaneously evaluate the pavement conditions and their implications, in order to identify critical areas and incorrect data;
- GIS can effectively complement many other information systems, where territorial management is absent and essential (road safety, road capacity studies, etc.);
- GIS capabilities of spatial analysis and user interaction provides versatile development environment for its connection with in other areas of transport.

III. INFORMATION ABOUT CONDITIONS OF THE ROAD NETWORK AND REPAIR PLANNING

The use of GIS technologies makes it possible to obtain information about the conditions of the road network and analyze the data of the attributes (Fig. 1).

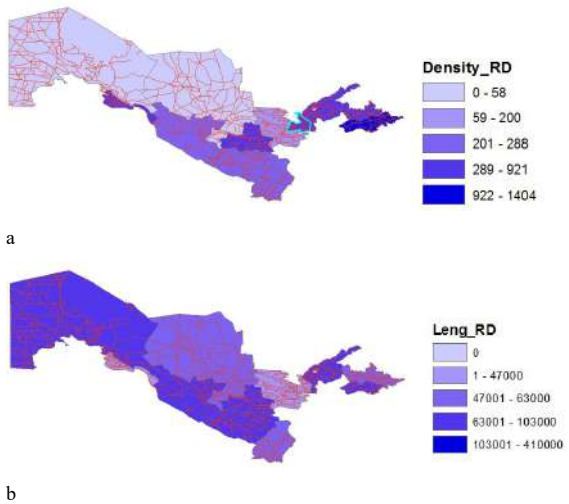

Figure 1. Information on the condition of highways: a - density of roads, b - length of roads

Monitoring the condition of the roadway and repair planning is one of the most popular applications of GIS in the road sector. [28] Often, only color coding of road sections by repair time is enough to significantly optimize the process and improve the quality of the road surface as a whole (Fig. 2). If you use GIS to integrate a variety of information on the road network (types / quality of coverage, transport load, repair dates), then based on it you can build a dynamic wear model and automate the planning of repairs. In the geodatabase, it is convenient to store information about road signs and other "roadside" information, tied to geographical or linear coordinates. Coverage monitoring is needed not only for roads, but for airports. A similar task with respect to railways is also for the railway transport. In all these areas of transport, GIS can significantly improve the efficiency of spending on maintenance of the cover or the way in good condition.

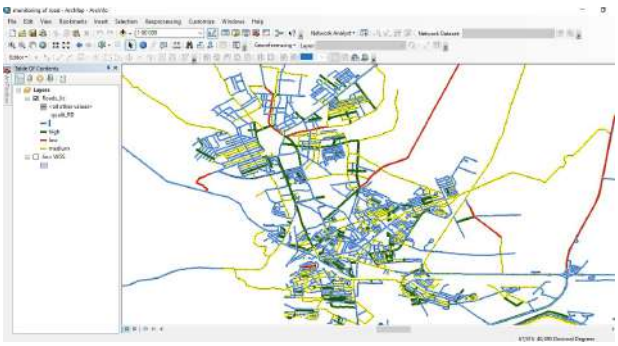

Figure 2. Monitoring of planning the reconstruction of the road network

Estimation of road congestion of highway is considered as one of the planning fields that could benefit from the use of GIS technologies. Congestion on the roads appears when a large number of vehicles are trying to use the general transport infrastructure [29]. This leads to deterioration in the use of existing infrastructure, thereby contributing to an accelerated increase in congestion, which in turn leads to further degradation of the infrastructure.

IV. ANALYSIS OF TRAFFIC CONGESTION

Engineers have many issues that can be better handled with GIS. [30] Analysis of traffic congestion is one such issue (Fig. 3). To achieve this goal, integration with software is measured, which has a graphical user interface that includes GIS.

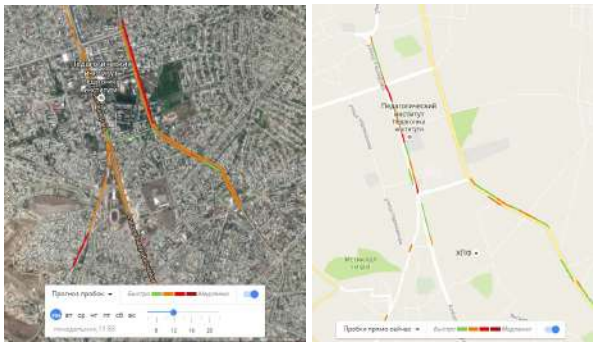

Figure 3. The analysis of traffic congestion

Nowadays, GIS has the ability to receive a huge amount of information about the road traffic of the road network due to advanced technologies [31]. This information is necessary for modeling the transport flow and is considered as a potential underlying platform for motion simulation data. The rapid growth of urban traffic requires effective methods of control [32-34].

V. LOGISTICS APPLICATION

Logistics is one of the traditional fields of application of geoinformation systems [35]. As part of the management, dispatching and delivery planning system, GIS has been successfully applied in large transport companies, in courier services of online stores, in the organization of service and emergency services and in other industries (Fig. 4).

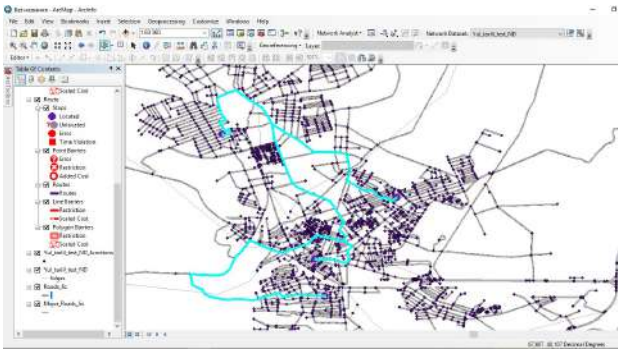

Figure 4. Analysis of the street-road network with ArcGIS 10.

It is known that the wide spread of satellite navigation has become an incentive in the development of transport GIS, however, the range of GIS tasks solved is much wider than the help in building routes or displaying the current location of vehicles on the map. Spatial analysis, modeling, maintenance of a single geographic database of various objects with all their attributes and other GIS capabilities make it possible to achieve significant cost reduction, shorten the delivery time, and optimally use the available resources. GIS in this case is used as an automated system for calculating routes for a variety of vehicles, delivery points and a variety of changing parameters.

Application of GIS in logistics - the choice of the optimal location for the placement of logistics assets (warehouses, distribution centers, transport bases, etc.). With the help of GIS, the analysis of the road network, the available facilities for the construction or lease of facilities, the location of the main customers and consignees of goods, etc. is carried out. The placement of maps, data and analysis results on the corporate geoportal will provide the necessary information to all the units of the organization that are involved in this work. There are data showing that the economic effect of optimizing the already established distribution network is usually 20-30%, while the optimization of individual delivery routes gives 5-10% [36].

VI. ROAD TRAFFIC ACCIDENTS ANALYSIS

Road safety plays an important role in any modern society. [37-39]. The goal is to reduce traffic accident statistics and, consequently, the number of lives and costs lost as a result of road accidents [40]. The implementation of a detailed analysis of road traffic accidents with the help of GIS will increase the opportunities for achieving this goal. According to the source [41-43] it is common practice to use statistical data, diagrams and tabular information to understand the traffic accident patterns. But to spatially visualize the situation in the city, as well as a map that displays the models, can increase the efficiency of work and visually show the dangerous sections of the street-road network of the city or region [44]. The use of GIS with the ability to display with attribute spatial data will allow to effectively developing measures for organizing traffic, as well as for ensuring traffic safety (Fig. 5).

The ability of GIS to associate data attributes with spatial data facilitates the prioritization of road accidents and the graphical presentation of results for more efficient planning and decision-making [45]. The locations of hazardous areas (urban streets, highways, intersections, junctions) can be identified using GIS based on the analysis of spatial characteristics of the identified locations, as well as the opportunity to identify the main factors causing accidents [46]. In many developed countries, GIS is widely used for the analysis of traffic accidents [47], and this method is called "black spots".

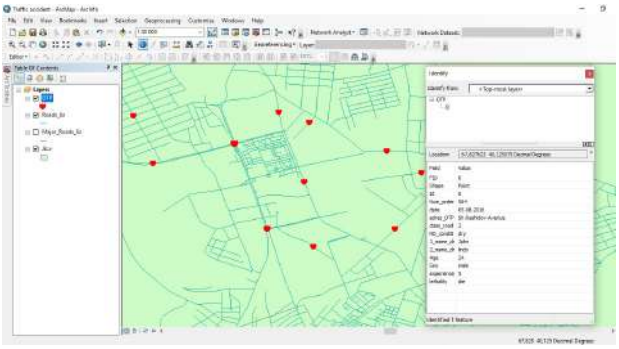

Figure 5. Analysis of traffic accidents with ArcGIS 10

Many government institutions and research centers, as well as higher education institutions, are working to create new tools and improve existing scenarios for the analysis of road safety using this method [48-54].

VII. ANALYSIS OF TRAFFIC NOISE

The continued increase in the traffic intensity of cars on the roads and the associated increase in the noise of traffic flows lead to a permanent increase in the noise load on the population living in the territories adjacent to the roads [55].

Deterioration of working and resting conditions with an increased level of traffic noise negatively affects labor productivity and quality, contributes to the development of nervous disorders and other health disorders. Therefore,

protecting the public from traffic noise is not only social, but also economic.

The application of GIS technology in the determination of traffic noise makes it possible to visually show on the map the propagation of noise in the environment [56] as well as to interpolate the data obtained by means of full-scale experiments.

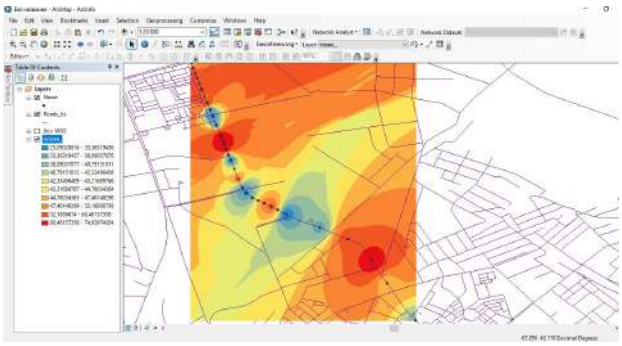

Figure 6. Analysis of traffic noise

The road network is best displayed on the geographic map. Therefore, the most visual and generalized representation and analysis of this information can only be done with the help of modern computer geographic information systems. The application of geographic information technologies increases the efficiency of work, as well as the solution of not only scientific problems, but also the solution of production problems.

VIII. CONCLUSIONS

The advantages of the use of GIS in automobile-road sector are related to its three main functions: data integration, geographic analysis of the information and its spatial representation. To comply with all these aspects, the essential condition is to have a reference of common location or geo-referencing of the data.

Integrating characteristic, linked to the function of gathering information from various sources (documentary information, maps, remote sensors, automated registration, etc.), allows show up correlation between different data series. This makes possible interrelate and analyse specific information of the transport sector with information of an external nature (economic, social, environmental, etc.) and understand its existing territorial manifestations.

Due to the intrinsic geographical nature of majority of transport data, GIS have a big potential to serve as a basis for the coherent organization of an integrated information system in any unit, company or agency responsible for transport activity.

Many transit and transportation agencies are facing the need to extend the road infrastructure and ensure its efficient use. It is possible by application of tools as GIS, that can be used to asses traffic congestion, manage road safety, ensure road network quality, as well as administrate its maintenance and repair planning.

In this area GIS are also can be used to prepare maps of streets, roads and routes, as well as dynamic maps that are resulting from vehicles monitoring, monitoring of road traffic conditions, etc. It is highly recommended their use as a support tool for design and construction of roads, enabling combine technical-engineering information with landscape characteristics and ecosystem conditions.

Regarding the operation of road transport, GIS proved their efficient use as an essential tool for activities related to logistics and fleet management, public transport route planning, urban traffic control (combining demographic information and land use) and modelling of scenarios for infrastructure and transport services demand.

We have identified following areas, where, according to our studies and reviewed research works, the application of GIS in automobile-road sector resulted to be the most effective: Obtaining information about the conditions of the street-road network; Monitoring planning for the construction of highways and city streets; Analysis of traffic congestion; Logistics; Accident analysis; Study of traffic noise. All the above directions are directly connected with the map.

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