DIAGNOSTICS OF THE ROAD CONDITION USING AN UNMANNED AERIAL VEHICLE

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ABSTRACT

Along with growing requirements for durability, reliability and safety of roads and their infrastructure, tools to control technical conditions of roads are being improved, involving operation of unmanned aerial vehicles that help to monitor the road infrastructure with the help of aerial photography. The authors of the article introduce a method of continuous automated monitoring developed by them, which is implemented in Moscow region. The wide functional capabilities of the UAV are confirmed for a number of diagnostic and technological tasks.

Keywords: automobile road, geotechnical monitoring, diagnostics of roadway, infrastructure, geomass, unmanned aerial vehicle, aerial photography.

Background. *The modern motor transport complex is characterized by an increasingly saturated infrastructure: various objects and engineering facilities (bridges, overhead roads, overpasses, tunnels, etc.). They are in a variety of hydro- and geological conditions, in areas with highly contrasted climatic features, increased seismic activity and the danger of landslide processes. At the same time, the state of geomasses immediately adjacent to roads and their infrastructure largely determines the level of safety of the facilities, both during operation and at the stages of design, survey and construction work.*

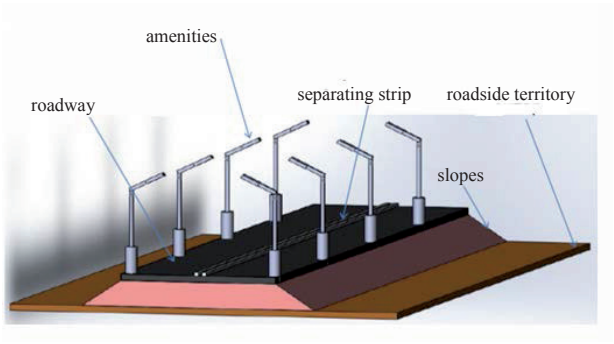
The relevance of the above topics increases in proportion to the pace of construction of the road network. Requirements for durability of structures of road infrastructure grow along with the structural complexity and tightening of their operating conditions, largely dependent on reliability of adjacent geomasses. In this regard, monitoring the state of structures and geomasses is increasingly becoming an integral part of the provision of all stages of the life cycle of objects.

The drawback of the use of classical diagnostic and monitoring methods is the need to perform manual measurements with sequential bypass of inspection points and mandatory expert analysis of the data obtained. However, periodic measurements and inspections of fragments of geomasses and the state of the highway do not give a full idea of the dynamics of the processes developing in them, and the use of high-precision specialized equipment requires the involvement of highly qualified specialists, which is often not economically effective. We need adequate and at the same time low-cost organization of constant monitoring during design, construction and operation of each structure [1].

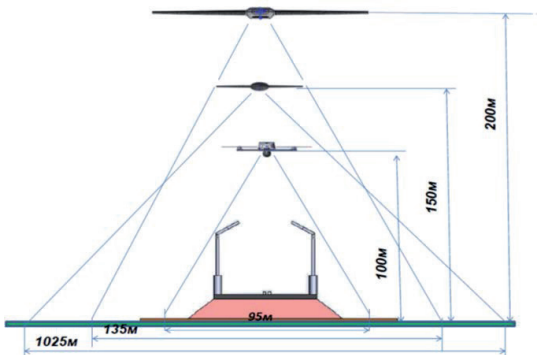
Objective. *The objective of the authors is to consider the use of unmanned aerial vehicles (UAV) for diagnostics of the road condition.*

Methods. *The authors use general scientific and engineering methods, comparative analysis, evaluation approach, graph construction.*

Results. *The authors are implementing a program to create automated systems for continuous monitoring of the state of all elements of the highway and its infrastructure. In recent years, noticeable progress has been made in the development of control methods using unmanned aerial vehicles*

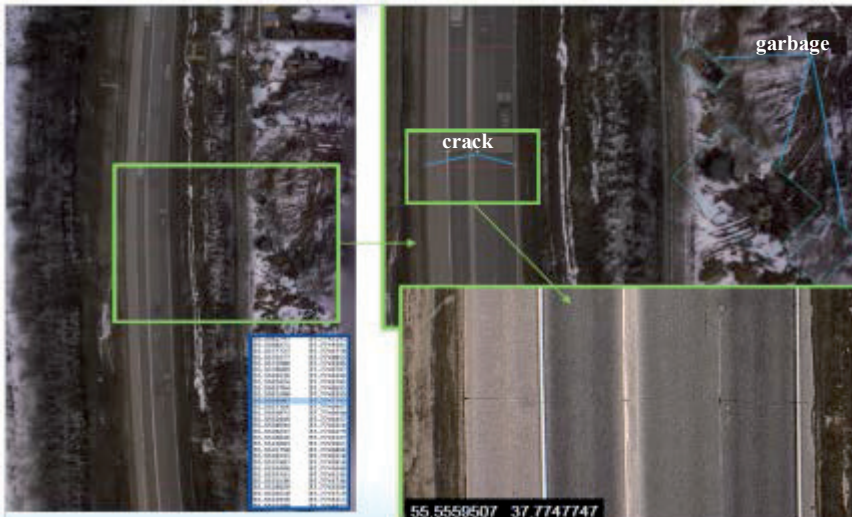


Pic. 1. The structure of a section of terrain with an automobile road.



Pic. 2. Aerial survey of the motorway by various types of UAV.

Pic. 3. Orthophotomap of the road section with georeferencing.



Pic. 4. Transverse defects of the roadway.

(UAVs), the manufacturer of which is a Russian company. The UAV system allows for operative remote monitoring of both highways and adjacent territories to obtain high and ultrahigh resolution data (Pic. 1, 2). With the help of the information received from the unmanned vehicle, the ground complex is coordinated, because on the basis of materials of large-scale survey, it becomes possible to influence the situation in places where significant violations are detected.

Unmanned aerial vehicles in comparison with satellite or traditional aerial photography have a number of advantages: the ability to take pictures at an altitude of 100–500 meters, fix the smallest elements of any surface of a few centimeters in size. Therefore, performing a flight over a given terrain in automatic or semi-automatic mode allows to rely on highly accurate georeferenced images.

The solution of such problems is in the interests of both state and commercial structures. The efficiency of using the UAV hardware and software complex was confirmed by studies conducted on the territory reporting to the company «Mosavtodor». In Moscow region it is responsible for repair and maintenance of regional highways, the length of which is 14,5 thousand km.

During the monitoring, digital photos were taken in the coordinate space. On their basis, the photoplanes of the sections of the motor road were compiled. A fragment of the photographic plan obtained from a height of 300 meters is shown in Pic. 3. The survey provides a sufficiently wide capture band along the road, with images of interchanges, a roadside and adjacent municipal infrastructure. However, in this case, the resolution of images does not meet the requirements for detailed interpretation of road surface defects and small erosion forms located near the roadway. This problem is solved by shooting from a height of 150–90 m with a spatial resolution of about 2 cm per pixel.

Based on the results of the interpretation of aerial photography materials, a special photo scheme of the highway and a number of thematic maps (area defects, exogenous processes, etc.) were obtained in a special program. With the help of aerial photography, area, linear and point defects of 2 cm in size and larger are reliably determined, in particular, it allows detecting transverse cracks (Pic. 4) on the road pavement. Based on the thematic cartographic materials received by the GIS, it is planned to compile forecast maps of the risks of defects and destruction of the roadway as well as study the dynamics of their changes in connection with development of exogenous processes.

The creation of a thematic map and a roadway scheme makes it possible to quickly obtain statistical data on distribution of density of roadway defects for a certain section of the route (Pic. 5). Thus, for

Pic. 5. Distribution of density of defects of a roadway.

example, areas with a higher defect density were identified.

One of the promising areas for using aerial photography with UAV is an operational monitoring for forecasting the condition of the roadway. Based on aerial photographs, exogenous processes proceeding in the vicinity of the road are well interpreted. Continuous monitoring with UAVs and the application of GIS will allow to assess the speed of development and direction of such processes, and in some cases – to establish the causes of their occurrence.

Based on the results of the monitoring, a list of measures was developed to maintain the pavement, the roadbed and other elements of the highway, which contributed to increasing the operational efficiency of «Mosavtodor» through operational control at all stages of the production process and timely management decisions.

The obtained results confirmed the effectiveness of the UAV complex application for solving the following problems:

- *maintenance of operative monitoring of a condition of a roadway;*
- *control over construction and repair work on roads;*
- *detecting defects of the roadbed and determining their parameters;*
- *obtaining digital imaging materials in the visible, infrared and ultraviolet ranges;*
- *obtaining a 3D-model of the road using stereopairs;*
- *fixing of aerial survey routes with mapping into GIS;*
- *formation of an aerial survey data base;*
- *obtaining information about the condition of the roadway, including the determination of geometric parameters (longitudinal and transverse slopes, the radii of curves in the plan and profile, elevations, visibility, distance traveled);*
- *obtaining video information for roads and artificial structures with the formation of a bank of video data;*
- *fixing of engineering facilities;*
- *determination of parameters of the transport flow.*

Conclusions. *The performed work showed that the proposed technology of UAV application is a modern and cost-effective means of studying the state of highways and adjacent territories, and it can also be an integral element for formation of intelligent transport systems when creating a single information space in future multimodal networks.*

In the UAV complex, the possibility of expanding the functional capabilities due to the inclusion in its composition of GPR, laser equipment, etc.

The provided methodology allows for data collection, accumulation, transmission, updating of information on the state of the soils of underlying and adjacent geomasses at all stages of the life cycle of facilities (design and survey works, design of structures and road infrastructure, construction, operation, maintenance and reconstruction) using GLONASS / GPS technologies, digital three-dimensional mathematical models.

It should be noted that the outlined approach to multifunctional geotechnical monitoring of road facilities using the latest achievements in the field of advanced information technologies and unmanned flights is relevant and in demand. On this basis, the tasks of ensuring the quality of design, construction and operation of roads, as well as road safety and the environment will be addressed.

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