ЦИФРОВИЗАЦИЯ ОХРАННЫХ ЗОН АВТОМОБИЛЬНЫХ ДОРОГ НА ТЕРРИТОРИИ ГОРОДОВ НА ОСНОВЕ ГЕОГРАФИЧЕСКИХ ИНФОРМАЦИОННЫХ СИСТЕМ

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Аннотация. В данной статье рассмотрен процесс цифровизации охранных зон автомобильных дорог общего пользования на территории города Намангана на основе географических информационных систем (ГИС). В ходе исследования пространственные данные, полученные по материалам дистанционного зондирования Земли, были проверены на точность координат с использованием GNSS-приемника Stec SV-1. Для определения и анализа охранных зон автомобильных дорог применялись программные комплексы ArcGIS и QGIS. Кроме того, была сформирована база пространственных данных в формате (*.mdb). Предложенный подход способствует экономически и экологически эффективному использованию дорожной инфраструктуры, оптимизации градостроительных решений, а также созданию системы цифрового мониторинга объектов дорожного хозяйства.

Ключевые слова: *ГИС, дистанционное зондирование Земли, GNSS, охранная зона, ArcGIS, QGIS, база данных, градостроительство.*

DIGITALIZATION OF ROAD PROTECTION ZONES IN URBAN AREAS BASED ON GEOGRAPHIC INFORMATION SYSTEMS

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Abstract. This article presents the process of digitalizing the protection zones of public roads within the territory of Namangan City using Geographic Information Systems (GIS). In the study, spatial data obtained from remote sensing materials were verified for coordinate accuracy using the Stec SV-1 GNSS receiver. ArcGIS and QGIS software environments were employed to identify and analyze road protection

zones. In addition, a spatial database (*.mdb) was developed and organized. The proposed approach contributes to the economically and environmentally efficient use of road infrastructure, optimization of urban planning decisions, and the establishment of a digital monitoring system for road assets and their protection zones.

Keywords: *GIS, remote sensing, GNSS, protection zone, ArcGIS, QGIS, database, urban planning.*

Introduction. Roads are one of the key components of urban transportation systems, ensuring population mobility, economic activity, and connectivity between different functional zones of a city. As one of the rapidly developing urban areas, Namangan City places increasing demands on its transportation infrastructure. Population growth, the expansion of residential neighborhoods, and the development of commercial facilities have significantly increased the load on the road network, making the maintenance of road conditions and compliance with road protection zone regulations increasingly important.

Traditional mapping methods are often unable to fully capture the speed and complexity of urbanization processes. Therefore, the digitalization of road protection zones using remote sensing technologies and Geographic Information Systems (GIS) has become highly relevant. This approach enables comprehensive spatial analysis of road infrastructure, automatic generation of buffer zones, identification of intersections with construction and land-use objects, and effective monitoring of adjacent territories.

Research Object and Data. The study focused on public roads located within the territory of Namangan City.

The following data sources were used:

- remote sensing data (satellite imagery);
- topographic base maps;
- road cadastre data;
- coordinates obtained using the Stec SV-1 GNSS receiver;

- road protection zone distances established in accordance with regulatory documents.

Research Methodology.

1. Processing of Remote Sensing Data. The road network was identified using satellite imagery, and an initial digital road layer was created. The images were georeferenced, and their spatial accuracy was assessed to ensure consistency with the selected coordinate system.

2. Verification of Coordinate Accuracy Using GNSS. The coordinates of selected road points were determined using the Stec SV-1 GNSS receiver. The obtained field measurements were compared with the coordinates derived from remote sensing data to evaluate their positional accuracy and reliability.

3. Digitalization in ArcGIS and QGIS Environments. Road protection zones were generated based on road centerlines using the Buffer analysis tool available in ArcGIS and QGIS software. The process included:

- conversion of the road layer into vector format;
- generation of buffer zones based on regulatory protection distances;
- spatial intersection analysis with buildings and other infrastructure objects;
- mapping and visualization of the results.

The parallel use of ArcGIS and QGIS enabled the comparison and validation of the obtained results.

4. Creation of a Spatial Database (*.mdb). - All spatial layers were integrated into a unified geodatabase developed in **Microsoft Access (*.mdb)** format. The database contains comprehensive information on road geometry, road protection zones, land parcels, construction objects, and GNSS control points. The established database structure ensures efficient storage, management, and retrieval of spatial information. Furthermore, it provides a reliable platform for future data updates, spatial monitoring, and decision-making processes related to urban road infrastructure management and protection zone control.

Results. As a result of the study, a comprehensive GIS-based model for the digitalization of protection zones of public roads within the territory of Namangan City was developed.

Figure 1. Determination of Point Coordinates Along the Road Centerline Using a GNSS Receiver.

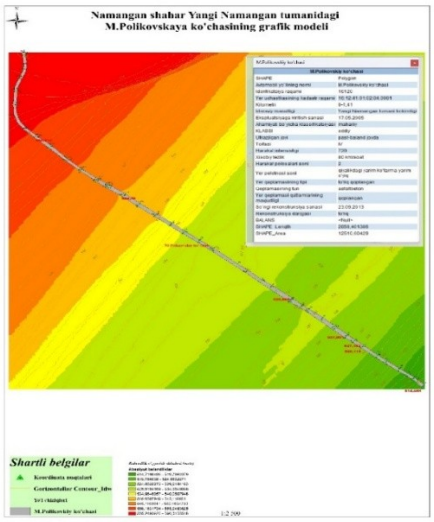

*Figure 2. Graphical Model of M. Polikovskiy Street in the .mdb Geodatabase Format

The implementation of the proposed methodology enabled the acquisition of the following scientific and practical outcomes:

- a digital model of Namangan City's road network was created;
- road protection zones were automatically generated based on regulatory requirements;
- areas where protection zones intersect with existing construction and infrastructure facilities were identified;
- the positional accuracy of spatial data was verified and confirmed using GNSS measurements;
- a unified spatial database was established for the storage, management, and analysis of geospatial information.

This system enables the digital verification of urban planning documents and compliance assessment of proposed development projects within road protection zones. The GIS-based digital monitoring system serves as an innovative tool for

urban management, supporting evidence-based decision-making, improving land-use control, and enhancing the efficiency of road infrastructure planning and protection.

Conclusion and Recommendations. The digitalization of urban road protection zones using Geographic Information Systems (GIS) represents an effective approach to transportation infrastructure management. The case study conducted in Namangan City demonstrated that the integration of remote sensing data, GNSS technology, and ArcGIS/QGIS platforms significantly improves the accuracy of spatial information and provides a reliable foundation for the digital management of road infrastructure.

The developed methodology enabled the automatic generation of road protection zones, regulatory compliance analysis, and the identification of spatial conflicts between protection zones and existing construction activities. These capabilities contribute to the rational use of land resources, improved urban planning practices, and enhanced transportation safety. The established spatial database serves as an important tool for monitoring road infrastructure and supporting digital decision-making processes. Furthermore, it aligns with the principles and requirements of modern Smart City initiatives by facilitating efficient data management and continuous infrastructure monitoring. Overall, the application of GIS technologies offers a highly effective solution for the management of road protection zones in urban environments.

Future research may focus on integrating artificial intelligence techniques, advanced spatial analytics, and three-dimensional (3D) modeling technologies to further enhance the accuracy, automation, and functionality of digital road infrastructure management systems.

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