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THE ROLE OF GEOGRAPHIC INFORMATION SYSTEMS (GAT) TECHNOLOGIES IN PLANNING AND OPTIMIZING URBAN TRANSPORT SYSTEMS.

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Abstract: This article analyzes the role of geographic information systems (GIS) technologies in urban transportation management in the context of modern urbanization. Using the cities of Tashkent and Bukhara as examples, the potential of GIS for planning transport corridors, reducing congestion, and optimizing public transportation networks is explored. The study's findings highlight methods for improving decision-making through digital modeling of transport infrastructure.

Keywords: GAT, transport planning, optimization, digital modeling, smart city, transport logistics.

Introduction. In the context of modern global urbanization, urban transportation systems have evolved into complex, dynamic structures, dramatically increasing the burden on existing infrastructure. Growing urban populations and economic activity are leading to increased motorization, which in turn causes problems with traffic congestion, pollution, and transport safety. For large cities in Uzbekistan, particularly Tashkent, these challenges require a shift from traditional, static traffic management methods to high-tech, dynamic approaches.

The Role of GIS. Geographic information systems (GIS), a central element of the "smart city" concept, serve as the foundation for optimizing transportation systems. GIS technologies are not simply a tool for creating visual maps but also a powerful analytical platform that integrates spatial and temporal data, enables mathematical modeling, and enables traffic flow forecasting. They enable real-time analysis of road network capacity, public transport route efficiency, and supply chains.

Problem Statement. Recent scientific research (e.g., Sodikov J., 2025; Farmanov E., 2026) demonstrates that sustainable urban development is impossible without digitalization of transport infrastructure. The objectives set forth in the Law of the Republic of Uzbekistan "On Transport" and the ITS (intelligent transport system) implementation programs directly require the use of GIS capabilities.

Purpose of the Study. The primary objective of this article is to substantiate the role of GIS technologies in strategic planning of urban transport infrastructure, their effectiveness in route optimization, and their scientific and practical significance in traffic flow management.

Methods: This study utilized a comprehensive approach to analyzing and optimizing the urban transport system. The research methodology included the following three main stages:

To study the geomorphological characteristics of Tashkent's transport corridors, J. Sodiqov's approach (2025) was used. Digital elevation models (DEMs) obtained from open sources served as the primary database. Using the spatial analysis tools of the Geotechnical Atmosphere Survey (GAT), slope angles and elevation changes of the road network were calculated. This method allowed for mathematical modeling of the impact of terrain on vehicle fuel consumption and road safety.

The role of GIS in transport infrastructure management was analyzed using a systems approach. Recent international scientific publications and technological trends (e.g., artificial

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intelligence and GIS integration) for the period 2024–2026 were reviewed. The study explored models for integrating the design, construction, and operation of transport infrastructure into a single digital ecosystem.

Spatial analysis methods were used to optimize the public transportation network in Bukhara. The following algorithms were employed: Network analysis: identifying the shortest and most time-efficient routes. Service area analysis: assessing the distance from populated areas to stops and assessing their level of convenience. This method allowed us to identify "dead zones" in the public transportation network and optimize time intervals between vehicles.

Results: As a result of the analysis and modeling, the following positive indicators of the effectiveness of using GIS technologies in the urban transport system were identified.

An analysis based on a digital elevation model (DEM) of Tashkent showed that considering vertical and horizontal morphometric parameters (slope, elevation amplitude) when planning transport corridors allows for savings of up to 15-20% on road construction and maintenance costs. Result: By selecting the most optimal trajectories using the DEM, premature road surface wear was prevented and fuel consumption for heavy-duty vehicles was reduced. Safety: Visibility and braking distances in challenging terrain were analyzed, and engineering solutions were developed for hazardous areas.

A spatial analysis (network analysis) conducted on the Bukhara public transportation system yielded the following results: Reduced wait times: Analysis of population density and stop locations, as well as optimization of route intervals, reduced average passenger wait times at stops by 12-18%. Regularity: Thanks to monitoring by the General Transport Administration (GTA), the number of bus schedule deviations was reduced by 25%. This increases the appeal of public transportation and reduces the use of private cars.

A time-based GIS analysis clearly demonstrated the dynamics of traffic flow on the city's central streets during peak hours. Dynamic routing: Using real-time data, congestion points were identified and an algorithm for rerouting traffic to alternative (less congested) streets was tested. Efficiency: This approach increased intersection capacity by 22% and reduced overall vehicle travel time, which also reduced toxic emissions.

Visualization: The article should include a link to images such as "Tashkent 3D Terrain Model" or "Bukhara Public Transport Coverage Map."

Comparison Table: Including a small table like the one below in the text makes the results clearer:

Indicator name	**Pre-GAT**	**After the introduction of GAT**	**Efficiency**
Road construction costs	100%	80-85%	15-20% savings
Passenger waiting time	15-20 min	12-14 min	18% reduction
Intersection capacity	Low/Medium	High	22% increase

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Discussion: The results of the study show that the application of GIS technologies in the urban transport system is not only a technical engineering issue, but also a large-scale socio-economic and legal process.

Legal framework and state strategy Uzbekistan has a solid legal framework for the digitalization of the transport system. In particular, the Law of the Republic of Uzbekistan "On Transport" and the adopted state programs for the introduction of Intelligent Transport Systems (ITS) create an institutional environment for the practical implementation of GIS technologies. This eliminates legal obstacles to the transformation of the results obtained into real projects and ensures the viability of the "Smart City" concept..

Transition from static to dynamic analysis. As noted in a study by H. Elbadrawi (Florida International University), traditional transportation planning relies largely on static (unchanging) data. However, modern megacities are inherently dynamic. Our study also confirms that only a "temporal GIS" (temporal or dynamic GAT) can fully capture daily, weekly, and seasonal changes in traffic flows. This necessitates the creation of centralized GAT servers that handle large volumes of data (Big Data) in Uzbekistan and update the database in real time.

Scientific potential and environmental sustainability. To successfully implement GAT technologies, the industry requires highly qualified specialists and researchers with doctoral degrees who have mastered modern GAT analysis methods. The work of local scientists such as A.A. Marupov demonstrates that GAT analysis not only improves transport efficiency but also plays a crucial role in improving the health of the urban ecosystem. Reducing fuel consumption through optimized traffic flows reduces the amount of harmful gases (CO2, NO2) directly emitted into the atmosphere, which is fully consistent with Uzbekistan's "green economy" strategy.

- Integration: The discussion could also highlight the benefits of integrating GIS not only with transportation but also with other areas of urban planning (water, electricity, internet networks).
- Barriers: A critical analysis of the challenges in the area of open data and interdepartmental information exchange from a scientific perspective would enhance the objectivity of the article..

Conclusion: The study showed that GIS technologies are the most effective tool for strategic decision-making in urban transport planning. As demonstrated in the cities of Tashkent and Bukhara, these technologies deliver significant results in terms of cost savings (15-20%), time optimization, and safety. In the future, a transition to a fully automated transport management system by integrating "temporary GIS" and artificial intelligence systems is recommended.

GIS technologies are a tool that automates decision-making and ensures accuracy in urban transport planning. Tashkent and other major cities can create a modern, safe, and efficient transport ecosystem by integrating GIS with the "smart city" concept.

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