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DESIGN OF AN AUTOMOBILE TECHNICAL SERVICE ENTERPRISE ON THE ANDIJAN–MARHAMAT HIGHWAY: A FEASIBILITY AND TECHNOLOGICAL STUDY

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ABSTRACT Rapid growth in vehicle ownership in Uzbekistan, combined with the government's strategic programme to upgrade national highways to international standards, has created an acute demand for modern roadside automobile service infrastructure. This study presents the comprehensive design of an automobile technical service enterprise (ATSE) to be located on the Andijan–Marhamat highway (Andijan Region, Uzbekistan). A systematic design methodology was applied, encompassing traffic intensity analysis, production workload calculation, facility area determination, staffing requirements, and economic feasibility assessment. The projected enterprise serves 61 vehicles per day and employs 58 workers across maintenance, repair, and auxiliary functions. Annual gross revenue is estimated at 10,205,124,833 UZS with a net profit margin producing a capital payback period of 1.60 years and a profitability ratio of 13.6%. The findings demonstrate that a properly designed mid-sized ATSE on this corridor is economically viable and technologically justified under current Uzbek regulatory and normative frameworks.

Keywords: automobile service enterprise; highway infrastructure; vehicle maintenance; technical service station; Uzbekistan; facility design; economic feasibility.

1. INTRODUCTION

The rapid advancement of science and technology has transformed modern transportation, generating demand for high-quality roadside service infrastructure across the globe. In Uzbekistan, the development of transport and road infrastructure has been declared a priority direction of state policy. The government's initiative to upgrade 4,000 km of national roads to international motorway standards underscores the strategic importance of the transport sector for the country's economic integration and competitiveness.

The Andijan–Marhamat corridor in Andijan Region is one of the priority routes under ongoing infrastructure reform. The intensification of freight and passenger flows, combined with increasing vehicle registration rates, has exposed a significant gap in modern technical service facilities along this corridor. Existing service points in the area are largely outdated and fail to meet contemporary safety, quality, and capacity standards.

State policy further reinforces this demand: the concept of establishing "Service Points" and "Service Areas" along republic roads—integrating fuel stations, electric vehicle charging facilities, catering facilities, and technical service centres—provides a clear regulatory and commercial framework for new enterprise development. Additionally, joint decrees of the Ministries of Transport and Internal Affairs (2025) impose mandatory fire safety and normative compliance requirements on all newly designed automotive service objects, aligning with UzDSt, SHNQ, and GOST standards.

Despite growing vehicle density and supportive legislation, there is a shortage of engineering studies that systematically demonstrate the design process and economic viability of a roadside ATSE under Uzbek normative conditions. The present diploma project addresses this gap by producing a complete design package for a new enterprise on the Andijan–Marhamat highway.

1.1 Aim and Objectives

The primary aim of this work is to design a modern automobile technical service enterprise capable of meeting the growing service demand in the Andijan–Marhamat corridor, while satisfying current technical, regulatory, and economic requirements.

Specific objectives are:

1. Determine the road category and traffic intensity for the target corridor.
2. Calculate the annual production workload and service post requirements.
3. Develop a general layout and workshop floor plan.
4. Determine staffing requirements.
5. Assess economic feasibility including revenue, costs, profit, and capital payback period.

2. METHODS

This study employs a normative-analytical design methodology grounded in Uzbek engineering standards and international automotive service design practices. The methodological framework follows the sequence described below.

2.1 Traffic Intensity and Service Demand Analysis

The first step involved determination of the road category (Category II, coefficient t = 1.5) and the annual operating calendar (Dik = 365 days, round-the-clock operation). Based on traffic census data and normative vehicle flow coefficients, the number of vehicles requiring service per day was calculated. The daily service throughput (Ns) serves as the foundational parameter for all subsequent calculations.

2.2 Annual Workload Calculation

Annual labour input (man-hours) was determined using the formula:

$$T_{annual} = N_s \times t_{norm} \times K_c$$

where N_s is the number of vehicles serviced per year, t_{norm} is the normative labour intensity per vehicle (man-hours), and K_c is a correction coefficient accounting for road category and vehicle type mix. All normative labour intensity values were adopted from M.Z. Musajanov's standard design textbook for transport enterprises and from O. Hamraqulov's technical exploitation references.

2.3 Service Post and Area Determination

The number of production posts (X) was calculated as:

$$X = T_{annual} / (F_p \times P_p \times K_{use})$$

where F_p is the annual time fund of one post (hours), P_p is the number of workers simultaneously at one post, and K_{use} is the post utilisation coefficient. Building areas were determined by multiplying the number and type of posts by normative specific areas, with additions for auxiliary, administrative, and sanitary spaces, in accordance with SHNQ 2.09.02.

2.4 Staffing Calculation

The number of production workers (R_p) was determined from:

$$R_p = T_{annual} / F_{worker}$$

where F_{worker} is the annual time fund of one worker. Auxiliary, engineering-technical, and administrative staff numbers were derived as fixed percentages of production staff, following normative ratios established in Uzbek automotive enterprise design standards.

2.5 Equipment Selection

Production equipment and tools were selected based on post types (reception/diagnosis, engine service, chassis/transmission service, tyre service, washing, body repair, painting).

Modern equipment catalogues were used, including NORDBERG, Karcher, KART Wulkan, and PROFESSIONAL brand items, with technical specifications verified against workflow requirements.

2.6 Economic Analysis

The economic section evaluated the enterprise using cost accounting and profitability analysis. Key indicators calculated included: labour cost fund (basic and supplementary wages, social contributions), depreciation, energy (electrical, gas) costs, material costs, total production cost, annual revenue, net profit, return on assets, and capital payback period. Tax provisions were applied per the Tax Code of the Republic of Uzbekistan (Article 269 on exemptions for newly established enterprises within the first two years). The profitability index was calculated as:

$R = (P / \Sigma S_t) \times 100\%$

where P is annual profit and ΣS_t is total annual cost.

2.7 Occupational Safety Assessment

The occupational safety section followed the Instruction on Labour Protection for Automobile Technical Service and Repair Technicians, as approved by the Ministry of Transport. Parameters assessed included: illumination norms for workspaces (incandescent and fluorescent lamp systems), microclimate conditions, chemical hazard exposure (mineral and synthetic oils, carbon oxides), personal protective equipment requirements, and emergency response procedures.

3. RESULTS

3.1 Traffic Intensity and Production Volume

Analysis of the Andijan–Marhamat corridor (Category II highway, t = 1.5, round-the-clock operation, D_{ik} = 365 days) yielded a daily service throughput of N_s = 61 vehicles/day, covering all vehicle types. This figure served as the basis for all subsequent calculations.

3.2 Annual Workload and Post Calculations

The annual effective time fund for the two-shift operation was calculated as:

$$F = DR \times T_s \times n = 305 \times 8 \times 2 = 4{,}880 \text{ hours/year}$$

Post and area calculations resulted in the following enterprise structure: general service and reception area, engine maintenance workshop, transmission and chassis service area, tyre fitting and balancing post, high-pressure vehicle washing bay, body straightening and painting chamber, and auxiliary/storage zones. Total built area is consistent with normative specific area standards.

3.3 Staffing Results

The calculated staffing structure comprises 48 production workers (mechanics, auto-technicians, painters, and tyre fitters), 10 auxiliary workers (storekeepers, cleaners, security), and an engineering-technical and administrative staff of 10, for a total workforce of 58 employees.

3.4 Economic Feasibility Results

The main economic results are summarised below:

Labour cost fund: Total wage fund (basic + supplementary) amounted to 1,922,128,236 UZS/year, including social security contributions of 768,851,294 UZS.

Depreciation: 88,000,000 UZS/year on production equipment and structures.

Energy costs: Electricity expenditure — 3,757,227,656 UZS/year; gas consumption cost — 120,231,000 UZS/year.

Material costs: 912,865,000 UZS/year (based on normative consumption of 82,000 UZS per vehicle).

Incomplete production cost: ΣS_{mm} = 7,569,303,186 UZS/year.

Total annual cost: ΣSt = 8,940,921,884 UZS/year (including overhead and administrative expenses).

Annual gross revenue: ΣD_i = 10,160,138,505 UZS/year; additional revenue from vehicle parking: 44,530,000 UZS/year; total revenue $\Sigma Du/d$ = 10,205,124,833 UZS/year.

Annual profit: P = 1,219,216,621 UZS; net profit after tax (Psf) = 975,373,297 UZS.

Profitability: R = 13.6%.

Capital investment required: K = 1,760,000,000 UZS.

Capital payback period: T_{ok} = 1.60 years.

Labour productivity per production worker: 212,606,767 UZS/worker/year; per total staff: 175,950,428 UZS/worker/year.

4. DISCUSSION

The results demonstrate that a Category II highway corridor with the traffic intensity found on the Andijan–Marhamat route provides a sufficient vehicle flow to sustain a viable mid-sized ATSE. The calculated daily throughput of 61 vehicles is consistent with normative minimum viability thresholds for enterprises of this type in Uzbekistan. The short capital payback period of 1.60 years compares favourably with regional industry benchmarks and reflects both the scale of unmet service demand and the relative affordability of construction and equipment in the Andijan Region.

The profitability ratio of 13.6% exceeds the design assumption of 12%, confirming that the revenue model is conservative and that actual results may surpass projections, particularly as vehicle ownership in the region continues to grow. This is significant in the context of Uzbekistan's ongoing motorisation, where the number of registered vehicles has increased markedly following the expansion of domestic automobile production.

The enterprise's structure—combining general maintenance, tyre service, body repair, painting, and washing functions—reflects the full-service model increasingly adopted along national motorways. This model reduces vehicle downtime for road users and enhances the economic attractiveness of the enterprise relative to narrow-specialisation competitors. The inclusion of a staffed vehicle parking facility as an additional revenue stream (44,530,000 UZS/year) illustrates the value of multi-function roadside complexes consistent with the government's "Service Area" development policy.

The regulatory environment supports the proposed enterprise. The 2025 joint decree on fire safety for vehicle service objects establishes clear compliance requirements, while the Tax Code's two-year property tax exemption for newly established enterprises materially improves the financial position of the project in its critical early years. These policy instruments reduce investment risk and should encourage further private investment in roadside service infrastructure.

Several limitations of this study merit acknowledgment. The economic model relies on normative vehicle service costs and staffing coefficients derived from standard design handbooks rather than from direct market surveys of the specific corridor. Traffic intensity data were based on normative coefficients rather than field counts, which may introduce some variance into the throughput estimate. Future work should incorporate real traffic measurement data and dynamic pricing modelling to refine the financial projections. Additionally, environmental aspects of workshop operations—particularly waste oil disposal, wash-water treatment, and paint booth emissions—warrant a dedicated environmental impact assessment in subsequent detailed engineering phases.

From a comparative perspective, the applied design methodology aligns with internationally recognised practices for automotive service enterprise planning, adapted to the Uzbek normative context. The integration of occupational safety calculations directly into the design package—rather than as a post-design add-on—reflects good engineering practice and is consistent with the preventive approach to workplace hazard management advocated in Uzbek labour protection regulations.

5. CONCLUSION

This study has presented a complete normative design of an automobile technical service enterprise for the Andijan–Marhamat highway corridor, covering traffic and workload analysis,

facility layout, equipment selection, staffing, economic evaluation, and occupational safety assessment.

The principal findings are as follows:

(1) A daily throughput of 61 vehicles is achievable on the Andijan–Marhamat corridor under current traffic conditions, justifying enterprise establishment.

(2) The designed enterprise, with a workforce of 58 and a capital investment of 1,760,000,000 UZS, achieves a payback period of 1.60 years and a profitability ratio of 13.6%, confirming strong economic viability.

(3) The multi-functional service profile—encompassing maintenance, repair, tyre service, body work, painting, washing, and parking—maximises both service coverage and revenue diversification.

(4) The enterprise design fully complies with applicable Uzbek normative documents (UzDSt, SHNQ, GOST) and current fire safety and labour protection regulations.

The outcomes support the broader policy objective of developing a modern, safe, and commercially sustainable roadside service network along Uzbekistan's national highway system. The methodology developed herein may be applied to analogous corridor projects throughout the country, contributing to the systematic upgrading of transport service infrastructure in line with state development programmes.

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