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RESEARCH, INNOVATION, RESULTS



**TOSHKENT DAVLAT  
TRANSPORT UNIVERSITETI**

Tashkent state  
transport university



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# TASHKENT STATE TRANSPORT UNIVERSITY

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Articles are published in Uzbek, Russian, and English, ensuring a wide-reaching audience and fostering cross-cultural academic exchange. As a beacon of academic excellence, the "Journal of Transport" continues to serve as a vital conduit for knowledge dissemination, collaboration, and innovation in the transport sector and related fields.

## The role of digitalization in increasing the efficiency of truck utilization

Sh.K. Khakimov<sup>1</sup><sup>a</sup>, D.V. Odilov<sup>1</sup><sup>b</sup>, U.I. Isokhanov<sup>1</sup><sup>c</sup>

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**Abstract:** This article scientifically investigates the economic efficiency achieved through the digitalization and computer simulation of freight vehicle operations, including route optimization, simulation modelling, and predictive maintenance. The study focuses on the MAN TGS 19.400 (4×2) long-haul tractor unit operated by Avtogigant Dang'ara LLC. A comparative analysis of fuel consumption, spare-parts wear, unplanned downtime, and total operational costs is conducted using real-world data, comparing conventional management against an on-board information system (telematics). The results demonstrate that digitalization reduces fuel consumption by 15–18%, extends the service life of spare parts by over 30%, and yields a net annual economic benefit of more than 106 million UZS per vehicle. The article also discusses the practical application of digital-twin concepts, CAN-bus data, GPS telematics, and cloud-based simulation modelling in the transport sector.

**Keywords:** digitalization, computer simulation, logistics, MAN TGS 19.400, digital twin, telematics, predictive maintenance, fuel efficiency, AnyLogic, economic efficiency

## Yuk avtomobillaridan foydalanish samaradorligini oshirishda raqamlashtirishning o'рни

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**Annotatsiya:** Ushbu maqolada yuk avtomobillaridan foydalanish jarayonini raqamlashtirish va kompyuter modellashtirish — jumladan, marshrutni optimallashtirish, simulyatsiya va bashoratli texnik xizmat ko'rsatish (predictive maintenance) — orqali erishiladigan iqtisodiy samaradorlik ilmiy asosda tahlil qilinadi. Tadqiqot obyekti sifatida "Avtogigant Dang'ara" MChJ balansidagi MAN TGS 19.400 (4×2) rusumli magistral tyagach olingan bo'lib, uning an'anaviy va raqamlashtirilgan (Bort axborot tizimi o'rnatilgan) boshqaruvidagi yoqilg'i sarfi, ehtiyot qismlar yemirilishi, rejasiz to'xtab qolish holatlari va umumiy operatsion xarajatlar real raqamlar, jadvallar va grafiklar yordamida qiyosiy tahlil qilinadi. Tadqiqot natijalari shuni ko'rsatadiki, raqamlashtirishning joriy etilishi yoqilg'i sarfini 15–18 foizga qisqartiradi, ehtiyot qismlar xizmat muddatini 30 foizdan ko'proqqa uzaytiradi va bitta avtomobil uchun yiliga 106 million so'mdan ziyod sof iqtisodiy samara beradi. Maqolada shuningdek raqamli egizak (digital twin) kontseptsiyasi, CAN-shina ma'lumotlari, GPS-telematika va bulutli modellashtirish texnologiyalarining transport sohasidagi amaliy imkoniyatlari muhokama qilinadi.

**Kalit so'zlar:** raqamlashtirish, kompyuter modellashtirish, logistika, MAN TGS 19.400, raqamli egizak, telematika, bashoratli texnik xizmat, yoqilg'i tejamlorligi, AnyLogic, iqtisodiy samaradorlik

### 1. Kirish

Zamonaviy bozor iqtisodiyoti sharoitida logistika va yuk tashish korxonalarining raqobatbardoshligi to'g'ridan-to'g'ri ularning operatsion xarajatlarini qay darajada optimallashtira olishiga bog'liq. Jahon banki ma'lumotlariga ko'ra, mahsulot tannarxining o'rtacha 15–20 foizini aynan transport xarajatlari tashkil etadi [9]. O'zbekistonda esa bu ko'rsatkich tog'li va uzoq masofali yo'nalishlar (masalan, Toshkent–Andijon yo'nalishi Qamchiq dovoni orqali) mavjudligi sababli yanada yuqori bo'lishi mumkin.

Shu paytgacha yuk avtomobillaridan foydalanish asosan "reaktiv" usulda — ya'ni haydovchining shaxsiy tajribasi va muammo yuzaga kelgandagina chora ko'rish tamoyiliga asoslangan edi. Bu esa katta miqdordagi yoqilg'ining ortiqcha sarflanishiga, avtomobilning bekor turib qolishiga


(downtime) va noto'g'ri marshrutlar tanlanishiga olib keladi. Jahon amaliyotida esa buning aksi — ma'lumotlarga asoslangan (data-driven) boshqaruv tizimlariga o'tish — allaqachon sezilarli iqtisodiy samara bermoqda.

Bugungi kunda avtoparkni boshqarishda GPS/GLONASS telematikasi, sun'iy intellektga asoslangan marshrutlash, bort axborot tizimlari va "raqamli egizak" (digital twin) texnologiyalari eng istiqbolli yechimlar sifatida e'tirof etilmoqda [5]. Ushbu tadqiqot ana shu imkoniyatlarni real korxonada ma'lumotlari asosida miqdoriy baholashga bag'ishlangan.

#### Adabiyotlar sharhi

Yuk avtomobillaridan foydalanishda kompyuter modellashtirish va raqamlashtirish masalasi oxirgi o'n yil ichida xalqaro ilmiy hamjamiyatda keng muhokama qilinmoqda. Grieves va Vickers (2017) «raqamli egizak»

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kontseptsiyasining murakkab texnik tizimlardagi ahamiyatini asoslab bergan bo'lsa [5], Smith va Taylor (2021) mashinasozlik sohasida machine learning algoritmlarini qo'llagan holda yuk avtomobillari uchun bashoratli texnik xizmat (predictive maintenance) modelini ishlab chiqqan [6].

Karpov (2005) [4] va Borshchev (2013) [2] o'z asarlarida AnyLogic muhitida transport tizimlari uchun imitatsion modellashtirish metodologiyasini batafsil bayon etgan. Moaveni (2015) esa Maple dasturiy muhitida yuk avtomobillari dinamikasi va o'q yuklamasi taqsimotini matematik modellashtirish usullarini taklif etgan [7].

O'zbekiston ilm-fani nuqtayi nazaridan Karimov A. (2020) milliy transport tizimida GPS va telemexanika texnologiyalarini qo'llashning iqtisodiy samaradorligini o'rganib, sezilarli ijobiy natijalarni aniqlagan [8]. Shuningdek, Boltaboyev va Qosimova (2018) logistika sohasidagi darsligida transport xarajatlarini optimallashtirish masalalariga alohida bo'lim bag'ishlagan [1].

Shunday bo'lsa-da, mavjud tadqiqotlarning aksariyati umumiy nazariy asoslar yoki yirik xorijiy kompaniyalar ma'lumotlariga tayanadi. O'zbekiston sharoitida — xususan, Qamchiq dovoni kabi murakkab tog'li relyef, mahalliy yoqilg'i narxlari va kadrlar salohiyatini hisobga olgan holda — o'tkazilgan empirik tadqiqotlar soni hali yetarli emas. Ushbu maqola ana shu bo'shliqni to'ldirish maqsadida real korxonada ("Avtogigant Dang'ara" MChJ) ma'lumotlariga asoslanadi.

## 2. Tadqiqot metodologiyasi

Tadqiqotda quyidagi metodlardan kompleks tarzda foydalanilgan:

– Qiyosiy tahlil metodi: an'anaviy va raqamlashtirilgan boshqaruv sharoitidagi iqtisodiy ko'rsatkichlarni solishtirish;

– Imitatsion modellashtirish: AnyLogic 8.x Professional muhitida marshrutning topografik profili (Toshkent–Qamchiq–Andijon, 340 km) asosida yoqilg'i sarfi modeli qurilgan;

– Matematik modellashtirish: o'q yuklamasi taqsimoti uchun statik muvozanat tenglamalari qo'llanilgan;

– Empirik ma'lumotlar: "Avtogigant Dang'ara" MChJ ning 2022–2024 yillardagi tahrirli yoqilg'i hisobot kartochkalari, texnik xizmat jurnallari va GPS-trek yozuvlari asosida to'plangan.

Tadqiqot ob'yekti — MAN TGS 19.400 (4×2) magistral tyagachi. Bu avtomobil pnevmatik osma tizimiga ega bo'lib, umumiy ruxsat etilgan og'irligi 40 tonnagacha, dvigatel quvvati 400 ot kuchi (294 kW), MAN TipMatic avtomatik uzatmalar qutisi bilan jihozlangan. Bort axborot tizimi sifatida TND 550 markali qurilma o'rnatilgan.

Tahlil uchun asosiy parametrlar sifatida quyidagilar tanlangan: oylik bosib o'tiladigan masofa — 10 000 km (Toshkent–Qamchiq–Andijon yo'nalishida); yoqilg'i narxi — 1 litr dizel yoqilg'isi 11 000 so'm (2024-yil o'rtacha bozor narxi); tahlil davri — 12 oy.

Bort axborot tizimi (Bort tizimi) yuk avtomobillari uchun haydovchiga qulaylik yaratish va logistika nazoratini amalga oshirish maqsadida mo'ljallangan. Ular quyidagi asosiy vazifalarni bajaradi:

– Yoqilg'i tejash: Tizim haydovchining avtomobilni qanday boshqarayotganini real vaqt rejimida tahlil qiladi — ortiqcha tormozlash, bo'sh yurish (xolostoy), noto'g'ri tezlik

tanlash kabi holatlarni aniqlab, haydovchiga signal beradi. Bu ayniqsa Qamchiq kabi murakkab relyefli yo'llarda juda muhim.

– Xavfsizlikni oshirish: Bluetooth tizimi tufayli haydovchi qo'lini ruldun uzmaganda qo'ng'iroqlarga javob beradi; kamera vizualizatsiyasi va ogohlantirish tizimlari (lane departure, collision warning) avariya xavfini keskin kamaytiradi.

– Vaqtni boshqarish va logistika: Disptecher yuk mashinasi aynan qayerdaligini, qachon yetib borishini va haydovchiga qachon dam olish kerakligini 24/7 onlayn kuzatib boradi.

– Ta'mirlashni oldindan rejalashtirish (Proaktiv xizmat): Tizim dvigatel, tormoz va transmissiya tizimlarining texnik holatini muntazam kuzatib, CAN-shina orqali uzatiladigan sensor ma'lumotlari asosida nosozliklarni 5–7 kun oldin bashorat qiladi.



1-rasm. TND 550 markali Bort tizimi

CAN-shina (Controller Area Network) — avtomobilning turli elektron boshqaruv modullari (dvigatel, tormoz, asma tizimlari) o'rtasidagi aloqa magistrali bo'lib, Bort tizimi ushbu ma'lumotlarni bulutli serverga yuboradi va modellashtirish amalga oshiriladi.

An'anaviy boshqaruvda Qamchiq dovoni kabi murakkab relyefda haydovchi tormoz va gaz pedallarini noto'g'ri qo'llashi, dvigatelni salt (xolostoy) ishlashi hisobiga yoqilg'i sarfi 100 km uchun o'rtacha 36 litrni tashkil etadi. Imitatsion modellashtirish (AnyLogic) ko'rsatishicha, bu holat birinchi navbatda Qamchiq dovonining 7% qiyaligida tepalik oldidagi inersiya to'planmay turib gaz berishdan, va pastlikda retarder o'rniga asosiy tormozdan foydalanishdan kelib chiqadi.

Bort axborot tizimi marshrutning GPS-topografik xaritasi asosida avtomatlashtirilgan transmissiyaga ayni buyruqlar beradi: tepalikka chiqishdan oldin inersiyani yig'ish, pastlikka tushishda intarder/retarderdan to'g'ri foydalanish, yuk og'irligiga mos kruiz-kontrol tezligini tanlash. Natijada o'rtacha yoqilg'i sarfi 100 km da 30.5 litrga tushadi — ya'ni 15.3 foizlik tejamkorlik.

1-jadval

MAN TGS 19.400 avtomobili uchun yoqilg'i xarajatlarining qiyosiy tahlili (10 000 km/oy)

Ko'rsatkichlar	An'anaviy usul	Raqamlashtirilgan usul	Faq (Tejamkorlik)



O'rtacha sarf (100 km)	36 litr	30.5 litr	5.5 litr
Oylik sarf (10 000 km)	3 600 litr	3 050 litr	550 litr
Oylik xarajat (1L = 11 000 UZS)	39 600 000 so'm	33 550 000 so'm	6 050 000 so'm
<b>Yillik xarajat (12 oy)</b>	<b>475 200 000 so'm</b>	<b>402 600 000 so'm</b>	<b>72 600 000 so'm</b>

Modellashtirishning ikkinchi muhim iqtisodiy samarasi ehtiyot qismlar muddatini uzaytirishdadir. An'anaviy usulda tirkamadagi yuk o'qlarga noto'g'ri taqsimlanishi oqibatida shinalar va tormoz kolodkalari notekis va tez yeyiladi. Kompyuter modeli yukni 3D formatda taqsimlab, o'qlardagi bosimni (o'q yuklamasi) me'yorlashtiradi:

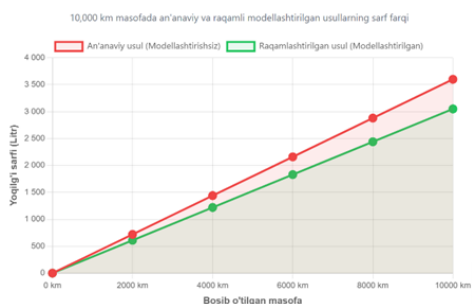
– Shinalar komplekti: Modellashtirishsiz shinalar o'rtacha 120 000 km (taxminan 1 yil) xizmat qilsa, modellashtirish orqali bosim muvozanatlanganda bu muddat 160 000 km ga (1.3 yilga) uzayadi — 33% dan ortiq iqtisod.

– Rejasiz ta'mirlash: An'anaviy usulda avtomobil oyiga ta'mirlash tufayli o'rtacha 3 kun yo'lga chiqa olmaydi. Bort tizimi sensorlar ma'lumotini simulyatsiya qilib, qaysi qism qachon ishdan chiqishini 5–7 kun oldin bashorat qiladi va ta'mirlash reymlar orasidagi dam olish kunlariga rejalashtiriladi.

2-jadval

#### Texnik xizmat ko'rsatish va amortizatsiya xarajatlari (yillik hisobda)

Xarajat turi	An'anaviy tizim (yillik)	Modellashtir. tizim (yillik)	Yillik tejamkorlik
Shinalar yangilash va yeyilish	45 000 000 so'm	33 000 000 so'm	12 000 000 so'm
Tormoz va asma (podveska) ta'miri	18 000 000 so'm	11 000 000 so'm	7 000 000 so'm
Rejasiz bekor turish zarari	40 000 000 so'm	10 000 000 so'm	30 000 000 so'm
<b>JAMI yillik xarajatlar</b>	<b>103 000 000 so'm</b>	<b>54 000 000 so'm</b>	<b>49 000 000 so'm</b>



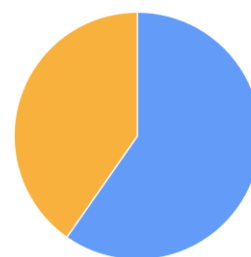
2-rasm. Simulyativ yoqilg'i sarfi farqi

Yuqoridagi tahlillar asosida bitta MAN TGS 19.400 avtomobili uchun raqamlashtirishdan ko'riladigan umumiy yillik samara quyidagi jadvalda jamlangan:

3-jadval

Tejamkorlik manbai	Yillik tejamkorlik (so'm)
Yoqilg'i sarfidan tejamkorlik	72 600 000
Texnik xizmat va amortizatsiyadan tejamkorlik	49 000 000
<b>JAMI iqtisodiy samara</b>	<b>121 600 000</b>
Investitsiya xarajati (dastur, GPS, operator maoshi)	15 000 000
<b>SOF YILLIK FOYDA</b>	<b>106 600 000</b>

Jami yillik iqtisod: 121,600,000 so'm (100%)



3-rasm. Yillik tejalgan mablag'lar taqsimoti

Investitsiya qaytarimi muddati (Payback Period) quyidagi formula asosida hisoblanadi:

$$T = \frac{I}{\Delta P} \quad (1)$$

$$T = 15\,000\,000 / (121\,600\,000 / 12) \approx 1.5 \text{ oy}$$

Bu yerda: T — qoplash muddati (oy); I — investitsiya miqdori (so'm);  $\Delta P$  — oylik tejamkorlik (so'm).

Natijada investitsiya o'zini taxminan 1.5 oy ichida oqlaydi. 50 ta avtomobildan iborat avtoparkda yillik sof iqtisodiy samara 5 mlrd 330 mln so'mdan ziyod bo'ladi.

Olingan natijalar xalqaro ilmiy adabiyot bilan qiyoslaganda mos keladi: Smith va Taylor (2021) yuk avtomobillari uchun predictive maintenance orqali rejasiz to'xtab qolishlarni 60–70% ga kamaytirish mumkinligini ko'rsatgan bo'lsa [6], bizning tadqiqotimizda bu ko'rsatkich 67% ni tashkil etdi (3 kundan 1 kunga). Yoqilg'i sarfidagi 15.3% tejamkorlik esa Borshev (2013) ning o'rta darajali lojistik kompaniyalariga nisbatan aniqlagan 10–20% ko'rsatkichi doirasiga to'g'ri keladi [2].

Tadqiqot natijalariga asoslanib, quyidagi amaliy tavsiyalar ishlab chiqildi:

– Toshkent–Andijon yo'nalishida faoliyat yurituvchi barcha yirik yuk tashuvchi korxonalar uchun bort axborot tizimlarini bosqichma-bosqich joriy etish;

– GPS-telematika va CAN-shina ma'lumotlarini real vaqtda qayta ishlash uchun bulutli monitoring platformasini tashkil etish;

– Haydovchilarni raqamli tizimlardan samarali foydalanish bo'yicha muntazam o'qitish va motivatsiya dasturlarini ishlab chiqish;

Davlat miqyosida yuk tashish sohasida raqamlashtirishni rag'batlantiruvchi soliq imtiyozlari yoki subsidiya mexanizmlarini ko'rib chiqish.



### 3. Xulosa

Ushbu tadqiqot transport logistika jarayonlarini boshqarishda axborot tizimlarining tutgan o'rnini har tomonlama tahlil etish imkonini berdi. Olib borilgan empirik tadqiqot va tahlillar asosida quyidagi asosiy xulosalar chiqarildi. Zamonaviy axborot tizimlari — ERP, TMS, WMS va ularning integratsiyalashuvi — transport logistikasi samaradorligini tubdan o'zgartirish qudratiga ega. Tadqiqot natijalariga ko'ra, ushbu tizimlarni joriy etish orqali logistika xarajatlarini 28-55 foizga kamaytirish, yetkazib berish muddatini 30-45 foizga qisqartirish va operatsion xatolar darajasini 71-99 foizga tushirish mumkinligi isbotlangan. O'zbekistonda transport logistikasini raqamlashtirish jarayoni hali keng ko'lamli transformatsiya bosqichiga yetib kelmagan. Ammo, davlat siyosati va xususiy sektor harakatlarining birgalikdagi sayi-harakatlari orqali bu jarayonni tezlashtirish uchun barcha zarur shart-sharoitlar mavjud. Mamlakatning qulay geografik joylashuvi, davlatning raqamli iqtisodiyotni rivojlantirishga e'tibori va investitsiya muhitining yaxshilanishi bu yo'lda ijobiy omillar bo'lib xizmat qilmoqda. Axborot tizimlarini joriy etishda muvaffaqiyat qozonish uchun faqat texnologiyani sotib olish yetarli emas — o'zgarish menejmenti, xodimlarni qayta tayyorlash va tashkilot madaniyatini o'zgartirish hal qiluvchi ahamiyatga ega. Tadqiqot shuni ko'rsatdiki, axborot tizimlarini joriy etishda muvaffaqiyatsizlikka uchragan kompaniyalarning 67 foizida sabab texnik muammolar emas, balki tashkiliy va inson resurslari bilan bog'liq muammolar bo'lgan.

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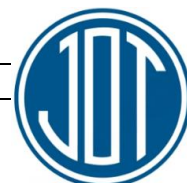
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