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MODELLING MAINTENANCE INTERVALS AND ROADSIDE SERVICE FACILITY SPACING FOR INTERNATIONAL ROAD TRAINS ON THE TRANSIT CORRIDORS OF UZBEKISTAN

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Abstract. International road trains operating on the transit corridors of Uzbekistan cover 3–7 thousand km per trip and pass through segments of different road categories, mountain passes, settlements, border crossings and climatic zones. The current normative approach assigns a single operating-condition category to a vehicle and therefore either overstates or understates the required frequency of maintenance. This paper develops a theoretical framework for the technical service of such vehicles. First, a complex coefficient of transit operating conditions K_{tr} is proposed as the product of length-weighted coefficients of road category and climate and an idle-time coefficient that converts engine operation at border queues into equivalent mileage. Second, the maintenance interval is made a multiple of the round-trip length so that scheduled maintenance always falls between trips at the carrier's base, and the semi-trailer interval is synchronised with that of the tractor. Third, the interval of individual elements is chosen as the smaller of a reliability-based limit (Weibull model) and a cost-optimal value that accounts for the high cost of a failure on the road. Fourth, the spacing of roadside service facilities is derived from the driving-time rules of the AETR and from the failure-flow parameter. For the Andijan – Ivanovo route (round trip 7 230 km) K_{tr} = 0.850, which gives maintenance every 7 trips (50 610 km) for a 60 000 km base interval. For the measured corridor speed of 46.1 km/h, the distance between full-service "Service area" facilities must not exceed 207 km, with about 100 km recommended. Microsimulation in PTV Vissim shows that a 150 m parking lane adjoining the carriageway reduces flow speed by 38.7 % on two-lane and 49 % on three-lane roads once traffic volume exceeds 1 500 and 3 000 veh/h, respectively.

Keywords: transit corridor, international road train, maintenance interval, operating conditions, Weibull distribution, preventive replacement, roadside service, Service area, AETR, PTV Vissim.

Introduction. Uzbekistan is a double-landlocked country, and road transport carries the bulk of its foreign trade and transit cargo between China, the Russian Federation, the European Union, South Asia and the Middle East. The Concept for the development of the transport and logistics system until 2030, approved by Presidential Resolution PQ-28 of 27 January 2025, sets the target of increasing transit cargo from 13.9 to 22 million tonnes, doubling international road freight and building about 400 modern roadside service facilities along roads of international and national significance, including 82 "Service area" and "Service point" facilities listed in Annex 4 of the resolution [1]. The CAREC corridor performance monitoring shows that the average speed of trucks without delay (SPWOD) on Uzbek corridor sections is 46.1 km/h, which is noticeably below the design speed of trunk roads and reflects the combined effect of road condition, settlements, checkpoints and the lack of equipped

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stopping places [2]. International comparisons of logistics performance also emphasise that the quality of trade- and transport-related infrastructure is decisive for landlocked countries [3].

The transit road network of the republic, its traffic safety problems and the development of world transport networks were analysed in the author's earlier works [4, 5]. The features of foreign practice in organising truck services on international highways [6] and the first results of designing a service infrastructure for international freight trucks on transit corridors [7] together with software tools for freight transport calculations registered by the author and colleagues [8, 9], showed that the existing system of technical service in Uzbekistan was formed for urban and local transport and does not reflect the specific conditions of international road trains.

The normative basis for maintenance (TO) of heavy vehicles in the CIS remains the Regulation on maintenance and repair of rolling stock [10], in which TO-1 and TO-2 intervals, mileage to overhaul and labour intensity are given for operating-condition category I and moderate climate and are corrected by coefficients K_1 (category), K_2 (modification) and K_3 (climate) [10–12]. The method assumes that a vehicle works in one category during its entire life. An international road train, however, crosses level trunk roads, mountain passes and settlements within one trip, spends hours at border crossings with the engine running, and passes several climatic zones. A single coefficient chosen "for safety" for the worst segment shortens the interval and increases downtime; a coefficient chosen for the dominant segment ignores the wear accumulated on difficult segments and at idle. In addition, modern tractors (MAN, DAF, VOLVO, Mercedes-Benz) are serviced according to manufacturer service books that are not adapted to the road and climatic conditions of Central Asia.

The second problem is the location of roadside facilities. Russian methodology RSN 62-86 and GOST 33062-2014 regulate the composition and placement of roadside service objects mainly from the point of view of the road owner [13, 14], while the EU TEN-T guidelines require parking spaces on motorways approximately every 100 km [15] and specify the level of service and security of safe and secure truck parking areas [16]. None of these documents links the spacing of facilities with the reliability of vehicles and the actual driving-time regime of the crew on a given corridor.

The **aim** of this study is to develop a set of models that (i) adjust the maintenance interval of an international road train to variable transit conditions, (ii) choose the interval of individual elements from reliability and cost criteria, and (iii) justify the spacing of roadside service facilities and their layout relative to the carriageway. The models form the theoretical basis of a three-level technical service system (Fig. 1) in which the carrier's base, the "Service area" complexes and the "Service point" facilities are connected by predictive diagnostics.

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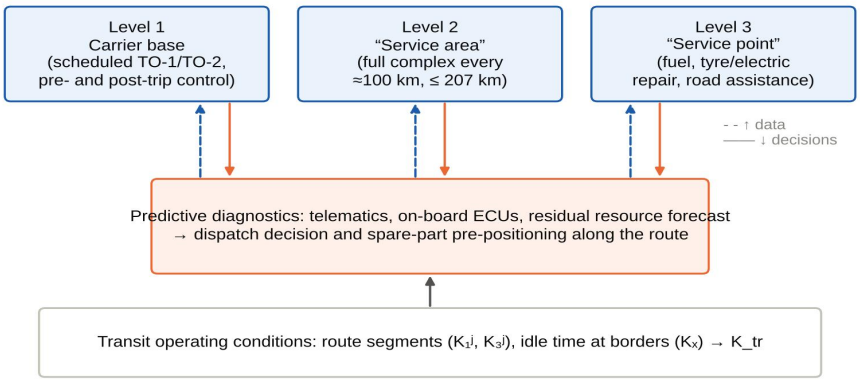


Fig. 1. Structure of the proposed three-level technical service system for international road trains

Literature review. The regularities of changes in the technical condition of vehicles and the principles of the planned preventive maintenance system were formulated by E.S. Kuznetsov, G.V. Kramarenko, V.M. Mikhlin and their schools [11, 12, 17, 18]. Kuznetsov showed that the interval of an operation can be determined by the admissible level of failure-free probability or by the minimum of specific costs [11, 12]; Mikhlin developed methods for forecasting the residual life of a machine from a diagnostic parameter [18]. The statistical description of component life by the Weibull distribution goes back to W. Weibull [19], and the age-replacement policy that balances the cost of preventive replacement against the cost of failure was formalised by R.E. Barlow and F. Proschan [20] and developed by I. Gertsbakh [21] and A.K.S. Jardine and A.H.C. Tsang [22]. Reviews of condition-based maintenance and remaining-useful-life prognostics [23, 24] and the work of R. Prytz et al., who predicted the need for compressor repair of Volvo trucks from on-board data [25], show that telematics allows the interval to be refined for each vehicle.

In Uzbekistan the problems of technical exploitation and design of motor transport enterprises are covered in the textbooks of Q.M. Sidiqnazarov, M.A. Nurdinov and I.B. Asqarov [26–28]; Q.M. Sidiqnazarov also edited the Uzbek edition of the textbook by E.S. Kuznetsov and co-authors, which made the methods of correcting maintenance standards available to Uzbek engineers, and summarised the organisation of car service [27, 29]. V.A. Topalidi and U.B. Yusupov showed for quarry trucks that resource norms for tyres must be corrected by coefficients reflecting the specific road conditions in which a vehicle actually works [30, 31]; S.S. Ortiqov proposed a model of component life for passenger cars that takes into account variation and recovery coefficients, road surface and operating conditions [32]. These works, however, consider one category of conditions per vehicle and do not address international road trains.

The location of service facilities is usually formulated as the p-median problem of S.L. Hakimi [33] or the maximal covering location problem of R. Church and C. ReVelle [34]; M.S. Daskin summarised these models for network applications [35]. For a linear corridor the controlling constraint is the driving time of the crew: the AETR and Regulation (EC) 561/2006 require a break of at least 45 min after 4.5 h of driving and limit daily driving to 9 h [36, 37]. The influence of stopping places on traffic flow is described by the theory of traffic flows [38] and by the Highway Capacity Manual [39]; microscopic simulation in PTV Vissim, based on the psycho-physical car-following model of R. Wiedemann [40–42], allows the effect of a specific roadside layout to be evaluated before construction.

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The literature therefore provides the elements of the solution but not their combination for a vehicle whose trip crosses several categories of conditions and whose maintenance must be performed between trips. The author's experimental study of the operating features of trucks on transit routes [43, 44] confirmed that the conditions change substantially along the route; this motivated the models presented below.

Methods.

Demand for roadside service. The demand for a roadside facility is generated by the moving flow of trucks rather than by a local fleet. The average daily number of requests on a segment of length ℓ is

$$Z = N_{tr} \cdot (p_d + p_f + \omega \cdot \ell / 1000 + p_c) \quad (1)$$

where N_{tr} is the number of international trucks passing the segment per day; p_d is the probability that a mandatory break or daily rest falls on this segment; p_f is the probability of refuelling; ω is the flow parameter of failures that require roadside assistance, failures per 1000 km; p_c is the probability of a planned control-diagnostic stop. The break probability is

$$p_d = min(1;\ \ell / (v_{av} \cdot t_d)) \quad (2)$$

where v_{av} is the average speed on the route and $t_d = 4.5$ h is the admissible continuous driving time [36, 37]. Arrivals at a facility are treated as a Poisson flow and service times as exponential, so the facility with n working bays is an M/M/n system with load factor $\rho = \lambda/(n\mu)$, $\mu = 1/t_s$. The probability of waiting and the mean waiting time are given by the Erlang C formula [45]:

$$P_w = [(n\rho)^n / (n!(1 - \rho))] \cdot P_0, \quad W_q = P_w / (n\mu - \lambda) \quad (3)$$

The required number of bays is the smallest n for which $\rho < 1$ and $W_q \le W_{adm}$. This part of the model is applied to the design of a service complex in a companion paper.

Complex coefficient of transit operating conditions. In the normative method the calculated interval of TO-1 and TO-2 is $L_i = L_i^n \cdot K_1 \cdot K_3$, and the mileage to overhaul is $L_{KT} = L_{KT}^n \cdot K_1 \cdot K_2 \cdot K_3$ [10, 11]. The coefficients are reproduced in Table 1; climatic zones are assigned according to GOST 15150-69 [46].

Table 1.

Correction coefficients of maintenance standards [10, 11]

Operating conditions / coefficient	Maintenance interval	Specific labour intensity of current repair	Mileage to overhaul
K_1: category I	1.0	1.0	1.0
K_1: category II	0.9	1.1	0.9
K_1: category III	0.8	1.2	0.8
K_1: category IV	0.7	1.4	0.7

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Operating conditions / coefficient	Maintenance interval	Specific labour intensity of current repair	Mileage to overhaul
K_1: category V	0.6	1.5	0.6
K_2: tractor unit	–	1.10	0.95
K_3: moderate climate	1.0	1.0	1.0
K_3: hot dry climate	0.9	1.1	0.9

For a trip consisting of m segments of length ℓ_j we introduce length-weighted coefficients:

$$K_1^{tr} = \Sigma_{j=1}^{m} (\ell_j / L_r) \cdot K_{1j}, \quad K_3^{tr} = \Sigma_{j=1}^{m} (\ell_j / L_r) \cdot K_{3j} \tag{4}$$

where $L_r = \Sigma \ell_j$ is the trip length and K_{1j}, K_{3j} are the category and climate coefficients of segment j. During border formalities and in queues the engine runs while mileage does not increase, yet oil, filters and many engine systems continue to wear. This is taken into account through an equivalent mileage $L_e = L_r + k_x \cdot t_x$, where t_x is the engine idle time per trip and k_x is the mileage equivalent to one hour of idling (km/h), determined from oil and filter degradation. The idle-time coefficient and the complex coefficient are

$$K_x = L_r / L_e = 1 / (1 + k_x \cdot t_x / L_r), \quad K_{tr} = K_1^{tr} \cdot K_3^{tr} \cdot K_x \tag{5}$$

and the transit interval is $L_i^{tr} = L_i^n \cdot K_{tr}$, where L_i^n is the base interval of the manufacturer's service book.

Trip-multiple interval and tractor–semi-trailer synchronization. Performing TO-1 or TO-2 of an international road train on the road is undesirable: it adds downtime, depends on the availability of a suitable workshop abroad and reduces quality control. The interval is therefore made a multiple of the trip length:

$$L_i^q = n_r \cdot L_r, \quad n_r = [L_i^{tr} / L_r] \tag{6}$$

where [ ] denotes the integer part and n_r is the number of trips between maintenance events. Rounding down guarantees that the safety-related interval is never exceeded. The semi-trailer interval is synchronised with the tractor:

$$L_i^{st,q} = k \cdot L_i^q, \quad k = [L_i^{st,tr} / L_i^q] \geq 1 \tag{7}$$

so that the semi-trailer is serviced together with every k-th maintenance of the tractor and the road train is not withdrawn twice.

Interval of individual elements: reliability and cost criteria. The life of a component is a random variable described by the two-parameter Weibull distribution [19]:

$$F(L) = 1 - \exp[-(L/a)^b], \quad R(L) = \exp[-(L/a)^b] \tag{8}$$

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where a is the scale parameter (thousand km) and b is the shape parameter. The mean life and the coefficient of variation are

$$\bar{L} = a \cdot \Gamma(1 + 1/b), \quad v = \sqrt{[\Gamma(1 + 2/b) - \Gamma^2(1 + 1/b)]} / \Gamma(1 + 1/b) \tag{9}$$

For safety-related elements (brakes, steering, coupling devices) the interval is set by the admissible failure-free probability R_0:

$$L_R = a \cdot (-\ln R_0)^{1/b} \tag{10}$$

For other elements the interval minimises the cost per unit of mileage under an age-replacement policy [20–22]:

$$C(L) = [C_p \cdot R(L) + C_f \cdot F(L)] / \int_0^L R(x)\,dx, \quad dC/dL = 0 \tag{11}$$

where C_p is the cost of preventive replacement at the base and C_f is the cost of a failure, including towing, downtime of the vehicle and the crew and penalties for late delivery. On a transit route C_f is several times higher than the cost of the same repair at the base. The final interval is

$$L_{el} = \min(L_R;\ L_{opt}) \tag{12}$$

after which it is brought to transit conditions by K_{tr} and rounded to a trip multiple by (6). Operations with different intervals are grouped into TO-1, TO-2 and seasonal service by moving each operation to the nearest smaller multiple of the base interval.

Spacing of roadside service facilities. The first constraint is the driving-time regime. A break must be taken in a safe, equipped place, so the distance between facilities must not exceed the distance covered before the mandatory break:

$$\ell_{AETR} \le v_{SPWOD} \cdot t_d \tag{13}$$

where v_{SPWOD} is the actual average speed on the corridor. The second constraint is technical: with failure-flow parameter ω the probability of at least one failure requiring assistance on a segment of length ℓ is $P(\ell) = 1 - \exp(-\omega \cdot \ell/1000)$, and the condition $P(\ell) \le P_{adm}$ gives

$$\ell_{tech} \le -1000 \cdot \ln(1 - P_{adm}) / \omega \tag{14}$$

For the road-assistance "Service point" the response time t_a of the assistance vehicle travelling at v_a is limited:

$$\ell_{SP} \le 2 \cdot v_a \cdot t_a \tag{15}$$

and the spacing of "Service area" complexes is $\ell_{SA} = \min(\ell_{AETR};\ \ell_{tech})$. The exact position of a facility within a segment is selected by the maximal covering model [34, 35], in which border-crossing approaches, foot and top of mountain passes, logistics centres and city bypasses are the demand points.

Data and simulation set-up.

The models were applied to the main route of the carriers "Vodiy Bars Trans Elit" LLC and "Bobirmirzo Hamkor Trans" LLC (Andijan): Andijan – Tashkent – Shymkent – Kyzylorda – Aktobe – Orenburg – Samara – Ulyanovsk – Nizhny Novgorod – Ivanovo. The one-way distance is about 3 610 km: Andijan – Tashkent along the A373 through the Kamchik pass about 330 km, Tashkent –

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Samara 2 335 km [47], Samara – Ivanovo 948 km [48]. The round trip is $L_r \approx 7\,230$ km. The lengths of mountain and settlement segments were estimated from the map (Table 2, Fig. 2).

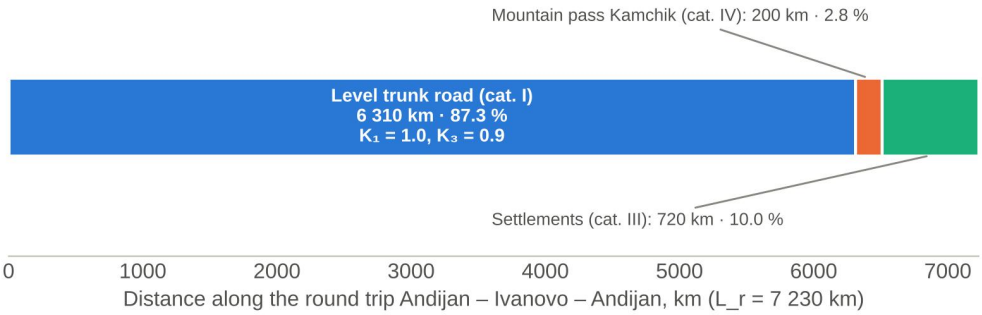


Fig. 2. Structure of the Andijan – Ivanovo – Andijan round trip by operating-condition categories

The impact of a parking lane adjoining the carriageway was studied in PTV Vissim 2021 (academic licence) [42]. Two- and three-lane carriageways with a parallel 150 m parking lane were modelled; traffic volume was increased stepwise, and speed, lost time, emissions and excess fuel consumption were recorded in the zone of the parking lane.

4. Results

4.1. Complex coefficient and maintenance interval for the Andijan – Ivanovo route

The segment data and the calculation of the weighted coefficients are given in Table 2.

Table 2.

Route segments of the Andijan – Ivanovo – Andijan trip and weighted coefficients

Segment type	Length ℓ_j, km	Share ℓ_j/L_r	K_{1j}	K_{3j}
Level trunk road (category I)	6 310	0.873	1.0	0.9
Mountain segment, Kamchik pass, both directions (category IV)	200	0.028	0.7	1.0
Settlements and city transits (category III)	720	0.100	0.8	0.9
Total L_r	7 230	1.000	$K_1^{tr} = 0.972$	$K_3^{tr} = 0.903$

By (4), $K_1^{tr} = 0.873 \cdot 1.0 + 0.028 \cdot 0.7 + 0.100 \cdot 0.8 = 0.972$ and $K_3^{tr} = 0.873 \cdot 0.9 + 0.028 \cdot 1.0 + 0.100 \cdot 0.9 = 0.903$. With four border crossings per round trip (Uzbekistan – Kazakhstan and Kazakhstan – Russia in both directions), idle time $t_x = 8$ h and $k_x = 30$ km/h, $K_x = 1/(1 + 30 \cdot 8/7230) = 0.968$. Hence

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$$K_{tr} = 0.972 \cdot 0.903 \cdot 0.968 = 0.850 \quad (16)$$

For a base interval L^n = 60 000 km, L^{tr} = 51 000 km and, by (6), n_r = [51 000/7 230] = 7 trips, i.e. L^q = 50 610 km. With two round trips per month the road train receives TO at its home base roughly every 3.5 months, always between trips. Figure 3 compares the proposed approach with the conventional single-category assumptions: if the whole trip is treated as category IV (K = 0.7·0.9 = 0.63), the interval is unjustifiably shortened by 37 % (37 800 km); if it is treated as category I (K = 0.9), the interval is shortened by only 10 % (54 000 km) and the wear accumulated on the pass and at the borders is ignored.

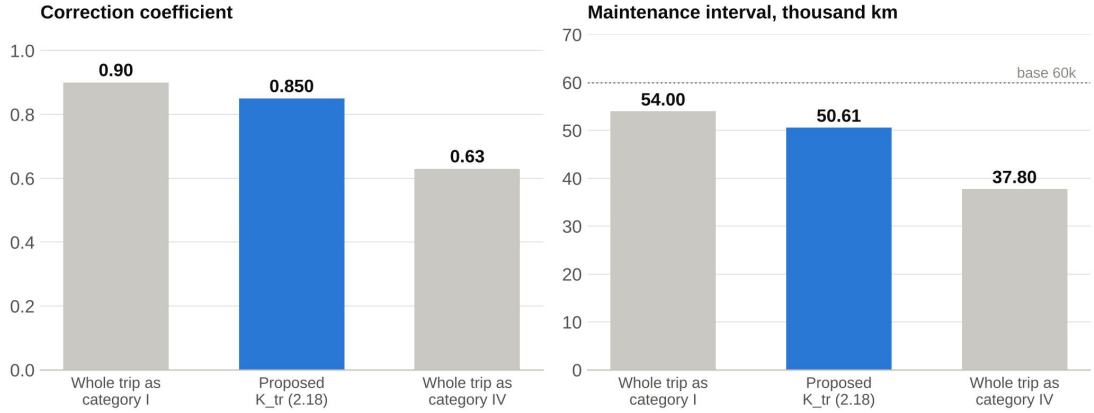


Fig. 3. Comparison of approaches to the correction of the maintenance interval (base interval 60 000 km)

4.2. Element intervals: reliability versus cost

Figure 4 shows R(L) for a = 150 thousand km and different shape parameters. For b = 2.5 (v = 0.43) the mean life is 133.1 thousand km, while the interval that ensures R_0 = 0.90 is 61.0 thousand km and for R_0 = 0.95 it is 45.7 thousand km. The larger b (the smaller v), the closer the safe interval is to the mean life and the more effective scheduled replacement is. For b ≈ 1 failures are random and scheduled replacement is pointless; such elements (electronic control units, sensors) must be replaced according to diagnostics.

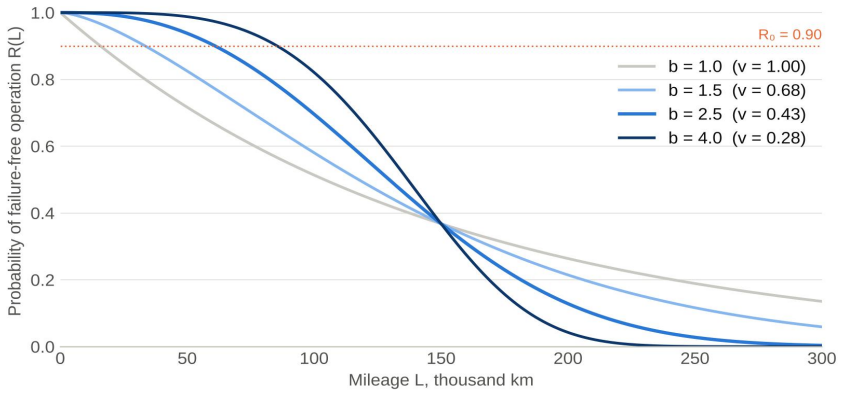


Fig. 4. Influence of the Weibull shape parameter on the probability of failure-free operation (a = 150 thousand km)

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The specific cost function (11) is shown in Fig. 5. With $C_f/C_p = 2$ the optimum is flat and lies at about 133 thousand km; with $C_f/C_p = 5$ the optimum moves to about 74 thousand km and with $C_f/C_p = 10$ to about 53 thousand km. Thus, the higher the cost of a failure on the road compared with the base, the shorter the cost-optimal interval. For transit operation, where a failure abroad involves towing, crew and vehicle downtime and contractual penalties, the cost criterion can become more restrictive than the reliability criterion for elements that are not directly related to safety.

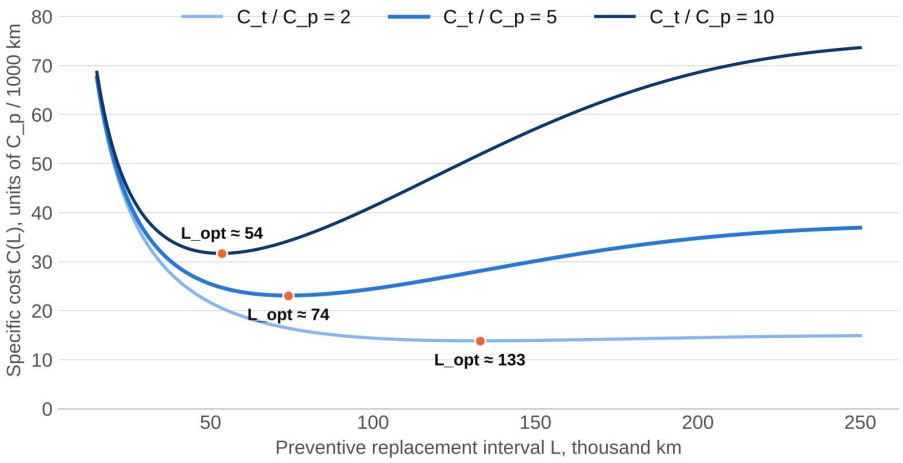


Fig. 5. Specific cost versus preventive replacement interval (a = 150 thousand km, b = 2.5)

4.3. Spacing of roadside facilities

With the measured corridor speed $v_{SPWOD} = 46.1$ km/h [2], condition (13) gives $\ell_{AETR} \leq 46.1 \cdot 4.5 \approx 207$ km. If the design speed of 70 km/h were used, the result would be 315 km, but it is the measured speed that determines how far a crew gets within its driving time. To allow the driver to choose the stopping place, two consecutive facilities should be within the break distance, i.e. $\ell \approx \ell_{AETR}/2 \approx 100$ km, which coincides with the TEN-T requirement [15]. The technical condition (14) is evaluated in Table 3 and Fig. 6.

Table 3.

Maximum spacing of facilities by the technical condition ℓ_{tech}, km

ω, failures/1000 km	$P_{adm} = 0.05$	$P_{adm} = 0.10$	$P_{adm} = 0.20$
0.05	1 026	2 107	4 463
0.10	513	1 054	2 231
0.20	256	527	1 116
0.30	171	351	744
0.50	103	211	446

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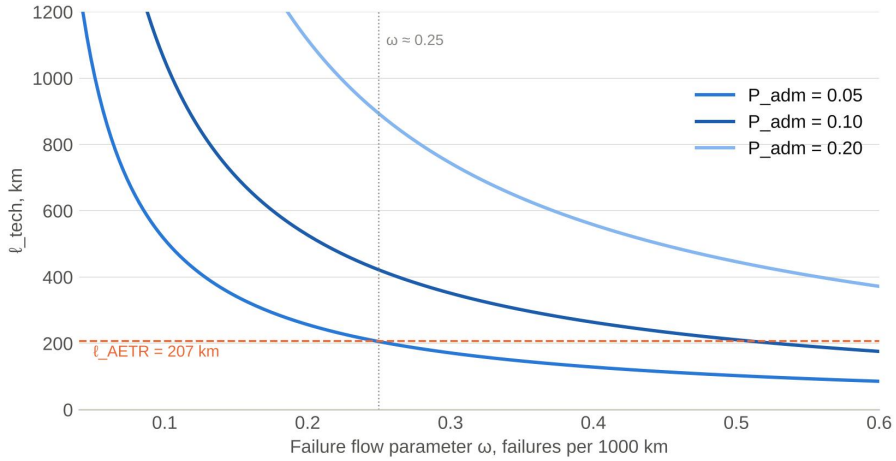


Fig. 6. Maximum facility spacing by the technical condition versus failure-flow parameter

For $\omega < 0.25$ failures/1000 km ($P_{adm} = 0.05$) the technical condition is softer than the driving-time condition, and the spacing is governed by ℓ_{AETR}. For a fleet in poor technical condition or on mountain segments ω increases and the technical condition becomes decisive, so facilities must be placed more densely. For road assistance, (15) with $v_a = 60$ km/h gives $\ell_{SP} \leq 120$ km for $t_a = 1$ h and $\ell_{SP} \leq 60$ km for $t_a = 0.5$ h. The average of 47 km of international roads per roadside facility envisaged by PQ-28 [1] therefore corresponds to the "Service point" level and ensures assistance within half an hour.

Applied to the A373 road (399 km), the driving-time limit requires at least two and the recommended scheme three to four "Service area" complexes. One of them should be located in Andijan region in front of the "Dustlik" border crossing, where trucks awaiting border formalities accumulate and which is the largest demand point; service stops before and after the Kamchik pass are needed for brake checks and engine cooling. The three facilities planned for Andijan region by PQ-28 [1] are recommended to be organised as one "Service area" (at the border) and two "Service points".

Effect of roadside parking on traffic flow. The simulation results are summarised in Fig. 7 and Table 4. On a two-lane carriageway the flow speed in the zone of the parking lane remains practically constant (52.5–51.7 km/h) up to 1 500 veh/h, falls to 41.9 km/h at 1 800 veh/h and to 32.2 km/h at 2 000 veh/h, i.e. by 38.7 %. On a three-lane carriageway the speed stays at 62.7–61.7 km/h up to 3 000 veh/h and drops to 34.2 and 32.0 km/h at 3 500 and 4 000 veh/h, i.e. by 49 %.

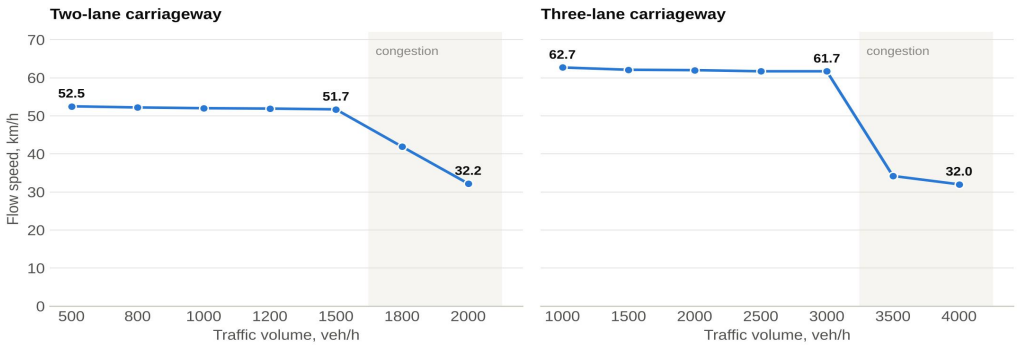


Fig. 7. Flow speed in the zone of a 150 m parking lane adjoining the carriageway (PTV Vissim)

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Table 4. **Threshold traffic volumes and speed reduction caused by a 150 m adjoining parking lane**

Carriageway	Stable speed, km/h	Threshold volume, veh/h	Speed reduction at maximum volume, %
Two lanes	52.5–51.7	1 500	38.7
Three lanes	62.7–61.7	3 000	49.0

Discussion. The proposed complex coefficient differs from the normative approach in three respects. First, it reflects the actual structure of the route: for the Andijan – Ivanovo trip more than 87 % of the distance is covered on favourable trunk roads, so treating the whole trip by the category of the mountain segment in Andijan region would shorten the interval by 37 % without justification. Second, it accounts for the wear that occurs without mileage at border crossings; the idle-time coefficient alone reduces the interval by about 3 % for 8 h per trip, and the effect grows with longer queues. Third, it is linked to the organisation of work: the trip-multiple interval (6) moves TO to the home base, where quality and spare parts are guaranteed, and synchronisation (7) eliminates a separate withdrawal of the semi-trailer. In contrast to the model of S.S. Ortiqov for passenger cars [32], the proposed model includes variable conditions along the trip (4), engine idle time (5), the trip-multiple condition (6) and the coupling of tractor and semi-trailer (7). The approach is close in spirit to the correction of tyre mileage norms by road category proposed by V.A. Topalidi and co-authors for specialised vehicles [30, 31] and to their conclusion that maintenance support must be planned as part of the logistics of transportation [49].

The cost criterion (11) explains why carriers on long international routes tend to replace brake linings, filters and tyres earlier than the service book requires: the cost of a failure abroad is several times higher than the cost of preventive replacement. The model makes this practice quantitative and separates elements for scheduled replacement ($v < 0.33$), combined replacement based on diagnostics ($0.33 \le v \le 0.5$) and condition-based replacement ($v > 0.5$) [11].

For facility spacing, using the measured speed of 46.1 km/h instead of the design speed is essential; on corridors where border delays are reduced and the average speed grows, ℓ_{AETR} increases proportionally, so the spacing should be reviewed together with CAREC monitoring data. The simulation results confirm the requirements of GOST 33062-2014 and the EU standard for safe and secure parking areas [14, 16]: parking of trucks directly on the shoulder or on a lane adjoining the carriageway is unacceptable on corridors with heavy traffic. Because a road train needs more time and distance to enter and leave a parking lane than a passenger car, the threshold volumes obtained for a mixed flow are upper bounds for transit roads with a high share of heavy vehicles.

The study has limitations. The lengths of mountain and settlement segments were estimated from the map and should be refined with GPS tracks; the coefficient $k_x = 30$ km/h was assumed and must be determined from oil analysis and telematics data; the Weibull parameters in Section 4.2 illustrate the method and are to be estimated for each component from the carrier's replacement records. These parameters are being collected in the course of the experimental part of the research [43, 44].

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Conclusions.

1. A model of demand for roadside service on a transit segment is proposed in which requests are formed by the passing flow of trucks through the probability of a mandatory break, refuelling, failures on the road and planned control stops; the number of working bays is determined by the M/M/n model from the admissible waiting time.

2. A complex coefficient of transit operating conditions K_{tr} is proposed, which combines length-weighted coefficients of road category and climate with an idle-time coefficient. For the Andijan – Ivanovo route (L_r = 7 230 km) K_1^{tr} = 0.972, K_3^{tr} = 0.903, K_x = 0.968 and K_{tr} = 0.850, compared with 0.63–0.90 under single-category assumptions.

3. The trip-multiple condition and tractor–semi-trailer synchronisation move scheduled maintenance to the carrier's base between trips; for a 60 000 km base interval TO is performed every 7 trips (50 610 km).

4. The interval of an element is taken as the smaller of the reliability limit and the cost-optimal value; with a = 150 thousand km and b = 2.5 the cost-optimal interval falls from about 133 to 74 and 53 thousand km as the cost ratio C_f/C_p increases from 2 to 5 and 10.

5. The spacing of "Service area" complexes on Uzbek corridors must not exceed 207 km, with about 100 km recommended; "Service point" facilities spaced at 60–120 km provide road assistance within 0.5–1 h. For the A373 road three to four "Service area" complexes are required, one of them at the "Dustlik" border crossing.

6. A 150 m parking lane adjoining the carriageway reduces flow speed by 38.7 % on two-lane and by 49 % on three-lane carriageways when traffic exceeds 1 500 and 3 000 veh/h; service facilities on transit roads must therefore be separated from the carriageway and provided with deceleration and acceleration lanes and one-way circulation.

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