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ANALYSIS OF THE TRAFFIC INTENSITY OF CARGO VEHICLES IN THE BORDER POINTS

Summary. The present work reviews the border checkpoints in Bulgaria and their work for one year. On the basis of collected information, the seasonal inconsistency of work at the border checkpoints is assessed and their work is modeled as a mass service system (queuing system or theory) to assess capacities to a specific point in the existing infrastructure and organization of work. Capacity of border crossing point is defined as the time for stay of heavy goods vehicles at different incoming flows as well as the limit value of the number of cars that can be handled. For the calculation of the parameter values, an application in a MatLab environment was created. A fractional rational function of the fourth degree is chosen as a numerator and denominator.

1. INTRODUCTION

Transport is an important element of the international trade activities of a country. The integration of the country into the European reach has led to a significant increase in the traffic on the main road directions. Effective and sustainable integration of the national road infrastructure into the European purpose improves coexistence and the relations between the Republic of Bulgaria and other EU Members, while at the same time, sets new challenges in terms of its construction, maintenance and optimization.

The relatively high share of road transport in the size of transport work on import and export as well as the indicated increase in the size of transport work is the premise for the envisaged increase in the number of border checkpoints already during the preparation period for accession of the country to the EU [6].

The border checkpoints (BCPs) are detached territories with a special transmission mode and security that only permit the crossing of the state border unless otherwise provided in an international contact.

The railway, rail and river border checkpoints are determined by agreement with the state bordering the Republic of Bulgaria. The opening, defining of the state borders, the expansion and the closure of the border checkpoints are performed by an act of the Council of Ministers. The work organization of the border checkpoints is built on the principle of integrated border control in order to facilitate the passage and increase of the crossing possibilities of the border crossings.

The technological sequence for processing the inbound and outbound traffic of trucks and their drivers when carrying out the border control at the border checkpoints is regulated by a by-law and is as follows:

• For traffic entering the Republic of Bulgaria:
- Entry at border checkpoints: customs control;
- Border control of goods of animal origin and feed: Border veterinary inspection post;
- Border inspection for veterinary control;

- Border Phytosanitary Control of Goods of Plant Origin: National Plant Protection Service;
- State border health control of raw materials and food of non-animal origin: Regional inspections for protection and control of public health;
- Payment of state fees and fines;
- Exit from BCP and entry into the country: customs control.

• By outbound traffic from the country:

- Entry at border checkpoints: customs control;
- Payment of state fees and fines;
- Exit from the border checkpoint and exit from the country: customs control.

A number of authors have worked in the area of optimization of work at border checkpoints [3-4, 7-8]. One of the known related studies has been done by Hsu et al [4]. This study considered the treatment of imported goods in an air terminal. After a system flow survey, a mathematical model was formulated to describe the delays in the customs clearance process and the impact on the delay of arrival of the cargo to the destination. The result of the work of cargo terminal is evaluated and analyzed based on the created model. It is proposed to introduce the RFID system, which reduces the time for processing the load. Although the work is for an air terminal, regarding a border checkpoint, it is similar.

By 2018, there are 37 border checkpoints in Bulgaria. The total number of points for heavy goods vehicles is 21.

The practice is to observe large queues of trucks at the border checkpoints. The reasons are different: poor interaction between the internal government services; poor international interaction with the respective neighboring state or with a third country; insufficient bandwidth of border checkpoints; poor organization of work; in some cases not using capacity capabilities of border checkpoints; and technical reasons, for example, problems with the information systems.

Assessing capacities at border checkpoints may provide preliminary information on the possible marginal number of processed cars and the waiting times for available infrastructure and work experience. The lack of a methodology for such an assessment does not allow pre-planning. In this publication, based on the collected information, the seasonal inconsistency of work at the border checkpoints is assessed, and their mass service system (queuing system or theory) work is modeled. The time for vehicles to stay at different incoming flows is determined, as well as the limit value of the number of cars that can be handled.

2. EXPOSITION

After the accession of the Republic of Bulgaria to the EU, the flow of goods through its borders has increased considerably owing to an increase of imports and exports (Table 1) as well as owing to transit flows across the country [2].

Table 1

Total import - export, gross weight / thousand tons /

Year	2010	2011	2012	2013	2014	2015	2016	2017
IMTERNACIONAL TRAMSPORT	Total (Thousand tones)							
Lorries up to 7.5 t	11.4	29.7	-	17.4	92.4	117.2	27.5	35.4
Lorries up to 7.5 t to 15 t	-	113.7	79.2	119.9	55.1	17.7	66.9	109.3
Lorries up to 15 t to 17 t	2.1	-	17.7	5.1	10.0	1.2	22.2	14.0
Lorries up to 17 t to 25 t	188.3	325.9	390.2	214.1	198.8	380.2	420.9	175.1
Lorries up to 25 t and more	1385.5	1442.3	2327.6	2020.2	1365.4	1676.9	1608.3	1551.3
Road tractors	11155.2	12710.4	16204.0	20433.4	18586.1	26401.2	32739.8	32837.5
Total	12742.5	14623.0	19018.7	22810.1	20277.8	28594.4	34885.6	34722.6

Bulgaria's main trading partner in recent years is the EU, with more than half of the country's exports and imports being levied with the Member States (Table 2).

Table 2

Exports and imports by groups of countries

Year	2013	2014	2015	2016
Export	43559.2	43233.5	44949.5	46110.3
of which				
CIS	2383.6	1881.7	1431.1	1018.4
OECD	5619.8	5558.5	5466.7	4943.4
EU	26111.1	26921.1	29049.4	311153.1
EFTA	381.1	311.0	224.2	159.6
Import	50515.4	51097.4	51549.0	51027.9
of which				
CIS	10781.1	9047.1	7308.1	5599.1
OECD	4495.3	4386.3	4576.3	4755.3
EU	30164.7	31512.3	33157.2	33938.5
EFTA	419.2	376.2	413.5	426.1

CIS includes Azerbaijan, Armenia, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russian Federation, Tajikistan, Turkmenistan, Uzbekistan and Ukraine.

The OECD includes Australia, the US Virgin Islands, Iceland, Canada, Mexico, New Zealand, Norway, the Republic of Korea, the United States, Turkey, Switzerland, Japan, Israel and Chile.

Croatia has been included in the EU since 1.07.2013

EFTA includes Norway, Switzerland, Iceland and Liechtenstein.

The percentage ratio of the quantity of goods transported on import and export by types of transport in 2017 is shown in Fig. 1. After sea transport (with a relative share of 62%), the largest amount of goods transported on import and export is by road transport. The quantity of goods transported by road transport is more than twice the freight carried by rail transport and almost four times more than the goods transported by river transport.

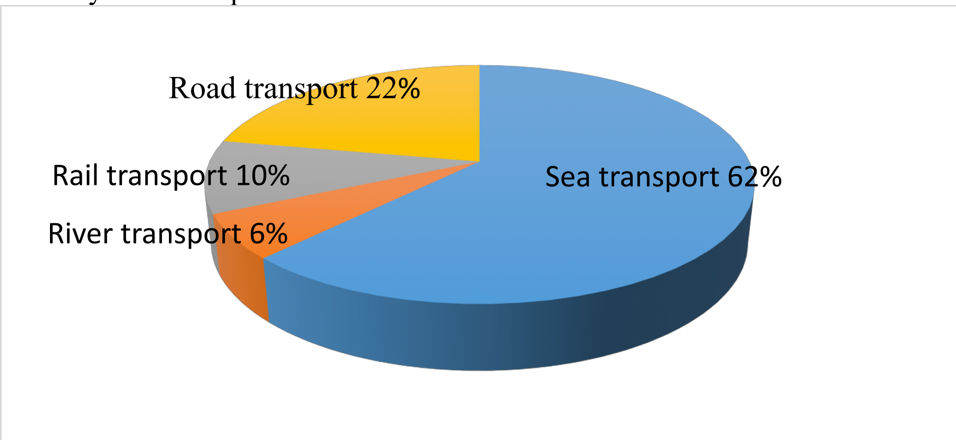

Fig. 1. Percentage ratio of transport work (quantity of goods transported) by different types of transport on import and export

More than six times is the increase in the volume of goods transported in international road haulage with Bulgarian registration vehicles for the period 2006-2017 (Table 3).

The relatively high share of road transport in the volume of import and export transport operations, as well as the indicated increase in the volume of transport activity, is a prerequisite for the envisaged increase in the number of border crossings during the accession period of an EU country.

The total length of the Bulgarian border is 2 245 km. Of which 470 km is river, 1397 km is land, and 378 km is sea.

Table 3

Freight with international road transport, Bulgarian registration vehicles
(including cabotage and transit)

Year	2004	2006	2014	2015	2016	2017
Thousand tons	1404,4	1404,0	5162,5	7576,0	9944,5	10187,2

Bulgaria borders five countries as follows:

- To the north with Romania;
- to the west with Serbia and Macedonia;
- to the south with Greece and Turkey;
- to the east is a maritime border

Until 2005, the transport system of Republic of Bulgaria was rated as a relatively closed system with few border crossings. However, now this applies only to railway transport system. In connection with the preparations for accession and later with the accession of Bulgaria to the European Union, new border checkpoints have been opened mainly on our land borders.

By 2018, 37 border checkpoints are operational. From these border checkpoints, 20 border checkpoints are at the external borders of the EU (5 at the Bulgarian-Serbian border, 3 at the Bulgarian-Macedonian border, 3 at the Bulgarian-Turkish border, 4 at the sea border and 5 at the air borders) and 17 at border checkpoints in the EU borders (6 on the Bulgarian-Greek border and 11 on the Bulgarian-Romanian) (Table 4).

Based on bilateral agreements with the neighboring countries, the construction of new border checkpoints is agreed as follows: Bulgarian-Greek border - road transit - Rudozem - Xanthi; Bulgarian-Romanian border - road transit - Krushari - Dobromir; Bulgarian-Macedonian border - road transit - Stroumyani - Berovo, Simitli - Pechevo and Nevestino - Delchevo; and the Bulgarian-Serbian border - road transit - the Salash-Novosite and Bankya-Pachechtsi [9-10].

Fig. 2 shows border checkpoints through which cargo vehicles pass in Bulgaria, - cars, buses, etc., as well as the European transport corridors valid until 2013. The strategic location of the country is essential for the cargo flows, with half of the European corridors passing through it - corridors IV, VII, VIII, IX and X (the corridor numbers were valid until 2013).

Regulation № 1316/2013 established a new Trans-European Transport Network (TNT-T) (Fig. 3). In Fig. 3 it`s shown the only one road corridor, who crosses Bulgaria - ORIENT / EAST-MED.

EU policy is geared to investitions in cross-border transport corridors. Projects which recieved priority support are those solving congestion problems and missing links in the TEN-T corridors, intelligent transport systems and urban transport systems [5].

The survey estimated the number of cargo vehicles, including semi-trailers, with no oversized and cargo vehicles crossing the border checkpoints of the country.

The total number of points through which the group of vehicles in question passes is 21 (Fig. 4). The four most busy border checkpoints with the vehicles included in the survey are the Danube Bridge (Ruse), Kapitan Andreevo, Kulata and Kalotina, respectively, with 535679, 529234, 460096 and 310437.

The flow of cargo vehicles in 2016 by months is shown in Fig. 5. The figure shows that there are no major variations in the number of cars for the country as a whole during the months of the year and there is also no significant difference between the inbound and outbound vehicles. The average monthly number of cargo vehicles passing through all border checkpoints in the country is as follows: incoming - 108521 and outgoing - 107076.

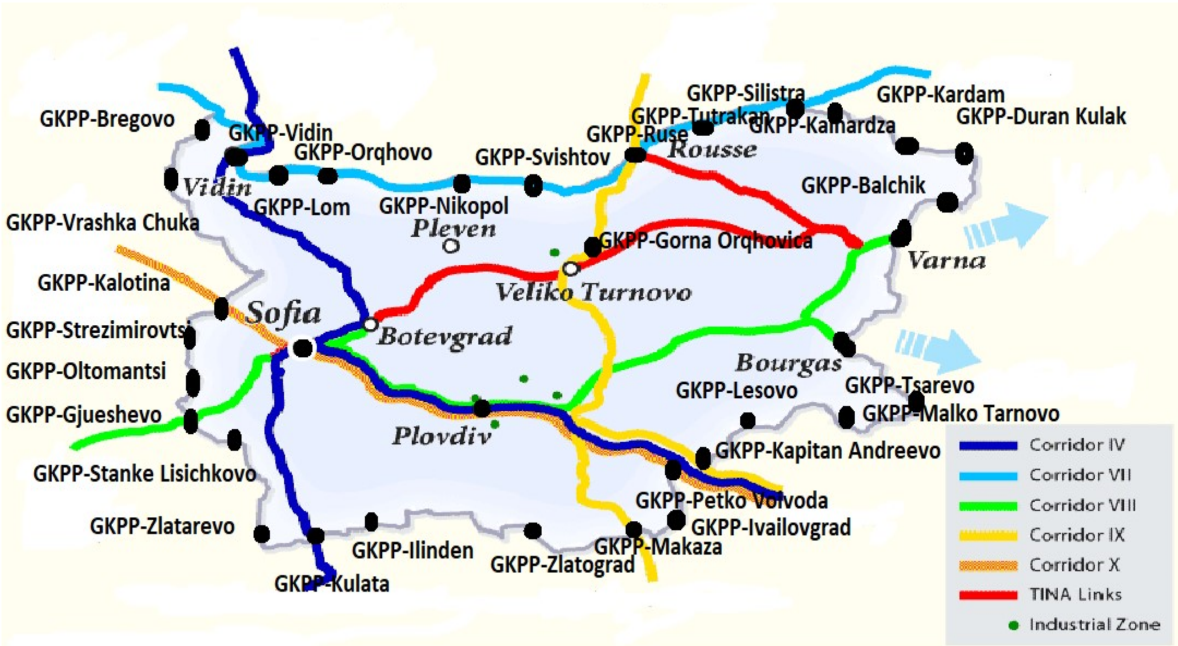

Fig. 2. Pan-European Transport Network (valid until 2013) with Bulgarian Border Checkpoint

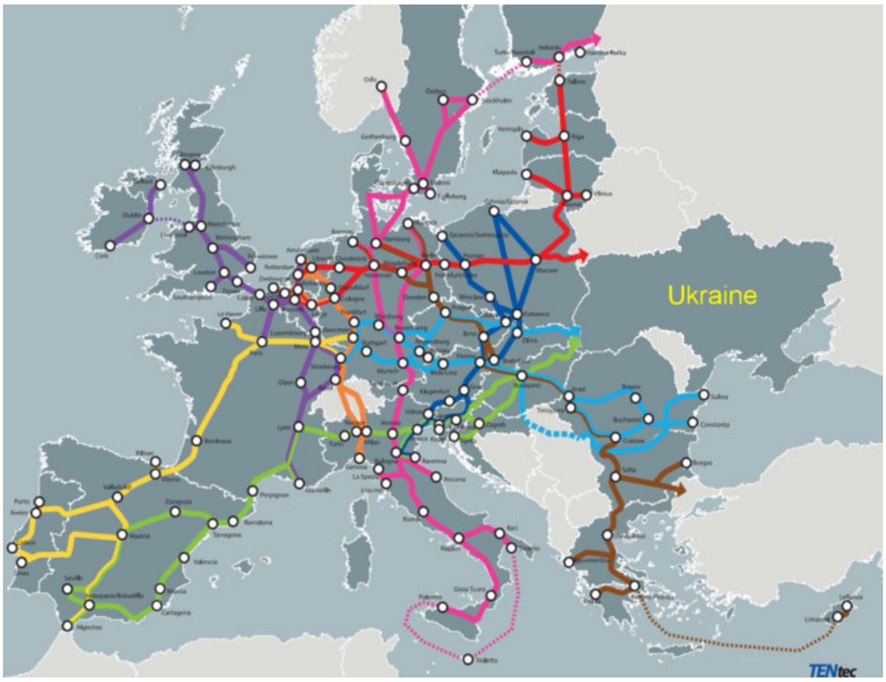

Fig. 3. Pan European Transport Network valid after 2013 (with Regulation № 1316/2013)

The inequality ratio for the country as a whole is:

$$k_{nBG} = \frac{Q_{max}}{Q_{av}} = \frac{239957}{215597} = 1{,}11 \quad (1)$$

A seasonal irregularity factor is determined for the two border crossing points.

$$\mathrm{k}_{\mathrm{u\,Ruse}} = \frac{50082}{44639{,}91667} = 1{,}12 \quad (2)$$

Table 4

Border Crossing Point, land borders and airports

Borders		Border checkpoint	TYPE OF BORDER CROSSING
Internal border	land border	Ruse border checkpoint	road, railway station and port
		Svishtov border checkpoint	ferry and port
		Silistra border checkpoint	road, ferry and port
		Tutrakan border checkpoint	Port
		Somovit-Nikopol border checkpoint	ferry and port
		Kardam border checkpoint	road and railway station
		Durankulak border checkpoint	road
		Vidin border checkpoint	road, railway station and port
		Lom border checkpoint	port
		Oryahovo border checkpoint	ferry and port
		Kapitan Petko Voivoda border checkpoint	road
		Ilinden border checkpoint	road
		Zlatograd border checkpoint	road
		Ivailovgrad border checkpoint	road
		Makaza border checkpoint	road
		Kulata border checkpoint	road and railway station
		Kaynardja border checkpoint	road
outside border		Malko Tarnovo border checkpoint	road
		Lesovo border checkpoint	road
		Kapitan Andreevo border checkpoint	road and railway station
		Bregovo border checkpoint	road
		Vrashka Chuka border checkpoint	road
		Oltomantsi border checkpoint	road
		Kalotina border checkpoint	road and railway station
		Stresimirovtsi border checkpoint	road
		Zlatarevo border checkpoint	road
		Stank Litichovo border checkpoint	road
		Gyueshevo border checkpoint	road
	air border	Varna Airport	airport
		Burgas Airport Border	airport
		Sofia Airport Border	airport
		Plovdiv Airport Border	airport
		Gorna Oryahovitsa Airport border	airport
	sea border	Balchik border checkpoint	port
		Burgas border checkpoint	ports, ferry and Nesebar sea station
		Varna border checkpoint	ports and ferries
		Tsarevo border checkpoint	port

$$k_{uK.Andreevo} = \frac{48486}{44102,83333} = 1,10 \quad (3)$$

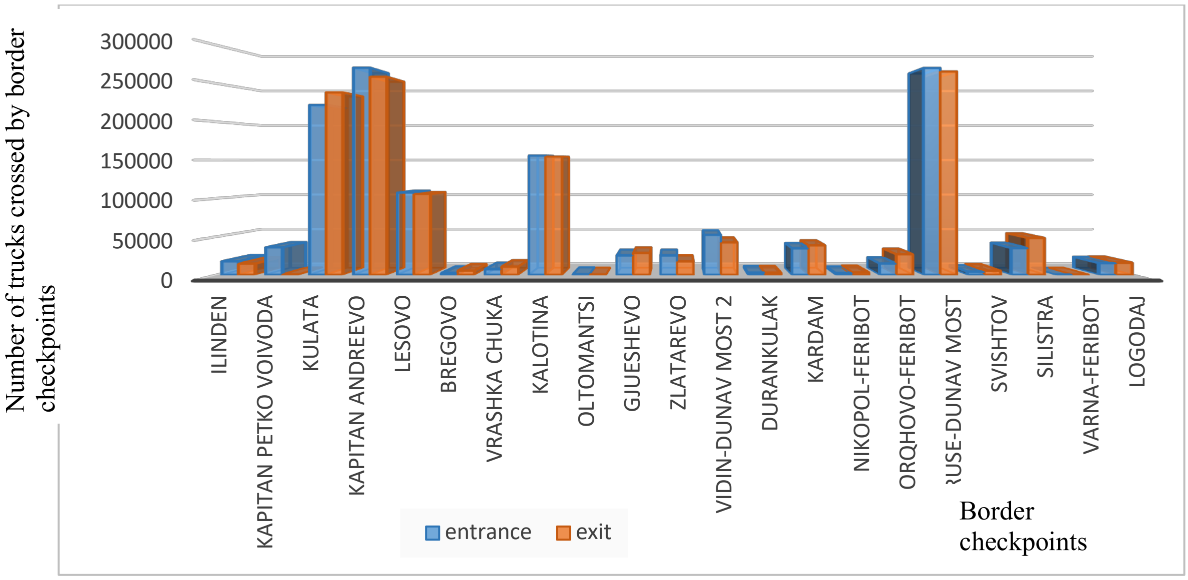

Fig. 4. Number of trucks crossed by all border checkpoints in both directions

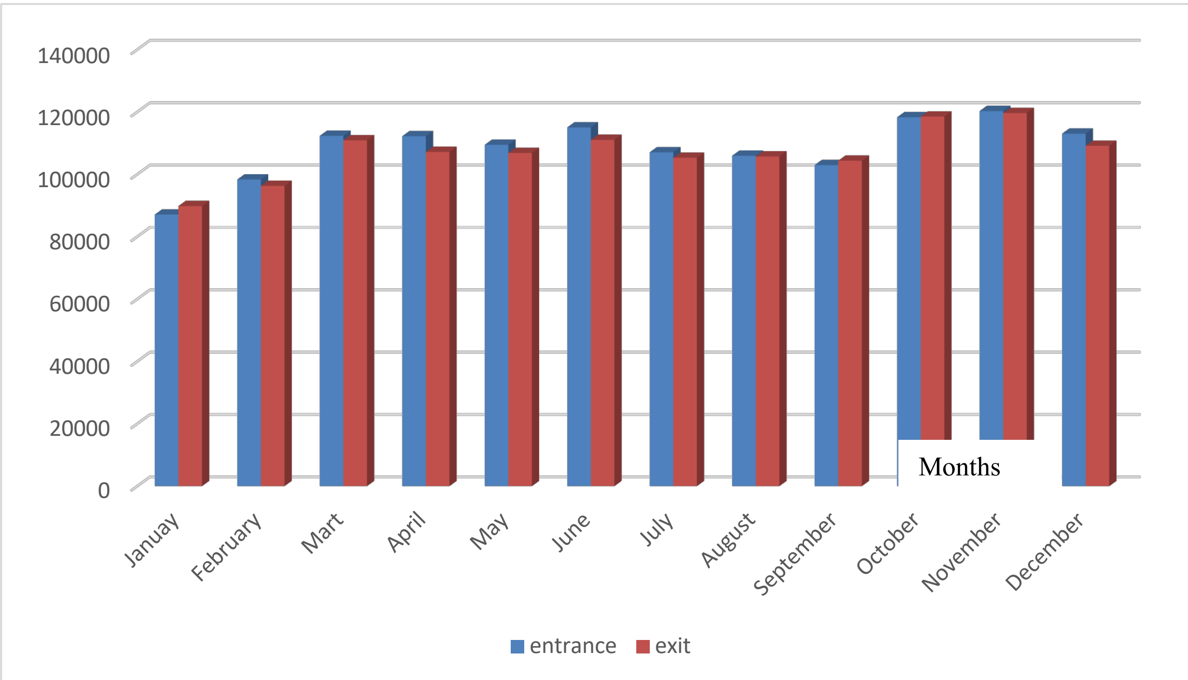

Fig. 5. Number of trucks transited during the year by months

The values obtained are close to the coefficient of seasonal imbalance for the country as a whole.

From Table 5, it is evident that the average load at the border checkpoints in Ruse is the highest during the surveyed period.

By observations as a rule show, that there are many heavy goods trucks waiting in queue. This queue at some point reach a few kilometers (Fig. 7) [1].

In this context, it is important to investigate the system of passing cars through the border checkpoints and to determine its possible capacity.

Table 5

The number of vehicles passing through the Ruse-Danube Bridge and Kapitan Andreevo border checkpoints for months for 1 year

Month	Ruse-Danube Bridge border checkpoint		Kapitan Andreevo border checkpoint	
	Inbound	Outbound	Inbound	Outbound
1	19537	20777	20112	18185
2	22585	22842	24085	22794
3	24864	24544	24576	23215
4	23574	22512	23168	22198
5	22635	20607	24473	22813
6	23344	21254	23318	22636
7	21010	20739	18440	18305
8	20903	20451	20321	19816
9	21136	20754	19009	18686
10	23011	23606	24259	23122
11	25001	25081	24889	23597
12	22526	22386	23861	23356

We model the system as a multi-channel mass service system (queuing system or theory) (Fig. 6) with an infinite queue and Poasson Input flow. Service times are exponential. From the collection of data for a period of one year, the intensity of the inflow in months is known. The average service time per channel per request is 7 minutes. The system changes the number of channels depending on the intensity of the incoming stream. At normal load, 4 channels work, and increasing the flow rate, opens additional channels [11-12, 14-16].

We will introduce the following system parameters [13]:

- s – number of servers (parallel serving channels) in the mass service system (queuing system or theory);
- λ_n– speed of arrival (expected number of requests per unit of time) a new client when the system is n clients;
- μ_n– serving speed of one client per server when there are n clients in the system
- ρ – flow intensity,

$$\rho = \frac{\lambda}{s\mu} \tag{4}$$

- P_0 – – probability of no customer service for the system,

$$P_0 = \frac{a!\,(1-\rho)}{(\rho s)^s + s!\,(1-\rho)\sum_{k=0}^{s-1}\frac{(\rho s)^k}{k!}} \tag{5}$$

- π - probability arrived client waiting in queue (all servers are busy),

$$\pi = \frac{(\rho s)^s}{s!\,(1-\rho)}P_0 \tag{6}$$

- P_k– probability arrived client not to wait (there is at least one free server),

$$P_k = 1 - \frac{(\rho s)^s}{s!\,(1-\rho)}P_0 \tag{7}$$

- $\overline{l}$– average number of free servers,

$$\bar{l} = P_0 \sum_{k=0}^{s-1} \frac{(s-k)\rho^k}{k!} \tag{8}$$

- k_q– average number of clients queuing (average tail length),

$$\overline{k_q} = \frac{\rho(\rho s)^s}{s!\,(1-\rho)^2} P_0 \tag{9}$$

- $\overline{k}$ – average number of clients in the system,

$$\overline{k} = \frac{\rho(\rho s)^s}{s!\,(1-\rho)^2} P_0 + \rho s \tag{10}$$

- $\overline{T_q}$ – average downtime of customers in the queue,

$$\overline{T_q} = \frac{(\rho s)^s}{s!\,(1-\rho)^2 s\mu} P_0 \tag{11}$$

- $\overline{T}$ – average time for client stay in the system,

$$\overline{T} = \frac{(\rho s)^s}{s!\,(1-\rho)^2 s\mu} P_0 + \frac{1}{\mu} \tag{12}$$

For the calculation of the parameter values, an application was created in a MatLab (Fig. 7) [13].

Table 6. presents the calculated values of the parameters of the surveyed system at the entrance and exit by months for Ruse-Danube Bridge border checkpoint.

Table 6

The values of the parameters of the mass service system (queuing system or theory) at Ruse-Danube Bridge border checkpoint

	s	λ	μ	ρ	P_0	π	P_k	$\bar{l}$	k_q	k	Tq	T
Check-in at the Rousse-Danube border checkpoint												
January	4	630,226	205,714	0,7659	0,034214	0,53644	0,46356	0,2381	1,7551	4,8187	4,01	11,01
February	4	778,793	205,714	0,94645	0,00553	0,88389	0,11611	0,043558	15,622	19,4078	28,88496	35,8848
March	4	802,064	205,714	0,97473	0,002479	0,94453	0,055471	0,019902	36,4338	40,3327	65,412	72,41184
April	4	785,8	205,714	0,95497	0,004579	0,90199	0,098013	0,036275	19,1267	22,9466	35,0496	42,05088
May	4	730,161	205,714	0,88735	0,012986	0,76234	0.23766	0,098252	6,0049	9,5543	11,8427	18,8424
June	4	777,133	205,714	0,94565	0,005621	0,8822	0,1178	0,044252	15,3489	19,1315	28,404	35,40384
July	4	677,741	205,714	0,82364	0,02298	0,63964	0,36036	0,16643	2,9873	6,2819	6,347232	13,34722
August	4	674,29	205,714	0,81945	0,02372	0,63188	0,36812	0,1713	2,8679	6,1457	6,124608	13,12459
September	4	704,533	205,714	0,8562	0,01759	0,70123	0,29877	0,13028	4,1753	7,6001	8,534016	15,53328
October	4	742,29	205,714	0,90209	0,010978	0,79198	0,20802	0,083898	7,2968	10,9051	14,15534	21,15504
November	5	833,366	205,714	0,81022	0,011981	0,57398	0,42602	0,11287	2,4504	6,5015	4,234176	11,2342
December	4	726,645	205,714	0,88308	0,013588	0,75383	0,24617	0,10251	5,6933	9,2256	11,28254	8,28224
Check-out the Rousse-Danube border checkpoint												
January	4	670,225	205,714	0,81451	0,024607	0,6228	0,3772	0,17709	2,7348	5,9928	5,875776	12,87576
February	4	787,655	205,714	0,95722	0,004332	0,9068	0,93199	0,03437	20,2899	24,1187	37,0944	44,09424
March	4	791,741	205,714	0,96219	0,003795	0,91744	0,082561	0,030209	23,344	27,1927	42,45696	49,4568
April	4	750,4	205,714	0,91194	0,009693	0,81205	0,18795	0,074574	8,41	12,0578	16,13808	23,13792
May	4	664,741	205,714	0,80784	0,025828	0,61063	0,38937	0,18503	2,5671	5,7985	5,561136	12,56112
June	4	708,466	205,714	0,86098	0,01685	0,71047	0,28953	0,12521	4,4002	7,8442	8,943696	15,94368
July	4	669	205,714	0,81302	0,024877	0,62007	0,37993	0,17886	2,6962	5,9483	7,245813	14,25649
August	4	659,709	205,714	0,80173	0,026974	0,59955	0,40045	0,19243	фев.43	5,6313	5,291856	12,29184
September	4	691,8	205,714	0,84073	0,020074	0,67166	0,32834	0,1471	3,5455	6,9084	7,38	14,37998
October	4	761,483	205,714	0,92541	0,008007	0,83981	0,16019	0,062172	10,4197	14,1214	19,70352	26,7048
November	5	836,033	205,714	0,81281	0,011733	0,57907	0,42093	0,11075	2,5144	6,5785	4,330944	11,33093
December	4	722,129	205,714	0,87759	0,014375	0,74296	0,25704	0,10804	5,3264	8,8367	10,6213	17,62128

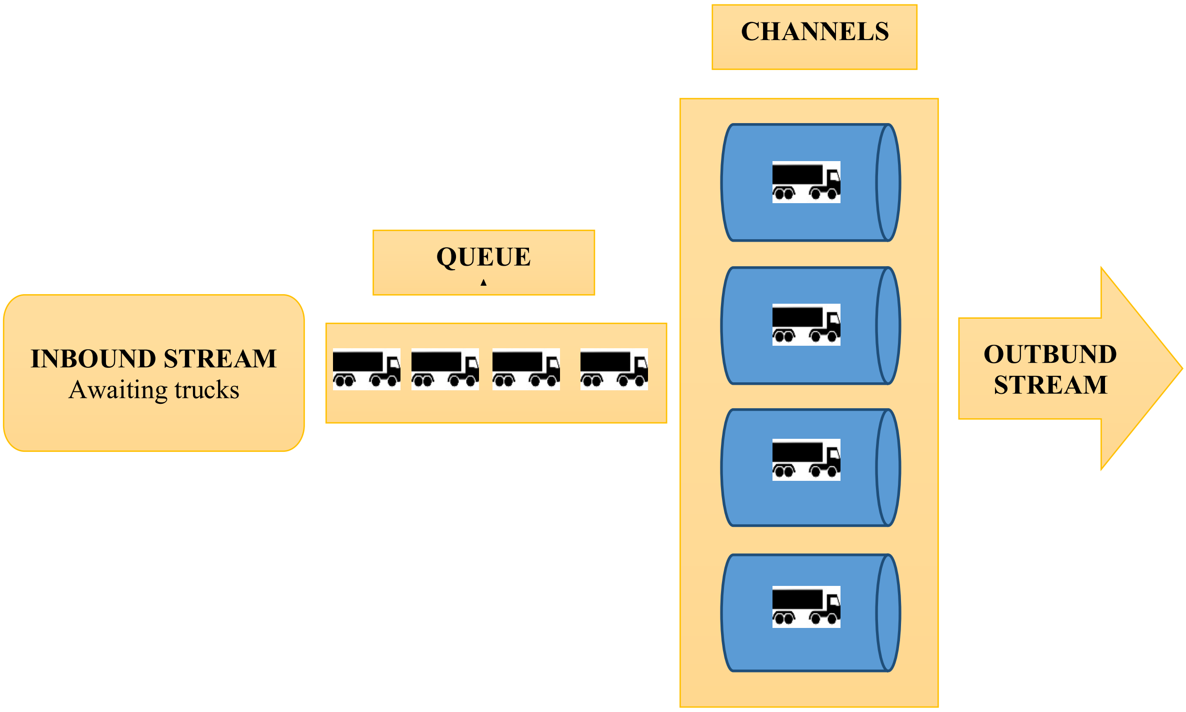

Fig. 6. Model System queuing truck traffic (Ruse-Danube Bridge)

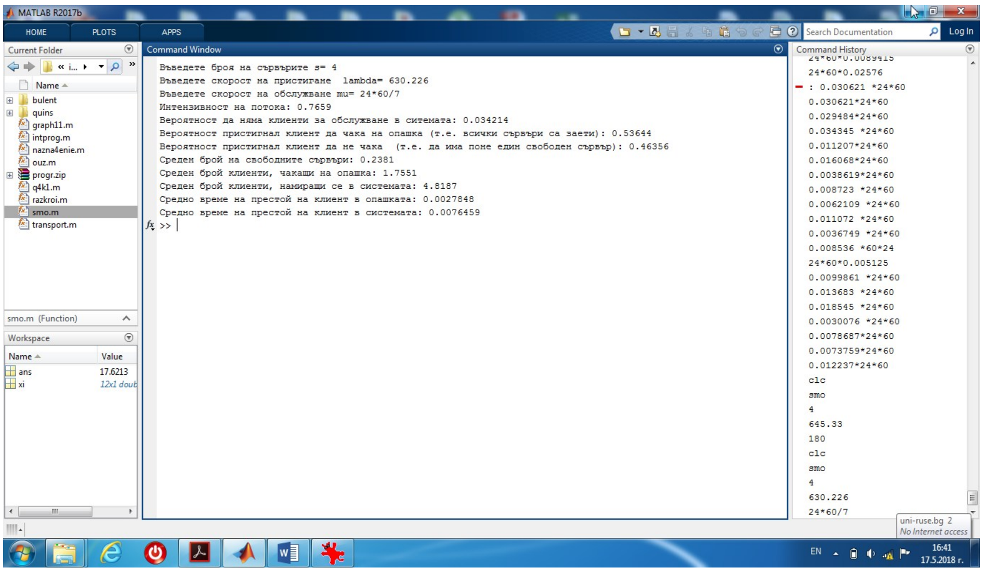

Fig. 7. Software application in MatLab for determining the parameters of the service system for cargo vehicles at Ruse-Danube Bridge

From Table 6, we can note that the waiting time in the system is between 8 and 73 minutes. The smallest value is for December and the largest is for March. For a month November, is foreseen that system will be work with five channels.

In the day-to-day work of the border checkpoints, they are not always open to cargo vehicles and the four streams. The system is very sensitive when changing any of the parameter values, therefore are formed queues shown in Fig. 8.

Very often for planning work and creating a good organization, it is necessary to determine the time to stay of trucks in different flows. The survey flow shows that the minimum average number of vehicles for 24 hours every day at the Ruse-Danube Bridge border checkpoint is 630 (Table 6), and the calculations show that the maximum number the system can serve is 822.

We look at the expected number of requests per unit time in the range $630 \leq \lambda \leq 820$.

Numerous variants were used in the numerical modeling of the mass service system (queuing system or theory), with a high determination coefficient with a value close to 1 being sought. A fractional rational function of the fourth degree was chosen as a numerator and denominator:

$$f(x) = \frac{p_1x^4 + p_2x^3 + p_3x^2 + p_4x + p_5}{x^4 + q_1x^3 + q_2x^2 + q_3x + q_4} \tag{13}$$

with values of the coefficients (Table 7).

Table 7

Values of the fourth degree fractional function coefficients

coefficients	values
p_1	5.74092988838851
p_2	-13946.9453058971
p_3	9018036.799544
p_4	36665.4185023743
p_5	99.8160823823998
q_1	-2637.87515306304
q_2	1493600.76212845
q_3	-82017.4799989688
q_4	-364.122686900433

The sum of square errors between the model and the actual values is SSE = 0.00689, and the determination factor is R - square: approximately 1. It follows that the chosen model is adequate.

The critical value of the system is at $\rho = \frac{\lambda}{s\mu} = 1$, which is obtained for a flow value $\lambda_{cr} = 822{,}85714$. To verify the pattern of vertical asymptotes, we cancel the denominator in (14):

$$x^4 + q_1x^3 + q_2x^2 + q_3x + q_4 = 0 \tag{14}$$

We get the following roots (critical points):
x_1= 1814.9625, x_2 = 822.8577, x_3= 0.05904 and x_4= - 0.00412.

The roots x_1, x_3 and x_4 are ineligible for the service being considered. We will only look at the behavior of the system at x_2= 822,85777:

$$\lim_{x \to x_2^-} \frac{p_1x^4 + p_2x^3 + p_3x^2 + p_4x + p_5}{x^4 + q_1x^3 + q_2x^2 + q_3x + q_4} = +\infty. \tag{15}$$

Point x_2 is a vertical asymptote for the model. The difference between λ_κ and x_2 is only 0.00063, which once again confirms the model even in the critical values.

Fig. 9 shows the curve equation and the real values, and Fig. 9 shows the error between the model and the real values, which in absolute value does not exceed 1.2 s.

It can be seen from the table that the wait for an incoming flow of 820 cars per day is over 8 hours (507.1228033 min), and for a larger number of cars the system will be waiting for an infinite amount of time, as is evident from the asymptote in Fig. 8. Therefore, the capacity of the Ruse-Danube Bridge border checkpoint is the capacity of 820 vehicles per day, provided there is always a waiting car for processing. From this result, the following recommendations can be made:

1. Increase the number of service channels, which is related to building new infrastructure or changing work organization and including a new channel that is used for other purposes.
2. Reduce vehicle care time by using modern information and communication technologies. For example: Entering the so-called electronic window, when the driver is asked by the driver to indicate the queue time interval; introducing an RFID system and more.

Fig. 8. Queue of waiting cargo trucks for crossing the Ruse-Danube Bridge border checkpoint, May 2018

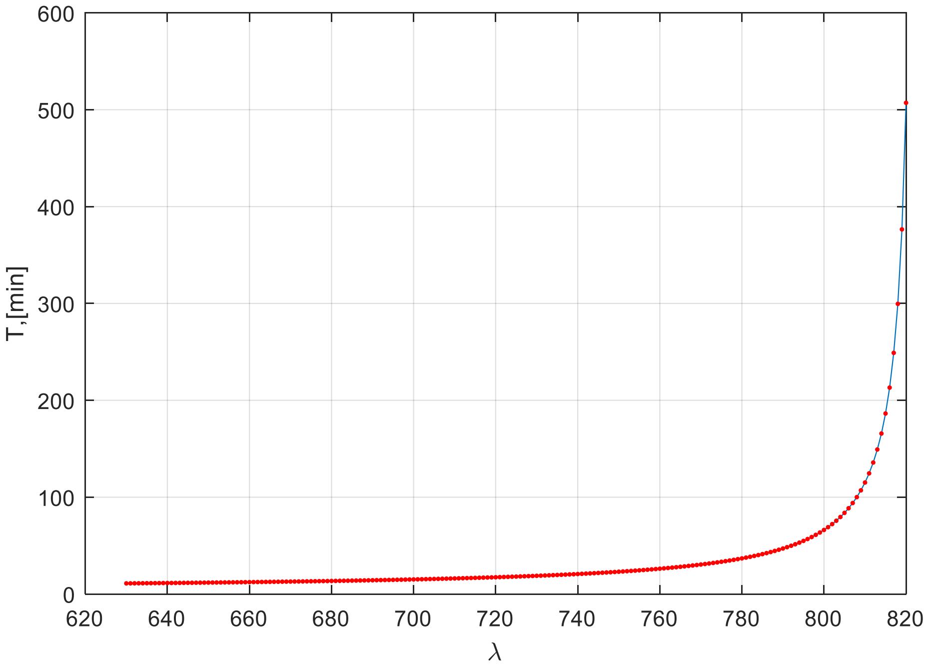

Fig. 9. Theoretical and experimental waiting time for the number of vehicles at the specific system at Ruse-Danube Bridge, min

3. CONCLUSION

From the present work, the following conclusions can be drawn:

- The yearly irregularity rate of crossing the border checkpoints shows relatively constant traffic.
- The investigation of the flow at the Ruse-Danube Bridge border checkpoint for 2016 shows that the minimum average number of cars per day is 630.

In order to expand the capacity of the cargo vehicle checkpoint system, it may:

- The BCP system can be modeled as a mass service system (queuing system or theory). A fractional rational function of the fourth degree is chosen as a numerator and denominator.
- The waiting time for the specific service system at Russe-Danube Bridge border checkpoint is as follows: at 630 cars 11,00 min and at 820 cars 507,12 min. With a larger number of cars, the system will be waiting for an endless amount of time.

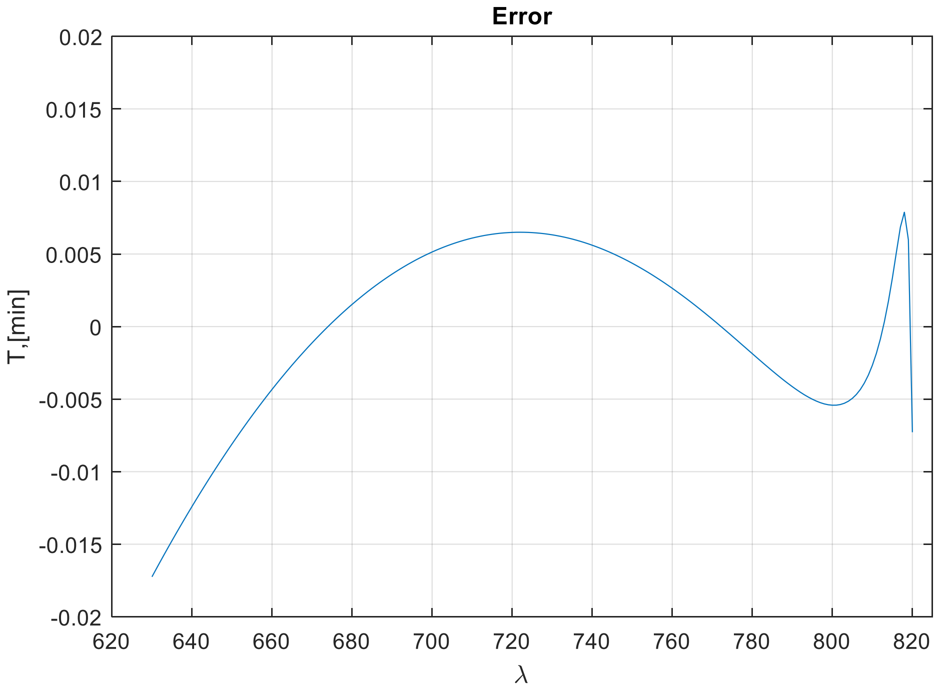

Fig. 10. Error between mathematical model and real values, min

Table 8

Waiting time for the specific service system
at Ruse-Danube Bridge and $630 \leq \lambda \leq 820$

Number of cargo vehicles passed per day	Waiting time in mass service system (queuing system or theory), min
630	11,00189882
640	11,38653269
650	11,81863912
660	12,30692056
670	12,86235675
680	13,49900186
690	14,23514155
700	15,09501517
710	16,11145352
720	17,33005532
730	18,81606226
740	20,66621265
750	23,03035672
760	26,15370488
770	30,46703328
780	36,80317735
790	47,00886111
800	66,16257864
810	115,142589
820	507,1228033

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