

IMPROVING THE AVAILABILITY OF TRANSPORT FLEETS BASED ON AN ANALYSIS RELIABILITY INDICATORS

Ioan VIRCA*, Tiberiu GIURGIU*, Cornel HAȚIEGAN**

*“Nicolae Bălcescu” Land Forces Academy, Sibiu, Romania

**Faculty of Engineering, Reșița, “Babeș - Bolyai” University, Cluj-Napoca, Romania
virca_ioan@yahoo.com, giurgiu.tiberiu@yahoo.com, c.hatiegan@uem.ro

Abstract: *The field of road transport has seen impressive growth in recent years due to the ever-increasing demand for the movement of people and goods, rising production levels, the diversification of transportation technologies, and the availability of advanced connectivity and fleet monitoring capabilities through efficient management. The purpose of this paper is to offer a solution for improving the availability of transport fleets based on the analysis of reliability indicators derived from fleet operations. The research methodology includes the steps of identifying the group of transport vehicles that make up the fleet, collecting operational data, establishing and calculating reliability indicators, determining the availability of the analyzed fleet based on these indicators, and formulating measures to improve its availability based on the results obtained. The proposed solution can be applied to any type of transport fleet, as it can contribute to the optimal planning of activities and missions, and consequently to an increase in specific managerial resilience.*

Keywords: availability, fleet, indicators, reliability, transportation

1. Introduction

Currently, the transport of goods and passengers is one of the most important areas of economic and social life, as it ensures their rapid mobility and, consequently, the efficient functioning of economic sectors. Furthermore, in the military sphere, movement and transport, as these two components of logistics are defined in NATO terminology [1], play a major role in troop mobility, supply, and the support of operations at all three operational levels: tactical, operational, and strategic. Thus, depending on the mode of transport used, the following types or modes of transport are distinguished: air transport, maritime transport, and land transport. Land transport, in turn, is divided into road transport and rail transport. Road transport is often used for short and medium distances due to its economic and logistical advantages, as well as its

flexibility and ability to deliver goods “door-to-door.” In contrast, for long distances, it becomes advantageous to combine at least two of the aforementioned modes of transport. In any plan for combined or multimodal transport, road transport will be an integral part, contributing a certain share and efficiency to the execution of the entire operation or mission.

1.1. Characteristics of Freight and Passenger Transport in the European Union and Romania

In the European Union in 2024, road freight transport accounted for an average of 25.7% of total transport, with the remainder distributed as follows: maritime transport 67%, inland waterway transport 1.7%, rail transport 5.4%, and air transport 0.2% [2].

Regarding passenger transport in the European Union, due to the existence in many countries of a modern rail transport

infrastructure that is safe, fast, comfortable, and affordable, offering travelers multiple communication facilities and digital services, this mode of transport is currently used more frequently [3]. Passenger air transport also accounts for a significant share, meeting customer needs depending on the purpose of their travel, whether business or personal. As such, the characteristics of modes of transport may undergo periodic changes depending on various factors that the authors of this paper consider to be technical, financial, organizational, and, last but not least, related to transport security, which determine the type of transport used. Thus, several important factors can be identified: the country's geographical location; access to maritime shipping routes; the existence of an inland network of river waterways; profitability; access through the Schengen

Area; management changes resulting from the COVID-19 pandemic; the level of security in direct control over transport and the risk of accidents, etc.

Taking into account the aforementioned factors, as they apply specifically to Romania, the share of transport modes shifts, with road transport gaining significant prominence at approximately 65–70% [2]. Thus, the distribution of freight transport in Romania, comparing the years 2023–2024 by mode of transport, expressed in thousands of tons, is shown in Figure 1 [4].

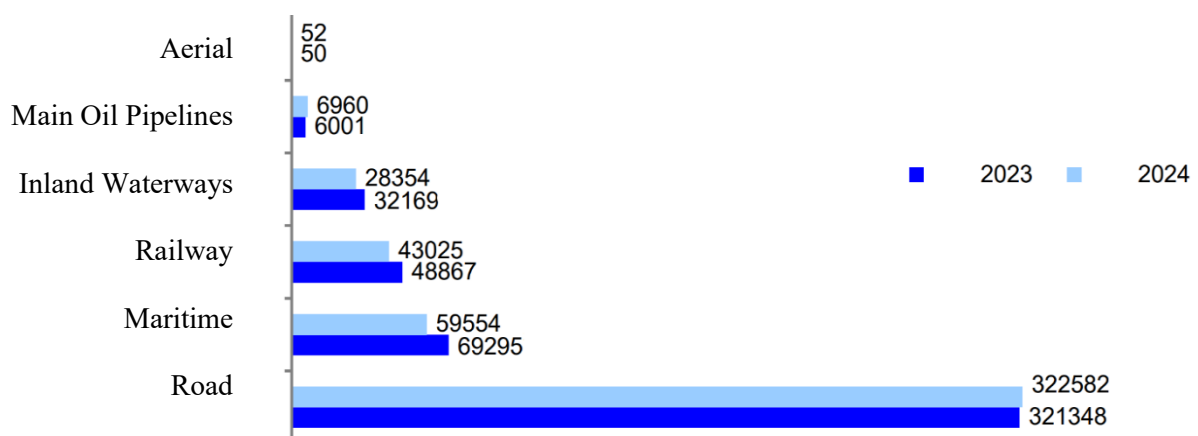


Figure 1. Distribution of freight transport in Romania, comparison between 2023 and 2024, by mode of transport, expressed in thousands of tons [4]

There is a similar distribution of freight volume between the two consecutive years, which demonstrates a certain consistency in procurement contracts and stability in the business environment across sectors and calls for bids. In contrast, the significant difference in the volume of freight transported by different modes of transport reflects the economic viability of each. Expressed as a percentage, the ratio of road freight transport to all other modes of

transport combined in 2023 was 67.26% (322582 thousand tons by road transport out of a total of 477730), and in 2024 it was 70.04% (321348 thousand tons by road transport compared to a total of 460527).

The distribution of passenger transport in Romania, comparing the years 2023–2024 by mode of transport, expressed as a percentage of thousands of passengers, is shown in Figure 2 [4].

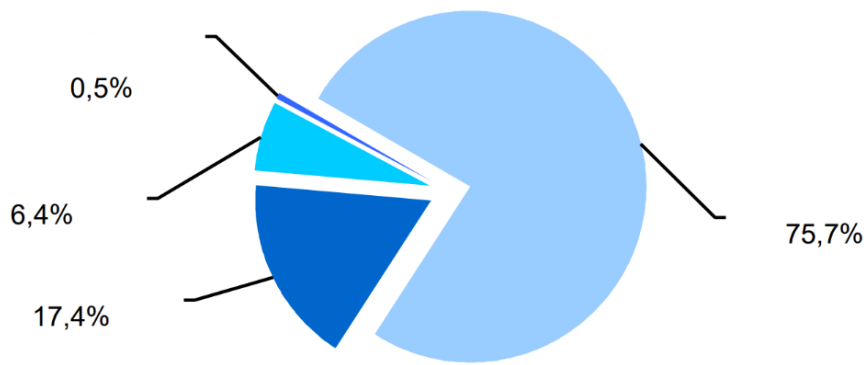


Figure 2. Distribution of passenger transport in Romania, comparison between 2023 and 2024, by mode of transport, expressed as a percentage of thousands of passengers [4]
 Legend: 75.7% road transport; 17.4% rail transport; 6.4% air transport; 0.5% Inland Waterways

In this sector as well, the significant 75.7% share of road passenger transport is due to the advantages this mode of transport offers in Romania compared to other modes, particularly because of the flexibility and accessibility that road transport provides.

Thus, the following conclusions can be drawn from the analysis of the statistical data presented so far in Section 1.1:

- Road freight and passenger transport, at the regional and global levels, has experienced rapid growth and will continue to develop in the future as the needs of human societies increase, as well as due to massive technological advances in specific road technologies and infrastructure;
- Road transport is best suited for the development of logistics chains, as it enables direct deliveries from producers to customers, allows for speed over short and medium distances through the use of flexible routes, and also provides accessibility in all urban and rural areas;
- Road transport has medium to high costs per unit of freight transported (cost per ton-km), but due to the advantages listed above, it is more efficient from a logistical standpoint;
- Transport fleet management and the optimization of fleet availability through the use of artificial intelligence in maintenance forecasting will lead to increased efficiency in transport operations, resulting in significant profits for transport

companies.

1.2. Ways to Improve the Availability of Road Transport Fleets

The technical availability of a road transport fleet, analyzed based on reliability indicators, represents the probability that a vehicle will be in working order at a given time, determined by the ratio of the mean time between failures (MTBF) to the sum of MTBF and the mean time to repair (MTTR). Thus, the technical availability of the fleet will depend on the operating times and the fault repair times, as shown in equation (1).

$$A = \frac{MTBF}{MTBF + MTTR} \quad (1)$$

It should be noted that this formula for calculating technical availability, as well as the model itself used to calculate reliability indicators for fleet vehicles, is indeed objective in nature, based on actual operational data from each vehicle's history; but the way in which defects are taken into account and whether or not they are classified as standardized repair types (minor or major, simple or extensive, etc.) is subjective, which can influence the overall availability value of the fleet. The approach depends on the maintenance system adopted by the transport organization or structure, namely: condition-based maintenance; fixed-

schedule maintenance; periodic inspection maintenance; planned preventive maintenance; and predictive maintenance [5]. Thus, the two categories of time, MTBF and MTTR, can have different values that will influence the technical availability level of the transport fleet, with direct effects on its productivity.

Improving the availability of transport fleets is a top priority for the management team of any organization that manages fleets. This goal can be achieved through various methods, which can be grouped as follows:

a) *technical methods*: preventive maintenance; predictive maintenance; optimization of repair times; telematics-based fleet monitoring;

b) *organizational methods*: spare parts management; staff training; fleet standardization; fleet planning; life-cycle cost analysis; digitization of fleet management;

These methods have been researched and highlighted in specialized literature and incorporated into plans for optimizing maintenance and technical availability that are implemented in practice, and refining these methods is a priority for organizations that manage transport fleets.

Another possible direction or method for improving the availability of transport fleets involves analyzing fleet-specific reliability indicators and taking organizational measures and decisions to improve these indicators, which would implicitly lead to improved fleet availability.

2. The purpose and objectives of the research

Given the authors' teaching and research experience in the fields of transportation, reliability, and maintenance of technical systems, this paper aims to analyze the technical availability of transportation fleets based on reliability indicators. This objective becomes feasible if the transportation organization or company incorporates the proposed solution into its

management practices, which will require additional actions from the technical departments and even the hiring of staff or the establishment of small units with responsibilities related to the statistical analysis of data characterizing the operation of transport fleets and the implementation of measures to improve technical availability.

Consequently, the following research objectives are formulated:

a) identifying reliability indicators specific to transport fleets and calculating them based on actual operational data collected from the history of each vehicle;

b) conducting a comparative analysis of two variants of reliability indicators to determine the technical availability of the transport fleet and, based on the results obtained, formulating proposals for its improvement.

3. Research methodology

The following steps were taken to conduct the research:

a) *identifying the reliability indicators to be analyzed*;

The specialized literature [6, 7, 8] specifies various reliability indicators applicable depending on the stage of the life cycle of the technical system under consideration: design, operation, maintenance, etc. Thus, reliability indicators may differ or complement one another because the objectives at each stage are different. For example, in the design phase, the probability of failure is estimated; during the use or operation phase, actual performance is monitored; and in the maintenance phase, the speed and efficiency of remedying technical system failures are analyzed. Thus, based on the analysis of indicators specific to each stage of the life cycle, the following viable reliability indicators were established for this research:

- mean time between failures (MTBF);
- mean time to repair (MTTR);
- failure rate, λ ;

- reliability $R(t)$ or the probability of failure-free operation up to time t ;
- technical availability of the system, A .

b) determining the transport fleet for the analysis of reliability indicators;

Seven transport trucks (four Iveco Trakker 6x6 trucks and three Iveco Eurocargo 4x4 trucks) were selected from an organization with complex tasks involving the transport of troops and materials, as well as the training of its own students in driving practices to obtain a Class C driver's

license C: the four Iveco Trakker 6x6 trucks (items 1–4 in Table 1) and one Iveco Eurocargo 4x4 truck (item 5 in Table 1) are used by the owner organization for troop and material transport, while the other two Iveco Eurocargo 4x4 trucks (items 6–7 in Table 1) are used primarily for practical driving instruction and additionally for transporting troops and materials. As such, the fleet utilization rate is uneven, a fact that will be evident in the collected operational data.

Table 1. Operational data for the transport fleet's trucks

Vehicle No.	Type Iveco vehicle	Analyzed period (3 years)	Distance traveled (km)	Operating time T_o (hours)	Number of defects N_d	Repair time T_r (hours)	Odometer reading (km)
0	1	2	3	4	5	6	7
1	Trakker 6x6	2023-2025	9.858	280	3	26	28.911
2	Trakker 6x6	2023-2025	12.958	370	4	38	30.447
3	Trakker 6x6	2023-2025	15.876	460	4	44	31.254
4	Trakker 6x6	2023-2025	14.174	405	5	60	31.187
5	Eurocargo 4x4	2023-2025	12.380	355	5	48	34.088
6	Eurocargo 4x4	2023-2025	23.978	1.300	4	42	50.896
7	Eurocargo 4x4	2023-2025	25.105	1.400	5	55	55.429

c) collection of operational data from the trucks in the transport fleet under consideration;

Data on mileage over a three-year period (2023–2025), as well as the number of defects and the total time required to perform the corresponding repairs, were collected from the maintenance records of each truck in the fleet; all of this data is presented in Table 1.

To determine the operating time T_o of the trucks listed in Table 1, the operating hours recorded on the tachographs installed on those vehicles were read. Using relation (2), the approximate average speeds of the

vehicles during their operation could also be calculated, resulting in an average speed of approximately 35 km/h in mixed traffic (urban, extra-urban, and off-public roads) for the vehicles in items 1–5 and approximately 18 km/h for the vehicles in items 6–7.

$$T_o = \frac{\text{no. of km traveled}}{\text{average speed}} \quad [\text{hours}] \quad (2)$$

d) calculation of reliability indicators;

The values of the reliability indicators are shown in Table 2 and were determined using the following relations [5, 6, 7, 8]:

- mean time between failures (MTBF)

using relation (3);

$$MTBF = \frac{T_o}{N_d} = \frac{1}{\lambda} [\text{hours}] \quad (3)$$

• average repair time, MTTR, as defined in relation (4);

$$MTTR = \frac{T_r}{N_d} [\text{hours}] \quad (4)$$

• the failure frequency or failure rate, λ , as given by relation relation (5);

$$\lambda = \frac{N_d}{T_o} [\text{hours}^{-1}] \quad (5)$$

• the reliability or probability that the system will operate without failure up to time t , $R(t)$, as given by relation (6);

$$R(t) = e^{-\lambda t} [\%] \quad (6)$$

• system availability, A with relation (7);

$$A = \frac{MTBF}{MTBF+MTTR} = \frac{T_o}{T_o + T_r} [\%] \quad (7)$$

4. Research Results and Their Interpretation

The MTBF values shown in Table 2 are determined by the accidental failures or random failures specified in Table 1 and are not predetermined values within a standardized framework for the execution of planned maintenance work, which significantly influences the values of the other reliability indicators. The mean time to repair (MTTR) has relatively low values compared to the times associated with planned extensive or highly complex repairs.

Table 2. Calculated values of reliability indicators

Vehicle No.	MTBF (h)	MTTR (h)	λ (h^{-1})	R(t)	R(t) (%)	A ₁ (%)	A ₁ average (%)
0	1	2	3	4	5	6	7
1	93.3	8.6	0.01071	0.0498	4.98	91.50	91.60
2	92.5	9.5	0.01081	0.0183	1.83	90.24	
3	115.0	11.0	0.00869	0.0184	1.84	91.26	
4	81.0	12.0	0.01234	0.00675	0.675	87.09	
5	71.0	9.6	0.01408	0.00675	0.675	88.08	
6	325.0	10.5	0.00307	0.0185	1.85	96.87	
7	280.0	11.0	0.00357	0.00675	0.675	96.21	

The failure rate λ (Table 2) also varies, influenced by the uneven usage or operating times of the fleet vehicles. Consequently, reliability $R(t)$ also varies and is very low relative to the actual operating times during the analyzed period of 2023–2025. In contrast, technical availability $A(\%)$ has fairly high values (Table 2, Column 6), due to the relatively low average downtime for repairs, which would allow the fleet to fulfill its transport tasks. Overall, the average technical availability of the analyzed transport fleet is 91.60% (Table 2, Column 7), a value that can be considered technically acceptable in a ranking of

technical availability $A(\%)$ developed by the authors of this paper, as follows:

- $A > 97\%$ – very good availability;
- $A = 95 - 97\%$ – good availability;
- $A = 90 - 95\%$ – acceptable availability;
- $A < 90\%$ – low availability.

The availability thresholds specified above were established by the authors based on their experience in the relevant field and following a review of specialized literature and sources from transportation operators [7, 9, 10, 11].

Thus, based on the analysis of the results obtained, as shown in Table 2, the following conclusions can be drawn:

- the average fleet availability is 91.60%, which can be considered acceptable, as it is close to the lower limit of the established range;
- the dispersion of the availability values for each individual vehicle in the fleet falls between the low availability zone and the upper limit of the high availability zone (Table 2, Column 6);
- the very low values and percentages of fleet component reliability (Table 2, columns 4 and 5) are due in particular to the long operating times (Table 1, column 4) for which the reliability determinations were made, so that the fleet may have low long-term reliability but high availability [12, 13]. This may be due both to the

implementation of a fast and efficient maintenance process resulting in short repair times, as well as to an appropriate process for planning and utilizing the fleet's vehicles [14].

Taking these conclusions into account, the authors of this paper set out to conduct a comparative analysis of the fleet's availability between the previous scenario and a new scenario in which lower values are established for the number of failures and repair times (Table 3), in line with the goal of improving the aforementioned processes in the following areas: lower failure rate, fewer maintenance interventions, and improved spare parts supply time.

Table 3. Operational data for the transport fleet's trucks

Vehicle No.	Type Iveco Vehicle	Operating time T_o (hours)	Number of defects N_d	Repair time T_r (hours)
0	1	2	3	4
1	Trakker 6x6	280	2	14
2	Trakker 6x6	370	3	24
3	Trakker 6x6	460	3	28
4	Trakker 6x6	405	3	22
5	Eurocargo 4x4	355	3	24,8
6	Eurocargo 4x4	1300	3	28.5
7	Eurocargo 4x4	1400	3	29

The new reliability indicators will be calculated using the same values for the fleet vehicles' operating times (T_f) as a reference point to ensure the relevance of the comparative analysis. However, the time t (relation 6) up to which each vehicle is considered to have operated without failing is set at 40 hours. In fleet vehicle maintenance practice, this value can be

represented by the time interval between two consecutive scheduled maintenance intervals or between two periodic inspections conducted to assess the fleet's operational status at the operational management level.

Thus, the recalculated values of the reliability indicators are presented in Table 4.

Table 4. The recalculated values of the reliability indicators

Vehicle No.	MTBF (h)	MTTR (h)	λ (h ⁻¹)	R(t)	R(t) (%)	A ₂ (%)	A ₂ average (%)
0	1	2	3	4	5	6	7
1	140.00	7.00	0.00714	0.7515	75.15	95.23	95,36
2	123.33	8.00	0.00810	0.7232	72.32	93.90	
3	153.33	9.33	0,00652	0.7704	77.04	94,26	
4	135.00	7.33	0.00740	0.7437	74.37	94.84	
5	118.33	8.26	0,00845	0.7131	71.31	93.47	
6	433.33	9.50	0.00230	0.9121	91.21	97.85	
7	466.66	9.66	0.00214	0.9179	91.79	97.97	

Based on the results obtained, there has been a significant improvement in reliability, achieved by calculating it over a time interval determined by a planned maintenance system and correlated with subsequent technical interventions, as well as by optimizing the spare parts procurement process.

Regarding the technical availability of the fleet, it has improved both for each individual vehicle and for the entire fleet,

with average availability increasing from 91.60% to 95.36%, moving from the acceptable availability range into the good availability range.

Figure 3 compares the technical availability values A(%) of the transport fleet vehicles (vertical axis) for the two analyzed variants (A1 and A2) for each individual vehicle (horizontal axis) for the analyzed period, namely 2023–2025.

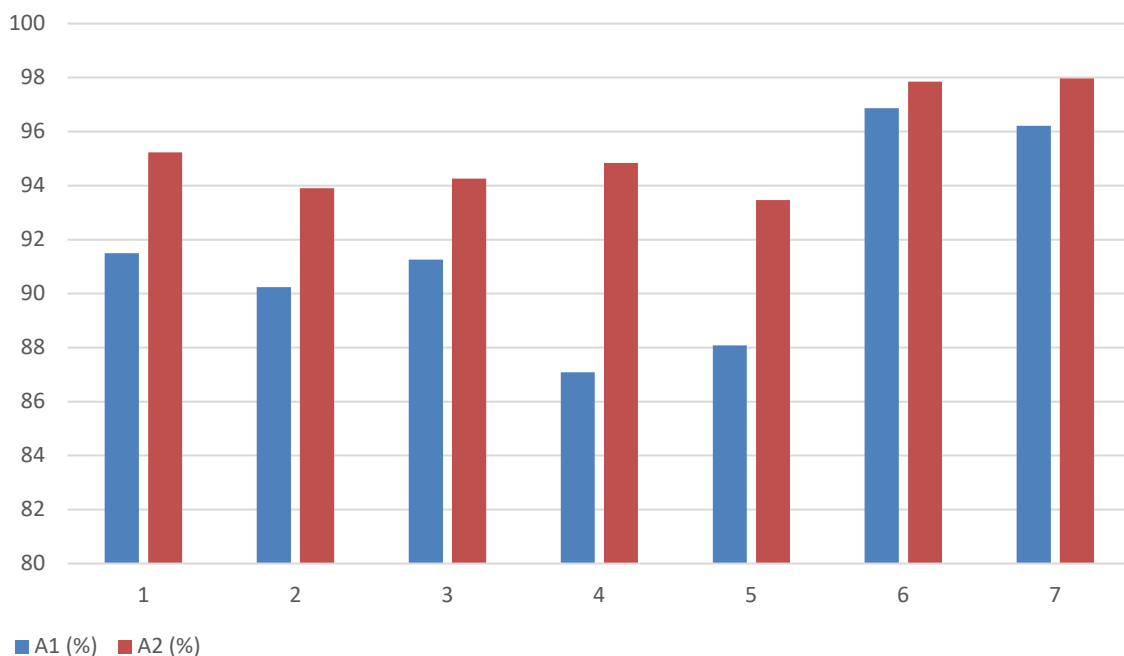


Figure 3. Comparative graphical representation of the technical availability of the transport fleet for each individual vehicle, Source: authors' conception.

6. Conclusions

The solution or approach to improving the availability of transport fleets through the analysis of reliability indicators can, together with the other approaches presented in Section 1.2, to achieving the highest possible level of technical availability, complementing them due to its analytical nature, based on the systematic analysis of reliability indicators and the making of technical decisions with beneficial effects on the availability of the transport fleet.

The research methodology used by the authors was a comparative analysis of two sets of fleet operation data: one based on actual historical data from the fleet's vehicles, and one estimated using modified data to optimize maintenance, planning, and fleet vehicle utilization processes. The results demonstrate that effective technical and organizational measures can improve both fleet reliability and the availability of individual vehicles and the fleet as a whole. Thus, the average fleet availability

increased from 91.60% (Table 2) to 95.36% (Table 4), a figure that shifts the overall availability status from an acceptable range to a good one, with positive implications for the company's profit and the profitability of its transportation activities. Furthermore, the graph in Figure 3, which presents the two data series, highlights the upward trend in technical availability and, accordingly, the opportunity to implement measures aimed at preventing defects and optimizing maintenance.

Consequently, the authors of this paper consider that the two research objectives stated in Section 2 have been met, and the proposals for improving fleet availability can be summarized as reducing the failure rate of vehicles in the fleet, decreasing the number of maintenance interventions, improving spare parts supply time, and optimizing maintenance processes.

The proposed solution can contribute to optimizing the planning of transportation activities and missions, leading to an increase in specific managerial resilience.

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