APPLICATION OF MODERN TOOLS IN THE EFFECTIVENESS EVALUATION OF VEHICLES OPERATION

Václav ZAJÍČEK, Jaromír MAREŠ, Jaroslav TALÁR

University of Defence, Brno, Czech Republic
vaclav.zajicek@unob.cz

Abstract: The authors reviewed the current traditional approaches to evaluating the operation effectiveness of ground military equipment. The article is focused on the role and possibilities of commanders and executives from traffic. The authors describe the experiences with the application a modern system in selected fleet of vehicles in ACR.

Research has shown the possibility to identify the causes of overconsumption. The vehicles were analyzed causes of exceeding the norm. The fundamental aspect of crossing the established standards were idle vehicles and irregular decrease of fuel.

Keywords: Efficiency, norm, fuel, operation of military equipment, vehicles

1. Introduction

The more sophisticated vehicles and facilities are, the more important it is to protect their functions with the aim to increase their reliability and life cycle [1].

The current effort of organizations to achieve maximal savings is aimed at employing the diagnostic methods in the operation of vehicles [2].

Efficiency is explained by a variety of definitions. Jablonský J. (2004) defines efficiency as the ratio of outputs which evaluated unit produces and input that in this production consumes. Each unit is thus characterized by a set of input and output of numerical characteristics [3].

The situation is efficient (in some particular respect), if it cannot be improved. If, in other words, there is no possible situation which could have been better [4].

A similar view we can also apply to the operation of ground forces military equipment in the Army of the Czech Republic. The vehicle is seen as a basic unit of monitoring the efficiency which is recorded in the information system of logistics.

The importance and range of tasks that the Army of the Czech Republic (ACR) fulfil require responsible and high quality logistic support. Technical management here has an important role especially in its organization of operation and maintenance of ground military equipment.

The operation of ground military equipment is coordinated system consisting of technical, legislative and administrative measures. These measures guarantee optimal use of equipment in the system throughout the ACR [5].

Another significant aspect is improper loading of cargo, which may be the result of rising costs or material damage, impairment of operation safety and jeopardising the health of persons concerned [6]. The experimental investigation of a failure mechanism and the values of impact energy or notched impact strength is an integral part of comprehensive research in material limit states [7]. The means of containerization are more and more often utilised in temperature ranges with significant temperature differences that can

primarily cause the occurrence of degradation processes in materials leading to the occurrence of a limit state [8].

Efficient reduction of fuel consumption has a most positive effect on the environment.

2. Equipment operation of AČR

The ratio of fuel consumption to the mileage is a fundamental aspect of evaluating the effectiveness of the operation of military equipment. However, this approach does not include all indicators that should be assessed. It is possible to include the following basic parameters of evaluating the operation effectiveness of ground military equipment:

- fuel consumption to the mileage,
- a compliance ordered axis transport activities,

- characteristics of a range transport activities.

2.1. Fuel norm standards

For monitoring of operation effectiveness of ground-based military equipment are set fuel norm standards per 100 kilometres, which are compared with the amount of mileage.

Generally known are the basic categories of fuel norm standards in city, outside the city and combined fuel consumption. Some fuel norms are also identified in the interval range, for example. T 810:

- general road 28 l per 100 km
- field and forest roads 31 l per 100 km
- difficult terrain 66 l per 100 km [9]

Table no. 1: The operation of vehicles TATRA 810 [9]

Type of Vehicle	Year								Total SUM [km]	Total SUM fuel [l]
	2009		2010		2011		2012			
	SUM [km]	Fuel [l]	SUM [km]	Fuel [l]	SUM [km]	Fuel [l]	SUM [km]	Fuel [l]		
T 810	281 149	89 000	2 585 324	860 578	2 202 568	840 236	2 723 125	920 428	7 792 166	2 710 242
Consumption per 1 km										0,348

The table 1 presents the values of the operating parameters of vehicles TATRA 810 across the AČR. The average amount of fuel consumption reaches 0.348 litre per kilometre.

2.2. Limit of fuel

The value of fuel limit per calendar year is a crucial aspect for traffic planning of ground military equipment. [10] In other words, the amount of mileage required to achieve the goals of the organizational unit is depended on the amount of allocated fuel.

The following rules are in the context of the traffic planning of military equipment limited by internal regulations:

- correct (required) technical condition,
- sufficient amount of operating units into service and maintenance,
- scheduled fuel limit. [10]

Fuel are each year distributed in the information logistics system for individual vehicles. The form for the input data is presented in Figure 2.

Sort of Fuel	M,název)	0154020220268	NAFTA MDT.54(F-54)	VPI
	MJ	121	litr (krychlový decimetr)	Přic
				Vla

Reg. No.	Ev.č.	026-27-25	Typ VT	0082180000106	AUT.T810 6X6.1R VALNÍK
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Operation Plan per year												Ujetý kilometr
1	166	2	166	3	166	4	166	5	166	6	166	CelkeSum of km
7	166	8	166	9	166	10	166	11	166	12	174	

Operation Consumption Plan per year of Fuel												
1	66	2	66	3	66	4	66	5	66	6	66	CelkeSum of Fuel
7	66	8	66	9	66	10	66	11	66	12	70	

Figure no. 1: The Operation Plan [11]

Fuels are divided according to tasks for each month and vehicles. The total sum of divided fuel must not exceed the assigned limit.

3. Materials and methods

As part of the research project were invited commercial organizations to cooperate in the project. The aim of the project was to determine the effect of the additive on fuel consumption. The selected companies provide sophisticated systems to monitor the vehicles operation with primary aim of eliminating substandard losses of the fuel tested vehicles.

The monitoring systems have been installed in vehicles, which can monitor the following parameters of operated equipment:

- online status and location of the vehicle,

- measurement of fuel,
- alarm in case of nonstandard decrease of fuel,
- evaluation of the operation effectiveness,
- records routes of transport activities - possibility of comparison set schedule of transport activities to real movement of the vehicle,
- monitoring of vehicle speed - a useful tool for monitoring the efficient and safe driving,
- driver identification,
- registration of drivers,
- frequency of depressing the accelerator or brake pedal - the possibility to identify a aggressive driving.

Figure no. 2: The identification of vehicle movement

The Figure characterizes the possibility of identifying the vehicle during movement. Commander of unit has an opportunity to watch movement, speed and other parameters. During the evaluation he can

take specific preventive measures.

Information from the systems are also used during the training of personnel.

Selected vehicles included in the project are shown in the table 2.

Table no. 2: The Monitoring List of Vehicles [9]

Sort of Vehicles	Number of Vehicles	Fuel	Norm per 100 km [l]
T 815 (6x6)	1	diesel	61
T 815 (8x8)	1	diesel	75
T 810 (6x6)	2	diesel	30

Project had two phases of vehicle operation:

- without a monitoring system - period 1.1.2012-30.12.2012
- with a monitoring system - period 1.1.2013-30.12.2013

In the case of vehicles was recorded and evaluated diesel consumption.

Obtained values were analyzed through the application of STAT 1. Special attention was focused to the fundamental statistical parameters:

- a) Arithmetic average $\square$
average consumption of fuel [12]

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i \quad (1)$$

where, x_i = Fuel Consumption; n =Number of refueling.

- b) Skewness - is a measure of the asymmetry of the probability distribution of a real -valued random variable about its mean [12].

$$a_3 = \frac{\sum_{i=1}^n (x_i - \bar{x})^3}{n s_n^3} \quad (2)$$

where, x_i = fuel consumption; $\bar{x}$ = arithmetic average; S_n = standard deviation.

- c) Variance - measures how far a set of numbers is spread out [12].

$$s_n^2 = \frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n} \quad (3)$$

where, x_i = fuel consumption, $\bar{x}$ = arithmetic average, n = statistics frequency of filling [12].

- d) Confidence interval $\square\square$ gives an estimated range of values which is likely to include an unknown population parameter measures how far a set of numbers is spread out [9]. The risk estimate is $\alpha=0,05$.

4. Results and discussion

The vehicle efficiency was monitored by standard procedures. The ratio of fuel consumption to the mileage is compared with fixed standards for vehicles. Outcomes are presented in Figure No. 3

Figure no. 3: The consumption development of vehicles

The measurement fuel economy of vehicle without monitoring system significantly exceeds the established standard. This phase is also characterized

by a high value of variance which indicates an irregular refuelling.

Absence of information about driving style, conditions and routes of transport

activities, does not allow a comparison of the real movement of the vehicle. Monitoring phase of vehicles operation with installed monitoring system has

shown significant reduction in consumption. The reducing of fuel consumption is also confirmed by the total sum values of the monitoring vehicles.

Figure 4 The SUM consumption development of vehicles

Specific values of basic statistical parameters are presented in Table No. 2.

Table no. 2: Fundamental statistical parameters

Statistics parameters	SUM of vehicles	
	Without monitoring system	With monitoring system
Mean μ	35,52	30,92
Variance S_n^2	21,40	4,70
Skewness α_3	0,64	-0,14
Confidence Interval for Consumption of Fuel (T_d, T_h)	(34,24: 36,81)	(30,21: 31,63)

Results in the table distinctly confirm the positive results in reducing fuel consumption of the vehicles. The same

results are shown by the Gaussian curves both monitoring phases in Figure 4.

Figure no. 4: Gaussian curves both monitoring phases of fuel consumption

Specifically, has been reduced fuel consumption by 4.6 litres. The consumption values almost correspond with set standards for vehicles T 810. Continuous inspection has also been a regular framework refilling vehicles. The high savings and overconsumption standards were eliminated in the refueling vehicles immediately after transport activities.

As a result was reduced the variance differences between fixed standards from value of 21.4 to 4.7.

By specifying 100 (1- α)% two-sided confidence interval for α , we can identify 95% probability interval of fuel consumption in the range of (30.21: 31.63) litre.

The skewness has a value $a_3 < 0$ (- 0,14). This means that most values in the range of consumption will be higher than the mean (α) value of 30.92 litres.

5. Conclusions

The sophisticated monitoring systems have a significant positive effect on increased efficiency of vehicles the Army of Czech Republic. Is it possible to continuously react to non-standard values of equipment operation. Current information on the basic parameters of operation, help increase operational efficiency. During the planning process, it is possible to optimally use vehicles to the specific transport activities.

A range of information can also be used for safety measures. It is easy possible to identify aggressive drivers who exceed the maximum speed limit. They brakes of the vehicle at the last moment and immediately accelerate.

Reducing fuel consumption also has a most positive effect on the environment. Especially it is the reduction of greenhouse gases.

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