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QUANTITATIVE COMPARISON OF FOREST FIRE ENGINES IN FOUR TACTICAL PARAMETERS

Abstract

The backbone of the fire department's vehicle fleet consists of medium and heavy weight class fire trucks. With these universal vehicles, the first respondent units arrive at the fire. The design of these vehicles may be optimal in urban, built environments, but when approaching wildfires, they are often unable to take advantage of their advantageous properties, such as the large amount of water transported or the transport of the entire swarm. This may be due to weight, physical dimensions, or inadequate off-road capability. As almost 50% of fires are wildfires, it would be reasonable to have vehicles on standby that can be used in such conditions. In order to determine the optimal vehicle, we need to know what capabilities are needed to get the intervention started most effectively and in the shortest amount of time.

Keywords: quantitative, forest fire, fire engine, effectiveness, tactical elements

TŰZOLTÓ GÉPJÁRMŰVEK KVANTITATÍV ÖSSZEHASONLÍTÁSA NÉGY TAKTIKAI PARAMÉTER TEKINTETÉBEN

Absztrakt

A tűzoltóság járműparkjának a gerincét a közepes, és nehéz tömegosztályú fecskendők alkotják. Ezekkel az univerzális járművekkel érkeznek az első beavatkozó egységek a káresetek helyszínére. Ezeknek a járműveknek a kialakítása optimális lehet városi, épített környezetben, de a szabadtéri tüzek megközelítése során gyakran képtelenek kihasználni az olyan előnyös tulajdonságaikat, mint a nagy szállított vízmennyiség, vagy a teljes raj szállítása. Ennek oka lehet a tömeg, a fizikai méretek, illetve a nem megfelelő terepjáró képesség. Mivel a tűzesetek közel 50%-a szabadtéri tűz, indokolt volna olyan járművek készenlétben tartása, amely

használata ilyen körülmények között is lehetséges. Az optimális jármű meghatározása érdekében tudnunk kell, melyek azok a képességek, amelyek ahhoz szükségesek, hogy a beavatkozás a leghatékonyabban, és a legrövidebb időn belül megkezdhető legyen.

Kulcsszavak: kvantitatív, erdőtűz, erdőtüzes gépjárműfecskendő, hatékonyság, taktikai elemek

1. DEFINITION OF FIREFIGHTING TACTICAL ELEMENTS

Wildfires are one of the most challenging disasters in Europa. If it is possible, these fires should be prevented [1] [2] [3] or the spread of fire should be reduced [4] [5]. However, if the prevention was not successful, the fire must be extinguished [6], because fire can endanger the human life and material goods [7]. On the one hand complex fire protection is very important for the successful firefighting and on the other hand [8], the effective technical background must be provided. If we examine the technical properties of different vehicles, taking into account our experience and the parameters, we can determine how each property affects the suitability of the vehicle for the performance of firefighting tasks [9]. These properties are called firefighting tactical elements. Different aspects are relevant to the performance of different tasks, so it is advantageous to consider the elements that most influence their subsequent application when selecting a vehicle designed for special tasks.

Extinguishing outdoor, forest and vegetation fires is one such special task. It is no coincidence that the Firefighting Tactics Code states that “large-scale forest and vegetation fires require special equipment and tactics” [10]. In reality, however, special devices and vehicles are limited, although they would be needed [11]. Fire is usually not constrained by physical constraints, combustible material and oxygen are also available. However, the conditions of the approach are extremely varied, and it often happens that there is no road to the site of the fire that could be traversed by the agents in the system. The key to eliminating the damage is quick arrival [12]. This requires a vehicle that can travel at high average speeds on different quality roads, and transports the interveners and the equipment and extinguishing equipment needed for firefighting as close to the fire as possible [13] [14].

Picture 1 - A fire is often inaccessible with heavy fire trucks.

If we examine these capabilities, there are still a number of properties that can be considered, but based on my professional experience, the most important ones are the average speed, the front surface, the ground pressure, and the useful weight. I performed comparative tests, during which I examined heavy, medium and light weight class fire engines, and also displayed the parameters of a pedestrian firefighter. In the comparative studies, the heavy weight class is represented by Komondor, the medium by Unimog, and the light weight class by a simple pick-up [15].

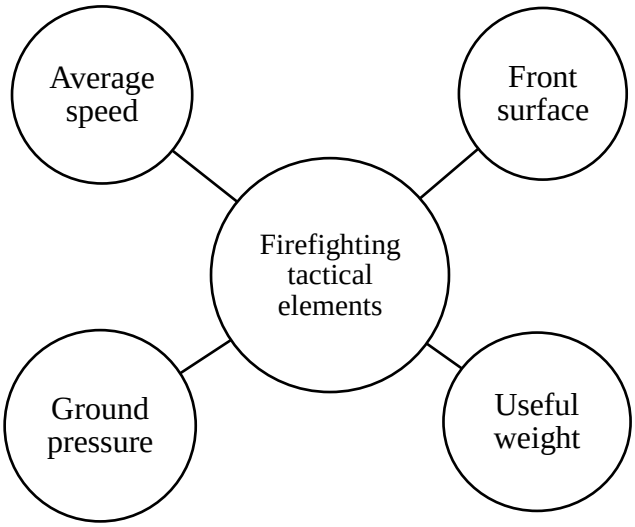

Figure 1 - Tactical elements selected for the study. Created by the Author.

Average speed

The average speed of vehicles basically determines how quickly units can respond to a fire [16]. This value is similar for all vehicles tested on a paved road, but the differences are significant when measured in the field. The maximum average speed available depends on the given terrain conditions, so in this case I determined the following values based on my professional experience [11].

The average off-road speed of medium-weight fire trucks is typically around 20 km/h. In the case of Unimog, in my experience, this is correct, and since I do not have similar data for Komondor, I used this value as a basis here as well.

The small size and maneuverability of light pick-ups can really be used in these conditions, so I calculated an average speed of 40 km/h.

In my experience, the average pedestrian speed of a firefighter in protective clothing, equipped with extinguishing water, reaches 4 km/h in the relatively long term.

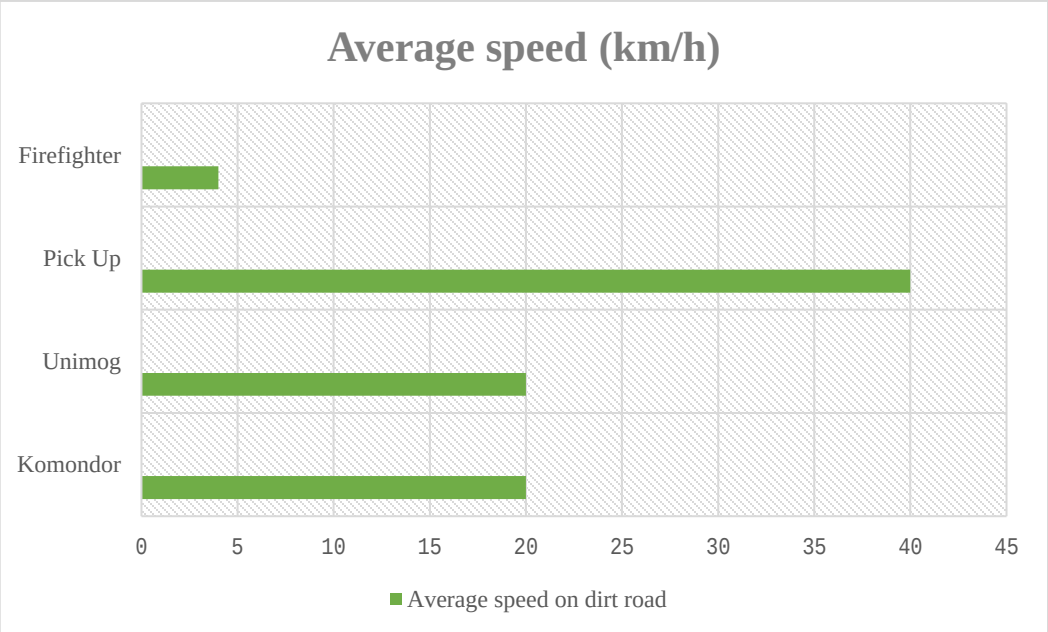

Figure 2 - Comparison of average speed on dirt road as a tactical element. Created by the Author

The key to successful firefighting is to apply the right forces at the right time and place. Ensuring this is closely related to the average speed available to vehicles.

Front surface

On forest roads, narrow roads make it harder, so the front surface is the value from which we know how narrow a device can get through. This value can determine how close the vehicle will be to the fire. When calculating the front surface, I multiplied the width of the vehicles (and the firefighter) by their height and multiplied by 0.85 to get a number as close to the real value as possible.

Front surface = width x height x 0.85

Komondor

Front surface = 2.55 m x 3.05 m x 0.85 = 6.6 m^2

Unimog

Front surface = 2.5 m x 3.5 m x 0.85 = 7.4 m^2

Pick Up

Front surface = 2.48 m x 1.8 m x 0.85 = 3.8 m^2

Firefighter

Front surface = 1.9 m x 0.62 m x 0.85 = 1 m^2

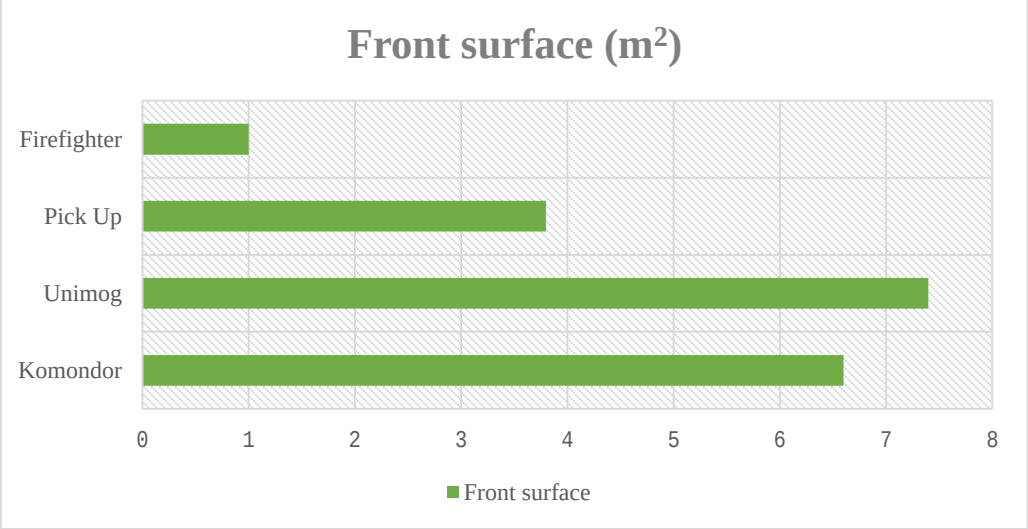

Figure 3 - Comparison of front surface as a tactical element. Created by the Author.

Among other things, the front surface is the value that makes a large number of fires inaccessible by car, only on foot. Here you can clearly see the advantage of light forestry over medium and heavy weight class.

Ground pressure

One of the defining elements of off-road capability is the pressure exerted on the surface. It is important when driving on loose ground, it mostly means sandy areas. This may also cause a possible sink, in which case not only the extinguishing water supply and the required forces will not be delivered as planned, but additional forces will have to be used to rescue the stuck vehicle. This can mean removing additional forces from firefighting. To determine this, I calculated the quantity from 4 perspectives for Komondor, Unimog, a Pick Up, and a pedestrian firefighter.

The Unimog Michelin X Terrian 20-inch, 365x85 tire has a ground contact area (upholstered, filled with water) of 980 cm^2 per piece, for a total of 3920 cm^2. Based on a weight of 16 t, 4.1 kg/cm^2.

Based on the pictures taken of the Komondor, it can be observed that it was fitted with this type of tire, so here I also calculated 980 cm2 per piece, in the case of the six wheels it is 5880 cm^2. The weight of 31 tons thus means a ground pressure of 5.27 kg/cm^2.

The ground area of the wheels of a Pick Up is 17 inches, 509 cm^2 per piece for 245/65 tires, for a total of 2036 cm^2. At a weight of 3.5 tonnes, this is 1.7 kg/cm^2.

The pressure of a firefighter on the ground is boot size 45 (156 cm^2) and 0.64 kg/cm^2 for an installed weight of 100 kg.

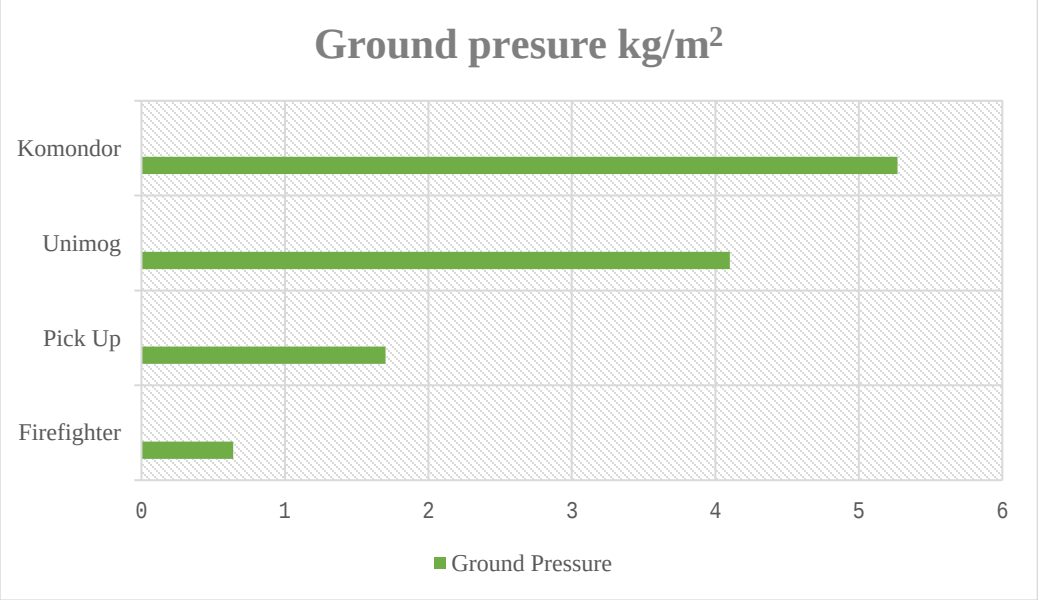

Figure 4 - Comparison of ground pressure as a tactical element. Created by the Author.

It can be stated, that the ground pressure of Komondor is very high, this is a clear tactical disadvantage, from the point of view of forest fire extinguishing it is manifested during traffic on loose ground.

Useful weight

By useful weight I mean the extinguishing water delivered, the crew, and the specialized equipment used for forest firefighting. If we divide the payload by the total weight and then multiply it by a hundred, we find out what percentage is the payload of the vehicle.

Pick Up

Total weight: 3500 kg

Extinguishing water supplied: 1000 kg

Crew with personal protective equipment: 600 kg

Special equipment (hand tools, saws): 200 kg

$$Useful\ weight = \frac{1800}{3500} = 51{,}5\%$$

Unimog

Total weight: 16000 kg

Extinguishing water supplied: 2700 kg

Crew with personal protective equipment: 100 kg

Special equipment: 200 kg

$$Useful\ weight = \frac{3000}{16000} = 18{,}8\%$$

Komondor

Total weight. 31000 kg

Extinguishing water supplied: 7000 kg

Crew with personal protective equipment: 100 kg

Special equipment: 400 kg

$$Useful\ weight = \frac{7500}{31000} = 24{,}2\%$$

Firefighter

The weight of the firefighter intervening in the forest fire extinguishing was determined in 80 kg body weight, 12 kg protective equipment, 25 l transported extinguishing water, and 1 piece of 3 kg hand tools.

Total weight: 120 kg

Extinguishing water supplied: 25 l

Personal protective equipment: 12 kg

Special equipment: 3 kg

$$Useful\ weight = \frac{40}{120} = 33{,}3\%$$

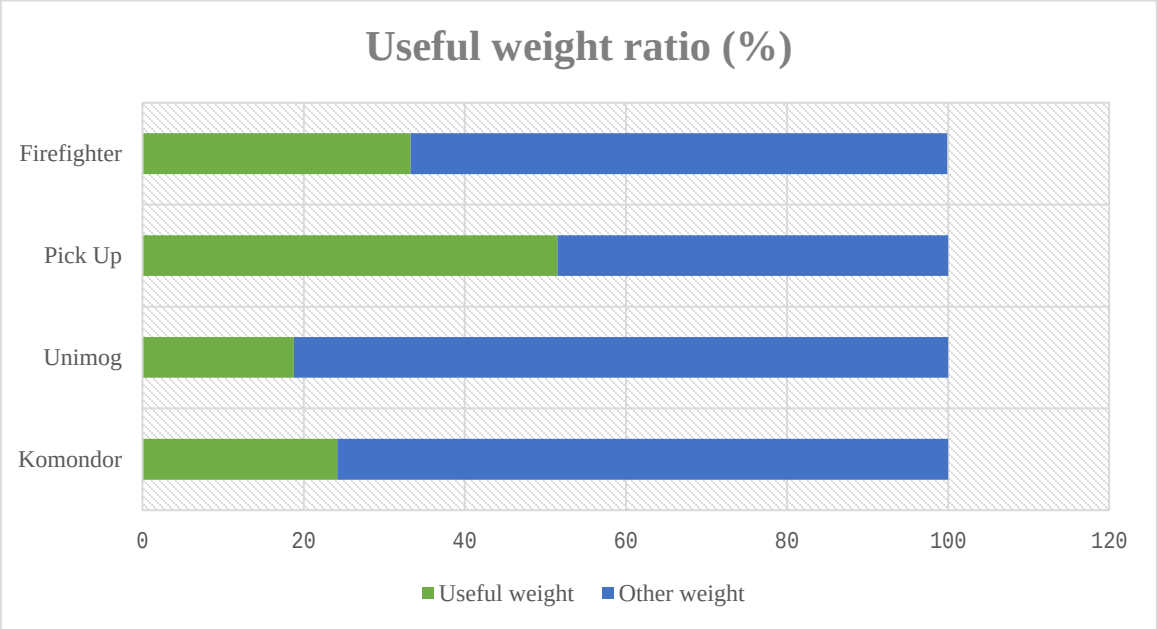

Figure 5 - Comparison of useful weight as a tactical element. Created by the Author.

It can be seen that the light forest alone soars in terms of fire that is too useful for the crowd. The reason for the heavy weight of the Komondor is the armour of the vehicle, which was kept by the manufacturer like the base version. This is justified for original military use, but only extremely rarely during firefighting interventions. According to the manufacturer's definition, armour protection will ensure its applicability even when approaching focal points where there is a risk of explosion and consequent the possibility of bursting. This is not justified in case of forest fires [15].

2. SUMMARY

I examined the tactical elements of firefighting that I considered most relevant to extinguishing forest fires. The choice of the elements was justified by the fact that, based on my professional experience, these are the properties that influence the unit to reach the fire in the shortest possible time.

Average speed is very important. Similar values are available on asphalt roads in any weight class, but lighter vehicles are preferred on dirt roads or off-road. In more complex terrain, this advantage is even more significant, which can be verified by further measurements.

The main goal, in addition to increasing the average speed, is to minimize the pedestrian approach. Large fire trucks are difficult to move on narrow roads, in an area bordered by trees, due to their width and height. In this respect, the advantage of smaller vehicles is also apparent. The front surface is therefore an important parameter.

Ground pressure is the most important value of transport on loose ground. The fire trucks that are currently widely used are already struggling, especially in the Hungarian Great Plain region. Similar problems can be expected in mountainous areas. Of course, these areas are not currently most affected by forest fires, but we need to be prepared for future interventions in such terrain conditions.

An interesting data for vehicles is the useful weight tested for forest fire extinguishing. Forest fire extinguishing as a special task requires well-defined tools. In addition to the necessary chainsaws, hand tools and extinguishing water are required, and of course firefighters. In addition, all other devices hinder the vehicle in motion, so the non-useful weight must be kept to a minimum.

I find it important to mention that in order to determine the optimal vehicle, it is necessary to examine more firefighting tactical elements than described [17], but this is not possible by the scope of the paper. We examine several aspects and use the obtained parameters to select the vehicle from which we can build the optimal wildfire fire truck. Such an analysis serves sustainable development within the field of the disaster management [18] and engineering sciences [19].

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