PROGRESS OF THE WHEELED AND TRACKED UNMANNED GROUND VEHICLES

Miroslava Cúttová[1] – Peter Droppa[1] – Vladimír Popardovský[1] – Eva Popardovská[1] – Štěpán Pavlov[1]

[1]*Armed Forces Academy of gen. M. R. Štefánik – Demänová 393, 031 01 Liptovský Mikuláš, Slovakia*

* Corresponding author e-mail address: miroslava.cuttova@aos.sk

Abstract

The article deals with the analysis of the current state of the advancement in the area of the unmanned ground vehicles (UGVs) at home and abroad. Currently, the army programs are focused on the development of UGVs in the three areas - light, medium and heavy ground vehicles. Each category has different main aim. The light vehicle can provide reconnaissance in urban environments. The heavy vehicles will be support the forces with the weapon systems to engage and destroy the enemy. The multifunction vehicle is vehicle medium size. Based on the obtained data, the concept of the wheeled and tracked unmanned ground vehicle was realized. This vehicle could be used in conditions of the Slovak republic.

Keywords: unmanned ground vehicle, wheeled vehicle, tracked vehicle, advancement

1 Introduction

Currently, there is an increasing number of articles written about the technology known as unmanned or unpiloted vehicles. Although the idea of robots replacing humans is not new, it became more visible recently. This is mainly due to possibilities of this offers to the emerging sectors of economy such as electronics or robotics. The reason for their rapid development is the effort to implement them in many different sectors where they could ease our work or, eventually, even fully replace us. Today, many functional prototypes can be classified according to criteria as:

- focus area (civil, military – fig. 1),
- chassis type (wheeled, tracked, walking, combined),
- method of control (wire, wireless),
- driving element (combustible engine, electric engine, hybrid),
- size and weight (light – man portable, light – self portable, medium and heavy),
- working environment (terrestrial, aerial, aqueous),
- type of undertaken work (research, demining and transport) [1, 2, 3, 4, 5].

Fig. 1 *Unmanned ground vehicle used in military sector, [2]*

Application of the unmanned ground vehicles into military sector helps protect human lives in the hazardous environments. Today, a lot of prototype in military sector exists, which are used on a daily basis to perform routine or very dangerous activities [2, 3].

2 Weight categorization of unmanned ground vehicles

Nowadays, unmanned vehicles can be divided according various criteria. Many of them, however, can fit into more categories and therefore it could be difficult to determine to which group they exactly belong. By weight, they can be divided in four categories. In the first category, light man portable vehicles are described. The second

one deals with light vehicles, but not man portable. Medium and heavy unmanned technology belongs to the third and fourth category [1, 6, 7].

Man transportable unmanned ground vehicles (MT UGVs)

Man Transportable or small unnamed ground vehicles are small portable robotic systems that often weight less than 10 kg. They are mainly used for research in built-up/urban areas and places with difficult access, such as caves or urban sewage systems. Special units in places occupied by the enemy mainly use these devices. Owing to its lightweight, one soldier only is needed for transportation of the vehicle and its operation. Many of them are able to perform a number of tasks and therefore they are a very valuable help in the situation of unknown territory that needs to be recognoscated as well as any objects that could pose a threat to the soldier's life and to his overall mission [7, 8].

One of the representatives of this group is system Dragon Runner – fig. 2. It is small, four-wheeled vehicle. Its maximum speed is 32 $km.h^{-1}$. Due to its low weight, it can move on low load terrain [8].

Fig. 2 *Dragon Runner, [8]*

Into this category also could be include vehicles as Viper or Matilda. Their some basic technical information are listed in the table 1.

Light, self-transportable unmanned ground vehicles (ST UGVs)

Despite the fact that the dimension is similar as in the previous category, their weight does not allow soldiers to carry them as part of their outfit. The operator carries only the remote control device, which forms part of it. The vehicles are transported to the desired location either by themselves or by any other aerial or terrestrial vehicle. The main task of most of these vehicles is reconnaissance, thus there are version designed for transportation of materials, disposal of explosives or performance of military tasks.

This group includes, for example vehicle Talon – fig. 3 or Swords. The basic technical data are listed in table 1.

Fig. 3 *UGV Talon, [9]*

Medium weight unmanned ground vehicles

This category includes vehicles that, given their size and look, resemble small trucks. Nowadays, there are many prototypes of remote controlled robots, whose main task is to assist soldiers in implementation of any mission. It includes mainly the vehicles or devices designed for transport of larger amount of material of any character. Their weight is usually one and more tons. Despite this fact, most of them have a high capability of movement in poorly accessible places and excellent maneuverability skills.

Into this category, we include vehicle Božena 4 – fig. 4, which is produced in Slovakia.

Fig. 4 *Božena 4, [10]*

Other representatives of this group are vehicles, for example Mule, Ripsaw or Crusher. Their basic technical parameters are in table 1.

Heavy weight unmanned ground vehicles

The last group includes mainly modified tanks whose primary role is the disposal of unexplored mines. Their large weight is due to heavy shell, which serves as the most useful protection of built in devices and the vehicle itself against damage. As they are rather noisy, they cannot be used for reconnaissance, but the soldiers can transport larger amount of materials on them. In addition, with their armament makes them a highly effective weapon.

M1 Abrams Panther II can be mentioned to this group. It is a specially modified tank, which is designed to destroy mines. This tank does not have a tower with a weapon system. In the front part is placed system for activation of unexploded mines. This system consists of heavy steel cylinders – see fig. 5.

Fig. 5 *M1 Abrams Panther II, [11]*

M60 Patton has undergone the same changes as M1 Abrams Panther II to become M60 Panther unmanned tank. The basic technical information are includes in table 1.

Table 1 *Technical parameters of unmanned ground vehicles, [6, 7, 8, 9, 10, 11, 12, 13]*

Name	**Dimensions [mm]** **length x width x height**	**Weight [kg]**	**Max. speed [km/hour]**	**Type of Chassis**
Dragon Runner	400×300×130	7.5	32	Wheeled
Viper	460×480×230	14	4 - 6	Wheeled-Tracked
Matilda	760×530×300	28	3.2	Tracked
Talon	860×560×1000	45	6.5	Tracked
Swords	860×560×1000	90	6.5	Tracked
Božena 4	5 375×1 960×2 250	5 800	4 - 9	Wheeled-Tracked
Mule	4 500×1 800×1 500	3 500	50	Wheeled

Ripsaw	4 500×2 500×1 770	4 000	100	Tracked
Crusher	5 100×2 600×1 520	6 000	42	Wheeled
Panther II	8 000×3 800×1 850	43 000	72	Tracked
M60 Panther	7 500×3 600×1 800	35 000	50	Tracked

3 Options of existing unmanned ground vehicles

Wheeled UGVs

Figure 6 shows a transport version of the Mule vehicle. It is a multifunctional utility and logistics vehicle designed to carry 3.5 tons of military equipment. It is approximately 4.5 m long, 1.8 m wide and 1.5 m high [14].

Fig. 6 *Transport version of the Mule vehicle, [14]*

It is powered by diesel-electric engine. On flat surface, it is able to move with the maximum speed of 50 km/hour. Its unique system of all six wheels drive, with the possibility of inclination towards the sides allows it to overcome obstacles that would certainly stop any other mechanism. The vehicle is able to accompany infantry even in a difficult terrain. Each of its independently attached wheels is connected to electric engine, which provide not only the inclination of the individual wheels towards the sides, but also the setting of its weight. It is even able to lift the forefront arms and, by their help, to lift itself when overcoming an obstacle. Due to this feature and changing lightweight, the vehicle has the capability to overcome obstacles up to 1 m high, watercourses up to 0.5 m deep and is able to negotiate slopes of up to 40 degrees inclination [14].

Wide-angled cameras and GPS form part of its outfit. The majority of these vehicles are also equipped with a group of sensors designed for detection of radioactive, chemical or biological threats.

Tracked UGVs

Another unmanned vehicle under development is Ripsaw MS1 (fig. 7). Its design and development are credited to the Howe brothers Geoff and Michael.

Fig. 7 *Remote controlled unmanned vehicle Ripsaw, [15]*

This 4 tonnes and 1.77 m high tracked vehicle had objectively earned the name of the fastest vehicle in the world. It is capable to increase the speed from zero to 80 km/hour in 4 seconds only. Its designers even developed a version, which can do so in 3.5 seconds, but unlike the previous one, it was not stable on uneven ground and therefore it had been abandoned [15].

The vehicle is able to carry up to 900 kg and to move at the maximum speed of 100 km/hour. These excellent accelerating and pulling properties are achieved due to its 6.6 liter, 8-cylinder Duramax type diesel engine with of 650-horse power. The distribution of engine torque from the engine towards the wheel is carried out through hydrostatic gear. A vehicle with such powerful construction elements would move under normal conditions similarly as tanks weighing up to several tens of tonnes. In fact, Ripsaw weights only little over four tonnes. This is because the body of the car is made of steel frame from welded profiles of circular cross section instead of the classic armour body [15].

The vehicle behaves very stable in the terrain due to its 0.75 m high centre of gravity despite its low weight. It is able to move vertically on a slope with the inclination of 50 degrees, and horizontally of the inclination of 45 degrees, and can overcome obstacles obstacle up to 1.5 m high.

As it can be seen from the Fig. 7, the majority of unmanned technology, regardless its weight or dimension, was in the past or still is in the presence based on band chassis. Their mayor advantage in comparison to their wheel version is the ability to reach high pulling power by using the whole weight of the vehicle that enables them to maximize the engine power. Because the contact area of the tracks with ground is larger in comparison to contact area of wheels, there is a decrease in measured pressure towards the land and thereby improving the overall tensile properties.

Among other mayor advantages are higher stability, good permeability of the terrain, addressing relatively high obstacles. Due to low measured pressure on the land there is a good permeability of the terrain with lower carrying capability. The vehicles with band chassis are in many cases able to cope up with the inclination of up to 45 degrees. In addition, the bands are structurally simple and not difficult to maintain.

4 Unmanned ground vehicle design under conditions of the Armed Forces of Slovak Republic

The purpose of this part is to create a possible concept of the unmanned mobile object that could be used by our units in life threatening operations. The proposed vehicles are designed on wheeled and tracked chassis. The tracked unmanned ground vehicle is based on the existing BVP-2 concept, which is used in the military of the Slovak republic.

Design of UGV on wheeled chassis

Currently, there is a new concept of light unmanned ground military vehicle LUGMV (Fig. 8) that has been developed for the use by the Armed Forces of Slovak Republic [16].

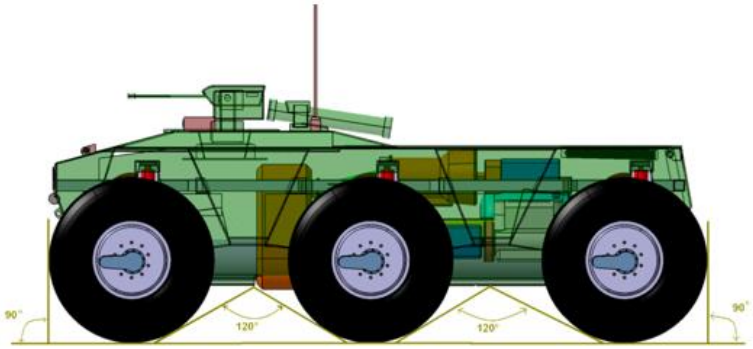

Fig. 8 *Design of LUGMV with wheeled chassis*

It is a six-wheeled terrain vehicle designed to reconnaissance and offensive or defensive operations. Its projected dimensions are: height – 1.869 m, width - 2.5 m and length – 4.788 m. The vehicle is characterized by high mobility on uneven terrain. It should be able to overcome obstacles up to 0.7 m high and manage up to 31 degrees inclination.

The main support part of LUGMV consists of spinal frame designed to increase the strength of the overall structure of the vehicle and for catching the purposed groups complemented by space frame. Curved half axles sprung by springs supplemented by the hydraulic shock absorbers make connection of the wheels with spinal frame.

It is a hybrid solution based on diesel-electric drive (fig. 9) able to work continuously for 10 hours under the condition of fully charged accumulators. The estimated maximum speed on the flat paved road is 120 km/hour and its acceleration from zero to 100 km/hour should not last longer than 14 seconds. It should be armed with 7.62 mm machine gun.

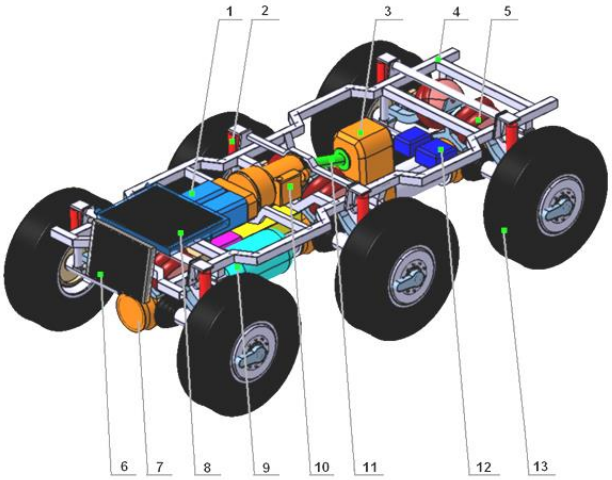

Fig. 9 *Construction of LUGMV*

1 - electric engines siemens, 2 - hydraulic shock absorber, 3 - interchassis differential, 4 - the frame of the vehicle, 5 - air suspension, 6 - cooler of explosive combustible engine, 7 - central skeleton backbone frame pipe, 8 - cooler of electric elements of drive, 9 - fuel tank, 10 - automatic 5th grades gear, 11 - joined drive shaft, 12 - control units of weapon systems and auxiliary electronics, 13 - vehicle wheel

Design of UGV on tracked chassis

The construction of proposed unmanned tracked ground vehicle (UTGV) is based on tracked vehicle BVP - 2. Than the dimensions of UTGV are approximately: height – 1.6 m, width - 2.8 m and length – 6 m. Its estimated weight would be approximately 11 tonnes (it would be lighter than original BVP-2).

There are two alternatives considered for its drive. The first would be a four-stroke, diesel, liquid cooled engine with the power of 200 to 250 kW supplemented with hydro-mechanical gear mechanism placed in the back part of the vehicle. The second alternative is a vehicle with hybrid drive (combination of diesel and electric drive). Hybrid drive advantages are low fuel consumption, improved driving dynamics, silent engine and reduction of harmful emissions and increase of its overall efficiency. In comparison to other types of propulsion, its construction is more complex and the vehicles have smaller cargo space.

The support part of the vehicle consist of a ladder frame. To this frame, a steel skeleton is mounted. It increased firmness of the upper part of the body and allows attaching the main functional groups and parts of the vehicle. Suspension of the chassis would be realized by torsion bars or similarly as in the Ripsaw vehicle by winding springs – fig. 10.

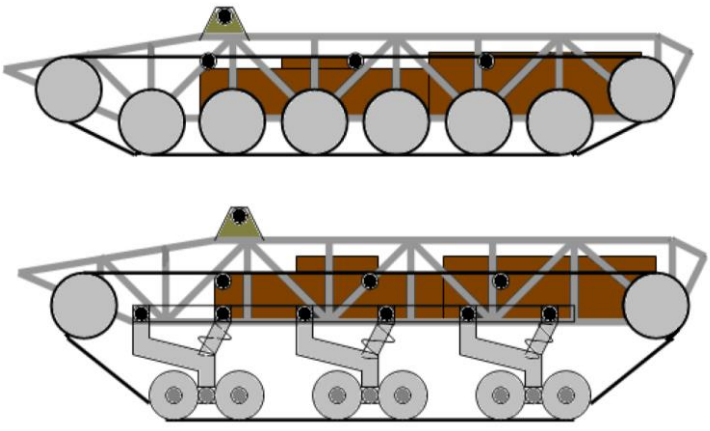

Fig. 10 *Suspension of UTGV by torsion bars (up) or winding springs (down)*

Weapon system design of UTGV - to enhance the combat capability of the vehicle, the weapon system ZSRD 07 on the upper part of the vehicle is located. ZSRD 07 is a remote controlled weapon station designed for tracked and wheeled vehicles. It is equipped with a sensor system capable of reliably working not only during the day but also at night and in low visibility. The location of the selected weapon system on the UTGV is shown on the following fig. 11.

Fig. 11 *Proposal for unmanned ground vehicle on tracked chassis*

5 Conclusion

Current trends in development of unmanned ground vehicles have brought number of construction solutions the use of which depends largely on the type of performed activity and working environment. The presented overview on the vehicles would suggest that despite the wide range of possible designs of wheeled and tracked unmanned vehicles, the most suitable and most widespread appear to be a tracked design, owing to its favourable drive and traction characteristics.

Although it is highly unlikely that tracked vehicles would completely replace the wheeled vehicles in the future, their use seems to be more efficient for a number of reasons.

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