REMOTE-CONTROLLED VEHICLE FOR REMOVAL OF DISASTERS

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Abstract

This paper presents an analysis of various natural and man-made disasters being angled as possibilities of usage of remote control or autonomous machines and vehicles. The certain requirements which such machines and vehicles have to meet to remove effects of natural disasters and local military conflicts or terrorist attacks are described. Proposal for remote-controlled vehicle assigned for operations in conditions hazardous to human live is presented.

The value of unmanned vehicles is directly related to the applications to which it can be successfully applied. This paper will highlight applications, missions, and capabilities that have been demonstrated on the "Lewiatan" platform to date as well as future application and mission considerations. This platform – assigned for both water and land operations – is equipped with remote control, surroundings observation and visualization systems. In this paper the advantages of hydrostatic power systems as the power transmission units for unmanned vehicles have been also presented.

Resolving problems with navigation of vehicles will allow expansion of it's applications from a military point of view in the upcoming few years, to a wide range of applications in times of crisis with direct human life threat.

Keywords: *disaster removal, remote control system, hydraulic power system*

1. Introduction

Dangerous events that occur more and more often in contemporary world, being result both natural disasters as well as terrorist attacks (e.g., contaminations, destructions and mining of terrains) and local armed conflicts extort necessity for wide utilization of different machines to remove (or limit) the negative results of them. However, the enormous majority of working machines (excavators, bulldozers, and mobile cranes) or combat engineering vehicles are used for such tasks being controlled directly by an operator (without remote control or computer-aided systems). It is possible to expect that threats will occur for operators and people who cooperate with them. Hence, we have to very intensely develop the remote control system for such machines and vehicles [2].

On the other hand, implementation of fixed elements on board of these vehicles that would adapt them to remote or automatic control is not often rational (reasonable) from the economic point of view. Hence, taking the attempt to define the general structure of a system which would adapt these vehicles for remote control, but only when it is needed, very easily, and with limited number of elements installed on board.

It is clear that the core of such a system (transmitter and control desk) and the operator should be located outside of the vehicle (in safe distance from them). It also requires to make a suitable outside subsystem of visualization of vehicle's position and its additional equipment, to define their coordinates in global coordinate system and to counteract in case of such critical incidents as damage or standstill of a vehicle or communication problems between the vehicle and the operator (break of transmission of control signals). The basic efforts of designers of control system of such vehicles should be focused on minimizing their onboard structure through [4, 5]:

- applying the simple and reliable elements of execution system,
- minimizing of the amount of data transmitted from the vehicle (decreasing the number of sensors and converters),

- introduction the “reliable core” of control system - operating in emergency states,
- possibilities of automatic reconfiguration of onboard systems in case of breakdowns and faults.

This extorts necessity of extension of external structure of control system (placed beyond range of direct influence of surrounding of vehicle), what causes:

- necessity of increasing of numbers of transmission channels and speed of sending of information and commands,
- growth of probability of occurring of errors - it requires to amplify signal power for keeping required range of transmission link,
- necessity of elaboration of detailed and complex steering procedures with many variants of operation.

Such designed control system of unmanned vehicles and machines with various extent of automatic and autonomous operation can execute wide range of works such as removal of effects of natural disasters and local military conflicts or terrorist attacks (Tab. 1) [1].

*Tab. 1. Classification of disasters being angled as possibilities of usage of the remote control vehicles**

DISASTERS	
NATURAL	**CIVILAZATION**
Landslips, earthquakes, volcanic eruptions	**Contaminations - radioactive, - chemical, - biological**
Floods	**Calamities and destructions of objects: - buildings, -communications**
Deep snowfalls, snowstorms, blizzards	**Fires**
Strong winds and hurricanes	**Terrorist attacks and different threats of public safety**
Long-lasting freeze or droughts, hailstorms or glazes	**Destruction damages of infrastructure in result of terrorist attacks and local military conflicts**
Plague of rodents and insects	

[*)] intensity of gray color indicates extent of usage of the remote control or autonomous machines

2. High mobility vehicle “Lewiatan”

A mobile platform which is a basic element of a remote controlling vehicle is also a carrier for sensors kit, control units with a software, transmission connection and additional equipment which depending on appropriately to a vehicle’s usage.

High requirements concerning the mobility of the platform, possibilities of conquering terrain obstacles, moving at minimum speed and flexibility to remote and autonomous steering are only some of the reasons for choosing a hydrostatic power transmission system.

An example of a vehicle equipped in a hydrostatic power transmission system is “Lewiatan” which is a light multi-role conveyer and accessories carrier. “Lewiatan” can be used either as a load carrier at a maximum weight to 1.5 t or as a basic vehicle-tools or engineering equipment carrier. Good traction properties, ability to conquer water obstacles without initial preparation as well as a possibility of feeding additional devices with a fluid drive extends a range of its employments (Fig. 1).

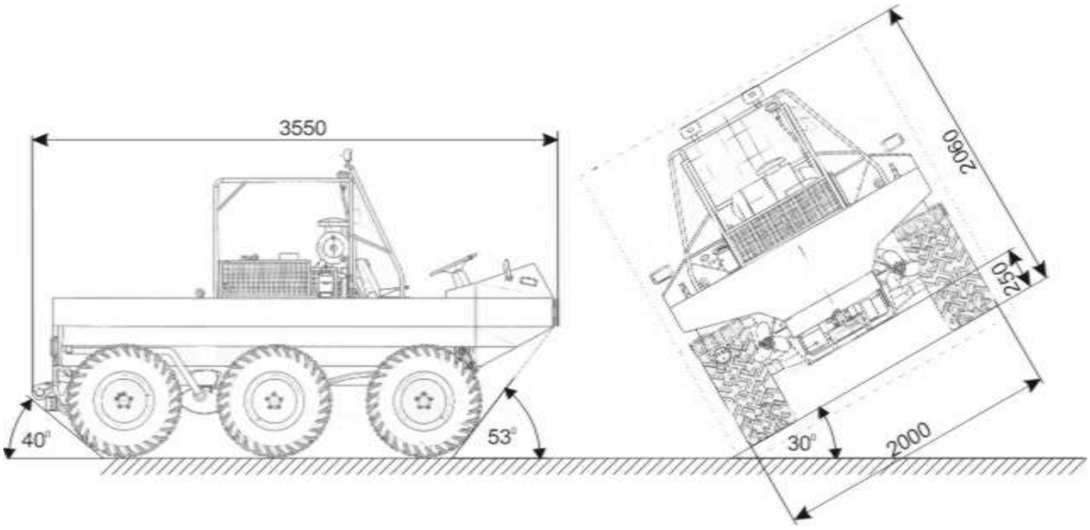

Fig. 1. Main dimensions of "Lewiatan" vehicle

The main elements of it's drive system are (Fig. 2): internal combustion engine and pumps block (7); three control blocks of driving axle (1, 2, 3); a propeller control block (4); two hydraulic motors for the propeller (5); six hydraulic drive motors (6) power distribution block (8); steering block (9); brake block (10); block for supplying external devices (11); cooling and filtering block (12); oil tank(13); and power supply for external devices (14).

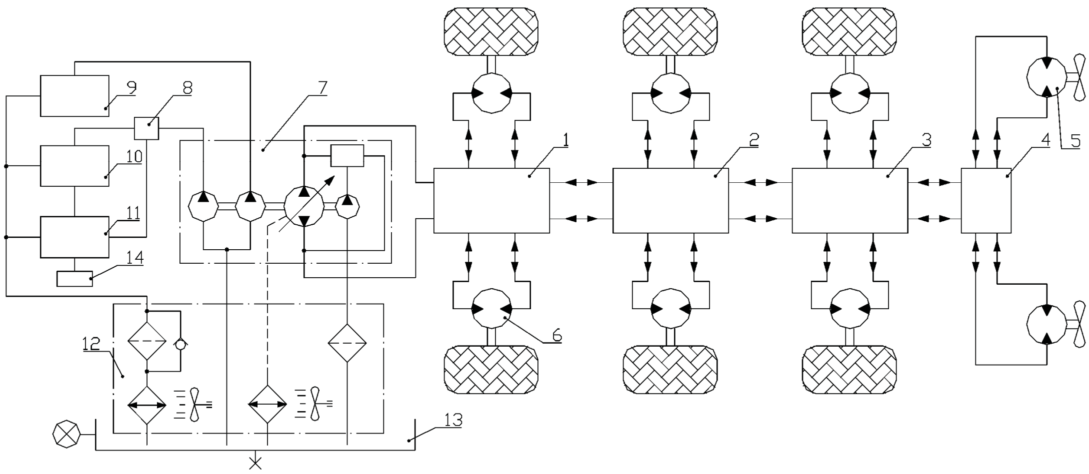

Fig. 2. Scheme a hydrostatic drive system: 1, 2, 3 – control blocks of driving axle; 4 – control block of screw propeller; 5 – hydraulic motor of screw propeller; 6 – hydraulic drive motor; 7 – pumps block; 8 – block of power distribution; 9 – steering block; 10 – brake block; 11 – block for supply external device; 12 – block for cooling and filtering; 13 – oil tank; 14 – terminal for external device

Steering a hydrostatic transmission is done by an automatic transmission ratio system influencing pump productivity.

Road wheels are driven independently by hydraulic motors. Special blocks are applied in the system that allows:

- switch on and off individual motors,
- synchronization of drive wheels work,
- a turn in a place by a motors drive forward at one side of the vehicle and backward at the other side of the vehicle,
- a turn and a choice of the swimming direction,
- a choice of vehicle drive direction.

Permanent productiveness auxiliary pumps have been installed behind the main pump to feed aided steering system, braking system and external receivers.

Due to a number of transmissions and using motors of permanent absorptive initial choice of off-road or road transmissions is done by switching off following axles motors. In that way a variable and summary motors absorptive is achieved. Fig. 3a shows traction characteristic of a vehicle on which individual curves show different variants of transferring drive on the drive wheels:
a) six motors drive,
b) four motors drive,
c) two motors drive.

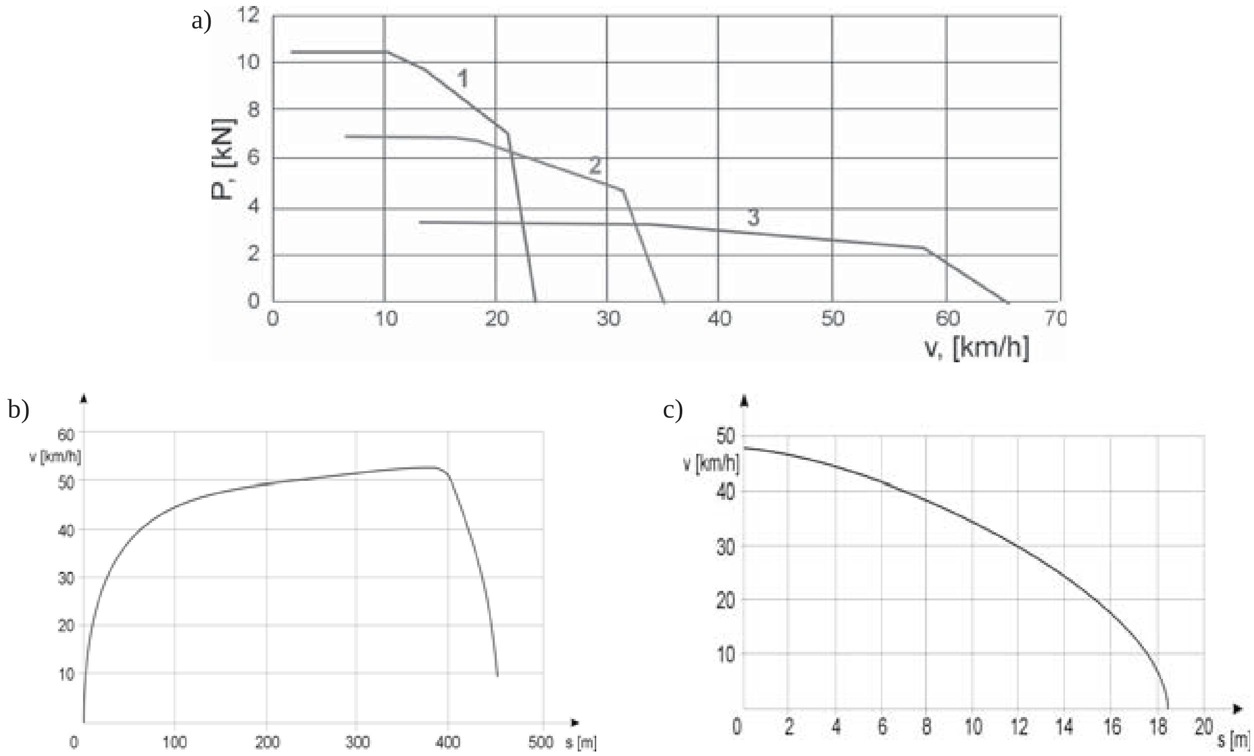

Fig. 3. Vehicle characteristics: a – traction parameters, b – vehicle acceleration, c – breaking distance course

A simultaneous work of driving bolts and chosen wheel motors is possible at the time of driving into and out a water obstacle. On the following figures a few research results of traction properties of "Lewiatan" equipped in a hydrostatic power transmission system are showed: a characteristic of vehicle acceleration for wheel pressure 0.2 MPa (Fig. 3b) and an example of breaking distance (Fig. 3c). A vehicle gathers maximum 54 km per hour speed in 31 seconds and its breaking distance (on hardened surface) is about 18 metres. A minimum turning radius has also been researched and amounts 3.38 m for a left turn and 3.86 for a right turn.

3. Remote controlled system for unmanned vehicle

Research on elaborating the remote control system is being carried out in Military University of Technology. Beside the remote control system a vehicle will be equipped in systems providing autonomous working. Based on self-research and literature studies [3, 6-8] a remote control system of "Lewiatan" vehicle was elaborated. This system consists of a console and a visualization system both assembled on the operator's station and a controller with sensors assembled on the vehicle. Sensors are divided into three groups: environment reconnaissance, vehicle localization and vehicle parameters control. Environment reconnaissance is done by video cameras and ranging laser. The pictures from cameras are transmitted via radio-link to an operator's station (external feedback loop) whereas the signals from ranging laser are sent in two directions: to an operator's station and to an aided operator's steering system. According to the steering signals and signals from ranging laser (internal feedback loop) an aided operator's steering system works out signals for governing a vehicle. Localization of the vehicle in terrain is done by GPS system and a vehicle's inclination sensor. These information are displayed on an operator's console. Signals from sensors that measure parameters of the vehicle are sent to a control system (Fig. 4).

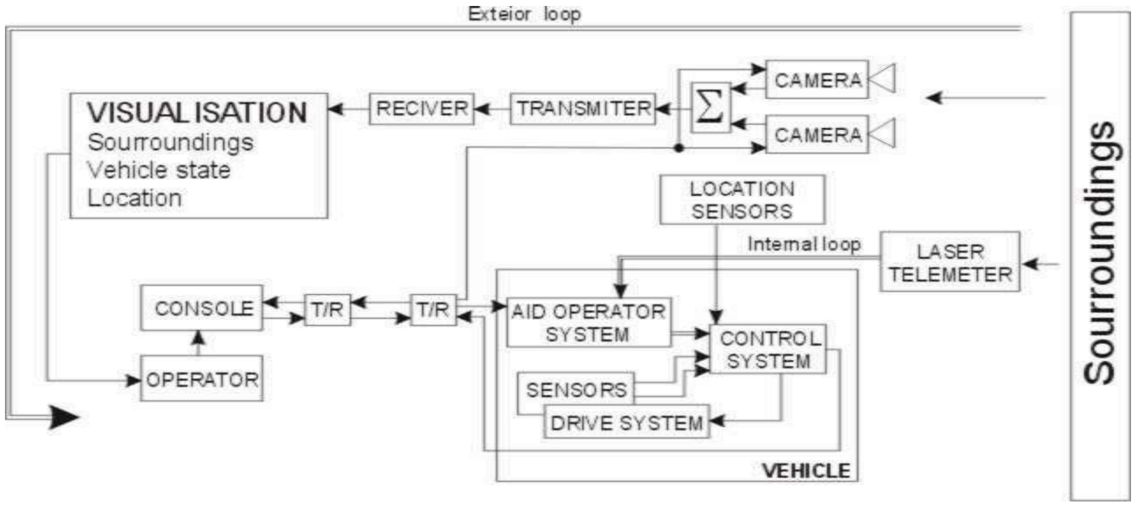

Fig. 4. Functional scheme of the tele-operated control system of unmanned ground vehicle

Figure 5 shows unmanned rescue vehicle which is based on "Lewiatan" vehicle with some elements of remote control and environment reconnaissance systems. Remote control system consists of: ranging laser SICK, video cameras, a vehicle controller, a radio kit for transmitting and receiving and an operator's console.

a)

b)

c)

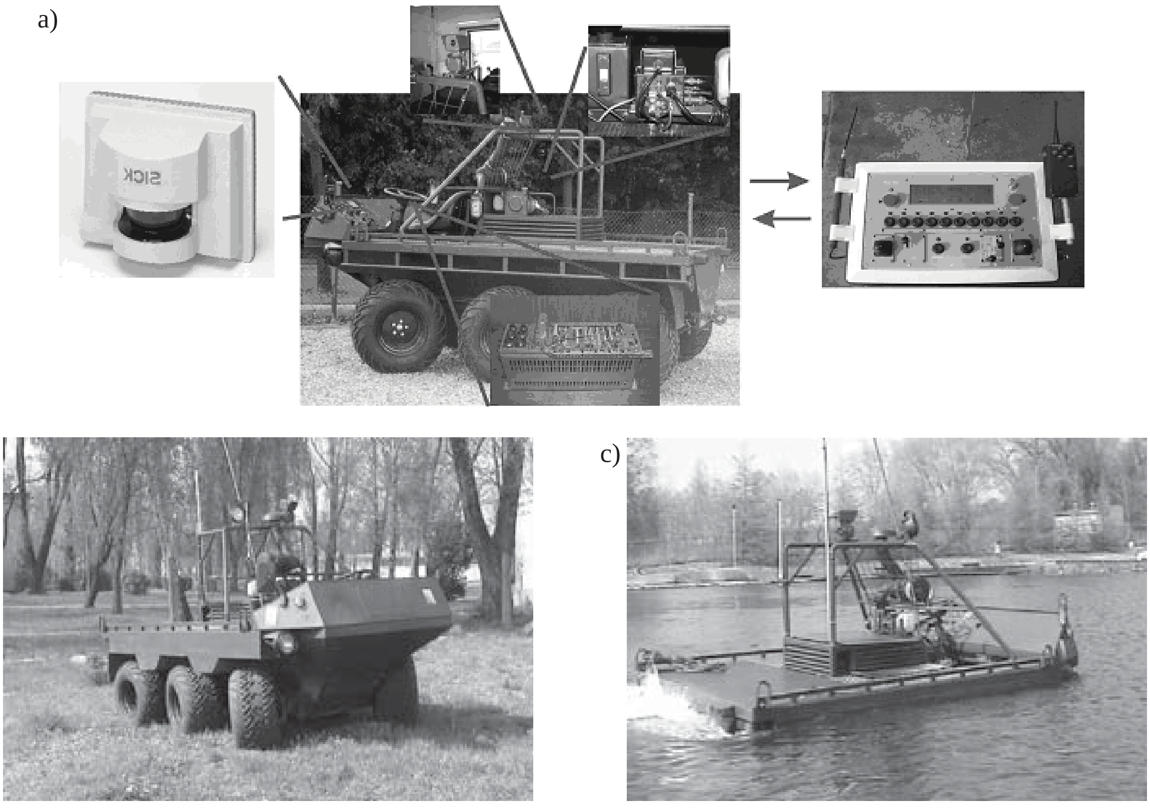

Fig. 5. Vehicle "Lewiatan": a – with remote controlled system, b – crossing terrain test, c – swimming test

Tests of adapting “Lewiatan” to a use as a remote controlled vehicle were carried out in Military University of Technology. Theirs results fully confirmed that – worked out system would be of use for elaborating and testing rescue operation and also actions connected with lifting and moving hazardous loads, taking of samples of ground contamination.

An unmanned platform can play a very important role when there are biological or chemical accidents. It can be used for disposal of dangerous materials, to take samples of contaminated soil or to make a map of a contaminated area with marking the level of contamination.

4. Applications suitable for UGV “Lewiatan”

There are many possible applications exist that are well suited for unmanned ground vehicles. Authors selected some of them as excellent examples for automation using the “Lewiatan” unmanned vehicle platform. Search and rescue efforts are most often conducted in areas with rough or dangerous terrain. A remote platform capable of traversing extreme terrain under varied weather conditions has the advantage of not putting additional human lives at risk. Water rescue missions involving flooded or swampy areas, fast moving water, and thin ice can also benefit from the vehicle’s floatation and mobility. The platform can easily be configured to accommodate stretchers, deliver equipment and supplies, and transport rescuers in circumstance where human intervention is critical.

Fire fighters, police officers, and emergency service personnel put their lives at risk every day to protect and serve the people of our communities. The use of the “Lewiatan” unmanned vehicle could have a dramatic impact on lowering accident and casualty rates among rioters, law enforcement personnel, rescue crews, and those involved in natural disasters. In many forest fire scenarios the rugged terrain often restricts heavy equipment from entering and extinguishing hot spots.

Unmanned sampling is especially important when the suspect materials could be harmful or fatal to humans such as in and around nuclear, chemical, and biological production and storage facilities. The precision used in site sampling can also aid in the creation of accurate documentation of contaminated areas. Auxiliary robotic arms, sensors, and tools used for sampling can be easily adapted to work with the unmanned vehicle by taking advantage of the vehicle's hydraulic and electrical power systems.

As a mobile communications link, “Lewiatan” can be deployed to sites to best optimize reception and transmission of signals. The ability of the vehicle to be manoeuvred in slow small increments over a wide variety of terrain is a distinct advantage that can ensure best placement of the communication link.

As a logistics platform, “Lewiatan” could play a pivotal chain role. The platform is specially predisposed to rummage contaminated areas. It can move through difficult terrain, and it’s low pressure exerted on the ground allows it to drive safely on snow, ice and swampy terrain. Furthermore it possesses an important ability is to cross water obstacles without having to change it’s configuration (Fig. 6).

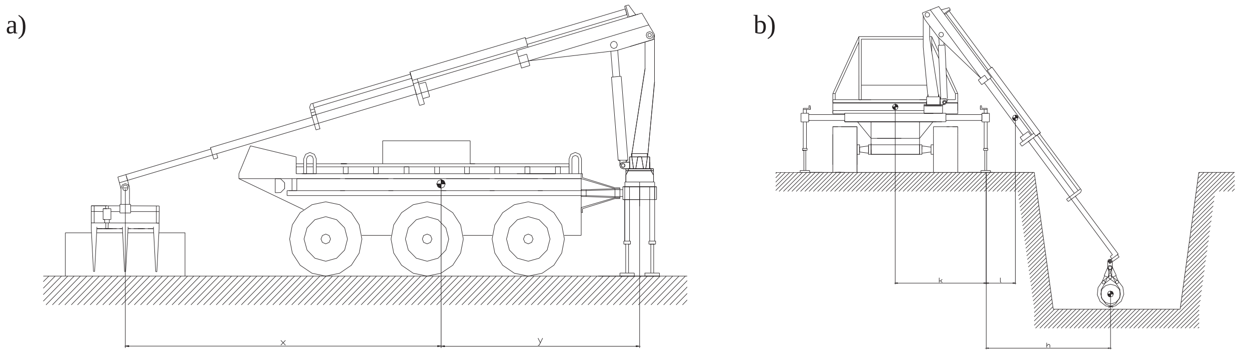

Fig. 6. “Lewiatan” equipped with the manipulator: a - lifting a cargo in front of the base vehicle; lifting a cargo from ditch with depth up to 2 m, permissible weight of cargo is up to 500 kg.

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5. Conclusions

The future holds a lot of promise for the farther development and deployment of unmanned vehicles of all types. Applications and missions suitable to unmanned vehicles will continue to be identified and robotic technologies will further evolve to fill those needs allowing more complex missions to be performed using unmanned systems.

Fire, police, and emergency service missions can also benefit from the use of an unmanned vehicle such as presented platform to keep police officers, fire fighters, emergency medical personnel, and search and rescue teams out of harms way while still allowing them to perform critical roles that enhance public safety.

Presented unmanned vehicle is highly mobile, mission capable, and well-suited for use in dull, dirty, difficult, and dangerous application environments. It is our belief that the system is capable of serving many current needs for unmanned technology and that the platform, software, hardware, electronics, and sensors will continue to improve and become an important asset in many more application areas in the months and years to come.

Resolving problems with navigation and steering of those types of vehicles will allow expansion of it's applications from a military point of view in the upcoming few years, to a wide range of applications in times of crisis with direct human life threat.

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References

[1] Bartnicki, A., Kuczmarski, F., Przychodzień, T., Typiak, A., Wrona, J., *Remote Control of Machines for Removal of Damages Being Result of Disaster, Wars, and Terrorist Attacks*, 19th International Symposium on Automation and Robotics in Construction, pp. 211-216, Washington 2002.

[2] Bartnicki, A., Kuczmarski, F., Typiak, A., Wrona, J., *Design of Control and Power Transmission Unit for Unmanned Ground Vehicles (UGV)*, Methods and Models in Automation and Robotics, pp. 897-902, Szczecin 2002.

[3] Borenstein, J., Cang, Y., *A new terrain mapping method for mobile robots obstacle negotiation*, UGV Technology Conference, Orlando 2003.

[4] Konopka, S., Kuczmarski, F., Typiak, A., *Obstacle Localization in Surroundings Remote Controlled Engineering Machine*, in Polish, Transport Przemysłowy, Nr 4, pp. 65-69, 2004.

[5] Kuczmarski, F., Siemiątkowska, B., Typiak, A., *A Multi-Element System of Surrounding Recognition and Objects Localization for Unmanned Ground Vehicles*, 20th International Symposium on Automation and Robotics in Construction, pp. 89-94, Eindhoven, Holland 2003.

[6] Kuczmarski, F., Typiak, A., *Light Remote Controlled Carrier Special Equipment and Weapon*, in Polish, Szybkobieżne Pojazdy Gąsienicowe, pp. 35-42, OBRUM, Gliwice 2004.

[7] Typiak, A., *Problems with environment recognizance*, in Polish, Pomiary Automatyka Robotyka, No. 1, pp. 12-16, 2003.

[8] Technology *Development for Unmanned Ground Vehicles*. The National Academy of Science, Washington 2002.