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POŽADAVKY NA BUDOUCÍ VOJENSKÉ ROBOTY PODPORUJÍCÍ MOBILITU

THE REQUIREMENTS FOR FUTURE MILITARY ROBOTS SUPPORTING MOBILITY

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Abstrakt

Text se zabývá úkoly, které se vztahují k ženijní podpoře pohybu, současnými požadavky na vojenské roboty a jejich budoucí aplikaci v rámci opatření podpory pohybu. Výsledkem tohoto textu je vyhodnocení požadavků na ženijní prostředky určené k podpoře pohybu a analýzu jednotlivých ženijních opatření z pohledu jejich realizace vojenskými roboty v budoucích operacích.

Znalosti získané studiem vědecké a odborné literatury byly vyhodnoceny metodami analýzy a dedukce. Vědecké metody indukce a syntézy byly využity pro identifikaci možné budoucí aplikace vojenských robotů a pro sumarizaci dílčích závěrů. Informace, které se zabývají požadavky na ženijní prostředky podporující pohyb, byly nashromážděny prostřednictvím metody strukturovaných rozhovorů s vybranými experty. Text poskytuje obecný náhled na téma robotizace ženijních opatření, vztahujících se k podpoře pohybu a požadavkům na vojenské roboty. Dále zprostředkovává náhled na budoucí realizaci ženijních opatření na podporu pohybu a může také posloužit jako vodítko pro zvažování možných investic v rámci Ženijního vojska Armády České republiky.

Abstract

The paper deals with tasks related to engineer support for mobility, contemporary requirements for military robots and their possible future application for mobility support tasks. The result of this paper is an evaluation of requirements for engineer vehicles designated for the tasks of engineer mobility support and an analysis of the individual engineer tasks from the perspective of implementation by military robots in future operations.

Knowledge obtained by studying scientific and professional literature was assessed by methods of analysis and deduction. Methods of induction and synthesis were used for exploring the possibilities of future application of military robots and for gathering partial conclusions. Information dealing with requirements for engineer means supporting mobility were gathered by the method of directed interviews with selected experts.

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The text provides a general insight into the issue of robotization of engineer tasks related to engineer support for mobility and requirements for military robots. Thus, it mediates a preview of the future performance of engineer mobility tasks and it can serve as a guidance for consideration of prospective investments into the Corps of Engineers.

Klíčová slova

Vojenský robot; ženijní opatření; ženijní podpora pohybu; vojenská operace.

Keywords

Military robot; engineer task; engineer support for mobility; military operation.

INTRODUCTION

The armies which invested in modern technologies and development of robotic systems have a considerable advantage over other less developed armies, which may make them stronger in combat. Even without a deep analysis we are able to predict that modern conflicts will be to a large extent carried by devices with a high degree of autonomy, thus with the greatest possible independence on human. Robotic automation is in fact an inevitable process of modern human civilization development and therefore the topicality of the issue is undeniable. If armies want to be competitive (facing new global threats), they will have to invest heavily in the development of modern technologies and especially into robotic systems.

The process of robotic application involves all military areas and military engineering (MILENG) is not an exception. Engineer support of mobility is one of the most important fields of activity of engineer corps and is crucial for meeting the goals of military operations. Based on technological development, it can be predicted that advanced robotic systems will play an essential role also in the engineer mobility support. This is the main reason from which the necessity to address this topic arises.

The paper identifies the most important tasks of engineer support for mobility and requirements for (robotic) devices that execute them. It also deals with the use/application of robotic systems for the engineer support for mobility and defines basic requirements resulting from previous analyses. The aim of this paper is to provide the first insight into robotic automation of engineer tasks for mobility support and to create a wider discussion among interested experts.

ENGINEER SUPPORT FOR MOBILITY TASKS

The engineer support for mobility is one of main MILENG roles. It is considered extremely important, as it is described in the Allied Tactical Doctrine for Military Engineering, where among the Joint Functions (JFs) Maneuver and Fires together with Force Protection and Sustainability are emphasized. It is because of the essential nature of MILENG consisting of shaping the physical aspects of the battlefield. This fact is also

supported by the results of the directed interviews conducted with engineer corps officers.

The engineer support for mobility is realized in order to create conditions for timely and concealed deployment of combat formation, to maneuver forces and to contribute to an increased force protection. In order to support mobility, engineers perform these main tasks:¹

- Gap crossing (including wet and dry gaps);
- Countermine operations;
- Counter obstacle operations;
- Routes (developing and improving routes for tactical movement);
- Explosive threat management (ETM);
- Route clearance (RC);
- Area clearance (AC);
- Military search (MS).

The type of military operation has a significant influence on the engineer support for mobility tasks. There are four basic types of operations:²

- Combat - tends to be characterized by a series of battles and major engagements with intense combat activity and high logistic consumption. Particular emphasis is placed upon maintaining freedom of action and denying that freedom to the enemy. The tempo of activities is usually high.
- Security (operations to enable stabilization) - the transition from combat operations to defeat the opponent to multi-agency stabilization operations in order to re-establish security, stability and prosperity. Even vanquished conventional opponents may re-appear or be reinforced by irregular activists. The long-term goal should be to soothe the underlying tensions that led to the inception or resurgence of conflict, and to create the conditions for a successful longer-term development. The immediate military contribution, however, focuses on re-establishing and maintaining sufficient security for the local population and civilian agencies to ensure the continuation of the stabilization process. This involves preventing or containing violence and protecting people and key institutions.
- Peace support - the use of force by peacekeepers is normally limited to self-defence. Typical peacekeeping activities include interposition and protection, the interim management of selected civil administration, and humanitarian assistance. Military forces contributing to peace enforcement should be capable of applying credible coercive force, impartially, to apply the provisions of any peace agreement.
- Peacetime military engagement - encompasses military activities involving other nations that are intended to shape the peacetime environment (for example confidence building measures including, where appropriate, the deployment of combat forces) to encourage local or regional stability. Routine activity, such as

¹ ATP-3.12.1. Allied doctrine for military Engineering. Brusel: NSA, 2016.

² ATP-3 (B). Allied joint doctrine for the conduct of operation. Brusel: NSA, 2011.

bilateral or multinational training and exercises, may have both an immediate and a longer-term cumulative impact, reinforcing cooperation and promoting stability. Military effort may also be required, separately, to support disaster relief and non-combatant evacuation operations (NEOs), focused on preserving the security of the civilian population.

A combat campaign theme may consist primarily of offensive activities, while security has a complex mix of all four types and requires respective application of offensive, defensive, stability and enabling tasks.³

During combat operations, engineer support for mobility has usually the nature of direct support for combat formations. Tasks may be conducted under intense enemy fire or in overall hostile environment. For this reason, a high crew protection of engineer vehicles against enemy fire will play a significant role, while maintaining high rate of the unit's movement. In contrast, in operations to enable stabilization there may be a lower overall tempo and intensity of combat actions. Nevertheless, engineer vehicles should still provide a high level of protection, especially chassis protection, which is based on threats in this type of operations, where IEDs (improvised explosive devices) are widely used. Engineer units will be required for detection and neutralization of these devices. In peace support operations, requirements for engineer vehicles will be focused from the crew protection to better technical mastery of specified tasks. In peacetime military engagement, it depends on the unit's task within the area. The main requirement in these operations will be precise technical managing of engineer tasks. The table below depicts specific main tasks of engineer support that will be most likely performed in the respective type of operation. As we can see in the table, four main tasks of mobility support are essential in combat operations.

Table 1: Main tasks of engineer support for mobility in military operations

Operations (Ops)	Engineer support for mobility tasks according to ATP 3.12.1							
	Gap crossing	Countermine ops	Counter obstacle ops	Routes	ETM	RC	AC	MS
Combat	x	x	x	x				
Security	x	x	x	x	x	x	x	x
Peace support				x	x	x	x	x
Peacetime military engagement	x	x	x	x	x	x	x	x

Source: Authors

³ ATP-3 (B), ref. 2.

ROLES OF ENGINEER ROBOTIC SYSTEMS IN THE FUTURE COMBAT OPERATIONS

Based on the analysis of national and foreign publications we can predict that the availability of advanced military robotic technologies will constitute new opportunities for NATO countries as well as for the potential hostile forces. The application of advanced robotic technologies will increase capabilities of the future forces and their effectiveness and decrease the number of casualties in modern conflicts.

The development of sensors and unmanned systems will continue and affect all military branches. Conventional manned systems will be replaced by unmanned (robotic) systems acting automatically and autonomously. There will be a progressive tendency of replacing manpower by unmanned systems.⁴

Minimization of losses is always one of the main goals of deployed units in military campaigns. Heavy losses can affect deployed unit very negatively. Resistibility and force protection are extremely important in the sense of survivability and minimization of losses of forces and means.

Force protection is a very complex phenomenon, which affects all military activities. Reducing the operating personnel participation in using weapon and other systems is one of the main demands for the loss minimization.⁵ Increasing of fires and limited possibilities of protection will lead to an unmanned theatre in the future. Modern technologies, such automated, unmanned and robotic weapon systems, will take over a large number of functions from the human in combat.⁶ It is evident that the application of unmanned technologies will have a great impact on MILENG and, of course, the engineer support for mobility.

Other conceptional publications directly refer to military engineering and application of engineer robotic means. According to the Czech army conceptual document “KVAČR” (Concept of Development of ACR 2025),⁷ land forces are composed of mechanized infantry, artillery, engineers, reconnaissance units, forces and means of electronic warfare, chemical corps, deployable logistics and forces and means of CIMIC and PSYOPS. To reinforce the engineer support capabilities, modern engineer means and material including intelligent robotic systems will be introduced and applied to many engineer tasks - road improvement and maintenance, breaching enemy obstacles, wet gap crossing, placing obstacles and improvised explosive device disposing.⁸ Application of advanced intelligent robotic systems is in fact one of the basic declared requirements for enhancing capabilities of engineer support for mobility. Several mentioned engineer tasks directly relate to mobility support - road improvement and maintenance, breaching enemy obstacles and wet gap crossing are the essential tasks to be conducted by advanced robotic system in the future (by 2025) according to the Concept of Development of ACR.

⁴ GALATÍK, Vlastimil and Libor FRANK. *Principles of Defence “2030”* (in Czech). Brno: University of Defence, 2008. ISBN 978-80-7231-513-0.

⁵ *The Long-Term Perspective for Defence in 2030* (in Czech). Praha: Czech Republic Department of Defence - VĚÚ Praha, 2015. ISBN 978-80-7278-666-4.

⁶ GALATÍK and FRANK, ref. 4.

⁷ *Concept of Development of ACR 2025: a modified version for publication* (in Czech). Praha: MO, 2015.

Available from: http://www.mocr.army.cz/images/id_40001_50000/46088/KVA_R_ve_ejn_verze.pdf

⁸ Ibid.

The application of advanced unmanned systems will probably continue in haste. Their significance will grow quickly in all operational domains and by now we can predict rising numbers of unmanned systems across all domains - air, land and sea. These systems confirmed that can improve situational awareness, situational understanding, reduce manpower, increase performance of own forces, minimize risks for civilians and reduce overall costs in recent military operations. Unmanned systems provide persistence, versatility, ability to survive and reducing risks threatening human life. In many cases, unmanned systems are a preferred alternative in tasks called as 3D - dirty, dull and dangerous.

Features of these systems contribute to possible replacement of soldiers by robots in military operations. These features can be very usefully converted for military use. Unmanned (inorganic) systems differ from classic manned (organic) systems in many ways. It makes them very special and very suitable for conducting military engineer tasks. Selected special abilities of advanced robotic systems exploitable in engineer support for mobility tasks are listed below:

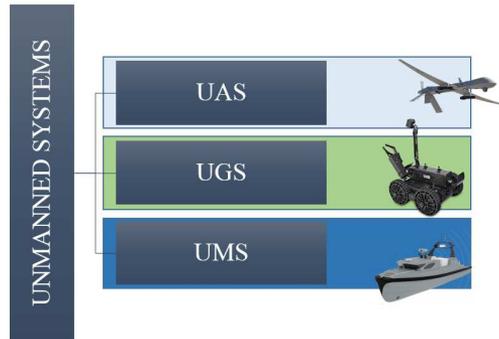
- Robots enable soldiers to concentrate on other tasks.
- Robots have the ability to perform tasks persistently.
- They are immune to fatigue (constant effort and persistence).
- They have immunity to stress.
- They are immune to fear and emotions.
- Robots have the ability to be non-aggressive and safe.
- They are resistant and capable of working in extreme conditions.
- They are expendable and replaceable.
- They are capable of advanced sensing of operational environment due to sensors.
- Robots have the ability to be faster than human (in terms of mobility and decision-making).
- They are able to perform tasks without previous individual training.

Military robot is a mechanical device, which is autonomous or remotely controlled. It can replace or strengthen the soldiers and its activity is related to military operations. Military robots are defined by individual operational domains. NATO countries currently use terminology, which is widely acknowledged. In NATO countries, military robots are frequently defined as unmanned systems. These systems are divided into:

- UAS (Unmanned Aerial System);
- UGS (Unmanned Ground System);
- UMS (Unmanned Marine System).

Defining of other domains related to unmanned systems as cosmic or cybernetic is beyond the scope of this text.

Figure 1: Unmanned system classification

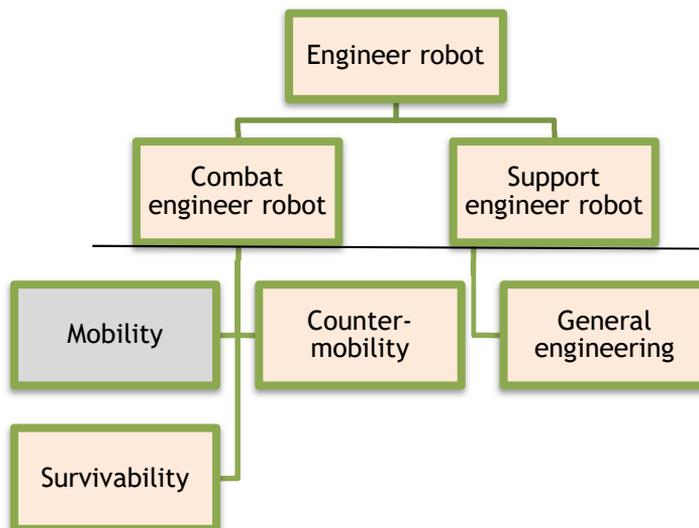


Source: Authors

For the purpose of this text, it is necessary to define the term engineer robot. We propose to define this term as follows: Engineer robot is a military robot, which is designed to perform the tasks of military engineering. Engineer robots can be divided into two main groups according to their application:

- Combat engineer robot - designated to perform combat engineering tasks (mobility, counter-mobility and survivability).
- Support engineer robot - designated to perform tasks of general engineering.

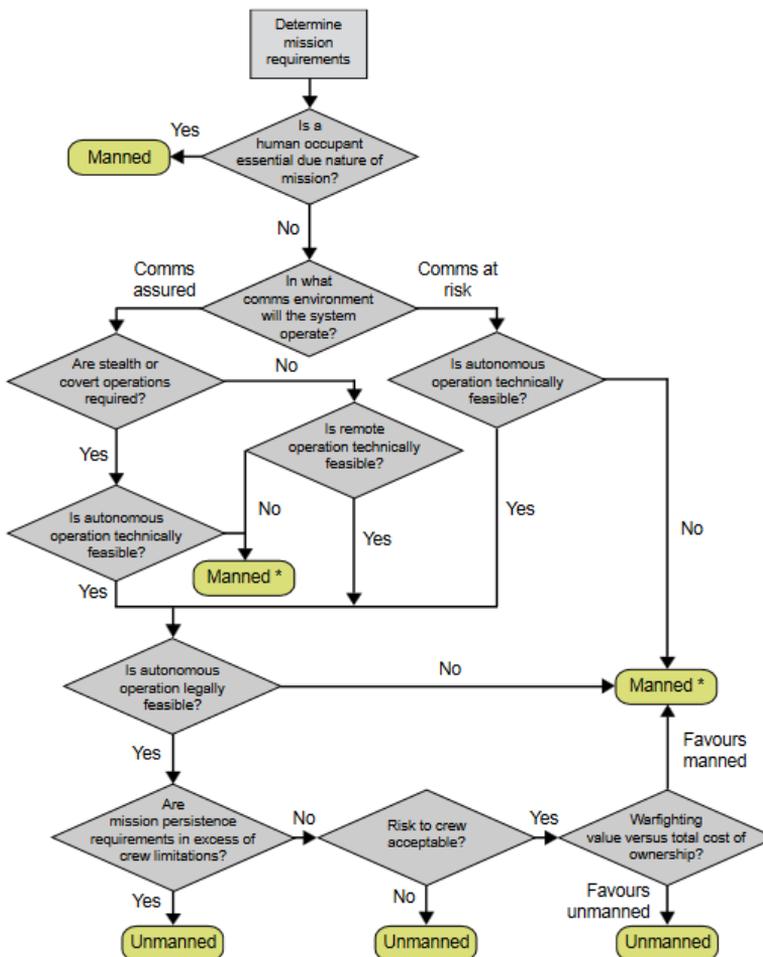
Figure 2: Possible engineer robot taxonomy



Source: Authors

Each system has its own advantages and disadvantages. There can be cases, where use of manned systems, unmanned systems or combination of both are possible. According to the diagram below, we can decide which system is the best to use for the specific purpose. This basic diagram is also suitable for the tasks of engineer support for mobility.

Figure 3: Decision flowchart to aid unmanned/manned thinking



Source: Joint doctrine note 2/11: The UK Approach to Unmanned Aircraft Systems. Swindon: MoD, 2011. Available from: <https://goo.gl/Tf7iKJ>

However, the real battlefield situation is usually more complex. Manned systems with human crew will be augmented by unmanned systems more often in the future. They will create united, cooperative and cohesive groups of human warfighters and robotic means. Advantages of both systems will be combined and it will bring synergistic effect.

This will also project into tactical engineer echelons like mobility support detachments. These permanent elements of combat formations are primarily detached to support the mobility of their own forces. They are equipped with special engineer means like reconnaissance, bridging, breaching, demining and other to provide adequate engineer support for mobility. Capabilities of mobility support detachments will be greatly expanded due to technological process. Unmanned systems have already been successfully fielded in the areas of airborne reconnaissance and ground-based, standoff-capable explosive ordnance defence. However, the technological developments to be expected in future exceed these developments by far and open new possibilities for the employment of unmanned systems.⁹

Table 2: Rating of criteria for combat engineer vehicles

Criteria	Rate of criteria according to each respondent										Average value
	1	2	3	4	5	6	7	8	9	10	
Speed of movement to a task	5	4	5	3	3	4	4	5	4	5	4.2
Speed of task fulfilment (mobility)	5	5	5	4	5	5	5	3	5	5	4.7
Level of protection	4	4	3	4	4	4	5	4	4	5	4.1
Subsequent usability of vehicle	4	5	4	3	1	3	3	4	4	3	3.4

Source: Authors

Technological progress will lead to the merging of aerial, land and maritime robotic systems with manned systems - Manned Unmanned Teaming (MUM-T). MUM-T will provide key capabilities such as:¹⁰

- Defeating the devices on the surface, in the tunnels, on the sea from distance;
- Providing mobility through more access points;
- Enabling movement and maneuver during offensive operations;
- Sustaining supply communications;
- Providing protection to simple forward operational bases;
- Providing persistent surveillance.

⁹ *Relevance and Possible Future Role of Robotic/Unmanned Systems for FINABEL Land Forces*. Brussels: European Land Forces Interoperability Center FINABEL, 2013. Available from: <https://goo.gl/kj3WTM>

¹⁰ *Unmanned Systems Integrated Roadmap 2013 - 2038*. Washington, D. C.: Government Printing Office, 2007.

BASIC REQUIREMENTS FOR ENGINEER VEHICLES

It can be noted, that the main request of the supported forces for the engineer support is an accomplishment of a task in the required quality and at the highest possible speed. The rate of task execution will be critical especially in a combat situation while supporting troops are in contact with an enemy.

Directed interviews were conducted with 10 officers of engineer corps. The interview concerned engineer support for mobility in combat. The following minimum criteria were set for the respondents:

- An officer of engineer corps who holds the position of deputy of engineer company, a member of operational part of battalion staff;
- Experience with planning and managing engineer support, participations on exercises (practical or simulation) within brigade task force or deployment in foreign operations during which he had solved an issue of engineer support.

In the directed interview respondents presented their views on criteria for engineer vehicles for mobility support of maneuver forces (see Tab. 2). They rated the criteria in the range of 1-5 and the same evaluation for more items was possible. Numeric values have the following meaning:

- 1 - insignificant;
- 2 - less significant;
- 3 - significant;
- 4 - very significant;
- 5 - totally significant.

The criteria stated in Table 2 have the following meanings:

Speed of movement to a task - how long does it take to a vehicle to be able to move from an assembly area to a place of task; this criterion is directly dependent on velocity and off-road capability of the vehicle, external factors influencing this criterion are the characteristics of the terrain and infrastructure.

Speed of task fulfilment - what time does the vehicle need to perform gap crossing, breaching or routes improving; this criterion is directly dependent on the ability of the working tool of the engineer vehicle, on its technological advancement, external factors are the width of the obstacle, depth of the barrier and degree of road damage.

Level of protection - ability to withstand enemy fire; this criterion is directly dependent not only on the armour of hull but also on the armour of the working tools of the vehicle (hydraulic distribution system, electrical cables, etc.), external factors are enemy firepower and closeness and level of suppressing fire for protection.

Subsequent usability of vehicle - after fulfilling its task the engineer vehicle may, for example, deplete engineer munition and then without further replenishment become unusable (explosive deminers); this criterion is dependent on the characteristic of the vehicle, there are no external factors influencing this criterion.

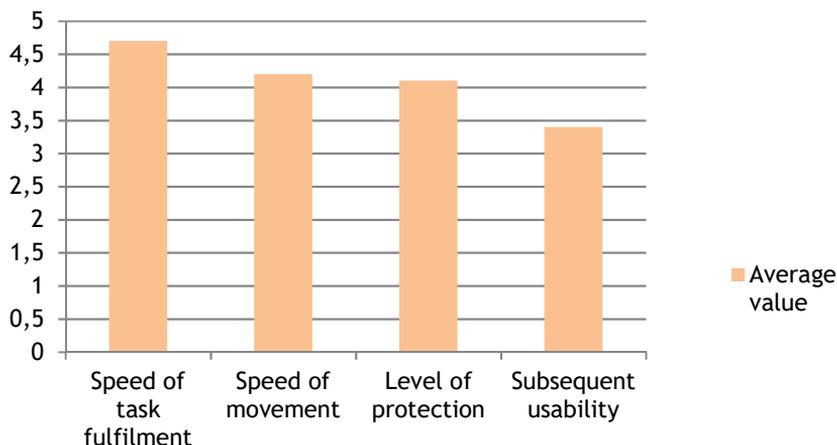
The most rated criterion is the “speed of task fulfilment” with value 4.7, which means totally significant. It is due to the purpose of the engineer task, which is fulfilled in favour of maneuver units. When there is an obstacle on the road/area, the supported unit needs to cross it as soon as possible to cause the smallest possible loss of movement speed (tempo of attack). The longer the unit will remain at the obstacle, the more they are in danger of exposure to enemy fire.

The second most rated criterion is the “speed of movement to a task” with value 4.2, which means very significant. In addition, this criterion relates to the tempo of operation. However, it depends where the engineer unit is located in relation to the supported unit. It means that the reduction of time for movement from the assembly area to the area of a task is necessary.

The third most rated criterion is the “level of protection” with value 4.1, which means very significant. There was an opinion that engineer vehicles should have the same level of protection as the supported vehicles/units. But the prevailing view was that engineer vehicles for mobility support, that are moving close to the forward line of their own troops (FLOT), should provide resistance against small arms fire and shell fragments. Too much armour would reduce the abilities of engineer vehicles for their own performance of engineer tasks, increase weight and reduce their speed. In addition, these vehicles will be under the protection of suppressing fire as much as possible during conducting their task, not to be damaged or destroyed. Therefore, they would remain available for another task.

The lowest rated criterion is the “subsequent usability of vehicle” with value 3.4 that still stands for “significant”. A bridge tank can serve as an example. After laying a bridge, the crossing units may load it, reach supported units and if necessary lay the bridge over another obstacle. There are also disposable devices, which have to be refilled/replaced after employment. These devices include, for example, explosive deminers containing demining charges. It always depends on the situation, when and which engineer vehicles will be needed.

Figure 4: Final evaluation of requirements for combat engineer vehicles



Source: Authors

During the directed interview, more than a half of respondents were dealing with the “philosophical” engineer issue when choosing/acquiring a new engineer vehicle/device - the decision whether to buy a multifunctional or single-purpose vehicle/device. Two respondents were definitely for the single-purpose one because of higher performance for one given task, less demanding personnel training and lower purchase price in comparison with multifunctional device. One respondent was, on the other hand, clearly for a multifunctional device due to overall lower number of vehicles needed to cover the full range of engineer tasks and better logistic support during their transportation. But during the discussion about this issue most of respondents agreed, that it depends on the situation, whether it is support of units close to the front line under enemy fire (when it can never be exactly determined in advance what means will be needed) or support on request behind FLOT (when specific engineer vehicles are sent on request for the clear purpose).

In another part of the interview, respondents suggested what types of engineer vehicles they could imagine to provide the engineer support for mobility. Suggested types of vehicles/devices are:

- Vehicle demining device - mechanical and explosive;
- Explosive demining device for infantry;
- Mechanical bridge with MLC (Military Road Class) 70;
- Armoured single-purpose engineer vehicle for managing tasks close to a forward line;
- Armoured multifunctional engineer vehicle on tank chassis;
- Modern engineer means for breaching obstacles;
- Modern amphibious vehicle.

The directed interview identified the emphasis on the speed of task fulfilment, speed of movement to a task and level of protection of engineer vehicles/devices for mobility support. Subsequent usability of vehicles has lesser value, but it is still a significant criterion.

APPLICATION OF ADVANCED ENGINEER ROBOTIC SYSTEMS IN ENGINEER SUPPORT FOR MOBILITY

Military engineering covers a broad spectrum of activities - from combat to construction. The character and phase of the operation affect the type of provided engineer support. Engineer tasks are usually very challenging and specialized. These types of tasks demand large quantity of time, forces, assets and require special equipment.¹¹ Traditionally, combat engineering tasks have been manpower intensive, time-consuming, logistically demanding and dangerous.¹² Engineer tasks are frequently

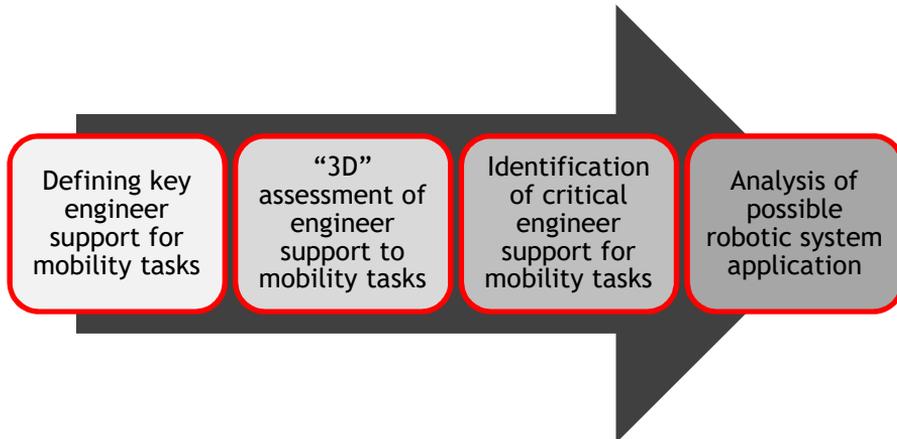
¹¹ ATP-3.12.1. Allied Doctrine for Military Engineering. Brusel: NSA, 2016.

¹² PHUA, Daryl, Chun TAN and Wong KIMBERLY. Technical Advancements and Innovations in Combat Engineer Equipment. DSTA Horizons [online]. Singapore: Defence Science and Technology Agency, 2015. ISSN 2339-5303. Available from: <https://goo.gl/XZyBRg>

conducted in a hostile environment with the risk of explosives. This makes them really dangerous for human personnel. The goal of this chapter is to analyse the usability of combat engineer robots in engineer support for mobility.

The analysis of possible use of robotic systems in engineer support for mobility tasks in combat operations is made in several steps illustrated by the figure below.

Figure 4: Analysis of possible use of robotic systems in engineer support for mobility



Source: Authors

The first step of the analysis is to define key engineer support for mobility tasks related to conventional combat operations. According to the first chapter, the key mobility tasks are as listed below:

- Gap crossing;
- Countermine operations;
- Counter obstacle operations;
- Routes.

The second step is to define criteria and assess every task from the “3D” perspective. The specification of each of the criteria is as follows:

DIRTY are all tasks, where there is a risk of using CBRN weapons. Dirty tasks are not suitable for human soldier and can have negative health impact. These (dirty) conditions can negatively affect soldiers and technical assets as well. Typical dirty engineer task is, for example, support for decontamination. (0=task is not dirty, no possibility of using CBRN weapons, 10=extreme risk of using CBRN weapons.)

DULL are all tasks, which are repetitive, boring and require a lot of time and material to be accomplished. Dull tasks are characterised by increasing fatigue, stress, physical and psychological impact, etc. For example, engineer reconnaissance is very demanding and dull task. (0=task is not repetitive, it can be accomplished in short-term, 10=extremely demanding activity with a high risk of fatigue and stress.)
