DIGITAL INFANTRY BATTLEFIELD SOLUTION

CONCEPT OF OPERATIONS

DIBS project

Part II

Editors

Uģis Romanovs

Māris Andžāns

Milrem in cooperation with

Latvian Institute of International Affairs

Latvian National Defence Academy

August 2017

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Digital Infantry Battlefield Solution.
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The book consists of a collection of opinions by authors from different countries and diverse research backgrounds, building on the first volume of this project with a multi-faceted review of the development of unmanned ground vehicles (UGV) in military use. In addition to reconsidering ethical and legal aspects of the use of UGVs, the book takes a closer view on how different nations have developed and are progressing with their UGV capabilities.

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FOREWORD: DEFENCE RESEARCH AND INNOVATION – FUTURE OF THE BALTIC MILITARY COOPERATION

Riho Terras,
Commander of the Estonian Defence Forces

All three Baltic states are rapidly increasing their defence budgets. Latvia and Lithuania are planning to catch up with Estonia and reach the 2% of gross domestic product (GDP) threshold by 2018. In all three countries, the defence priority areas are related to the development of combat and combat support capabilities, combat training support, information, surveillance, target acquisition, and reconnaissance (ISTAR), and command and control capabilities, including cyber defence. In other words, all three countries are working hard to close some of the most critical capability gaps. Needless to say, there are areas such as air defence and maritime defence where the Baltic nations are and will be heavily dependent on the support from NATO allies.

Furthermore, all three countries are aiming to build civil societies that are more organised and resilient against various types of military and non-military threats. The roots of these threats are primarily related to the methods and tools Russia applied in the military conflicts with Georgia and Ukraine. However, we must keep in mind that each war and conflict is unique, and making our predictions only based on past events is a short-sighted approach. Due to rapid technological developments, the importance of defence research and innovation is growing and it should be treated as one of the key elements that shapes the design of defence, and it is of importance for the Baltic states to acknowledge this fact.

Russian research and development in defence has significantly increased during the recent years. The Russian Federation pays particular attention to the digitalisation and cyber security of communication and weapon systems; the development of weapons of the next generation; and the introduction of unmanned systems on the battlefield. Russia has taken one of the leading roles in the world in the context of the development of weaponised unmanned ground vehicles. This means that the nature of land warfare might change radically in the coming years. Defence-related research and development allows us to stay on the top of this matter and prepares us to face new challenges of the future battlefield.

Defence related innovation, research and development requires the involvement of institutions from various sectors. This means that military research and development sponsors and enhances civilian innovation, consequently contributing to the competitiveness and progress of these companies. In addition, it helps broadening the circles of society involved in defence-related matters, which is critically important for the "whole-of-government" approach to defence.

With this in mind, the Baltic states – buoyed by rising defence budgets – should allocate more resources to defence innovation and research, particularly to projects conducted by various consortia of cross-sector and regional organisations.

Our defence establishments should also facilitate and help with the involvement of military and civil research intuitions, as well as the defence industry, into NATO and EU-organised and sponsored research and development activities. These include NATO's Science for Peace and Security Programme, European Defence Agency's research projects and activities under the umbrella of the newly introduced European Defence Fund.

Development of new defence systems takes a long time and implies high risks for industry as technical requirements and military capability priorities can rapidly change. Consequently, industries might be reluctant to invest into military technologies if there is no clear commitment from the national authorities. Thus, the Baltic states have to look into new forms of military-industrial cooperation and communication, which assures and promotes circumstances for safe investments into innovation and research into the next generation of capability development.

Furthermore, I would recommend the adjustment of the professional military education curricula by promoting future leaders' understanding of the potential and importance of defence-related innovation and research.

And finally, each of the Baltic states separately has very limited possibilities to support the whole cycle – from the initial concept, through to research and on to the development of the product or capability. It is due to various reasons, including financial resources, availability of subject-matter experts and military units, which can be used for experimentation and testing of the product, capability or doctrine. Therefore, I suggest that the Baltic states consider pooling their defence and innovation efforts and resources. Furthermore, projects, such as Digital Infantry Battlefield Solution (DIBS), should be taken as an example. Defence research and innovation is the future of the Baltic military cooperation.

FOREWORD: MILITARY EVOLUTION AND UNMANNED GROUND VEHICLES

Glen E. Howard,
The Jamestown Foundation

Technology and warfare have been strongly interconnected throughout the history since the age of antiquity. The use of Unmanned Ground Vehicles (UGV) is a part of that evolution, albeit one that is lagging behind its sister – Unmanned Aerial Vehicles (UAVs) – both in sheer numbers, technological advances and doctrine. Nonetheless, UGV technology continues to be developed and is evolving in terms of its application on the modern battlefield, particularly in support of ground operations. As this collection of articles demonstrates, some sectors of technology have, and will continue to affect modern warfare and UGVs will be a part of this effort as their roles and missions evolve. Robotic UGVs will one-day provide critical support for surveillance and target acquisition in ground based operations as their testing and trials continue around the world.

From the battlefields of Eastern Ukraine, to the use of ground penetrating radars by Israel in its struggle against Palestinian militants, new and novel techniques are being used for the development of UGV's, especially in urban environments where the threat of Improvised Explosive Devices (IEDs) appear to be fuelling the greatest needs for UGVs. For this reason it is important to assess the development and growth of UGVs, which is the purpose of this volume of articles. One of the particular goals of this book is to identify key trends in UGV development and how this field is shaping the use of warfare based upon a variety of perspectives, ranging from the ethical and legal dimensions to the modern application of this technology in combat by persons from different countries of the world.

Many reasons exist for why it is important to follow developments in the UGV field. First of all, given Russia's ongoing defence build-up and conceptualization on how it plans to use UGVs deserve special attention. It is particularly important to understand how the Russian military perceives the use of this technology as military research centres in Russia are working feverishly toward the goal of introducing military robotics on the battlefield by 2025. Russia has pursued this tradition understanding the military relevance of using UGVs in modern warfare, despite the fact that Western sanctions over Russian involvement in the conflict in Ukraine appear to be hindering Russian access to Western technology. Ultimately, this may force Russia to turn to the People's Republic of China in its quest to acquire the latest technology, which it is unable to obtain covertly from the West in order to field the latest robotic weaponry.

With one eye on Russia, we also need to keep a close look on Ukraine when it comes to modern warfare. Ukraine today is a modern laboratory for testing of new weapons' systems. What happens in the war in Ukraine is of extreme importance to the United States and its allies in NATO, especially as western armed forces develop proper countermeasures necessary to deter Russian advances in the use of new weaponry. This is notably true in radio-electronic warfare where after the end of the Cold War Russia invested enormous resources in the technology of jamming, while the United States allowed its electronic warfare capabilities to languish as the US military focused its attention on counter-insurgency doctrine and expeditionary warfare in Iraq and Afghanistan. Now the United States and its NATO allies find themselves in a race to catch up with Russia in some key areas it is behind in because of the lessons of the war in Ukraine.

Ukraine had to resort to defence innovation after basically failing to invest in any type of military robotics or UGV technology for the past 25 years of independence. Russia's major advantage in Eastern Ukraine is UAV. It has provided Russia with critical artillery targeting coordinates – it has given Russian backed militants a key technological edge over Ukraine. In its race to make up for its shortcoming in various fields of military technology, Ukraine is racing to invest in new UGV technologies that deserve closer attention in the Baltic.

With the creation of the Anti-Access/Aerial Denial (A2/AD) capabilities from Kaliningrad, UGVs may one day play a critical role in a hypothetical future battlefield in the region. The use of UGVs for providing battlefield intelligence in lieu of humans, including the use of sensors for artillery targeting may be the future role of UGVs as NATO searches for ways to deter the Russian A2/AD, which has been home to the nuclear capable Iskander type missile systems. It is not too difficult to envision a battlefield use for an army of bots penetrating the defences of Kaliningrad in the event of a future showdown with NATO as part of western efforts to obtain intelligence and targeting information to deter the Russian nuclear threat posed by the Iskanders. While UGVs are not going to immediately blanket the battlefield of the future, their increasing relevance in supporting ground operations will continue with new advances in technology, particularly in a tight urban combat environment where UGVs would be ideal for removing ordnance and clearing the city and outlying areas of minefields.

In conclusion, dozens of future scenarios exist where we can see the use of deployment of UGVs in modern warfare. This collection of articles will add to our ability to assess how other countries are utilizing UGVs in their own plans and how this may affect the future of conflict.

INTRODUCTORY REMARKS: TOWARDS CONCEPTUALISATION OF DIGITAL INFANTRY BATTLEFIELD SOLUTIONS

Uģis Romanovs and Māris Andžāns

This book follows the initial volume of the project *Digital Infantry Battlefield Solution. Introduction to Ground Robotics. DIBS project. Part One*. It was published in December 2016 and provides a collection of opinions by various authors from different countries and diverse research backgrounds aimed at reviewing the development of unmanned ground vehicles (UGV) in military use. The first volume covered both the retrospective and prospective development aspects of UGVs, as well as the current issues and challenges of using UGVs from military, technical and legal perspectives.

This volume takes a step further in considering the use of UGV. On the whole, the authors of this book agree that UGVs will become an integral part of land warfare in the near future, whereas in a longer run unmanned systems might even have a revolutionary impact on ground combat operations.

First, Asta Maskaliūnaitė reviews the ethics of industry and the development of autonomous systems in the military sector. She sets both the historical context of ethics in defence industry and also elaborates on the corporate social responsibility of the defence industry. Next, Olavi Jänes examines legal aspects of using UGVs in support of military infantry operations. He reviews the current legal frameworks and takes a closer view at such aspects as autonomy of UGVs, as well as the use of UGVs both in armed conflicts and in situations falling short of armed conflicts.

In addition to reviewing ethical and legal aspects of use of UGVs, this volume takes a closer look at how different nations have developed and are progressing with their UGV capabilities. Boaz Zalmanowicz, Liran Antebi and Gal Perl Finkel analyse UGVs' historical development and current progress in Israel – one of the global leaders in the use of UGVs. Next, Nora Vanaga examines the state of play relating to the development and employment of UGVs in the People's Republic of China. Mirosław Smolarek assesses Poland's approach to UGVs, whereas Zdzisław Śliwa analyses the current situation in the Russian Federation, country that has recently heavily invested in the development of UGVs. Next, Serhiy Zghurets reviews the current situation in the development of military UGV capabilities in Ukraine, which has witnessed a surge in the development of new military technologies given the still active military conflict in the east of the country. Finally, among the country studies, Ron LaGrone examines UGV development in the United States.

In the third part of this book Igors Rajevs provides an extensive assessment of the currently most advanced Baltic-made UGV – Milrem's Tracked Hybrid Modular Infantry System (THeMIS) – in the framework of provision of support in light infantry operations. Rajevs examines the efficiency of THeMIS in twenty-four different separate case examples of light infantry operations. This analysis allows him to identify both the advantages and disadvantages of the system and to arrive at conclusions about the most suitable operations the system could contribute.

ETHICAL AND LEGAL CONSIDERATIONS

(MILITARY) ETHICS OF INDUSTRY AND DEVELOPMENT OF AUTONOMOUS SYSTEMS

Asta Maskaliūnaitė

Since the dawn of the age of total war, military ethicists have grappled with the issue of the boundaries between combatants and non-combatants and their responsibilities. The distinction itself is at the core of the Western just war doctrine; therefore, the question deserves the attention it gets. The discussion often centres on some blurry and ambivalent situations, such as whether a naked soldier is still a soldier and could be ethically attacked, or whether civilians supporting the war effort by working in factories could be seen as combatants. In the latter case, the question is raised whether a distinction should be drawn between those working in armaments manufacturing and thus directly supporting the war effort and those who are dealing with food processing that could be used for rations for troops, but could also be consumed by civilians.

The role and responsibilities of industry were also discussed, especially after the Second World War and the Nuremberg trials, and even more so after the outgoing American President and the former Supreme Allied Commander, Dwight Eisenhower, gave his famous military-industrial complex speech in 1960. In this speech, Eisenhower warned of the "conjunction of an immense military establishment and a large arms industry" that exercises great influence on all levels of society and especially politics.[1] Since the speech, the "complex" was expanded to include also the media and entertainment industries, which supposedly work as a unified organism to militarise society primarily in the US, but, given American cultural influence, also around the world.[2] As an answer to such accusations, the supporters of defence industries emphasise the utility of the military industries for their countries' security, arguing that by contributing to security they are underwriting the well-being of the nation and thus serve a public function.

Development of autonomous systems adds a new dimension to this discussion. In their current semi-autonomous form, these systems do not pose a great challenge, as there is still a human operator behind the computer screen even if he is far removed from the ground in which actions take place. However, the move towards more autonomous, self-thinking, and a more robust intelligence system, does pose a challenge as to who is responsible for any potential mishaps. Here, the ethical responsibility of the industry should also be discussed.

In this paper, such aspects of industrial ethics will be put in their historical context. The first section will deal with the rise of the discussion on the role of industries at war in the Nuremberg military tribunals and the ethical implications that could be derived from those decisions. The second section will deal with industrial ethics, the approach of social corporate responsibility and its applicability for the defence sector. The third section will look at another angle of ethical responsibilities of the defence industries within the framework of just war theory. Finally, the fourth section will address the challenges that development of autonomous systems pose.

HISTORICAL CONTEXT: NUREMBERG MILITARY TRIBUNALS AND RESPONSIBILITIES OF THE INDUSTRIALISTS

The Nuremberg tribunals after the Second World War were designed not only to establish the legal responsibility for the outbreak of war, but also to serve as a "history lesson" that would show the way and the extent to which various individuals and organisations were implicated in these crimes. The International Military Tribunal (IMT), which tried the most prominent living Nazis, was followed by the subsequent sectoral military tribunals, some of which dealt with the largest German industries at the time, including cases against Flick Concern, IG Farben and Krupp.[3] These cases revealed the dilemmas of legal and ethical responsibility of industries in war time. In all three cases, some defendants were convicted on the charges of the use of slave labour and plunder. In the case of IG Farben and Krupp, these indictments were complemented by the charges against the defendants for participation in acts of aggression and the contribution to German rearmament with the "awareness that Hitler intended to use its arms to wage aggressive war."[4] In both cases, however, no one was sentenced for "crimes against peace". In this respect, it could be argued that the tribunals saw only *ius in bello* as applicable in the cases of the industries, while *ius ad bellum* and responsibility for waging aggressive wars was left on the shoulders of political leadership exclusively.

It should be noted, however, that the trials took place in the developing context of the Cold War, which, at the time, had a real chance of turning hot with the Communist coup in Czechoslovakia in February and start of Berlin blockade in June 1948. In this setting, the trials were seen as too political by the American judges, hence they were reluctant to prosecute the industrialists in general and gave light sentences to the defendants. The American Chief prosecutor in the IMT, for example, strongly believed that the trial of industrialists and financiers "would be a propaganda coup for the Soviets",[5] as they may have created an image of superiority of the Soviet system, which shunned individual entrepreneurship. Given the standoff between the capitalist and communist systems, these trials were seen as controversial. In addition, there were concerns that such forms of prosecution would make the American industrialists reluctant to support the US war effort,[6] which by the time these cases reached courtroom seemed more likely than not in need of such support.

The outcomes of the trials notwithstanding, they established the necessity to look at the military-industrial base when discussing the waging and conduct in war. The trials also gave a forewarning about the difficulties to deliberate on such industrial obligations in the context of the Cold War. The controversial activities undertaken by the Western governments supposedly bound by democratic principles and high moral values, such as (military, but not only) support for the dictatorial regimes, particularly in Latin America, worked to increase demonisation of the "war machine" during the years following the end of the Cold War.

CORPORATE SOCIAL RESPONSIBILITY (CSR) OF THE DEFENCE INDUSTRY

The CSR movement in business ethics argues that economic firms have certain responsibilities to society, contrary to the traditional economic theories which posit that the firms are only responsible to their shareholders and are thus only concerned to make profit. This responsibility can come from four domains: economic, legal, ethical and philanthropic[7] or, put differently, from a firm's answers to questions such as "how well it maximises profit, satisfies social demands, honours ethical values and uses political power."[8] While the CSR movement has been influential in business ethics and came to be linked to the consumer that is more demanding of the high ethical standards from the producer, its role in the defence industry has been largely neglected.

Edmund F. Byrne broke the silence about CSR of defence firms in 2007, complimenting his initial article in 2010.[9] In these articles, the author contends that the "arms industry" or even broader military-industrial complex is "circumstantially unethical". It is unethical because, his argument goes, their "products or services are unjustifiably harmful". However, it is unethical not in its nature, but given the particular circumstances, which are the "pursuit of imperial hegemony in the interest of corporations that seek its assistance".[10]

As an answer to these, what they call, ideological claims, Halpern and Snider conducted research into CSR orientations of the executives of the defence industries. Their study included data from the survey of 169 firms and found that CSR orientations of the managers of these firms do not differ significantly from those of the other types of firms; and where it does differ, it is actually to the side of a stronger orientation towards social responsibility.[11] The authors thus suggested to look at Byrne's arguments as ideological rather than empirical.

This debate seems to leave the question of CSR of the defence industry unresolved. Therefore, it is worth turning to the just war theory to seek some answers as to what could be a legitimate defence business and which practices should be shunned in it.

IUS AD BELLUM, IUS IN BELLO AND THE DEFENCE INDUSTRIES

In an investigation of the potential uses of the Just War theory in the defence industries, Aaron Fichtelberg argues forcibly that the defence industries should abide by the rules of military ethics, arguing that these industries and the engineers working in them "bear unique and important obligations in relation to the weapons that they design – obligations that are obscured if they are perceived only as researchers and employees".[12] He continues his argument along the two lines already identified in the section on history – responsibilities with regard to *ius ad bellum* and those stemming from the moral conduct of war in *ius in bello*.

The *ius ad bellum* includes a set of principles, the main ones being that the war is only legitimate if it is defensive; that it should only be used as a last resort; and that it has to originate from a legitimate authority. *Ius in bello*, which deals primarily with the correct conduct in war, including such principles as that of discrimination between combatants and non-combatants and proportionality, i.e. "acts of war should not yield damage disproportionate to the ends that justify their use."[13]

It can be argued that there is no straightforward application of these principles to the industry. The popular argument here is used by the arms lobby in the US: it is not the weapon, but the person behind the weapon who is responsible for the deeds committed with that weapon. On a larger scale, the defence industries are said just to provide the goods and have no control over how they can be used, especially in a case of a dual use technology, which can be valuable in both military and civilian sphere. Such arguments are employed to dismiss the possibility of applying rules of the Just War to industrial activities. In terms of *ius ad bellum*, even stronger arguments can be made that it is the politicians who make decisions about peace and war, and it is with them exclusively that the responsibility for decisions about war should rest. These notions, as could be seen from the discussion of the Nuremberg trials, have deep historical roots.

There are some arguments, however, to hold the industries to the standards of the Just War too. In terms of *ius ad bellum*, a strong case could be made that, as Fichtelberg writes, "An arms manufacturer who sells powerful weapons to unstable and aggressive states must bear some moral responsibility for its acts."[14] The accusations of the defence industries in cynicism and their bad reputation as the "salesmen of death" stem from disregard of exactly such rule. The famous case of French sale of Mistral ships to Russia followed this pattern. Though there were doubts and questions of legitimacy of the sales of advanced military technology to Russia already before the events in Ukraine, the annexation of Crimea and the war in Eastern Ukraine made this sale even less appealing. Yet, after the sale to Russia was taken off the table, France aimed to sell the same ships to Egypt, a move that was criticised by human rights groups because its regime was at the time engaged in brutal crackdown of dissent against Abdel Fattah al-Sisi's government.[15]

On a smaller scale, small arms manufacturers are often called to account for aiding to perpetuate conflicts through supplying arms to the warring factions. Though this might be done without the knowledge of the manufacturers themselves, there are claimes that the makers should take some responsibility and try to ensure some control of their products so that they do not end up in wrong hands.

In terms of *ius in bello*, the strongest case can be made about the manufacturing of certain "forbidden" weapons, such as nuclear, biological or chemical weapons. Fichtelberg argues that such weapons should contain one or all of these characteristics: these are weapons which are either "inherently cruel"; "inherently indiscriminate"; or "inherently unchivalrous".[16] Most of the weapons produced fall somewhere along the continuum of weapons where non-lethal ones could be seen as more permissible while the chemical and biological should be seen as purely unethical. It is thus implied that the designers of weapons should carry some responsibility for their use. Just how much responsibility is the question for a deeper discussion; however, in general terms, it is possible to follow Fichtelberg here too, where he writes that:

> While it is clear that engineers do not bear a strict liability, they are not free of any responsibility for the destruction caused by "mixed" weapons, and they bear a very strong responsibility for inherently immoral weapons such as nuclear, chemical and biological weapons.[17]

CHALLENGE OF AUTONOMOUS SYSTEMS

The deliberations about ethical responsibilities of designing and manufacturing equipment to be used in war are taken one step further with the development of systems that have more autonomy. Current technology is often described as semi-autonomous with a human operator still taking most of the decisions on how it would be used, therefore absolving the producer and developer from most of the moral questions of war. Yet, the "relentless drive towards autonomy"[18] makes this position less tenable. Indeed, there are voices calling for arms industries to abandon their cosy assumption of neutral producers of goods and to own up to the ethical implications of the products they produce.[19]

The major concern here is with the drive to produce systems which dispense with the human operator altogether. On the positive side it is argued that such systems increase efficiency on the battlefield, working as force multipliers, increasing precision, dispensing with human error and thus saving human lives (or at least lives of the military personnel). On the other end of the spectrum, deliberations on the use or lack thereof of such systems are those critics to whom the introduction of more autonomy into military robots brings in visions of Terminator. For those in between, the failure of those scientists, designers and manufacturers who pursue such greater autonomy to appreciate the concerns and objections of critics "constitutes an attitude toward public welfare and the substantial risk of unintended consequences that is characterized by these critics as ranging from *reckless endangerment* to outright *criminal negligence*."[20]

Thus, increased automation of war machines, especially those wielding potentially lethal force, require a serious discussion in the engineering society. There are at least two major directions of inquiry here. On the one side there are the followers of Ronald Arkin, who aim to improve the design of the autonomous systems to equip them with what he called an "artificial consciousness", giving them a possibility to act ethically on the battlefield.[21] On the other there are those who, like George R. Lucas Jr., who believe that there is no need for ethical criteria in such machines, but that we should talk about safety, reliability and risk when we discuss the potential employment of autonomous systems on the battlefield. These thoughts are also echoed by Sparrow, who identifies safety and reliability, especially for the humans, alongside which they are deployed, as one of the essential requirements for the design of future unmanned systems.[22]

Both of these positions, however, have clear implications for the designers and manufacturers of such machines. Arkin's project requires the development of such "ethical governance" of the autonomous machines, demanding that they be equipped with such level of "artificial conscience" that would allow them to make moral judgements on the battlefield that are the same or better than those of the humans. Lucas's discussion indicates that while there is no need for such machines to possess an ability of complicated moral judgements, they need to be "safe and reliable in their functioning, and to perform their assigned missions effectively, including following instructions that comply with the laws of armed conflict."[23] This, in turn, means that autonomous systems "must be designed within carefully defined limits of mechanical tolerance and risk, and operated and deployed only for very specific, scripted missions."[24]

Robert Sparrow suggests that the various ethical concerns, especially with regards to the *ius in bello* requirements of discrimination and proportionality could be ""designed out" or at least "designed around"."[25] Yet, this requires a clear recognition of the issue on the side of designers and manufacturers of such platforms. Currently, as authors such as George Bekey and Peter Singer suggest, this recognition is largely missing.[26]

CONCLUSION

The end of the last total war, which coincided with the use of the first nuclear weapons, brought questions of the role of science, engineering and industry to the attention of ethicists. Yet, the requirements of the Cold War obscured these concerns, hiding them under the agendas of complete rivalry between the two superpowers.

With the end of the Cold War, these issues came back to the agenda and especially so in the last decade when the development and use of unmanned systems and the "relentless drive to autonomy" gained momentum. Sets of responsibilities for the industries have been proposed in this regard. On a more general level, it has been suggested that the industries should follow the rule of the *ius ad bellum* and be conscious of the potential buyers of their products and their intentions. Going to the *ius in bello*, it has been suggested that while development of some weapons, such as nuclear, chemical and biological, can never be seen as ethical, , while other weapons are somewhere in between the "completely permissible" and "completely impermissible" weaponry.

The semi-autonomous and autonomous systems with lethal potential fall in this grey area in between. However, it is suggested by the most prominent figures in both the field of engineering and in that of military ethics, that the designers and manufacturers of such systems should be ethically conscious of their work and its potential implications. Given the current ever changing environment of war, the presumption of moral neutrality, which is often a mask for a moral ignorance is untenable. The designers and manufacturers of such systems should be deeply aware of their ethical implications and be ready to provide their product either with the type of "artificial conscience" argued for by Arkin, or at least the standards of safety and reliability within clearly defined limits, demanded by authors like Lucas.

ENDNOTES

1 "Military-Industrial Complex Speech, Dwight D. Eisenhower, 1961", Lillian Goldman Law Library, Accessed June 3, 2017, http://avalon.law.yale.edu/20th_century/eisenhower001.asp

2 See, e.g. James Der Derian, *Virtuous War: Mapping the Military-Industrial-Media-Entertainment-Network* (Routledge, 2009).

3 Gustav Krupp was initially cited as a defendant in the IMT case, yet, he was dismissed from that case due to health reasons. His son, Alfried Krupp was indicted in the subsequent trials.

4 Kevin Jon Heller, *The Nuremberg Military Tribunals and the Origins of International Criminal Law* (Oxford University Press on Demand, 2011), 93.

5 Ibid., 24.

6 Ibid., 95–96.

7 Barton H Halpern and Keith F Snider, "Products That Kill and Corporate Social Responsibility: The Case of Us Defense Firms," *Armed Forces & Society* 38, no. 4 (2012): 605.

[8] Edmund F Byrne, "Assessing Arms Makers' Corporate Social Responsibility," *Journal of Business Ethics* (2007): 201.
[9] See, "The Us Military-Industrial Complex Is Circumstantially Unethical," *Journal of Business Ethics* 95, no. 2 (2010). and "Assessing Arms Makers' Corporate Social Responsibility."
[10] *"The Us Military-Industrial Complex Is Circumstantially Unethical,"* 162.
[11] Ibid., 613–14.
[12] *Aaron Fichtelberg, "Applying the Rules of Just War Theory to Engineers in the Arms Industry," Science and Engineering Ethics* 12, no. 4 (2006): 687.
[13] Ronald C Arkin, *"Governing Lethal Behavior: Embedding Ethics in a Hybrid Deliberative/ Reactive Robot Architecture"* (paper presented at the Proceedings of the 3rd ACM/IEEE international conference on Human robot interaction, 2008), 2.
[14] Fichtelberg, 693.
[15] Ben McPartland, *"Egypt Steps in to Buy French Mistral Warships,"* Accessed May 14, 2017, https://www.thelocal.fr/20150923/breaking-egypt-to-buy-mistral-warships-russia-france.
[16] Fichtelberg, 694.
[17] Ibid., 698.
[18] George R Lucas Jr, *"Industrial Challenges of Military Robotics," Journal of Military Ethics* 10, no. 4 (2011).
[19] For one of the most forceful voices in this regard see, e.g. Peter W Singer, *"The Ethics of Killer Applications: Why Is It So Hard to Talk About Morality When It Comes to New Military Technology?,"* ibid. 9 (2010). *Patrick Lin, George Bekey, and Keith Abney, "Autonomous Military Robotics: Risk, Ethics, and Design,"* (DTIC Document, 2008).
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[21] Arkin.
[22] Robert Sparrow, *"Building a Better Warbot: Ethical Issues in the Design of Unmanned Systems for Military Applications," Science and Engineering Ethics* 15, no. 2 (2009).
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LEGAL CONSIDERATIONS OF USING UNMANNED GROUND VEHICLES

Olavi Jänes

Unmanned ground vehicles (UGVs) enjoy the same key characteristics as their counterparts in the air (unmanned aerial vehicles) and maritime domains (unmanned underwater vehicles), i.e. they are unmanned. This means that they are either remotely controlled by a human operator or autonomous, and because of that they can perform tasks that would be excessively dangerous for the crew. In other respects, they are similar to manned vehicles.

UGVs are already used for performing multiple functions. These include *inter alia* terrain surveillance (incl. spotting snipers, ambushes, explosive devices), provision of ammunition and other supplies, medical transport, but also performing combat functions. They come in different sizes, depending on their intended use – be it, for example, for in-door use in urban environment or for operating in open terrain. As in case of manned vehicles, the same platform, depending on what is mounted on it, may be used to perform different tasks. It needs to be emphasised that not the platform, but the way the UGV is used determines the applicable rules and consequently the legality of such use.

Armed UGVs continue to lag behind unmanned aerial vehicles (UAV) because of their mission: close-quarter firefights.[1] Making positive identification and satisfying the rules of law is a bigger challenge to compare with UAVs due to the more complex land environment. UGVs are also considerably more vulnerable to destruction by adversaries, which affects the cost of using them.

UNMANNED GROUND VEHICLE AS A WEAPON SYSTEM OR WEAPON

According to *Encyclopaedia Britannica* a weapon is:

> An instrument used in combat for the purpose of killing, injuring, or defeating an enemy. /.../ Weapons have been carried and delivered by a wide variety of vehicles, often called weapon platforms. These have included such naval craft as the ship of the line, battleship, submarine, and aircraft carrier; aircraft such as the fighter, bomber, and helicopter; and ground vehicles such as the chariot and tank.[2]

The *Weapons Law Encyclopaedia* defines a weapon system as follows:

> A weapons system is a device or coordinated set of devices or objects that consists of one or more weapons and a means of delivery as well as integral equipment and materiel. A weapons system is distinguished from a weapon in that while it incorporates one or more weapons in many instances it can also be used for other purposes than killing, injuring, disorienting, or threatening a person or inflicting damage on a physical object. For instance, an aircraft can conduct surveillance and a ship can transport personnel and materiel.[3]

One may deduct from these definitions that a platform itself is not a weapon. However, if a weapon or weapon system is mounted on a platform (e.g. tank), then it shall be described as a weapon system. Although weaponised UGVs usually fall under the notion of "weapon system", certain UGVs may be described technically also as "weapons" (e.g. robot soldier). Respectively, the UGVs that are not equipped with a weapon (system) or designed to be used as a weapon, are not considered as weapon systems or weapons.

With regard to UGVs falling under the notions of "weapon system" or "weapon" one has to follow the rules of international humanitarian law (IHL) contained in Geneva Conventions and Additional Protocols (particularly Additional Protocol I), but also in treaties focusing on specific weapons.[4] Both, the weapon itself and its use have to be lawful. In case of new weapons, if certain UGVs would fall under this category (e.g. fully autonomous weapon systems), Art. 36 of the Additional Protocol I should be taken into account:

> In the study, development, acquisition or adoption of a new weapon, means or method of warfare, a High Contracting Party is under an obligation to determine whether its employment would, in some or all circumstances, be prohibited by this Protocol or by any other rule of international law applicable to the High Contracting Party.[5]

This means that a state (manufacturing or purchasing) is under an obligation to carry out a domestic legal review related to the weapon in question. The International Committee of the Red Cross has worked out a Guide to the Legal Review of New Weapons, Means and Methods of Warfare, that may serve as a useful tool in this process[6]. The focus of the review is whether the weapon *per se* is legal. The commentaries to the Art. 36 emphasise that the article is intended to require states to analyse the normal or expected use of the weapon, and not requiring the state to foresee or analyse all possible misuses of a weapon, for almost any weapon can be misused in ways that would be prohibited[7].

The key rules of IHL against which the legality of UGVs as weapons should be tested are the prohibition of indiscriminate weapons and weapons causing indiscriminate effects,[8] and the prohibition of weapons causing superfluous injury or unnecessary suffering.[9] Depending on a specific weapon mounted on a UGV or the specific type of UGV itself, the other specific rules of IHL could come into play (e.g. certain weapon may be prohibited by a specific convention). If the UGV passes the review, it can be used by the armed forces when carrying out military operations.

AUTONOMY

One of the issues raised by both supporters and opponents of unmanned military vehicles used for engaging the adversary is their level of autonomy. This, though, seems not to be an issue in case of vehicles used for other than target engagement purposes. As the traditional weapon systems require a human operator to select and engage targets, then fully autonomous systems can do this job themselves. This is the key element of defining autonomous weapon systems.

Existing autonomous weapons systems (AWS) are not yet capable for complex decision-making and reasoning as humans. Therefore, they are highly constrained and used in performing rather defensive tasks in more simple predictable environments. They are used to target objects rather than personnel.[10]

Due to the continuous development of artificial intelligence solutions, one can assume a growing trend in defence industry to develop increasingly autonomous weapons systems. So far, the role of the human operator has survived (in several countries as a matter of policy[11]), but in years to come it is reasonable to expect it to decline.

The supporters of AWS claim that unlike human soldiers whose decision-making could be affected by their emotions (e.g. fear, hatred, revenge) the AWS make more objective judgements. They may also better discriminate possible targets and engage them more precisely, due to their reduced vulnerability to being attacked first to compare with human soldiers,[12] and good sensors. The multiple human errors have demonstrated that a human judgement in the fog of war is not necessarily superior to the judgement of the machine.[13]

The opponents of the AWSs claim that unlike human soldiers the AWS lack subjectivity and thus cannot understand the actual intentions of their targets.[14] Thus it makes it difficult for AWS to distinguish between lawful and unlawful targets and apply proportionality test, as these may be highly subjective matters under the circumstances.

Even in the case of human-supervised systems there is a concern that because the speed of war requires quick decision making, the human operator often has little choice but to trust the robot's suggested action.[15] This makes the issue of autonomy highly relevant even in case of today's semi-autonomous systems that are controlled by a human operator. There are voices demanding that governments recognise that human control must be "meaningful" – i.e. it must be more than a person pressing a button when instructed to do so by a computer.[16] The human control helps to avoid also the possible liability gap as discussed below, as the responsibility would lie with the human operator.

USE OF UNMANNED GROUND VEHICLES IN ARMED CONFLICT

The rules applicable to UGVs' use in armed conflicts, be these international or non-international, depend on the actual use of a UGV. For example, if the UGV is used for the purposes of medical transport, then the rules applicable to medical transport and vehicles apply.[17] To enjoy the protection the vehicle has to be exclusively assigned for the medical transport, i.e. during that time any other function should not be performed (incl. collection of intelligence). The use of the respective distinctive emblem of the medical services of the armed forces (e.g. red cross, red crescent or red crystal) is encouraged to make the medical function and protected status visible.

The uses of UGVs in armed conflict can from legal perspective be broadly divided into target engagement and functions other than target engagement. As the functions, other than target engagement, do not pose legal concerns specific to the use of weapons, these are not addressed. Regarding target engagement, the main principles of IHL – military necessity, humanity, distinction and proportionality – must be respected. These principles are also a cornerstone of any targeting process that follows the IHL.[18]

It is important to mention that compliance with the main principles of IHL is assessed not retroactively, but at the time of the engagement and based on available information. What matters is that the person deciding on the engagement of the target has done everything possible under the circumstances to be sure that the principles are satisfied. In an armed conflict it is often impossible to gather all the information one would like to have (due to the lack of resources, threat to own forces, urgency of the situation, etc.) and certain room is left for probability.

The **principle of military necessity** permits the use of only that degree and kind of force that is required in order to achieve the legitimate purpose of the conflict.[19] On the international level the principle has its roots in the St. Petersburg Declaration of 1868 on renouncing the use of certain explosive projectiles.[20] In its preamble it states that "the only legitimate object which States should endeavour to accomplish during war is to weaken the military forces of the enemy" and "this object would be exceeded by the employment of arms, which uselessly aggravate the sufferings of disabled men, or render their death inevitable". Later on this principle found its way into the Hague Regulations and Additional Protocol I. The latter states in its Art. 35 that the right of the parties to the conflict to choose methods or means of warfare is not unlimited and it is prohibited to employ weapons, projectiles and material and methods of warfare of a nature to cause superfluous injury or unnecessary suffering.[21] In short, the principle of military necessity, by combining elements of other principles (e.g. humanity and distinction) makes clear that engagement of a target is lawful if it provides clear military advantage, is directed against a military objective and does not cause unnecessary destruction or suffering.

When a UGV is operated by a human, the determination of military advantage follows the standard procedure applied by armed forces. The military advantage attributed to a target is often subjective and contextual, thus requiring constant assessment during an operation. This might be a problem for fully autonomous UGVs as they might not be able to carry out such subjective and contextual analysis before engaging a target. It makes it important to analyse the conformity with the principle of military necessity also in the review process of new weapons as described earlier.

The **principle of humanity** is primarily meant to protect both active participants of an armed conflict and the rest of the population from superfluous injuries and unnecessary suffering. The principle of humanity has its roots also in the St. Petersburg Declaration of 1868 and can later be found in numerous conventions, particularly in those that prohibit or restrict the use of certain weapons (e.g. chemical and biological weapons, incendiary weapons). It acknowledges the principle of military necessity, but tries to balance it – although there is a military necessity to engage a certain target, the engagement shall not cause superfluous injury or unnecessary suffering both in terms of means and methods of engagement. Thus, a proper weapon and method of attack shall be chosen to satisfy this principle. In case of UGVs it relates to a weapon mounted on the platform and the actual use of a UGV.

Although there is no consensus on examples of weapons causing superfluous injury or unnecessary suffering, the ICRC has provided a list of weapons that have been cited in practice as causing unnecessary suffering if used in certain or all contexts.[22] The list includes, for example: expanding bullets, explosive bullets, anti-personnel landmines, incendiary weapons, blinding laser weapons, and nuclear weapons. When conducting a weapons review in relation to a UGV, the International Committee of the Red Cross's (ICRC) SIrUS Project – initiated in 1997 – also matters. This aimed to contribute to the evaluation of the lawfulness of weapons, as it helps to provide some objectivity in the evaluation of the expected health effects of a weapon that had to be weighed against the foreseen military utility.[23]

The **principle of distinction** requires the parties to an armed conflict at all times to distinguish between the civilian population and combatants and between civilian objects and military objectives, and accordingly direct their operations only against military objectives.[24] With regard to the latter, Art. 52 (2) of the Additional Protocol I explains that in addition to combatants the military objectives include "objects which by their nature, location, purpose or use make an effective contribution to military action and whose total or partial destruction, capture or neutralization, in the circumstances ruling at the time, offers a definite military advantage."[25] These could be, for example, a weaponised UGV, a bridge, an oil refinery, or a church used by the adversary's snipers. In addition to the prohibition to direct the operations against civilians or civilian objects, the IHL also prohibits launching indiscriminate attacks. According to Art. 51 (4) of the Additional Protocol I indiscriminate attacks are those, which are not directed at a specific military objective; which employ a method or means of combat that cannot be directed at a specific military objective; or which employ a method or means of combat the effects of which cannot be limited as required by the IHL.[26] All these cases would violate the principle of distinction if there is under the circumstances a risk to engage military objectives and civilians or civilian objects without distinction. Well-known examples include launching attacks against an area or object that is not verified to host military objectives, use of grossly inaccurate weapons against objects in densely populated areas, use of too powerful weapons against a specific target or poisoning the sources of drinking water.

With regard to UGVs, both in the weapons review process and in an actual use of UGVs the principle of distinction must be satisfied. As the UGVs operated by a human operator do not raise in the light of this principle issues beyond standard procedures used by armed forces, there are still remarkable challenges related to the fully autonomous UGVs. As discrimination between military and civilian objects and their status varies in different environments, being for example very challenging in urban environments and much less challenging in the desert, then fully autonomous UGVs may not be able to satisfy this principle adequately in all environments. The issue relates to whether a robot can understand well enough the status or subjective intention of the possible target (e.g. directly participating in hostilities or not, wounded, surrendering, military medical or religious personnel, committing act of perfidy). Reading these situations correctly is directly linked to the ability to follow the principle of distinction. A human can read these situations in most cases adequately, but a robot requires an artificial intelligence on the level of a human for that.

The **principle of proportionality** prohibits attacks "which may be expected to cause incidental loss of civilian life, injury to civilians, damage to civilian objects, or a combination thereof, which would be excessive in relation to the concrete and direct military advantage anticipated".[27] According to this principle, proportionate "collateral damage" to civilians or civilian objects is acceptable under the IHL. What is proportional and what is not is not explained in the treaties, but many states have developed their own systems to carry out the assessment. It is also up to a commander to introduce further measures/limits within the legal boundaries, if he/she sees it necessary. For example, the commanders of International Security Assistance Force (ISAF) in Afghanistan used tactical directives and standard operating procedures to address the need to limit collateral damage.[28]

The acceptable level of collateral damage may depend on the type of weapons available and their accuracy, protection of force arguments, importance of the target, urgency of the target engagement, etc.[29] It is a subjective and contextual assessment balancing the requirements of military necessity and distinction.

UGVs that are operated by a human follow the standard collateral damage assessment procedure. However, due to the pace of the operation and reliance on the information provided by the sensors of the UGV, the subjective and contextual part of the assessment may be somewhat reduced. At least theoretically such a risk exists. In case of autonomous UGVs determining the military advantage of a target may present a significant challenge:

> The military advantage of a particular target is extremely contextual, and its value can change rapidly based upon developments on the battlefield. Human operators may be able to develop sliding scale-type mechanisms which regularly update and provide the AWS with the relative military advantage value of a given target. Operators might also help fulfil this principle by detailing strict rules of engagement and establishing other controls, such as geographic or time limits on use. Nevertheless, these complicated issues would need to be resolved, if the future use of AWS is to comport with the principle of proportionality.[30]

The importance of following the main principles of IHL is not demonstrated only through the number of saved innocent lives, but also by a criminal responsibility linked to their violation. A wilful violation of main principles of IHL constitutes a war crime. It can be assumed that in cases a life of a person has been taken in violation of IHL principles, it is also a violation of human rights law and triggers respective additional consequences.

USE OF UGVS IN SITUATIONS SHORT OF ARMED CONFLICT

From the state's point of view, such situations may include different forms of internal unrest. Additional Protocol II describes these as "situations of internal disturbances and tensions, such as riots, isolated and sporadic acts of violence and other acts of a similar nature, as not being armed conflicts".[31] In these situations the expected main user of UGVs is the police. As in the case of an armed conflict, the key matter triggering the applicability of one or another rule is whether a UGV is used as a weapon that may cause injuries or death to persons that it engages. The type of engagement depends on the situation and chosen tactics, but in general is less robust than in armed conflict and mostly defensive. It may vary, for example, from riot control to an arrest operation against a well-armed criminal group.

As the situation does not amount to armed conflict, the IHL (incl. its previously addressed principles) cannot apply. It is necessary to turn to human rights law. The most relevant provision of human rights law in this context is the right to life, i.e. prohibition of arbitrary killings. It is stated in Art. 6 of the globally applicable International Covenant on Civil and Political Rights (ICCPR),[32] and in Art. 2 of the regionally applicable European Convention of Human Rights (ECHR).[33]

Deprivation of life is not regarded as inflicted in contravention of Art. 2 of the ECHR when it results from the use of force which is necessary in defence of any person from unlawful violence; to effect a lawful arrest or to prevent the escape of a person lawfully detained; or in action lawfully taken to quell a riot or insurrection.[34] The ICCPR prohibits arbitrary killings, but does not provide a clear list of exceptions. Thus, it is up to a national law to elaborate on cases that do not constitute "arbitrary killings". One can assume that the outcome of both conventions' protective regime is and should be very similar.

Despite of the different applicable rules, the key challenge related to the use of UGVs is their autonomy. In case of UGVs operated by humans, standard procedures developed by the police can be followed, but in case of UGVs forming autonomous weapon systems, the absence of or very limited human control may increase the risk of violating applicable law. As in the case of an armed conflict, the risk increases when operating in a more complex environment or solving a more complex task. The more the context and actual intentions of possible "targets" matter, the less reliance can be put on autonomous weapon systems, at least in their current level of development.

RESPONSIBILITY

The legal frameworks, through which persons could be held accountable in relation to the use of UGVs, include individual criminal responsibility, state responsibility and manufacturer's responsibility.[35] In the light of the previous analysis on IHL and HRL, only criminal responsibility related to the violation of these frameworks will be addressed below. International criminal law is the main tool to deal with the violations of IHL. Thus the focus is on responsibility for committing a war crime through the use of UGVs.

The liable persons can theoretically be the operator of the UGV, his/her superior, and the manufacturer/programmer of the UGV. One could say that in cases when a UGV is controlled by a human operator, the responsibility lies primarily with the operator. Additionally, a superior's responsibility may be invoked if an unlawful behaviour of a superior contributes actively or passively to the criminal act.[36]

The application of responsibility may become much more complicated with the increase of autonomy of UGVs. In case of a fully autonomous weapon system (a robot) that operates without a human operator's control, it would be difficult to make the robot subject to criminal law as the current rules apply only to people, not objects. Consequently, in case of fully autonomous weapon systems, there could be an accountability gap.[37] As an object, a fully autonomous UGV cannot be itself criminally liable, and as it is making decisions (incl. on engagement of target) independently, then no one else can be effectively liable either. Even when the laws foresee criminal liability for objects with artificial intelligence, it would still be difficult to imagine the goal of the punishment to be fulfilled – would imprisonment deter or punish the robot or satisfy the victims? In case of manufacturer (e.g. programmer) one could theoretically see a possibility for criminal responsibility in case of intentionally mis-programming the robot, but the intention might be difficult to prove. Superior responsibility might be also difficult to invoke as a superior "would not always have sufficient reason or technological knowledge to anticipate the robot would commit a specific unlawful act."[38] The prevention of possible unlawful act would also be challenging in situations where robot acts too fast to compare with a human, communications do not function properly or reprogramming of the robot without specialists is too difficult.[39]

However, others claim that the liability gap does not actually exist. The responsibility of manufacturers/programmers and superiors may depend on how they set operating conditions that may lead the robot to commit a crime or fail to establish adequate constraints on robot's autonomy.[40] Thus, knowing about programming flaws or inadequate constraints, providing deficient rules of engagement, or even using robots in environments that create high risk of mistakes for them, may invoke manufacturers'/programmers' and superiors' criminal responsibility.

Regarding the use of autonomous UGVs, criminal responsibility is a challenge and it cannot be ruled out that certain accountability gaps exist. What makes the fully autonomous weapon systems in this regard different from human soldiers is the lack of effective direct responsibility. Indirect responsibility (manufacturers'/programmers', superiors') is usually more difficult and less effective to invoke.

CONCLUSION

The use of UGVs is a reality and one can expect the continuous development of UGVs for multiple possible uses by the armed forces and law enforcement agencies. UGVs, when considered as weapons, have to follow the same rules as applicable to any other weapon, and the same procedures on use of force (e.g. target engagement). In case of using UGVs in armed conflict, the main principles of IHL must be complied with; in case of using UGVs in situations short of armed conflict, rules of HRL shall be followed, particularly the right to life.

One could say that UGVs operated by humans can follow standard targeting procedures, although special care should be paid to the reliance on information provided by the sensors and possible recommendations of the computer, especially when the pace of operation is putting pressure on an operator. However, the procedures related to the use of autonomous UGVs, particularly fully autonomous ones, depend on the proven abilities of the autonomous weapon systems. As the targeting decisions are highly contextual and subjective, it would be very challenging, if not irresponsible to use autonomous weapon systems in environments where establishment of military necessity, status and intention of the possible target and assessment of collateral damage are difficult.

The use of progressively autonomous weapon systems requires also attention to the responsibility issue. In case of violations of IHL, responsibility should not be avoided through the employment of robots. Rethinking and, if necessary, re-regulating the criminal responsibility in the context of new circumstances on the battlefield might be required for effective deterrence and punishment of crimes.

In 2013 the UN Special Rapporteur on extrajudicial, summary or arbitrary executions for the Office of the High Commissioner for Human Rights, Professor Christof Heyns, released a report on lethal autonomous robotics (LARs) and recommended that the Human Rights Council "call on all States to declare and implement national moratoria on at least the testing, production, assembly, transfer, acquisition, deployment and use of LARs until such time as an internationally agreed upon framework on the future of LARs has been established."[41] The challenges related to the use of autonomous weapons may require, if not a moratorium, then at least a development of universal legal framework. Historically, the states have been able to create numerous agreements on weapons and methods of warfare, and now they face another set of issues that can be best solved by a special agreement. The interpretation of existing rules cannot provide satisfactory answers to these specific issues.

ENDNOTES

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3 Weapons Law Encyclopedia, "Weapons system," Accessed May 15, 2017, http://www.weaponslaw.org/glossary/weapons-system

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UNMANNED GROUND VEHICLES IN DEVELOPMENT AND PRACTICE: COUNTRY STUDIES

CHINA

Nora Vanaga

Robotic research as such in the People's Republic of China (hereafter – China) started in 1980s when rapid developments in the US and Japanese markets pushed for developments in China's market as well. Most of the robotic research at the time was mainly focused on civilian applications; and only in recent years (basically starting from the 2000s) it has expanded into the military sector.[1] The main reason for that is the willingness of China, besides becoming an economic superpower, to gain status as a respected military power.[2] To achieve that it has been rapidly increasing its defence expenditures from USD 43.2 billion in 2000 to USD 225.7 billion in 2016,[3] additionally allocating two percent of its GDP for research and development in 2014.[4] In its 2014 Military Strategy China acknowledged that the revolution in military affairs is proceeding to a new stage as there are new sophisticated weapon systems such as long range, precise, smart, stealthy and unmanned weapons, which put China in front of a new arms race in the technological realm. Therefore, one of the main tasks for China's armed forces in this sphere is to "pay close attention to the challenges in new security domains and work hard to seize the strategic initiative in military competition".[5] To keep up the arms race in the research and technology, China invested in the development of unmanned platforms, particularly in the development of unmanned aerial vehicles.[6]

In comparison with other unmanned systems, unmanned ground vehicles (UGVs) were introduced last. Other unmanned system research centres had developed in years before, including dozens under the management of state-owned defence enterprises, such as the Aviation Industry Corporation of China and the China Aerospace Science and Industry Corporation; and hundreds of other privately owned firms and institutes. Consequently, the market of unmanned systems nowadays can be characterised as very fragmented and not sufficiently regulated, resulting in a high degree of duplication of developed unmanned systems. Strikingly enough the cause for that according to Jon Grevattis is the lack of the country's ability to formulate a strategy for the exact purposes of unmanned systems, on one hand, and immense commercial interests from sectors such as oil and gas, on the other.[7] It seems that just as many future technologies, including unmanned systems in China, are increasingly driven by off-the-shelf developments by private companies which is intensified by globalisation processes.[8]

As for the development of UGVs for military purposes, addressing the needs of the People's Liberation Army (PLA), China's leading military enterprise North Industries Group Cooperation (NORINCO) established a facility only in the middle of 2014. NORINCO announced that the new UGV development centre would not only serve the PLA's purposes, but also paramilitary and civilian customers. Additionally, there would be attempts to explore export opportunities. To boost research for UGV development, NORINCO aimed to enter collaborative agreements with research groups from Russia, Germany and Finland.[9] Overall, there is a significant interest from the companies of Western countries to establish branches in China and form partnerships with Chinese companies.[10] The reason for that is the dynamics of the Chinese market, well developed automotive manufacturing and the perspective of rapid growth.

Still, despite ambitious aspirations, Chinese military industry is aware of being in a very initial UGV development stage. As the director of the China North Vehicle Research Institute noted "it will take at least five years for China to catch up with these UGV powers when it comes to cutting-edge technologies and expertise in the field, such as system integration, environmental perception and decision-making mechanisms"[11].

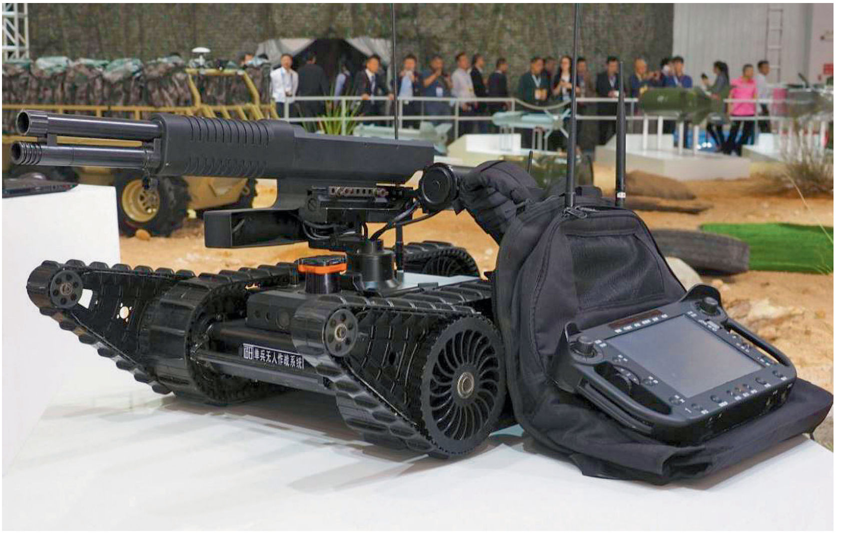
CHINESE UGV PROTOTYPES

When it comes to the specific UGV prototypes, they are developed in three areas – EOD, combat and logistical support. The very first one was UGV REX-1 – remote-controlled explosive ordnance disposal (EOD) robot – which was already presented in 2010. UGVs developed by Poly Technologies are aimed for the tasks in military, paramilitary and police forces. Mainly suited to roles that require access to confined and small spaces, such as on board of an aircraft, and its relatively light weight (70 kg) allows it to be deployed from non-specialised vehicles. A complete REX-1 system consists of a single robot and an 8 kg portable control console that has a flat-panel display showing imagery from the on-board cameras. The vehicle can be fitted with one of two differently sized front-facing scissor-type arms with 3 kg of carrying capacity and can transverse and pitch through 180 degrees. The endurance of the REX-1 UGV is between three and five hours. It can climb 21 centimetre vertical obstacles, traverse a 35-degree slope and turn around on its own axis. The movement of REX-1 is provided by widely used wheelbarrow-type EOD system and the maximum speed is 2 kilometres per hour. It was expected at the time that Chinese defence industry companies are also involved in developing four and six wheeled vehicles for reconnaissance tasks.[12]

The latest EOD UGV – Leobot EOD – was presented in the spring of 2017 (See Picture 1). It is produced by the Inner Mongolia Zhongyi Electric Instrument Automation company. The Leobot EOD is a medium size tracked robot that can move at maximum speeds of 2.3 kilometres per hour and capture and transfer objects on a variety of terrain. It is designed to deal with such tasks as inspecting suspicious explosive objects, addressing urban anti-terrorism threats, providing public safety, and assisting in earthquake relief and others. Hence it can be used for EOD, route clearance, reconnaissance, handling hazardous material, chemical and biological material detection and building clearance. The UGV weighs 58 kg and is fitted with a manipulator arm. It has four cameras that provide 360 degree situational awareness. It can move on slopes up to 30 degrees and climb obstacles up to 25 centimetres. Leobot EOD can endure up to four hours of work and can be remotely operated wireless through a hand-held control terminal from a distance up to 100 meters.[13]

Chinese companies are also focusing on the development of combat UGVs. In 2014 NORINCO presented a Battle Robot designed for operations in confined environments, intended for surveillance and combat missions in constrained urban or natural terrain (Picture 2). The UGV's system comprises backpack-mounted transmitter and handheld integrated display and control unit. The weapon system consists of close-range Type-09 derived self-loading 12-gauge shotgun and a sub-machine gun of an unspecified type. The UGV has a modular design, which enables soldiers to reconfigure the platform to adjust a range of mission profiles as well as install upgrades if necessary. For instance, the weapon could be replaced by manipulator arms to perform simple EOD functions or advanced sensor and camera systems that provide situational awareness.[15]

Picture 1: Leobot EOD robot[14]



Picture 2: NORINCO Battle Robot UGV[16]

UGVs have been an important logistical support for infantry. In 2012 NORINCO started to develop a 6x6 UGV Crew Task Support Unmanned Mobile Platform, which was concluded in 2016 (Picture 3). The UGV is meant to provide logistical support for up to eight troops and deal with such tasks as casualty evacuation, ammunition transport, border patrol, search and rescue and so on. As experts note, the developed UGV is very similar, if not to say, an exact copy of Lockheed Martin's Squad Mission Support System, which performs the same missions – transportation of troops' weapons and ammunition, mission critical equipment, food, water and medical supplies on unpaved roads and country terrain (Picture 4). The Chinese UGV platform has all-wheel drive and steering capabilities and a capacity to carry up to 600 kg of paraphernalia. The vehicle is over three meters long, is capable of fording water up to 70 cm, and can develop maximum speed up to 35 kilometres per hour on an uneven terrain. It is also equipped with run-flat tires and an active hydraulic suspension system. It is believed that the UGV runs with hybrid engine technology. There are four modes of operation – tele-operation, follower behaviour, waypoint navigation and fully autonomous. The latter modes foresee performing real time mapping of the surrounding terrain and generating its own paths.[17]

To provide logistical support in mountainous areas NORINCO issued in 2016 Mountain Quadruped Bionic Mobile Platform or to put it short – Da Gou (in English – Big Dog) – which is four-legged walking UGV and it is meant for transport, reconnaissance, combat missions or use in disaster relief (Picture 5). Also, this UGV bears striking similarities to the US Google-owned Boston Dynamics "BigDog" when it comes to dimensions, weight and system architecture (Picture 6). This UGV weighs 130 kg and has the capacity to carry up to 50 kg loads. It can develop speeds up to 6 kg per hour on paved road, transverse 30 degree slopes and endure work for 2 hours.

Picture 3: Crew Task Support Unmanned Mobile Platform by NORINCO[18]

Picture 4: Lockheed Martin's Squad Mission Support System[19]

The next aim of NORINCO is to produce an imitation of yak that will weigh around 400 kg and have a significantly bigger payload.[20]

ROLE OF UGVS IN THE LAND FORCES' OPERATIONS

Whilst assessing the developments of Chinese UGV systems, it can be concluded that all of them are focused on supporting infantry, especially logistical support in an austere environment. Additionally, EOD and

Picture 5: Mountainous Bionic Quadruped Robot "Da Gou"[21]

Picture 6: US Boston Dynamics' "BigDog"[22] combat UGVs are meant for urban warfare, where logistical support is less demanding than, for instance, in remote mountainous terrain. This is in line with the military strategic vision of China, as in its Military Strategy: among numerous threats to national security and social stability, the most topical are terrorism, separatist forces, serious natural disasters and epidemics. The People's Armed Police Forces (PAPF) are more likely to be the main receivers of UGVs because their main task is to maintain internal political and social stability. The strategy foresees to develop PAPF into multi-functional and modular unites that can perform multiple functions in different regions – guard and security, counter-terrorism operations, stability maintenance, emergency rescue and disaster relief, contingency response, emergency support and air support.[23] The EOD and combat UGV platforms are characterised with a high degree of modularity and multi-functionality, hence providing the necessary flexibility when assistance for the implementation of PAPF tasks is needed.

Of course, UGVs may also be used in tactical unit operations of the PLA, especially when it comes to logistical support. The necessity to enhance modernisation of logistics is emphasised, claiming that it is crucial to "innovate the modes of support, develop new support means, augment war reserves, integrate logistics information systems, improve rules and standards, and meticulously organise supply and support, to build a logistics system that can provide support for fighting"[24]. Hence China, despite having a significant manpower in comparison to other leading military powers, is also trying to optimise the usage of its forces, introducing UGVs for logistical support.

Besides using the developed UGV's for the provision of internal stability and territorial defence, they also have the potential to increase the PLA's capabilities for expeditionary missions, for instance the UN missions. China's military strategy sets aims to gradually intensify the country's armed forces' participation in operations such as international peacekeeping and humanitarian assistance where all so far developed UGV's can support infantry units in accomplishing their tasks.[25]

At the same time, there are several challenges that China's armed forces will face when using UGVs. Firstly, the low capacity of armed forces personnel to use high-technology unmanned platforms. The necessity to “cultivate” the talents of the military personnel, in order to improve the scientific and technological capabilities of the officers and soldiers, is emphasised as one of the main priorities in the PLA personnel development process. It is to be achieved through reviewing education and training programs in the higher military education institutions and educating military personnel in civilian educational institutions.[26] Despite these incentives it will take time while the Chinese army develops expertise in high-technology field cadres.

Secondly, Chinese UGV systems, at least the prototypes that are publicly presented, are technologically lagging behind their Western equivalents. The Western UGVs already embrace the elements of artificial intelligence leaving only decision-making to the operators. Lack of a clear vision for what purposes and in which force structures they would be integrated in, makes it significantly harder for the military research and technology institutes to find the focus and develop more sophisticated and unique systems. So far Chinese UGVs are visually and even in the sense of technology, copies of the Western military UGVs, which does not give China the necessary advantage in the arms race in the realm of research and technology.

Thirdly, just as with any military that uses UGVs, China also shares the same vulnerabilities of unmanned platforms. UGVs’ operational requirements foresee electromagnetic-bandwidth and satellite connection. There are high risks of accidental disruption or deliberate enemy targeting using electromagnetic warfare that makes platforms that are linked to a controller increasingly vulnerable and potentially unable to accomplish their missions.[27] Therefore, in modern non-contact warfare, satellite-jamming and cyber-attack capabilities are one of the most important capabilities to be developed and are feared by opponents. Since the US still has superior cyber-attack capabilities, for China it is a challenge to provide protection to its UGVs systems.

CONCLUSION

China started to seriously focus on UGV development very late, only from 2014, producing UGVs that focus on the land forces' needs – EOD aspects, for logistical support and combat missions. From a strategic point of view, it was necessary to keep up with the technological developments in the Western militaries. The shortcomings of the Chinese UGV development approach is that they started so late and, most importantly, have not managed to formulate a strategic vision about what kind of purpose UGVs should be developed for. So far, China's research and technology institutes limit themselves with copying the Western UGVs in order to provide a particular set of capabilities; but are unable to innovate and generate technologically more sophisticated equipment, which could compete with the Western UGV platforms.

The developed UGV prototypes also give room for speculations, about what kind of operational needs they have been developed for. According to China's Military Strategy, the main threats for national security and internal stability are separatist forces, terrorism, natural disasters and of course geopolitical developments, especially, in Southeast Asia. Considering the multi-functionality and modularity of the UGV platforms, they have the potential to increase PLA capabilities both for territorial defence and expeditionary missions. From a historical point of view and considering the size of the PLA, it is very interesting to observe that China, a country that historically has not had a problem with manpower, has chosen the Western approach by safeguarding troops and increasing its non-contact capabilities. China's decreasing willingness to accept losses can be explained with the latest developments that indicate that the Chinese population is in decline.

Lastly, UGVs are produced specifically for the tactical level, providing small units with EOD capabilities, logistical support for infantry and equipment in normal and austere conditions, and weapon platforms that also serve for reconnaissance and surveillance. UGVs could be primarily used for PAPF and PLA's small units' tasks in urban warfare, mountainous warfare and other missions. At the same time, some scepticism needs to remain as there is a lack of open source information about how effective and reliable the UGVs produced in China are and how suitable they are for unit level tasks.

Summing up the main challenges that China is facing in developing UGVs are the late start of investments in UGV industry which has put it in a "catch-up" position for at least five years. Additionally, the lack of strategic vision about UGVs' purposes and role in the PLA's development has hampered the development of China's own UGVs. Last but not least, the absence of educated and capable personnel that have knowledge about technologically sophisticated unmanned platforms is also a challenge for PLA.

Still considering the dynamics and scope of China's automotive and robotics engineering market there are no doubts that China can catch up with the Western military industries, especially, if it is supported by Western companies. Additionally, the main enhancement is the dual use of UGVs that significantly widens the market. This is the characteristics of the market of unmanned systems as such because it is increasingly driven by off-the-shelf development by private and state-owned companies.

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ISRAEL

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The Israel Defence Force (IDF) was a pioneer at utilising Unmanned Aerial Vehicles (UAVs) for military purposes. In the past few decades, there has been a rising tide in utilising UAVs and senior officers estimate that within a few years the use of long-distance aerial vehicles will outweigh the use of manned systems. On the contrary, the unmanned on-land realm, although holds great potential for the use of unmanned tools, is far behind its aerial equivalent. This is due to a variety of technological, doctrine and psychological reasons. However, the IDF has tested and deployed Unmanned Ground Vehicles (UGVs) for at least two decades. This article briefly elaborates on the development directions in this field in the IDF, and whether the IDF is willing to integrate them doctrinally and practically in the Ground Forces (GF) with emphasis on the Infantry Corps.

ISRAEL'S VISION CONCERNING THE FUTURE ROLE OF UGVS IN SUPPORT OF LAND OPERATIONS AND ITS RECENT DEVELOPMENTS

The GF's mission, according to the political and the IDF leadership's demands is as follows: **Manoeuvre against its enemies.** Israel shall take through the IDF offensive measures through aerial and ground fire and **ground manoeuvre** on enemy territory designated to cease enemy's fire, strike its capabilities (forces and infrastructure) and to overwhelm the enemy. **Conduct routine border control and counter-terrorism operations** – the GF operate on many outlines in operational routine and border control, for pre-emptive measures, prevention and to fight in times of need against small enemy forces. These main missions affect the IDF's force structure and that of the GF, and is to be taken into consideration in the field of UGVs.

Since 2014, resulting from lessons learned from Operation Protective Edge[1] and also from the growing influence of the worldwide military tendency to develop and integrate UGVs in the ground forces, the GF increased in conjunction with R&D agencies and the defence industries the attention towards UGVs. In this context, it was tested how the IDF is going to integrate the UGVs as part of the capabilities and means required for the ground forces in performance of its core tasks including routine patrolling around the borders, counter-terrorism, combat engineering missions, underground warfare, as well as collection of information, reconnaissance tasks, observation and combat service support operations.Routine security operations – the ongoing mission of the IDF in border control around Israel is a significant factor for developing UGVs and their use. The Defence Ministry with the IDF have built in the past two decades a massive border control systems which includes road infrastructure, fences and observation, detection and alert systems controlled from war rooms as well as sub-systems for support of command, control and intelligence functions. Efforts to integrate UGVs have begun over a decade ago using the Gardium UGV produced by the Israeli company G-NIUS.

This UGV was built for patrolling along the border with Gaza and to assist detection of activities near the border or its penetration towards Israel. The autonomy level of the tool was relatively high with the ability to drive through a pre-programmed route and overcome obstacles in its way without any human intervention, however the UGV is supervised and can be activated (such as opening fire or call for troop support) by the soldiers based on transmitted pictures from the field.[2] Although project Gardium was shut down in 2016, the IDF continues testing UGVs for border control. An example is a border controller UGV that was developed by the IDF through ELBIT SYSTEMS.

This vehicle, Ford model F350 is equipped with day and night vision systems, which are adapted for observation and surveillance over the large obstacles such as a fence. The vehicle is remotely controlled from a combat collection regional war room and is operated by two soldiers – one that controls the vehicle and the second – observation systems. The IDF is going to install a remote-controlled weapon system and to increase the movement autonomy in the future.[3]

Picture 1: UGV Ford model F350[4]

The engineering robots are the main "pulling force" for the development of technological and tactical solutions for UGVs in the IDF. The primary function for UGVs within engineering realm is countering Improvised Explosive Devices (IED) and mines. Small and medium sized UGVs for handling IEDs are being used by bomb disposal units for many years. Another widely used application of UGV in IDF is route clearing missions. The IDF has made a wide use of armoured maned bulldozers for that need, but at the same time have developed remotely controlled bulldozers. In the mid 2000's, the IDF developed the armoured bulldozers, which are remotely controlled. These bulldozers were actively used during the operations in the past decade.[5]

Following Operation Protective Edge, one of the main operational problems IDF is trying to solve with the help of UGV technologies is to combat tunnels.[6] Gaza Strip tunnels are known for over 25 years.[7] Robotic means offers excellent solution to this type of operations due to their unique technical capabilities as well as by narrowing down the threat to the soldiers.[8] Combat engineering units that were established in order to deal with the evolving tunnel systems continuously test specially adjusted UGVs for action in underground terrain. This challenge requires creative tactical and technological solutions. For example, a few months prior to the operation in 2014, a bomb disposal robot TALON 4 was introduced. This is one of the most used bomb disposal models in the military sphere around the world (quantity-wise). It can also be armed with a gun and is capable to transmit video stream from out of sight locations.[9] Another UGV solution by the Israeli company ROBOTEAM, which was integrated in real time in Operation Protective Edge, is based upon a known robot called MTGR. This tool combines caterpillar track movement and hovering using rotors in a way that allows mixture of both land and aerial movements in order to deal with rough and challenging terrains. This tool transmits picture from within tunnels and takes certain actions such as revealing IEDs or neutralizing them.[10]

Picture 2: MTGR seen on a tunnel reconnaissance mission[11]

Initial experiments of the GF to utilize robotic means up to the company level operations – primarily to collect information and observe the battlespace – were done already during the early 2000s. In Operation Cast Lead[12], ground forces that fought in Gaza Strip used several tools that are considered ground robotics that include: I-Drive by ODF, a ball which is thrown into a building prior to combat soldiers' entrance and allows prior mapping of the area by using cameras and remote movement capability; also, Explorer by "IROBOT" company, which was activated by engineering combat units and moved ahead of the force in order to collect intelligence and conduct observation.[13]

In the realm of Combat Service Support function application of UGVs is limited to transportation tasks. During Operation Protective Edge, an Armoured Personnel Carrier (APC) type M-113 that was converted into unmanned vehicle and was used to transport supplies into the combat zone. Nowadays, the GF examines integration of transportation robots into infantry units. This matter was put into examination in 2016, and the intention is to enter operational examination in the near future. The IDF examines transportation robots such as PROBOT of the company ROBOTEAM and REX of ISRAEL AIRSPACE INDUSTRIES (IAI) to be used by the infantry units. These tools are designed to accompany small infantry forces and carry supplies and ammunition. One very specific technical requirement for transportation UGVs defined by IDF is Leader-Follower Function. This function is desired to minimize the attention of the soldier on operating the robot. In longer perspective IDF is planning to integrate autonomous vehicles such as autonomous trucks in supply chains. Currently, IDF is examining potential of using UGVs for casualty evacuation tasks. However, sending an autonomous UGV with a wounded soldier is problematic due to the need to supervise the wounded and potential need for treatment during sustained movement.

UGVS INFLUENCE ON THE CAPABILITIES AND TACTICS OF SMALL INFANTRY UNITS

IDF alongside other western militaries including the US, will conduct operations in complex and closed territories. Lebanon, Gaza Strip and other possible combat zones are characterized as complex built up terrains (urban and sub-urban), and with consistently developing underground terrain.[14] Therefore, tactical level operations of the IDF will be more "spherical", more decentralized, and more integrated.[15] Closed-complexed territories and methods the enemy will apply in their "home-court", will increase the difficulty to locate single targets.[16] This will result in very short target exposure time. At the same time the mobility of the Infantry Fighting Vehicles (IFV) and other means of transportation in urban terrains will be severely limited. Closed areas, obstacles, civilians and other challenges will not permit to use the combat power embodied within tanks and IFVs.[17] Accordingly, a primary operating unit of IDF will become a light infantry unit. UGVs have a potential to replicate some elements of the combat support and combat service support otherwise provided by tanks, and Infantry Fighting Vehicles.

Operation Protective Edge and the tunnel threat gave significant amplitude towards integration of UGVs in the Infantry Corps. GF has acquired for the infantry battalions a portable designated robot ("Roni") for the purpose of use by the infantry companies. This robot MTGR is a product of by ROBOTEAM. In 2016 the Infantry Corps published a doctrine for urban warfare, in which it for the first time elaborates integration of UGVs in infantry warfare on the doctrine level. The UGVs are designated for combat in the underground warfare (tunnels) and urban areas, and have a variety of missions: observations, scanning and securing. It is intended to operate two UGVs in a company.[18] Integration of robots in infantry units has led to the establishment of a body responsible for training and qualification that will certify UGVs operators.

Picture 3: Israeli military robot Roni[19]

Amongst the reasons for the rise in use of robotic tools in the IDF is the need to minimize casualties and for surgical hits of the enemy that tend to emerge for short periods of time. However, there is a certain level of risk of exposure to danger, but this type of operation puts some distance between the direct threat and the operator. This issue serves the common approach in the IDF of minimizing casualties and operating, as much as possible, from afar. In infantry units that advance in urban and other complex territories, operating UGVs will allow a more secure access to destination and movements within them, as long as the combat tempo isn't affected. Another possible use is deployment of robotic systems in positions far from the force for observation and fire, without any extra risk to soldiers of isolated forces.

WHAT SHOULD BE DONE IN THE FIELD OF UGV RELATED RESEARCH AND DEVELOPMENT

As the Second Lebanon War[20] was a cornerstone in the field of utilizing of UAVs, it is possible to address Operation Protective Edge as a cornerstone in regards to the introduction of unmanned ground instruments, with emphasis on the needs that rose from the challenges that the underground warfare presented.[21] When we examine historically, the integration the UGVs in the IDF's ground forces, we learn that there were initial attempts in this field in the early 2000s, however they were based mainly on tools that were used by engineering units and designated for bomb disposal. This trend lasted until 2014, and as said, the UGV the infantry recently acquired, was originally designated for engineering outlined for dealing with tunnels and IEDs.

Another accelerator, which might affect increasing integration of UGVs in the IDF is the entrance of the Israeli security industries into the world UGV market and taking the leading role in its advancement, as they are in the UAV market. It relates to more experienced companies that use the capabilities and knowledge acquired in other fields, and younger companies that focus on developing only UGVs. The weaponry developing bodies in the IDF, in the GF and the Corps need to present a solid operational demands and to supervise the military development on one side, and be well aware for the needs to detect and integrate military and civil technologies from the shelf on the other, all in order to be relevant in the competition against development of capabilities against Israel's enemies.

In the introduction to the book that discusses the course of action of the 35th Paratroopers Brigade during the First Lebanon War (1982), the Defence Minister back then, Yitzhak Rabin, wrote that the war:

> proved once again the necessity and vitality of the Infantry. In the era of planes, rockets and computers, there still is no replacement for the soldier that determines facts with his body, his legs and mind […] in places that tanks have yet to reach and planes didn't penetrate, only the infantry soldier could have gotten the job done over there, and successfully.[22]

It can be determined, for conclusion, that this statement by Y. Rabin in regard to the infantry forces specifically and the ground forces of the IDF generally remains true even after Operation Protective Edge in 2014. The use of ground robots in the IDF falls behind its aerial equivalent. However, the operational need of the contemporary combat zones, the accumulating operational experience and the advancing technologies suggest that increasing integration of UGVs in the ground forces of the IDF is vital.

ENDNOTES

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POLAND

Mirosław Smolarek

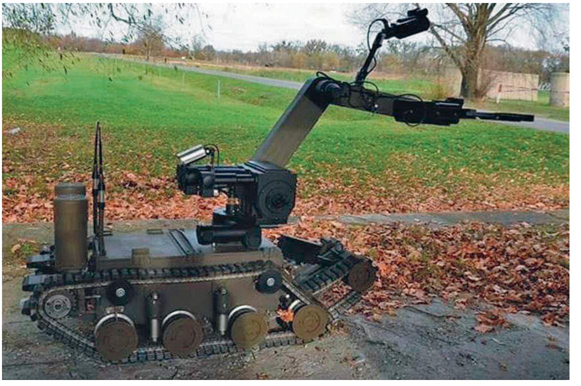
The 21st century is a period where diametric changes in the ways of conducting operations can be observed, especially by land forces. There has been a change in the role of land forces from the dominant that could be observed in the "classical" generations of war, to more complex and comprehensive assignments, which are the characteristic for wars of the fourth generation. New combat circumstances, which land forces must face, such as relocation of combat activities from deserted battlefields into dense urban areas cause new needs not only for new tactics, procedures and attitude to civilian societies (e.g. strategic communications), but also for compelling technological achievements. Another trend in military operations forced by live coverage by the media is the necessity of significant casualty reductions. These, as well as a number of other factors, such as the need to increase the effectiveness of soldiers on the battlefield, increase manoeuvrability and efficiency of operations etc., outline the direction for future armaments' development. Military thinkers talk about "non-contact warfare", which is called "5th generation war",[1] where technology like precision guided, "intelligent" ammunition or armed unmanned vehicles can engage enemy targets by operators sitting in front of a screen thousands of kilometres away. The robotisation of the armed forces and the battlespace is no longer a science fiction dream, but is becoming a fact.

Today, all military components employ unmanned vehicles.[2] UAVs observe enemies, armed versions strike enemies' objectives, UGVs, USVs and UUVs protect military compounds, facilities and heavy equipment, conduct mine clearance, ISR tasks, support soldiers logistically, engage enemies with their firepower, and so on. The greatest progress in implementation of unmanned vehicles can be observed in the Air Force, however Land Forces of modern armies are following this trend. Areas of employment of UGVs are quite broad, however the biggest progress is observed in their use for detecting and neutralising improvised explosive devices (IEDs) (e.g. American TALON) reconnaissance (e.g. Israeli MTGRR), and combat (e.g. Russian Uran-9). Many armies and the arms industry are working on the construction of robust logistics/ transportation UGVs. The tendency to introduce UGVs is not only reserved for the major powers and large armed forces; smaller countries are also trying to develop such systems (e.g. Estonian THeMIS with .50-cal. machine gun CIS50MG).[3] International armaments consortiums have spotted this sector and are preparing a wide range of UGVs' offerings for land forces. Some countries try to develop their own military systems using national military research institutions (e.g. American DARPA, Russian FPI[4] or Chinese Junweikejiwei[5]), while others focus on acquiring equipment offered by commercial manufacturers. Poland belongs to the second group.

UGVS IN THE POLISH ARMED FORCES – PAST AND PRESENT

The Polish Armed Forces have over ten years' experience in using UGVs, also in combat operations conducted in Afghanistan and Iraq. As in other countries, the robotisation of the Polish Land Forces began with the introduction of C-IED and UXO clearing robots. The Polish Land Forces use commercial solutions offered by international armaments companies, although the Polish industry also has a lot of experience and potential in the field of construction of such automatons. In 2006, the first Polish-built UGV was purchased from a manufacturer called Przemysłowy Instytut Automatyki i Pomiarów (PIAP – Industrial Automation and Measurement Institute). This producer is one of the most experienced Polish companies in the area of construction of robots and unmanned vehicles, since it has been involved in this business for more than twenty years.[6] The army purchased two different UGVs: a heavy-duty machine (550 kg) "Inspector", designed for the remote clearance of shells, munitions (UXOs) in open areas, both for "traditional" combat

Picture 1: UGV "Inspector" (PIAP). Photo: Paulina Wojciechowska, kpt. Ewa Nowicka-Szlufik (Engineer and CBRN Training Centre, Wrocław, Poland)



operations and anti-terrorist actions. In addition, the robot's equipment consists of sophisticated supplementary gear, among others the XR200 X-ray tube, recoilless gun for destroying detonators and neutralization of explosives (Richmond Maxx De Armer Disrupter) with several types of ammunition. Moreover, the development version can be used as a sentry platform equipped with several types of weapons.

The second UGV bought from PIAP was a smaller and lighter (about 180 kg) variant called "Expert". This robot is also designed to operate in small spaces including aeroplanes, buses, trucks, railway carriages or ships. This machine can lift suspicious loads of 5-15 kg from difficult to reach nooks or high shelves. Both robots were used by Polish demining teams during the ISAF mission in Afghanistan.[7] Additionally, Poland's involvement in this peace support operation created the need to strengthen troops' protection against IEDs and increase the technical capacity for explosives' detection and neutralisation. For this reason the operation was supported by small-scale UGVs Foster-Miller Talon 4 with the ability to detect and destroy anti-personnel landmines and IEDs. Next, in 2008, the Polish Ministry of Defence purchased the remotely-controlled mine clearance system Božena-4 of the Slovakian company Way Industry. The tracked automatous equipped in minesweeping gear allows the detonation of anti-personnel landmines and anti-tank mines containing up to 9 kg TNT. The use of this type of robot greatly increased the safety of not only the Polish soldiers but of the entire

Picture 2: LRR Balsa backpack. Photo: Przemysłowy Instytut Automatyki i Pomiarów (PIAP)

ISAF mission. These UGVs are still used by Polish sappers, and the operators are trained in using of the equipment in the Engineering and CBRN Training Centre in Wrocław. Currently, the Polish demining teams extend their operational capabilities in area of demining by purchasing from PIAP company 53 UGVs codenamed Balsa (demining type 1507 – based on the universal platform Fenix). This lightweight (15–20 kg) demining robot will be used to remove suspicious cargo, hazardous materials and for engineering reconnaissance. The company has already launched its first deliveries and should finalise the contract by the end of 2018.[8]

UGVS IN THE POLISH ARMED FORCES – THE NEAREST FUTURE

With the future UGVs, it is important to note that unmanned platforms are not only an area of interest for the Polish Ministry of Defence. Research funding for the development of this type of equipment (called "demonstrators") are allocated also by the "civil" ministries, which promote and support this kind of activities. For example, the National Centre for Research and Development, an executive agency of the Minister of Science and Higher Education, has provided a platform for effective dialogue between the research and business community and offers research grants for implementation of the so called "Unmanned Technology Platform". The Centre is co-founding research projects in the following areas: *GROUP I,* including Unmanned Aerial Vehicles, Unmanned Ground Vehicles and Unmanned Surface Vehicles/ Platforms (USVs); and *GROUP II,* including subsystems, components and technologies for UAVs, UGVs and USVs, industrial applications for mission-critical crisis management support, critical infrastructure protection, environmental protection, and industrial surveillance. Such projects also indirectly support the development of unmanned military platforms as well, because research institutes and industries have access to the state's financial support and general help in implementation of the developed projects.[9]

Regarding the military concept behind the acquisition of unmanned platforms, in 2013 the Polish government adopted a multiannual programme "Priorities of the Technical Modernisation of the Armed Forces of the Republic of Poland within the framework of operational programmes". The document defines the modernisation plans of the Polish Army until 2022. The programme's goal is to increase the operational capacities of the Armed Forces by obtaining sophisticated military equipment. The goal is to be achieved by technical modernisation of the Armed Forces, and by upgrading the currently possessed hardware and purchasing new equipment.

The programme supports the tasks defined in the Strategy for the Development of the National Security System of the Republic of Poland by 2022. This strategy defines Objective No 2 – strengthening the state's defence capabilities. One of the main actions for the realisation of this objective includes "increased saturation with modern military hardware and equipment, including participation in international programmes". To achieve the intended goals, the Polish government adopted 14 operational programmes, which defined modernisation areas for all components and types of troops.

In addition, decision-makers decided to increase expenditures on the modernisation of anti-aircraft defence, airborne troops, and navy, land forces, integrated command systems, individual soldier equipment etc.; the programme also envisages intensive development of unmanned vehicles (platforms). Special emphasis is placed on UAVs – mini, short, medium range UAVs both CTOL and VTOL, as well as the operational application of MALE-type automatons; however, the 14th programme entitled Patrol Reconnaissance assumes the acquisition of mobile unmanned ground reconnaissance platforms.[10] The result of this programme was a tender organised by the Armaments Inspectorate – the institution responsible for purchasing equipment for the Polish Army – for the purchase of fifty reconnaissance UGVs, codenamed Tarantula. This light unmanned vehicle should be capable of:

- Conducting reconnaissance tasks in direct contact with an enemy, including penetration of dangerous places and locations inaccessible for human beings;
- Performing patrols without the need to introduce live force into areas and objects, which have been mined or under enemy's' direct fire;
- Wireless audio and video data transmission from sensors to the operator's console in real time mode.

The machine should move over any terrain, including urbanised zones, off-road or vegetated areas. Its construction is designed to allow transportation inside a reconnaissance vehicle and carried by a single soldier (weight about 15 kg). Uninterrupted operation time of the UGVs should be up to six hours, including at least two hours driving. The traction system was supposed to be able to overcome field obstacles such as ditches, slopes, stairs or kerbs. Several companies have entered the tender, but the conditions have been fulfilled only by two: Reago Group Sp. (LLC); and the previously mentioned PIAP company. In the first phase of the tender, a slightly cheaper offer was presented by Reago Group, offering Israeli UGV Roboteam MTGRR. However, the tender was cancelled in November 2016, and the reason was "…untimely delivery of the equipment, which was an object of the contract…".[11] Until now, the Polish Ministry of Defence has not decided whether it is going to select the PIAP's offer, or to launch a new tender, which will cause delays in delivery of this equipment to the Polish reconnaissance sub-units.[12]

The presented applications of UGVs in the Polish Armed Forces do not exhaust the scope of research work related to implementation of the land platforms. The Polish Ministry of Defence supports creating of military-civilian consortia established by research institutions and universities. For this purpose, the Defence Ministry has established the Inspectorate for Implementation of Innovative Defence Technologies (I3TO), which is responsible for supervision and development of selected technologies. Moreover, the inspectorate oversees implementation of chosen projects into selected systems. In addition, I3TO defines proposals and directions for research particularly important for the defence and security of the state. Furthermore, the institution deals with creation of the departmental policy for science and research development in the field of technology. An example of such military-civilian cooperation is a project related to developing a family of unmanned land platforms called BPL – Medium Platform (Class 800 kg). The arms industry, the Military University of Technology (Warsaw) and military research institutes are involved in the project. The task for these institutions is to develop two variants of a platform that could be used as a universal base for implementation of various types of equipment, reaching from logistics to combat applications.

CONCLUSION

The Polish Armed Forces have many years of experience in using UGVs. Initial employment included the use of robots for engineering and demining purposes. The introduction of this type of equipment has been forced by the geopolitical situation and Polish involvement in the operations in Iraq and Afghanistan. It should be clarified, however, that currently the Polish Army allocates considerable resources into the development of UAVs but the defence ministry does not forget about land platforms aimed at supporting demining teams, ISR process and increasing the safety of soldiers on the modern battlefield. Funds for acquiring this type of equipment are guaranteed by the Polish government and allocated in the budget for short and long-term military operational programmes. However, since the army is looking for commercial solutions offered by the international arms industry, without favour towards national producers, this process is sometimes slowed down and delayed by external factors. Nonetheless, the Defence Ministry's area of interest is not limited only to such development. The government and the military decision-makers promote and sponsor the research and development of land platforms that could then be used to build UGVs for logistics purposes (transport and supply tasks), as well as creation of armed platforms capable of fighting with the enemy's combat power. Moreover, Poland's armament companies are not waiting for this kind of governmental support for research, and independently develop their own products not only for orders coming from the Polish Army, but also genuine constructions for foreign armed forces or entities involved in the security sector and fighting terrorism. The lack of such dependence on supplies only for the Polish Armed Forces compels the Polish arms industry to compete with other international companies for armaments markets and, on the other hand, allows the Polish Army to acquire state-of-the-art equipment offered by international arms suppliers.

The robotisation of the army, especially of the land forces, is inevitable and – like many other militaries – the Polish Armed Forces are only at the beginning of this road. The introduction of robots to modern battlespace creates new opportunities but also new challenges. Today, this is particularly visible at the lowest command and single soldier levels. The use of the unmanned vehicles in current peace support operations, particularly in Iraq and Afghanistan, has significantly reduced the number of casualties, especially in relation to attacks with the use of the IEDs. While UAVs have tremendous importance at the operational level (e.g. ISR) and attack on high-value-targets (HTVs) etc., UGVs will play a decisive role at the contemporary battlefield especially at the lowest tactical level in combat, de-mining, reconnaissance, and logistics.

It should be noted that the land forces of many armed forces are still not fully prepared for implementation of such solutions in terms of both hardware and training. The Polish Army is no exception. The Polish Land Forces should increase their investment in the implementation of terrestrial platforms not only in the field of counter-IED and ISR, but also in logistics and offensive as well as defensive combat operations. The contemporary battlespace has become more complex and armies enter very quickly into new areas that researchers are trying to identify as the fifth and sixth generations of war - the spheres, which the military strategists did not predict even a few years ago. The Polish Armed Forces should focus especially on unmanned platforms supporting combat activities at the lowest tactical levels and even at the level of a single soldier's activities. Purchasing equipment does not solve the problem, as the soldiers need to be trained how to operate it. Decision-makers may not currently see the need for investment e.g. in offensive robots; however, it is still a good idea to train the crews to use them, and somehow, to get the soldiers accustomed to the fact that their operations will be supported by robots. On the other hand, unmanned vehicles are very technologically advanced and sophisticated devices. UGVs' operation requires skills that troops, especially reserve soldiers, do not currently possess, because they were not trained for such activities. Therefore, even if at present the Polish Army does not have typical combat or logistics robots, the soldiers should get trained in using them by utilising specialized trainers, because when the equipment appears in the military units – especially during the eruption of a conflict – it will be too late to begin such training.

The above-mentioned facts lead to the conclusion that the Polish Army should dictate standards, especially relating to the capabilities and simplicity of operating the unmanned systems, rather than accept products, which are offered by the arms industry. Robots should be simple and intuitive to use, require no advanced manual skills and extended knowledge of IT. In addition, the military automatons should have a modular structure and be easy to repair so that even a single soldier without advanced technical training should be able manually and quite quickly replace defective modules directly on the battlefield (even now the replacement of a modular drive unit in the Leopard 2 tank takes practically only 15-20 minutes).[13]

Certainly, further development of UGVs requires a very close cooperation with the military as a customer of the arms industry. The Polish Armed Forces is in a very good situation because it has military research institutes and the Military University of Technology (Warsaw), which can determine the requirements for this type of equipment, participate in development process as well as conduct verification tests on the delivered products. Moreover, these institutions conduct their own advanced research and are involved in military-civil projects in the field of UGVs.

Finally, even though unmanned platforms can greatly increase the effectiveness of soldiers in the modern battlespace and reduce human losses, robots will probably not eradicate the human factor from the battlefield completely. Moreover, opponents are also developing solutions designed for combating the adversaries' live force and equipment.

ENDNOTES

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RUSSIA

Zdzisław Śliwa

The Russian Federation (hereafter – Russia) has been very active in modernising its armed forces and pursuing innovative programmes, recognising that it is behind in these domains. After analysing the utilisation of unmanned vehicles, especially in the air, by the US in Iraq, Pakistan and Afghanistan, the country has decided to do more. Russians were shaken by the war in 2008, when Georgian forces used Israeli drones, demonstrating Russia's lack of well-developed solutions. There are new concepts of unmanned platforms already in development by research institutes and they are being used during tests and exercises. Defence Minister Sergei Shoigu's intention "to spend 320 billion roubles (about USD 8.8 billion) by 2020 on a programme to supply the Russian Armed forces with unmanned aerial vehicles"[1] suggests Russia is now trying to catch up. Russia began experimenting in the field of UGVs already in the 1920's and 1930's (Russian Reno, T-18, TT-26, TT-27, Teletank), but this stalled for many years, except for unmanned air vehicles (UAVs). Russia's armed forces showed some increase of interest in unmanned systems in the beginning of the 2000s but it was short lived. The development of UAVs took off again with the programme called Development of Prospective Military Robotisation until 2025 under the Ministry of Defence's auspices. Parallel, military scientific and research centres under the General Staff of the Armed Forces of the Russian Federation started to develop concepts of UGVs' tactical employment. The importance of such trend was highlighted by President Putin during a meeting of the Military-Industrial Commission in January 2017. He said that "the direction of autonomous robotic complexes is important and promising. They are able to fundamentally change the whole system of armament, and we need our own effective achievements in this field".[2]

This paper will discuss Russian concepts of UGVs. It is based on following the current programmes and their implementation into the Armed Forces, National Guard and other security related services. This paper presents UGV programmes under development and gives an overview on the UGVs introduced into the land forces. Not only is Russia gaining significant progress in the development of unmanned land combat systems, but it is also working on their conceptual utilisation in warfare. It is, however, limited by the international sanctions as there is shortage of necessary technologies for further progress.

CURRENT CONCEPTS UNDER DEVELOPMENT

The Russian Armed Forces increased interest in unmanned systems was a result of orders from the Ministry of Defence (MoD) and an initiative of the industry after recognising the need to procure such specialised and multifunctional vehicles. It was linked to modernisation of the armed forces and the allocation of funds for research into new types of weapon systems. The MoD's move to establish the Main Research and Testing Centre in Robotics in 2014 supported progress by developing concepts to utilise robotics platforms. Other steps include a new MoD's commission on robotisation, establishment of expected standards, test and training centres for UGVs, along with a system for training robots' operators. Sergey Popov, the head of a centre employing thirty-three academics, estimated that from 2011 the number of UGVs has increased threefold.[3] Major tasks for UGVs are supposed to be reconnaissance, patrolling, fire support, and contributions to anti-terrorist missions. There is a trend to create multirole systems that could be able to engage a variety of targets both on ground and in the air by merging suitable weapon systems on a single platform.

One UGV that stands out is Rosoboroneksport's 10-ton Uran-9 tracked robot tank. It is heavily armed with a machine gun, 30 mm cannon, a coaxial 7.62 mm machine gun and guided missiles.[4] Its antitank missiles 9M120 Ataka (AT-9 Spiral-2) can engage targets from as far as eight kilometres. Other armament options are Shmel-M reactive flamethrowers with a range of 1700 metres or Igla surface-to-air missiles. The robot is ready to be deployed in line with infantry to deliver fire support, having a "cutting-edge laser warning system, target detection, high-tech identification and tracking equipment".[5] The typical unit is composed of two-four robots, one-two semi-trailer trucks and a mobile command post on a Kamaz truck, from which it is controlled remotely at a distance of 3000 metres. A single operator is able to control movement and weapon systems from the command post, when complemented by Uran-9s automatic systems plus a laser rangefinder, a thermal imager, and a ballistic computer. After testing and presentation during the exhibition Army 2016 the UGV entered service at the end of 2016 and is to be introduced in bigger numbers in the future. The Uran series is not limited to Uran-9 and this is a general trend in Russian armed forces to reduce number of base platforms. An example is Uran-14, which could be configured as fire-fighting, obstacle-breaching and mine clearance vehicle or other. It is based on "technological documentation acquired from the Croatia-based company DOK-ING. It is directly inspired from DOK-ING's MVF-5 robot".[6] Another example is 6 tons Uran-6, a multipurpose demining robot, 1.8m-wide bulldozer blade, self-propelled Boikova mine sweeper, robotic arm, solid milling, tiller, trailer, crane, tong-type gripper with a cargo lifting capacity of 1,000kg, solid roller and Katkov demining trawl.[7] It is estimated than it could replace as many as twenty sappers when performing tasks.

A 14.7-ton scout-attack UGV Vikhr is the platform able to reach a destination without an operator at controls, the sensors allow it to follow a track and avoid obstacles, while being capable of engaging in "ground and aerial targets, reinforcing operations and protecting strategic facilities"[8] allowing to use soldiers for other tasks and decreasing human loss. Based on BMP-3 hull, Vikhr has a range of 600 kilometres and a top speed up to 60 kilometres per hour, and is able to cross water obstacles. It is armed with a 30 mm automatic cannon 2A72, a coaxial 7.62 mm machinegun and six guided anti-tank missiles 9M133M Kornet-M (AT-14 Spriggan). Other options include "single or twin-barrel 23 mm 2A14 anti-aircraft cannon, 12.7 mm NSVT or Kord heavy machine guns, or a 30 mm GSh-6-30K six-barrel naval automatic cannon. The vehicle can use surface-to-air missiles Igla (SA-18 Grouse) or 9K333 Verba man-portable air defence systems, as well as Shmel-M reactive flamethrowers"[9]. Sensors allow correction of fire and selection of weapon system to engage them, but still leaves the operator in charge of the final decision to fire. The UGV is supposed to be supported by mini UAV and mini UGV for reconnaissance and movement. BMP-3 hull is also used in another heavy UGV named Strike or Udar and it will have even more combat power and extended protection against enemy fire using active protection systems such as Arena-E, which is developed by the Engineering Design Bureau on Kolomna.[10] The UGV's Epoch remote weapon station is also fitted for other infantry fighting vehicles such as: T-15 Armata, Kurganets-25 or Bumerang. It is equipped with a range of sensors and armed with 2A42 30 mm automatic cannon, one 7.62 mm PKT coaxial machine and two launchers for the Kornet-EM anti-tank guided missile on both sides of the turret. The vehicle will deliver fire support and intelligence data for dismounted soldiers using Ratnik (Warrior). The Infantry Combat System such as Udar is designed to transport eight soldiers. Kovrov-based VNII Signal Scientific-Research Institute, developing Udar, is working on integrating it with artificial intelligence, allowing it to analyse the battlefield and to work in automatic mode.[11] These programmes are still under development to enter service in 2018 or later but they are giving an idea of Russia's tendencies towards the future UGVs.

In 2013, Russia's Military-Industrial Company revealed the concept of a hybrid-powered silent armoured personnel carrier (APC) that could eventually be remotely operated. The Krymsk APC concept is based on BTR-90 Rostok vehicle and is to possess a hybrid engine, which would enable the APC "to move virtually silently on a battery-driven electric motor when its diesel engine is turned off"[12]. There have been considerations to use it as a platform for new types of weapons, where laser or electromagnetic weapons can complement conventional capabilities. The unmanned platforms are not only under development, they are also being tested during military exercises. UGVs BAS-01G Soratnik and Nerehta participated in a drill of the Central Military District to deliver reconnaissance data and fire support for mechanised infantry. The Soratnik is able to deliver fire support and reconnaissance in combination with data acquired from an aerial drone "in an environment where soldiers' lives are at risk".[13] It can operate autonomously, select targets and can be commanded in manual mode from a distance of up to five kilometres from the command centre. Nerehta is a multifunctional platform that can be configured into eighteen variants using replaceable modules.[14]

Russia's NITI PROGRESS Company has developed a prototype of a tracked robot Platforma-M, which is remotely controlled mobile armed platform with its own opto-electronic observation systems. It can be used for "supportive tasks and it can destroy targets in automatic or semiautomatic control systems".[15] The robot can be armed with grenade launchers, machine guns and even laser guided anti-tank missiles. It can also be used to mount loudspeakers for use during anti-terrorist operations. Another advantage is given by two silent-mode 6.5 kilowatt motors, powered by batteries. Other armed prototypes include the Wolf-2 (mobile robotic system); the Shooter (Strelok) (has a machine gun fixed atop a tracked chassis); and the MRK-27-BT storm robot with two Schmel (Bumblebee) flamethrowers, a machinegun, two grenade launchers and six smoke grenades. There are also some smaller projects such as Varyag, Vepr, Verkholaz, Tornado, Tral Patrol 4.0, Shatun and Sanitar.[16] Those are designed by a variety of research institutes, and some projects will be continued if they will receive recognition from the MoD or other ministries. They are dependent on receiving funds for development and procuring in the future. Some will just be abandoned with no further development. The stationary guard stations in combination with mobile UGVs are predicted to enhance force protection of selected high value assets. The stationary system SRK armed with small arms and a grenade launcher was tested in Kozelsk to protect the 28th Guards Missile Division equipped with RS-24 Yars or Topol-MR (SS-29) intercontinental ballistic missiles. The SRK could provide circular protective fire up to 400 metres and is equipped with "optical-electronic and radar reconnaissance".[17] The system was complemented by the mobile UGV Tajfun-M with capability to stay in passive standby mode for seven days.

The competition among Russian companies and huge internal and external markets for new robotic platforms supports an innovative approach to make the armed forces' decision makers interested in their products ability to result in profitable contracts. The technical development is underpinned by advancing software to further enhance autonomy, survivability and effectiveness. The United Instrument-Making Corporation from ROSTEC Company during the International Military-Technical Forum Armiya-2016 presented software and hardware enabling the "control of ten combat units simultaneously along with transmitting data, including video, at a distance of several kilometres, while remaining invisible to enemy radio-electronic reconnaissance."[18] This is an important innovation for the Russian Armed Forces as it is extending capabilities to control more UGVs at the same time, limiting the number of personnel, while preserving the combat effectiveness.

TRENDS AND CONCEPTS FOR THE FUTURE ROLE OF UGVS

On the battlefield, the UGV can be used for a variety of purposes but the main idea is to avoid casualties. UGVs can potentially perform most risky tasks related to reconnaissance including reconnaissance by fire. UGVs advancing in front of manned platforms will cause the enemy to engage first, and allow troops to attack more effectively and avoid casualties. It requires a heavy training from operators and an extended ability of unmanned systems to operate in case the enemy uses radio-electronic weapons; especially as land domain is much more complex and unpredictable than air or maritime environments. There are plans to integrate UGVs with other vehicles and also dismounted soldiers. There is an option to transmit reconnaissance data using their personal Strelets command-and-control system, which will increase their situational awareness when conducting close combat. It is especially important in urban battles and other environments with limited visibility. Moreover, vehicles are planned to be integrated with land forces' squads, companies and battalions. This trend is supported by the military leadership.

Russian designers are closely following the developments of the US UGVs; for instance, Rys (Lynx) is very similar to the Boston Dynamics and Foster-Miller's BigDog, sponsored by the Defence Advanced Research Project Agency (DARPA). This biomorphic robot is supposed to perform variety of missions like "reconnaissance, fire support, mine clearance, medevac, logistic support and combat engineer reconnaissance vehicles".[19] According to Rosoboronexport's Deputy Chief Executive Officer, Igor Sevastyanov:

> automatic and remote control systems that have become available in the world arms market suggest a new stage of the evolution in the means of warfare. They offer great opportunities for the development of advanced weapon systems and military equipment. We are actively working to meet the demand in this area. As of today, Rosoboronexport's portfolio of orders for land forces weapons and military equipment, which includes UGV systems, exceeds [USD] 7 billion.[20]

Projects are currently under development for the third generation robotics that can communicate and collaborate. When using aerial surveillance, they will be able to navigate and create three-dimensional digital maps of the terrain even without GLONASS support.[21] In 2015, the Russian United Instrument Manufacturing Corporation tested Unicum technology, which "automatically and concurrently controls up to 10 unmanned vehicles. The research and development has resulted in a software package where the robotic vehicles independently take roles within a team, vote for a leader, replace out-of-action units, take up advantageous positions, search for targets and engage them automatically upon receiving the operator's confirmation."[22] The Zelenograd-based company Neurobotics is working on technologies allowing the use of brain impulses to control and manage robots. Even though the technology is not ready yet, it shows the direction of research. There is a strong belief that "Russian developers possess all of the required competencies to create modern military robotics that will be in demand on the international market. This is a fast-growing segment of the arms market,"[23] as estimated by Boris Simakin, head of the Analysis and Long-Term Planning Department. Technologies based on emerging know-how allow implementation of new tactical-technical characteristics and new ways of leading combat, which are not available for manned platforms. According to some sources, Russian UGVs have already been tested in real combat conditions during the war in Syria giving valuable experiences for further development. Uran 6 complex was tested in mine clearing operations in North Caucasus and Palmyra.[24] There is unconfirmed information about using UGVs Platforma-M and Argo in Syria, but if it was true it would be a major verification of the combat capabilities of UGVs; however, their utilisation is not clear or confirmed. UGVs have been used during exercises like Centr 2015 to familiarise soldiers with their new "brothers in arms" and emerging capabilities of building trust and reliance on their support. According to the British Forces TV, UGVs Platforma-M have been deployed to Kaliningrad to protect air defence units equipped with S-400 missiles, exploiting their ability "to direct weapons, accompany and hit targets in automatic and semi-automatic modes."[25]

There already are conceptual developments to integrate UGVs with combat units as part of the MoD programme Weapons Robotising 2015. It is supplemented by analysing current conflicts, which proved the value of air and ground robots to supplement soldiers in variety of environments. Initial concepts were developed for attaching an unmanned platforms unit with some thirty soldiers to each motor rifle battalion. They could be equipped with five mobile command-and-control posts, two reconnaissance UGVs, six UGVs armed with 122 mm unguided rockets, six UGVs armed with 80 mm unguided rockets, six UGVs armed with anti-tank guided missiles 9M133 Kornet (AT-14 Spriggan), and seven UAVs (three armed with Kornet, two reconnaissance, two UAVs with laser designators and radars).[26] Such unmanned assets could increase reconnaissance abilities and fire precision (even by 100%), fire power (by 30-130%) and fire range of a battalion. Parallel, the number of troops could be decreased by some 25-30%.[27] Another concept concerns creation of robotised companies (RC) equipped with advanced, remotely controlled combat robots (RCCR) and assault vehicles (AV) to support manned tanks and infantry fighting vehicles (IFVs).[28] The assessment is that during an attack the deployment of RCs will minimise human loses and the possibility to achieve desired outcome will be much higher. AVs are to be based on existing tanks but reinforced with a 152 mm howitzer and modified fighting compartment. It would extend firing range and firepower of units. The concept considers attacking in three waves. The first wave is composed of RCCR with mine flails. The second one includes both tanks and AVs. The third echelon will have regular IFVs with troops ready to be dismounted. It is assessed that the speed and effectiveness of such attack will be much higher than that of a typical mechanised infantry tactics. Moreover, using UGVs in the first echelon will provoke concentration of enemy fire, and their armour is better suited against anti-tank and artillery fire than soft skin IFVs. At the same time, the number of soldiers in a company is expected to drop from more than one hundred to some eighty troops. The creation of robotised brigades could follow in the future by using the surplus of tanks, which are in the military storage.

The concepts are to be tested and verified in the coming years using specially designed training areas including urban training facilities. They look very promising but are not achievable in the nearest future because of the limited capabilities of the Russian military industry, and the sanctions that are stopping the transfer of technologies. There are many concerns related to the reliability of UGVs in combat because of the possible countermeasures from opposing forces using variety of electronic warfare assets, denying control of such systems. The trend to develop more robotics platforms will continue as the share of high-tech products is growing. It is linked with a variety of land platforms, as there are conceptual works to develop further remotely controlled fighting vehicles and tanks, including T-90s and well-known T-14 Armata along with combat support and combat service support platforms. The development of new concepts and platforms is supported by research related conferences, such as the 1st Military-Science Conference Robotisation of the Russian Armed Forces in February 2016. During discussion, it was agreed that land forces have fallen behind other services and robotisation is to be prioritised. In March 2017, the Second Military-Academic Conference and Exhibition Robotisation of the Russian Federation's Armed Forces took place, where new platforms were presented to the armed forces, with the future concepts of both theoretical and practical dimensions.

CONCLUSION

There is no reason to believe that the Russian Armed Forces will slow the pace of robotisation; the concepts will grow in number, in quality and sophistication. It is linked with the interests of the military and the increased funds to the research of UGVs. The cost of UGVs is slowly going down and their capabilities are growing rapidly, which will lead to a growth in their density in the armed forces in the coming years. The Russian military and academics are already recognising the need to develop further UGVs to support soldiers on the future battlefield as parts of united combat teams. These teams will be based on a constant flow of data from variety of platforms allowing commanders to use manned or unmanned systems based on his assessment of threat and situation. Some products have already been presented during military exhibitions such as the International Exhibition of Weapons Systems and Military Equipment KADEX-2016 in the capital of Kazakhstan; or Armiya-2016 in Russia. Russia is an important exporter of military equipment and the country wants to preserve this position; major buyers are China, India and Vietnam. Those nations could be interested in Moscow's achievements in UGVs sector and are a potential market to support Russia's economy. Such exhibitions as KADEX-2016 or Armiya-2016 are used to promote new weapon systems and concepts, and they stand out because the major Western military industry companies are not present there, hence, limiting the number of competitors for Russian enterprises.

There is a trend to develop multirole platforms that could be used to mount variety of weapon systems or to be adapted to combat and non-combat functions like combat support and logistics. This reflects a tendency within ongoing modernisation of armed forces, as one of the purposes is to limit the number of base platforms to reduce an effort of maintenance and logistics units and workload. There are multi-vector approaches, besides UGVs; the country is developing immobile combat sentries, which can operate in close contact with other unmanned platforms such as UAVs. Besides the weapon systems, UGV protection has been increased by using active security systems and by reducing their electromagnetic radiation level. The combat power and mobility of UGVs is comparable with conventional armoured vehicles, and their weapon systems could be adapted to requirements of a customer. It makes them very attractive to foreign customers and allows to enter competition in the international markets. The projects will continue as funds for research are already allocated, and by 2025 robotic systems are supposed to comprise around thirty percent of all military equipment.[29] The goal is rather ambitious, but it shows the general trend, which is visible not only in the Russian Armed Forces, but also worldwide. Russia is facing the international sanctions, which limit its national industry capabilities. However, there are attempts to get technologies from other sources. There is also a lack of qualified specialists in the military sector, as many have already retired without replacement. Another issue relates to a failure to integrate interests in various ministries, and lack of fully developed technical and conceptual requirements. It is supplemented by development on too many platforms, and requires their unification in the future to limit logistics challenges. There is, however, recognition of the major challenges and those are discussed during conferences and exercises, but it will take years to fully overcome their limits on further development of UGVs. The number of different projects, which still require conceptual and technical development, is not indicating the real capabilities and could be misleading, hiding the real situation.

The recognised advantage of the UGVs' implementation is to avoid casualties, as there is a lack of conscripts in for the Russian Armed Forces to enlist. It is caused by an ageing population, limited attractiveness of the military service and a lower physical condition of the younger generation. On the other hand, the younger generation is skilful in operating computer based combat systems, allowing easier control and utilisation in combat. The variety of systems under development is rather impressive and some have been tested in supporting role during operations and exercises. There is also competition among the Russian companies as those have significant experiences in producing armoured vehicles. Their priority is the internal market – armed forces and security services – but they also recognise the possibility to sell their products abroad. The Russian Ministry of Defence and the National Guard have already demonstrated their interest in UGVs' capabilities and they will be procured to complement the troops. In the future UGVs will be further developed, making them more independent by investing in research on artificial intelligence systems. Therefore, the first targets in a future conflict could be engaged by UGVs and robots could play an important role.

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UKRAINE

Serhiy Zghurets

The character of warfare is changing, as is the role and place of humans on the battlefield. There are tendencies suggesting that, in the future battlefield scenarios, the dirtiest and most dangerous missions will be performed by robotic platforms of different levels of autonomy, from remotely operated to fully autonomous. This future is already demonstrated by the most technologically advanced armed forces, which are adding increasing numbers of unmanned robotic platforms for various purposes, deployed at sea, in the air and on land. Ukraine, although taking its first steps on this path, is trying to keep pace with these tendencies in modernising its military forces.

Three years of a military conflict in East Ukraine and a continuous build-up for a credible defence against potential military aggression from the Russian Federation have prompted the Ukrainian military authorities to revise their approaches to the development of advanced military weapons and equipment systems and providing these to the forces in the field.

After the Russian occupation of Crimea and the start of military action against Russian Armed forces in 2014, Ukraine's defence and political establishments have seen the severity of the gap that needs to be bridged to provide deployed forces with reliable situational awareness by acquiring advanced unmanned aerial vehicle (UAV) platforms capable of operating in all weathers, day and night. Because of this revision, Ukraine's military began fielding new UAV capabilities, both domestically made and imported from international suppliers.

Appreciating the battlefield value of UAV capabilities, Ukraine's military authorities and both government-run and private sector defence industries decided to start developing unmanned ground robotic vehicles. To achieve this goal Ukraine needs to address organisational, technical and financial pressures.

IDENTIFICATION OF GOALS AND OBJECTIVES

The emergence of new threats necessitates advancement in the means and techniques of warfare and with it the development of advanced unmanned ground robotic systems. This strategy is enshrined in a series of new papers outlining frontiers to be achieved in Ukrainian military robotisation. One such paper, Ukraine's Armaments Development Programme 2020, enacted on 30 March 2016, includes the development of a new (and the upgrading of existing) military weapons and equipment systems, inclusive of remotely operated vehicles deployed on land, in the air and at sea.

To implement the land component of the programme, a dedicated paper was developed, entitled The Concept for Employment of Unmanned Ground Robotic Systems in Performance of Ukraine's Armed Forces Missions. Enacted by a directive of the General Chief of Staff in 2016, the Concept outlines key frontiers and benchmarks to be achieved by 2030. The paper highlights the creation and fielding of unmanned ground vehicles (UGVs) in support of Ukraine's Armed Forces operations to be a key force multiplier and an important beneficial factor in the transformation of the nature, means and techniques of modern warfare.

The role and place of UGV capabilities in Ukraine's Armed Forces armaments system are defined as follows:

> UGV platforms will complement conventional weapons and equipment systems in almost all battlefield scenarios; will be employed for a wide range of roles (intelligence gathering, attack, special) in various battlefield situations; will be suitable for use in wars and military conflicts of various degrees of intensity, and during peacekeeping and antit-errorist operations.

It is noted by the concept that the key advantage of using UGV platforms for various missions is that the goals set will be achieved with fewer casualties and with reduced impact of human factor on mission success. The range of potential UGV uses includes combat operations; combat logistics operations; combat engineer support and mine-clearing operations; chemical, biological, radiological and nuclear (CBRN) reconnaissance operations; security guarding of perimeters, areas, locations, positions, and infrastructure; search and rescue operations; and defence logistics operations.

Specific missions will require specific types of UGV platforms varying in terms of weight, size and the level of artificial intelligence and automation. Future UGV platforms and their components will have to meet certain unified standards regarding the Form Factor, design commonality, and modular architecture. These standards need to be enshrined in relevant guidelines, rules and regulations and in unified specification requirements.

CATEGORISATION

Ukraine's Armed Forces' requirement for UGV capabilities might be categorised in three major groups depending on functionality as specified by the Defence Ministry. These are combat capable UGVs, combat support UGVs (which are sub-categorised into scouting UGVs, engineering UGVs, and utility/logistics UGVs), and general-purpose UGVs.

Combat capable UGVs will execute special missions during combat operations. These will be used for the engagement of enemy personnel and vehicles; breaching the enemy's prepared defence lines; providing defensive support for tactical forces by creating a network of robotic weapons emplacements to engage enemy soldiers and armoured vehicles in covering force zones; providing fire support to attacking forces; suppressing enemy fire with carried automatic and anti-tank weapons; providing close air defence against precision attacks and UAV threats; carrying out deceptive firing; and guarding high-security infrastructure (perimeter and area protection against unauthorized ingress; neutralisation of intruders).

Future combat capable UGV platforms of whatever purpose are required to be equipped with production weapons systems: machine guns and grenade launchers against enemy personnel; anti-tank grenade/rocket launchers against armoured vehicles; anti-aircraft missile launchers against low flying aerial threats. To enable day/night, all-weather operational capability, combat capable UGV platforms are required to be outfitted with electro-optical and infrared (EO/IR) cameras, laser rangefinders, navigation equipment, ballistic computers, and gyrostabilizers.

Combat support UGVs will be used for support of battlefield logistics missions. These are subcategorised into scouting UGVs and engineering UGVs.

Scouting UGVs will carry out battlefield surveillance; perform target search and identification and transmit target data to their operators and/or a battlefield control centre. The key roles to be performed with these robotic vehicles include combat Intelligence, Surveillance, Reconnaissance (ISR) missions (inclusive of artillery observation, support for ground gun firing and missile/rocket launches) in close-in tactical combat; detection and identification of low/extremely low flying aerial threats; tracking of enemy weapons; and the detection and electronic suppression of enemy information systems. Scouting UGVs are required to be suitable for modification with communication retransmission equipment.

Engineering UGVs will perform engineering missions during combat/battlefield logistics operations. The key roles to be performed with engineering UGVs include the detection and neutralisation of explosive hazards; clearing paths for troops to advance through minefields or areas where landmines or unexploded ordnance might be buried; clearing roadblocks and other obstructions to movement of friendly forces; search and rescue of casualties from battlefields and contaminated areas; setting up smoke/aerosol obscuring screens under enemy fire; NRBC reconnaissance in contaminated areas; and the detection and clean-up of environmentally contaminated sites.

For NRBC reconnaissance roles, engineering UGVs will carry equipment for detection of nuclear, radiological, biological and chemical contaminations and transmission of output data to a remote operator. Engineering UGVs optimised for mine-clearing missions can be equipped with sub-surface mine ploughs that will dig up and neutralise buried mines to create safe passageways for forces and vehicle movement.

Utility/logistics UGVs are designed to perform combat logistics missions, especially the transport of troops and battlefield supplies, and technological clean-up missions. The key missions to be performed with these unmanned ground vehicles include the transportation of munitions, fuels and other supplies to soldiers deployed downrange; loading/unloading and emergency clean-up under battlefield conditions and at bases, arsenals and depots in hazard-prone environments; casualty evacuation from the battlefield or accident sites; and towing and retrieval of damaged vehicles under enemy fire or NRBC contamination conditions.

Utility/logistics UGVs optimised specifically for transport missions are required to have all-terrain capability and be equipped with lifting devices. For improved operational autonomy, they need to be able to move along a pre-programmed path, travel in convoy formation and return to a pre-determined destination. Under certain circumstances, these UGVs can be attached in support of military elements to perform the transportation of supplies and equipment.

General-purpose UGVs combine several functionalities in a single vehicle (where combat functionality is combined with logistics or other functionality). Structurally, general-purpose UGVs will be self-propelled platforms carrying weapons, scouting equipment, or a set of equipment and tools that can be swapped in and out as required by specific mission scenarios.

Equipment options for general-purpose UGVs can include equipment for mine/road-side bomb reconnaissance and disposal, and communication relay/retransmission. Weapons payload options can include machine guns, grenade launchers, anti-tank rocket launchers, and sniper rifles. Where appropriate, target situation data will be transmitted to a remote operator for the final decision-making.

Each UGV platform, depending on its respective place and role in the disposition of troops (forces), functionality, usability, operational mobility, the degree of operational autonomy, survivability and other characteristics is required to be prepared to operate alongside the existing and future weapons and equipment systems without compromising their combat effectiveness and capabilities.

In addition to categorisation by functional utility, UGVs are classified by weight class. The heaviest class of UGVs will be from 1,500-15,000 kg, the medium-weight class from 150-1,500 kg, and the light-weight class from 15-150 kg. All these will be self-propelled wheeled or tracked vehicles. The lightest class are man-portable UGVs weighing up to 15 kg. These can be carried by a single soldier as part of his individual equipment kit. Alongside weight and functional utility, UGVs can be described in terms of the degree of their operational autonomy. In this case, they are categorised into three classes: tele-operated, semi-autonomous and fully autonomous.

ON THE BATTLEFIELD

In Ukraine, formalised procedures for battlefield use of unmanned robotic systems have been only established for unmanned aerial vehicles as of to date. Over the three years of anti-terrorist operation in East Ukraine, the country's military has tested and practiced different techniques of using UAVs for battlefield surveillance and artillery fire adjustment roles. These techniques are described in dedicated guideline papers used both by UAV operators and different echelon commanders concerned. In the face of an ever increasing complexity of operational environments (for example, the increasing use of counter-UAV electronic countermeasures by Russian forces), applicable guidelines have been regularly updated based on user feedback and the acquired operational experience.

Nonetheless, the means and techniques for military use of UGVs in Ukraine are still in the discussion stage. On rare occasions, software simulations are carried out to verify probable scenarios involving the use of UGVs in standard infantry assault and defensive operations. Military experts at the General Staff have evaluated one "ideal" scenario applicable to the future UGV types referred to in the concept. The scenario is "ideal" in that it presupposes the availability of some key capabilities, which are actually not there in Ukraine: high level of automation and command and control systems in Ukraine's Armed Forces (which is far lower); the availability of unmanned robotic vehicles for various purposes in the country's Armed Forces (the vehicles actually are yet to be developed); rules for the use of UGVs in battlefield situations are formalised in articles of war and service regulations (which is not the case actually).

A report on the "ideal" scenario argues that UGVs will be most effective if used in all-arms operations combining the use of unmanned aircraft systems; scouting UGVs; combat capable UGVs equipped for enemy weapons tracking and for engagement of enemy personnel; self-propelled artillery gun systems tasked to suppress identified enemy's weapons emplacements; and mechanised infantry units tasked to capture enemy fortifications.

Combat control is carried out with a command and control computer system (C2CS) based on real-time battlefield situational awareness coming from all sources available. This enables effective and prompt decision-making on the use of participating forces and weapons capabilities in volatile battlefield situations.

Combat capable UGVs will be the first to come into action, shelling enemy positions and encouraging the enemy to take counteraction (engage artillery fire, relocate forces to different positions, etc). Scouting UGVs and UAVs will transmit intelligence on the location of enemy batteries and/or concentrations of forces to a battlefield command centre for decision-making on defeating these with self-propelled artillery guns and combat capable UGVs. In this case, target acquisition data will be automatically transmitted directly to the weapons' fire control systems.

Once the identified enemy's batteries have been suppressed and the amount of damage done to the enemy's weapons' capabilities and personnel is enough to preclude any further counteraction, mechanised infantry will be brought into action to complete the seizure of the enemy positions. During the assault operations, engineering UGVs might be employed for obstacle breaching, setting up smoke/aerosol obscuring screens and carrying out other special missions.

The use of a combination of different UGV types under this scenario would enable the goals set to be achieved with a lot fewer casualties, both killed and wounded. In this case, the level of personnel casualties will be a factor of the amount and performance of the UGV capabilities used, and it will be reduced to the minimum if forces are trained well enough to perform standard missions under conditions of intensive tactical and technical enemy counteraction.

Much of the areas adjacent to the occupied Donetsk Oblast and Luhansk Oblast regions contain landmines, which is putting in jeopardy both combatant and non-combatant lives. Ukraine's State Service for Emergency Management estimates the area in East Ukraine that needs to be surveyed for the presence of landmines and other explosive hazards at about 7,000 square kilometres. In 2015 alone, mine-warfare elements of Ukraine's Armed Forces disposed of over 75,000 pieces of explosive ordnance, and this is not inclusive of anti-tank/anti-personnel mines and other explosive hazards. Regarding the explosive devices planted by Russia-backed forces in Donbas, Ukrainian bomb disposal experts disposed of more than 600 remote-controlled anti-tank/anti-personnel mines, powerful bombs and other deliberately planted explosive devices over 2015. The most horrible type of mine threat is posed by anti-personnel mines disguised as household items or children's toys, adding to the toll of civilian fatalities on the insurgent territories.

The situation did not change too much in 2016, with civilian-populated areas along both sides of the separation line being most hazard-prone in terms of the mine threat. Under the current circumstances, it is hard to assess the demand for mine clearance because of the lack of access to the insurgent areas.

Regarding the experience with using utility/logistics UGVs for transport roles, and engineering UGVs for explosive hazard clearing roles, it appears to be more usable and streamlined in terms of technology and the use in real-world tactical scenarios.

STARTING POINT

Being guided by the Concept for Employment of Unmanned Ground Robotic Systems in Performance of Ukraine's Armed Forces Missions 2030, and taking into account the current vision and the requirements made by Ukraine's military with respect to UGV technology development, defence research organisations affiliated with Ukraine's Armed Forces' General Staff have drawn up and brought to enactment tactical and technical specification requirements on six UGV types: an unmanned robotic vehicle carrying in-close combat weapons; a robotic anti-tank vehicle; a scouting UGV; a utility/logistics UGV; an engineering robotic system; and an NRBC reconnaissance robotic system.

These requirements mark a starting point in the domestic UGV development and the development of international counterparts aimed at possible Ukrainian Armed Forces' requirement. As of the beginning of 2017 Ukraine has no fielded UGV capabilities (with a minor exception of a few robotic platforms currently used to support the clean-up of anti-tank/anti-personnel mines and unexploded ordnance left in the East Ukraine because of the Donbas hostilities). Ukraine operates a very limited fleet of the robotic scouting and mine-clearing systems Talon, Andros F6A, Codham, and Digital Vanguard ROV – all obtained as gifts from international aid partners. The domestic market for ground robotic vehicles is expected to grow in pace with the demand for mine clearing.[1]

The focus of Ukraine's domestic UGV development is on multi-purpose ground robotic platforms with intelligence gathering and combat functionalities. The first prototypes were demonstrated in 2016. These included the Piranha – a remote-operated, track-driven combat platform developed by JSC Lenkuznya, Kyiv.

Kyiv Armor Plant, which is incorporated with Ukroboronprom defence industries holding group, demonstrated a prototype of its unmanned combat ground vehicle to be known as Phantom. This multi-role 6x6 robotic vehicle is designed to support combat, battlefield surveillance and logistics missions. Along with developing tracked and wheeled robotic platforms, Ukrainian industries are working to add remote operation capabilities to the already fielded wheeled and tracked combat platforms used by the Armed Forces and the National Guard. In 2016, Infocom Ltd, Zaporizhia, partnered with AvtoKrAZ truck maker to demonstrate the first domestic prototype of the Spartan APC vehicle offering the Pilotdrive automated driving capability. The vehicle can be controlled remotely via a tablet PC, a smart glove or an operator station. WiFi/Wimax network is used to control the vehicle within a radius of 10-50 kilometres.

The unmanned robotic KrAZ Spartan vehicle is designed to help minimize risk and save lives of soldiers in different tactical scenarios involving the transportation of supplies (ammunition, fuel and medical aid stores), and the rescue of wounded casualties from the battlefield. Mock designs and working models of indigenously-developed UGVs imply they essentially are all radio-controlled robotic vehicles. As the vehicles are all controlled from a fixed-base facility, there needs to be visibility between any given vehicle and its respective control centre. So, the vehicles will be most effective and efficient when operated on a favourable, flat terrain allowing unobstructed communication. But they still need to learn to move over complex terrains – woodlands, cities and rural areas, and especially in ECM heavy conditions.

In the near future, then, it is unlikely that unmanned robotic vehicles will participate in attacks alongside tanks or infantry fighting vehicles during the Ukrainian Armed Forces operations.

CONCLUSION

In all the years up to 2016, there was no systematic work done by Ukraine's Armed Forces to develop and produce military unmanned robotic capabilities and to operationally deploy these with forces in the field. Ukraine is lagging far behind the technologically advanced world in this innovative technology development domain. In Ukraine's Armed Forces, UGV capabilities (if few robotic mine clearing vehicles obtained as gift under international military aid programmes are not included) are not there. In Ukraine, however, there is a certain amount of research and development and technological capabilities needed to develop and produce military UGVs.

The development and enactment of the Concept for Employment of Unmanned Ground Robotic Systems in Performance of Ukraine's Armed Forces Missions; and the adoption of strategic programmes aimed to meet the Armed Forces' requirement for robotic capabilities are indicative of Ukraine's striving to keep pace with the trends that are shaping a new reality on the battlefield. Military robotisation is being considered to be an irreversible trend that would transform the means and techniques of warfare and would significantly reduce the risks to personnel when performing combat, counter-terrorism or peacekeeping missions. Another encouraging factor is the behaviour by neighbouring Russia, which is seeking to have a strong combat robotic capability that potentially might be used against Ukraine just like it was the case with the “little green men”. Ukraine needs to have the means to counter this new threat.

There is general acceptance that, to be able to ensure rapid indigenous development of military robotic capabilities at this stage in time, Ukraine is lacking the requisite financial resources, technological resources, knowledge and experience, adequately skilled human resources, component technology base and industrial base, and a common vision of and approaches to the place and role of military robotic systems in the Armed Forces’ armaments system. Having familiarised themselves with characteristics and combat capabilities of the domestically developed prototype systems, Ukraine’s military authorities seem to be doubting whether the systems are good enough to be accepted for service. But this doubt seems reasonable as Ukraine is just at the initial stage on the path to military robotisation.

Handling the challenge of military robotisation requires strategic planning of measures that should be consistent with the place military robotic systems will hold in the Armed Forces’ armaments system. Proceeding on this track, the General Staff is considering the possibility of establishing a new military executive body to be known as the General Centre for Robotic Systems. This will be responsible for developing and pursuing a common policy with respect to military robotics technology development. This policy will apply to all robotic systems deployed on land, in the air, at sea surface and underwater.

Another important step is selecting an umbrella research and development organisation that would maintain liaison with the General Centre, coordinate research and development in robotics, provide feasibility plans for the development and acquisition of military robotic systems, draw up technical specification requirements related thereto, provide full lifecycle research and development support for robotic systems, and draw up applicable guidelines, rules and regulations. The latter documents will regulate the use of UGVs and other robotic platforms on the battlefield and at times of peace, and will mandate responsibility for the damage caused by accidents with or improper use of unmanned robotic vehicles.

There are also discussions about the feasibility of setting up experimental military units – a kind of "battle labs" that would carry out user evaluation, experiment with different techniques and tactics of using UAV and UGV platforms in various battlefield situations, and propose relevant insertions into applicable service regulations. These measures are expected to enable sooner fielding of the new systems, help ensure their proper use, and reduce the probability of developers/suppliers proposing ineffective or unnecessary technical solutions, or military customers/users taking inappropriate organisational or tactical decisions.

Backlog demand – pending demand and potential demand from Ukraine's security agencies – offer significant opportunities to both domestic and international suppliers of military robotic systems. However, the first attempts to domestically develop ground robotic systems for the needs of Ukraine's Armed Forces revealed several complex technological challenges that need to be addressed in collaboration with international research and development organisations and suppliers of key component systems, and with engagement of highly experienced professionals. The absence of a modern-day domestic component and assembly technology base makes the creation of competitive UGV technologies a virtually unattainable goal for Ukraine. Realities require the formulation of a sustainable strategy of collaboration with top international suppliers, and especially as it concerns technology transfers.

To meet the Armed Forces requirement for robotic capabilities, plans are being drawn up to implement different patterns of international military technology cooperation as it pertains to procurement (lease, offset, rent use) of individual robotic systems from international suppliers or licensed production at Ukrainian factories.

There is a risk that measures proposed by the Concept for Employment of Unmanned Ground Robotic Systems in Performance of Ukraine's Armed Forces' Missions 2030 will be too slow or produce little effect, especially against the background of rapidly growing commercial information technology and the resultant emergence of new technology solutions based on new software and component technology. These solutions are immediately adopted by private-sector companies, for purposes that may include inter alia the development of new robotic technologies with artificial intelligence that makes them smart enough to operate without human intervention. Indeed, in the short term, the demand for robotic systems for commercial, special and dual-use purposes will outpace the demand for purely military UGVs and especially combat capable UGVs. It is, therefore, probable, that a simplified approach to meeting the Armed Forces' UGV requirement will be implemented on a parallel track with measures included in the Concept. To put it specifically, specification requirements on UGV systems will highlight interoperability with battlefield C2CS networks and systems as key capability. In Ukraine, C2CS capabilities are being developed as part of a broader program that also includes the development of modern-day digital communication and electronic warfare capabilities.

ENDNOTES

[1] Much of the areas adjacent to the occupied Donetsk Oblast and Luhansk Oblast regions contain landmines, which is putting in jeopardy both combatant and non-combatant lives. Ukraine's State Service for Emergency Management estimates the area in east Ukraine that needs to be surveyed for the presence of landmines and other explosive hazards at about 7,000 square kilometres. In 2015 alone, mine-warfare elements of Ukraine's Armed Forces disposed of over 75,000 pieces of explosive ordnance, and this not inclusive of anti-tank/anti-personnel mines and other explosive hazards. Regarding the explosive devices planted by Russia-backed forces in Donbas, Ukrainian bomb disposal experts disposed of more than 600 remote-controlled anti-tank/anti-personnel mines, powerful bombs and other deliberately planted explosive devices over the year 2015. The most horrible type of mine threat is posed by anti-personnel mines disguised as household items or children's toys, adding to the toll of civilian fatalities on insurgent territories.
The situation did not change too much in 2016, with civilian-populated areas along both sides of the separation line being most hazard-prone in terms of the mine threat. Under the current circumstances, it is hard to assess the demand for mine clearance because of the lack of access to insurgent areas.

THE UNITED STATES

Ron LaGrone

It seems somewhat counterintuitive that the development and employment of unmanned ground vehicles (UGV) has lagged-behind those unmanned vehicles that operate in the aerial and maritime domain. After all, we had developed robust surface transportation networks long before conquering the air and the water's subsurface. There are two reasons why development and general use of UGVs has been in the "slower lane".

Firstly, the surface terrain and environment is extremely varied. The maritime and air environments are hostile and unforgiving, but they are less complex than the surface of the earth. Basic designs of aircraft and watercraft are simple, in principle compared to the limb system, developed over during millions of years of evolution, which allows humans to navigate and operate upon a large expanse of the earth's terrain.

Secondly, UGV systems have a much higher probability of interaction with humans, and society has been reluctant to employ them more extensively for safety, moral, legal and economic reasons. The elimination of vehicle operators for ground transport on established roads seems just around the corner, but this goal seems to always be just out of sight. The major shortfalls are not just technical, they are based on our justified and unjustified fears of the consequences of direct human interaction with these machines.

Employment of unmanned ground vehicles for military land operations are subject to these trends and limitations. There is also the additional consideration of the semi-autonomous and autonomous use of lethal force in complex battlespace where the distinction between declared combatants and civilians are subtle and ever changing.

THE STATUS OF UGV DEVELOPMENT

The acquisition process that has governed UGV use by the armed forces in the past roughly twenty years has centred on off-the-shelf procurement to meet the immediate needs of the warfighter. As many UGV systems were available because of development by and for non-military users, there were systems available for quick modification and development during this period. As a result, many such systems are present in the military forces and many piecemeal programmes are in place. Budget concerns and an effort to prepare forces for conflicts beyond the Iraq and Afghanistan wars are driving efforts to bring unmanned systems into a more structured and formal development process.

All armed forces have interests in the development and employment of unmanned ground systems, but the United States Army has a leading role in the development and fielding of UGVs (also known as unmanned ground systems, UGS). The primary document that promulgates the army's vision concerning these systems is the US Army's Robotic and Autonomous Systems Strategy (RAS).[1] The RAS was specifically prepared to support the 2015 National Military Strategy in that it seeks to employ "human-machine collaboration to increase operational options for Joint Force Commanders".[2] The document's foreword identifies five capability objectives: increase situational awareness; lighten the warfighter's physical and cognitive workloads; sustain the force with increased distribution, output, and efficiency; facilitate movement and manoeuvre; and increase force protection within near (2017-2020), mid (2021-2030), and far terms (2031-2040). The document goes on to identify three "compelling challenges":

1. Increased speed of adversary actions, including greater standoff distances;
2. Increased use of RAS by adversaries; and
3. Increased congestion in dense urban environments where communications will be stretched to the breaking point.[3]

Although the strategy is clear to identify desired progress in measured steps starting from tethered operations, the army is clearly seeking to employ armed fully autonomous systems.[4] The direct linkage of the RAS

Strategy to the National Military Strategy coupled with the "compelling challenges" and adequate funding will place RAS and supporting unmanned ground systems on the development "fast track". As a result, we should expect a rapid response from the army and the other services not only in terms of material development but just as importantly, the doctrine, military education, and training communities. Doctrine, education, and formalised training concerning UGV systems have lagged during the years of rapid "off-the-shelf" procurement during the wars in Afghanistan and Iraq.

Restricting the discussion to near-term development, UGV systems under development seem to be branching into two types: lighter weight systems that are intended to be easily deployed, with some even designed to be transported and employed by one person, and heavier systems in the metric ton weight class. The lighter systems are suitable for sensor deployment and light work. To provide transportation and fire support, the mass of the vehicle must increase considerably.

Determining resource data for any military procurement program is a slippery business. This is especially true given past procurement practices, the modular nature of UGV development, and an uncertain budget environment. It is made more uncertain considering that UGVs are still largely in a research development test and evaluation (RDTE) status. It is safe to say, however, that total RAS funding for the US Army has been on a steadily upward trend with USD 770 million identified for funding in the 2016-2020 Programme Objective Memorandum (POM).[5] Considering the current US Army's approach to support the President's Budget,[6] certain RAS systems will maintain their position or enter the procurement cycle in the next three years. The 2017 Fiscal Year US Army budget includes USD 20.6 million for specific UGV procurement and at USD 53.31 million in research, development, testing and evaluation for UGVs.[7] It should be noted that the Congress has not yet funded the entire fiscal year and the services are operating under a continuing resolution for 2017 as of 20th April 2017 making these figures no more than a projection.

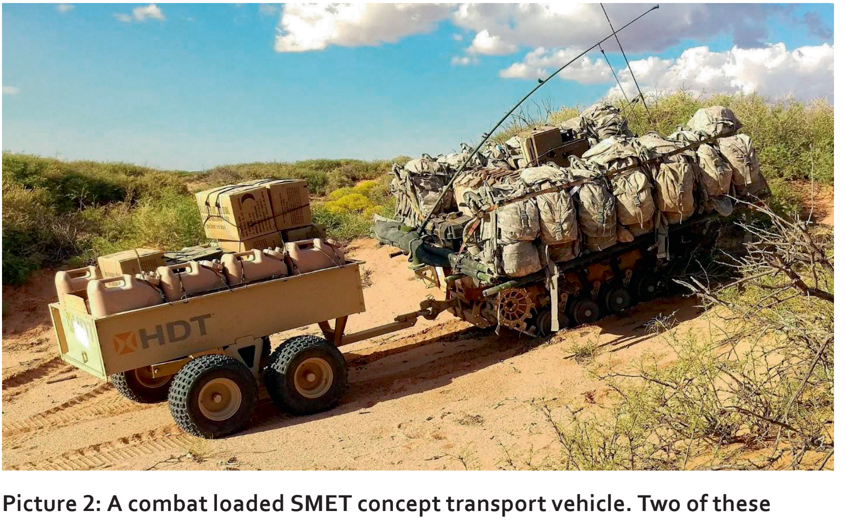
The most specific priority for Army RAS in the near-term is continuance and improvement of explosive ordnance disposal (EOD) and mine/IED avoidance systems. The US Army has over fifteen years of experience with these systems and they are essential force protection assets. Improvised Explosive Devices (IED) have been the most potent killers of friendly forces in recent conflicts, and it should be expected that defeating them would be a priority task for UGVs. Support will continue for the fielded M160 Anti-Personnel Mine Clearing System,[8] and modular payloads to support EOD and counter-IED operations should be expected for other smaller systems.

Picture 1: The M160 Anti-Personnel Mine Clearance System in Afghanistan, 2011, (US Army photo, Captain Jason Allen)[9]

The Man-Transportable Robotic System Increment II (MTRS Inc II) is intended as a common platform for sensors and light capacity manipulator arm systems.[10] Planned payloads include but are not limited to optical sensors, chemical, biological, and radiological and nuclear (CBRN) sensor and warning systems, and mine detection capability. The army plans to field over 1,200 of these systems over a seven-year period with a planned contract awarded in the fourth quarter of the Fiscal Year 2017.[11]

The Small Unmanned Ground Vehicle (SUGV) produced by iRobot Corporation is a man portable robot that has gained acceptance by both the US Army and the US Marine Corps (USMC). It is an example of the over 7,000 nonstandard robotic systems that have been purchased "off-the-shelf" to meet immediate combat requirements during recent wars. The current RAS is the army's effort to bring these systems back into the normal development and fielding process.[12] The one man deployable concept typified by the SUGV will continue as the Common Robotic System-Individual (CRS(I)). This robot is a lightweight unmanned system designed to be employed by dismounted forces with a planned weight of 10 kg. Its planned modules include standoff short range sensors systems and other capabilities much like the MTRS Inc II.[13]

The Squad Multipurpose Equipment Transport (SMET) is intended to provide support to the small unit with a planned distribution to infantry brigade combat teams and engineer platoons.[14] The SMET concept represents a considerable increase in mass compared MTRS Inc II and CRS(I) with overall loaded weight more than a metric tonne. Although the initial capability is centred on load carrying for dismounted units, a modular approach will eventually be taken with this platform and capabilities, much like described in the other near term systems are likely to be added. An exercise in early 2016 conducted with an infantry company and engineer squad, provides considerable insight into the capabilities and limitations of these systems.[15]



Picture 2: A combat loaded SMET concept transport vehicle. Two of these systems were used to haul an infantry platoon's equipment during field-testing[16]

EMPLOYMENT OF UGV SYSTEMS IN COMBAT

The challenges in the employment of UGV systems are related to their practical utility and the limits of the law and public acceptance. The acceptance gap between surveillance and transport functions and the application of lethal force by an UGV in an autonomous mode is vast.

Public acceptance and law will translate into a matter of governmental policy and should be a matter of research and discussion. Public policy has not caught up to UGV capabilities and we face the fairly common situation of possessing a military capability that cannot be employed because we either lack political will or its use does not meet civilised standards of behaviour. Establishing these conditions for UGV deployment during war is a necessary and essential task for governments. We should not underestimate the significance of policy and laws that will govern the use of unmanned ground systems during conflicts. From well-established scientists to the entertainment media, the public is being conditioned against the use of robotic systems that may pose a danger to humans both on the battlefield and in society in general.[17]

At present UGVs negotiate terrain using wheels or tracks. Tracked systems are more capable despite a maintenance penalty for heavy use. The systems that are likely to deploy in the near term are tracked. Dismounted units can navigate terrain that would stop any UGV cold, especially those in the one or two metric ton weight class and up. Mobility limitations of UGVs while adding additional capability will increase demands on leaders who must add additional terrain reconnaissance and contingency plans to their operational workload when UGVs are a part of the operation.

Combat is a hard environment and soldiers are prone to abuse equipment under pressure. Design specifications are often overlooked or ignored when equipment is put to the test. Exceeding weight limitations is a common practice. Robust designs that can carry heavy loads with simple maintenance procedures are required for systems that will see front line service. Vehicle rollovers should be expected and systems should be designed to sustain this level of abuse.

Armed UGVs will require additional safeguards to ensure that their lethal capabilities will not be turned against friendly forces. Some current communications' equipment has a capability to be rendered inoperable at a distance. Similar safeguards will have to be in place for these systems. These safeguards should include an explosive "self-destruct" capability that would use the energy of the fuel, batteries and ammunition on board the UGV to utterly destroy the system and make it useless to the enemy.

EMPLOYMENT OF UGVS BY LIGHT INFANTRY AND OTHER DISMOUNTED UNITS

Soldiers in light infantry units have a wonderful instinct for discarding equipment and techniques that they find less than useful. Their leaders are constantly considering the factors of their mission, the enemy, the operational environment, and the time available. We should not expect that UGVs are a benefit to every mission. First consider the terrain. The light infantry platoon and squad can operate well in places UGVs simply cannot go. This requires some innovation to overcome. Secondly, we must think about the operational environment in terms of who is there. Combatants are not always easy to identify. If the squad has to operate among the civilian population, very tight control of the UGV is necessary to avoid its loss through emerging threats and the avoidance of civilian casualties.

A possible organisational plan, as stated, would be to place unmanned systems and their maintenance assets at the Brigade Combat Team level with some heavier SMET type systems being organic to engineer units. As the systems prove themselves in the field, they will become a scarce asset that must be assigned on a priority basis and retrieved for other operations or maintenance as required. This will free direct combat units from maintenance close to the zone of action and assign the systems to suit the Brigade's overall mission.

Fighting units either attack or defend. These missions can shift quickly and have many variations. In combat the attacking commander has the great advantage of selecting the point of the offensive action. In the attack, UGVs have a great potential to extend the limits of the commander's combat reconnaissance, provide fire support from dangerous terrain, breach obstacles, cover the flanks of the attacking force and provide resupply when the attack is paused. All these advantages may be lost however as the enemy is also trying to defeat your best ideas and nasty surprises often await the advancing force. If the unit leader, depending on the UGV for mobility and firepower, is deprived of that support, then mission accomplishment is in jeopardy. If the UGV breaks down and is stopped, then the difficult decision to abandon expensive equipment on the battlefield or siphon off manpower to guard it must be made. Use of these systems during the offensive would require a very good terrain analysis and a backup plan if they are lost.

Frederick the Great acknowledged the attacker's advantage when he famously stated: "He who defends everything, defends nothing". His quote, made in the in the 18th century is applicable today. Commanders who are forced to defend often must engage in "economy of force" operations. Autonomous armed UGVs are nearly ideal for such operations in open and unpopulated terrain. As the operational environment becomes more restricted and populated, unmanned systems require significantly more control and oversight.

Employment of UGV systems during more deliberate defensive operations is somewhat easier to visualise and is potentially of great value. Within limits, the defender can select terrain suitable for UGVs employment. These systems could be invaluable in maintaining surveillance and early warning. Obstacles are often integrated in a defensive plan. These are commonly put in place by engineers and the defending infantry. UGVs systems could be employed to move material and provide over-watch during obstacle emplacement to protect force during such work. Defensive operations often require high rates of fire. The SMET class system would prove invaluable in mortar firing and crew served weapons positions where high rates of fire and the ability to displace quickly to avoid counter fire would be required to continue fire support to defending units. Forward resupply in the defence could be conducted more easily and free up unit members for less mundane tasks. They would also allow increased rest and decreased workload keeping units at a higher readiness.

During retrograde and delay operations, the retreating unit must often leave a detachment left in contact. This force normally consists of about one third of the retreating force's manpower and about half of its crew served weapons. Autonomous armed UGVs would be of significant value during these operations allowing the delaying force to leave less manpower in the force left in contact with the enemy.

TASKS IN THE UGV-RELATED RESEARCH AND DEVELOPMENT

Public Policy and the Law of War (LoW): UGV capabilities are on a strong improvement trend, but public policy and acceptance of UGVs operating in close proximity to the human population are lagging behind. Most of the media attention and application of the law has been on aerial devices, but it is only a matter of time before these issues are applied to UGV in a more complete way. One state legislature in Connecticut has advanced a law that would place lethal capability on aerial drones.[18] This follows the use of an UGV to kill a shooter in a standoff in Dallas, Texas on July 2016.[19] If a direct command link is the only method used to employ lethal force, then the UGV may be considered an extension of a soldier in combat and the LoW can be applied in a straightforward way. The direct application of the LoW is less certain in the operation of a UGV in an autonomous manner.

Recent conflicts have seen the acceptance of "collateral damage" in the application of military force. Military commanders have accepted these occurrences to accomplish the mission but have placed control measures on the type and amount of these incidents. Are we willing to accept the loss of non-combatants due to autonomous UGV employment of lethal force and use the same concept of "limits", and if so how will these limits be applied in a practical way? We must explore the limits of public policy and the law before employing UGV in a lethal combat role.

Communications and Data Security: Soldiers are trained early on to make the enemy's resources their own when opportunity presents itself. An UGV equipped with lethal capabilities could be "hijacked" and turned on its own forces by a well-trained and capable opponent. A vehicle's unique electronic signature may reveal critical information to the enemy through traffic analysis even if those transmissions are encrypted. Spread spectrum and other low signature command and communications means must be developed to conceal the use of UGVs in the friendly operations area. GPS spoofing is a real threat to any system that relies on this technology.[20] Potential denial of service is another serious GPS vulnerability. Secure independent, and redundant navigation and control means would be a very desirable capability of any UGV.

Stealth Capabilities: Small military units live and die by their light, noise, and electronic emissions discipline. UGVs of the size and capability to be useful are also vulnerable to detection by surveillance radar, thermal imaging, human senses, and so on. Vehicle noise and movement draws fire, gives away positions, and endangers the very units they are intended to support. Quiet hybrid drive systems are a good step in the right direction. The larger the UGV, the more risk and more payoff for research to decrease the signature of these systems.

Traffic ability: Mobility enhancements will always be welcomed in UGV development. The well-trained light infantry squad can quickly task organise its methods and equipment to match the mission, enemy, and terrain. They routinely operate in environments not suitable for current UGVs. At present, wheels and tracks seem to be the state of the art. A breakthrough in this area would greatly enhance the utility of the UGV to ground forces.

Endurance: Practical endurance of ground vehicles is based the energy density of the fuel source. At present, liquid fuels such as JP8 are essential to mobility on the battlefield. Although improvements have been made around the edges, improvements in fuel and battery technology has been evolutionary rather than revolutionary since the first thirty years of the twentieth century. Current operational goals have UGV endurance goals in the range of one hundred kilometres and twenty-four hours in operation. Research in this area will continue, but current vehicles will continue to represent a trade-off between weight, speed, and endurance at current levels. Some engineering solutions such as modular add on fuel tanks and common battery systems will help mitigate this issue in the field.

CONCLUSION

UGVs have long represented a significant potential to increase the application of combat power at the small unit level. Despite the uncertainties of the current budget process and the uneven fielding of these systems during recent conflicts, the United States has continued the development of these systems. This capability has been a long time coming, and the field continues rapid development. The flexibility and utility of a modular approach for UGV systems is undeniable. In the end, it will be the soldier in the field that validates and realises the full potential of these systems. They will innovate in ways we cannot imagine. We should expect to be surprised and challenged by the results.

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MILREM'S TRACKED HYBRID MODULAR INFANTRY SYSTEM IN SUPPORT OF LIGHT INFANTRY OPERATIONS

ASSESSMENT OF THE MILREM'S TRACKED HYBRID MODULAR INFANTRY SYSTEM IN SUPPORT OF LIGHT INFANTRY OPERATIONS

Igors Rajevs

The MILREM Unmanned Ground Vehicles (UGV) Tracked Hybrid Modular Infantry System (THeMIS) is an advanced platform that was originally designed for support of infantry units on the battlefield. Overall usability and effectiveness of THeMIS varied, depending on the type of operation, environment, tactical set-up for operation and battle formation used. The evaluation shows that THeMIS showed a good potential for use in the future actions. It suits best for logistical support activities and operations that do not require direct engagement with an adversary's manoeuvre units.

The efficiency of THeMIS, acting in support with the light infantry squad conducting combat operations, was low and the assessment showed that the use of UGV equipped with the Remote Weapons Station (RWS) was largely ineffective. THeMIS increased the firepower of the fighting unit, but it lacked adequate mobility and protection, so it could not fully substitute support provided by standard infantry fighting vehicles. The UGV's low level of protection was the main deficiency that limited its use on open terrain. Units equipped with THeMIS should avoid all kinds of operations on open terrain and operations that require lengthy firefight engagements with the adversary's heavy forces, and rapid mobility on the battlefield. Restricted terrain provides some degree of flexibility for use of THeMIS, but it has its limitations too. However, under certain circumstances THeMIS can successfully fight the adversary's forces. The defensive operations on restricted terrain and urban environment favours light forces supported by UGVs. THeMIS can

successfully support light forces and ensure early warning and situational awareness, effectively engage the adversary's targets and avoid return fire by conducting survivability moves from one position to another. Reloading the system remained problematic, since it either puts at risk the security of the system's operator or significantly degrades fire support provided to the attacking unit. Those deficiencies could be reduced to a certain degree by increasing the protection level of the UGV and the armament of the RWS, and implementing new tactical solutions on the battlefield.

The UGV performed well and unit supported by the system was able to accomplish their combat support tasks better. All UGVs were fitted with special equipment sets tailored towards performance of specific tactical tasks. The UGVs were capable of conducting different types of reconnaissance, anti-tank, combat engineer, bomb disposal, CBRN defence, and patrolling and security tasks. The unit supported by the UGV was able to execute different tasks remotely, therefore significantly decreasing engagement, destruction and contamination risks to the personnel.

The unit supported by the UGV performed very well and could execute combat service support and other supporting tasks much better than the unit without the UGV. The combat service support modifications of THeMIS are well developed systems and they all could effectively execute resupply, casualty evacuation and communication support operations. The use of the UGV allowed successful execution of supporting tasks when supported unit is in the direct contact with the adversary.

Finally, the use of THeMIS in support of the mechanised infantry unit was reviewed. A combination of the UGVs with legacy platforms represented by infantry fighting vehicles and other new unmanned vehicles and sensors has a very promising potential for the future use on the battlefield. Combining the firepower, protection and mobility of the infantry fighting vehicle, ability of the UAS to provide a real-time battlefield picture and early warning to the unit, and the ability of the UGVs to conduct detailed reconnaissance of objects on the spot, to breach obstacles, and conduct BDA, creates a very powerful combination of capabilities, which, when used properly, will vastly increase fighting capabilities of the mechanised infantry unit.

BACKGROUND

THeMIS is an unmanned vehicle that serves as a platform for a family of diverse functional systems capable of accomplishing different combat, combat support and combat service support tasks. THeMIS is a middle-class UGV (weight 1,000 kg – 10,000 kg) that is capable of carrying significant weight payload for that type of vehicle.[1] THeMIS has a sufficient speed to support light infantry units during tactical operations and on marches. The UGV is equipped with diesel engines and electric motors; the combination ensures selection of the appropriate movement methods, putting emphasis either on maximising speed or selecting a quiet movement mode. The capacity of the batteries ensures an appropriate operational time without recharging. THeMIS is a tracked vehicle capable of moving off-road and crossing obstacles on restricted terrain. However, crossing obstacles is somewhat limited due to the fact that the system's technical parameters reduce the size of vertical (210 mm) and horizontal (770 mm) obstacles that could be crossed. THeMIS has a very low silhouette, the height is less than one meter, which is an important factor for covert and concealed movement on the battlefield. Small dimensions of the UGV reduce the possibility of detection on the battlefield and achieve the first level criteria for design of modern combat vehicles with large-calibre armament.[2]

A large variety of different modifications of this UGV have been developed to increase the diversity of the tasks that this system can accomplish. THeMIS could easily follow light infantry units and, depending on the modification and the equipment of the UGV, support it in many different ways. THeMIS could increase the firepower of the light infantry unit with the RWS, anti-tank or other installed combinations of different weapons systems. Special UGVs fitted with different kinds of observation sights, sensors and detectors can perform observations, special reconnaissance, intelligence collection, fire support, target recognition, detection and identification, battlefield damage assessment, battlefield hazards identification and other supporting tasks. Specially equipped THeMISs are able to provide real time battlefield visualisations to the supported unit using a combination of mounted unmanned aerial vehicles and different sensors. It is also capable of conducting narrow specialised combat support tasks like bomb disposal, obstacles breaching, and personnel and equipment decontamination.

This paper will assess the possibility to use THeMIS in support of the infantry unit in different situations on the battlefield. THeMIS performance will be reviewed in different tactical roles using it for combat, combat support and combat service support tasks, and a diverse combat environment will be utilised accordingly.

The performance of THeMIS will be assessed by reviewing different tactical situations, where the light infantry and other types of units supported by the UGVs would conduct different types of operations. The usability of the UGVs will be tested through the review of combat, combat support and combat service support operations. The tactical situation will modulate offensive, defensive and delaying actions, and intelligence, anti-tank, fire support, combat engineers, chemical, biological, radiological and nuclear (CBRN) defence, patrolling, security, logistic and medical support operations. Three types of terrain will be used for modulating basic combat engagements: open, restricted and urban environment. An open terrain is a flat land with good fields of observation and fire, contains no obstacles and provides no cover and concealment to opposing sides. A restricted terrain is a territory with moderate slopes, a large amount of vegetation and natural and man-made obstacles that to some degree hinder movement of the troops and the UGVs. Fields of observation and fire are restricted and landscape offers good cover and concealment possibilities. An urban terrain is an environment where man-made constructions impact the tactical options available to the commander of a light infantry unit. It is characterised by a large number of natural and man-made obstacles, limited fields of observation and fires, and good opportunities to conceal movement of the troops and firing positions of the weapon systems. THeMIS will be placed in different positions within combat formation of a light infantry unit. Initially it will stay in two major positions – up-front and behind the unit's formation, and will move to the appropriate position during the execution of the task.

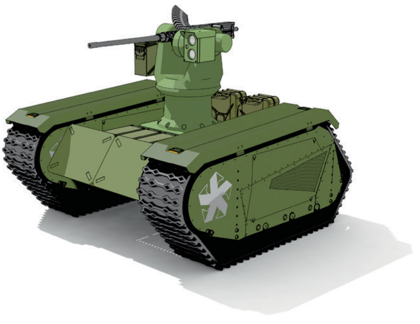
All tactical situations will undergo a theoretical wargaming exercise, where tactical action of both sides, own and adversaries, will be played in a logical sequence and, as a result, produce certain outcomes. The theoretical outcomes will later be used during practical tests of THeMIS. The practical part will included the same tactical situation that will be modulated on simulated battlefield.

A standard light infantry squad with two fire teams will be used as a basic structure during evaluation of different operations. Additional combat support capabilities that are available to the infantry squad from higher levels of command will not be reviewed in this paper due to the large variety of available options. Influence of the adversary's electronic warfare capabilities to jam or intercept control over THeMIS will not be reviewed either.

UGVS FITTED WITH THE REMOTE WEAPONS STATION FOR COMBAT TASKS

It is assumed that the most suitable THeMIS modification for execution of combat tasks in support of the light infantry unit is the UGV fitted with the RWS. Currently available modifications of the integrated RWS include 12.7 mm heavy machinegun, 40 mm automatic grenade launcher/ grenade machinegun and 20 mm automatic cannon. It is also possible to integrate different weapon systems or combinations of weapon systems. The number of different sensors, day/night and thermal sights installed on the THeMIS may vary, but all of them provide improved observation capabilities and increased situational awareness capabilities to the system's operator and supported unit.

The effectiveness of the THeMIS system equipped with the RWS will be reviewed through different tactical situations, where the UGV could be used together with the infantry unit. Twelve tactical situations



Picture 1. The THeMIS system with the integrated Remote Weapons Station (RWS)

will be assessed altogether. Six of them will include different offensive set-ups, where THeMIS will support the light infantry squad on different types of terrain and in different places of formation of the attacking units. The defensive operations' part will include four scenarios for different types of defence, conducted in diverse settings. Finally, two tactical situations for delaying operations will be evaluated.

Offensive Operations

The usage of THeMIS fitted with the RWS will be assessed in six tactical situations during the offensive operations; the operations will be executed in different environments and with THeMIS placed in different parts of the combat formation with the light infantry squad. The environment for the offensive operations would include operations on open terrain, on restricted terrain and in an urban setting. THeMIS would be integrated into the light infantry squad's operations and placed into two possible positions within its combat formation: up-front of the infantry unit and behind tactical formation of the infantry squad.

All tactical situations will include a number of similarities, since they all will review the same type of operation conducted by the same unit that is supported by the same UGV fitted with the RWS. The light infantry squad will be tasked to seize an objective that is defended by an adversary and destroy its forces on the objective. The squad will attack in standard formation that is appropriate for the particular situation. The operator of THeMIS would be located within/behind the squad formation and close to the squad leader. The THeMIS operator would simultaneously control and manage: movement of the system on the ground; observation of the terrain, situation and adversary; and engagement of the adversary by fires of the RWS. The RWS would be equipped with one of the following weapons: 12.7 mm heavy machinegun, 40 mm automatic grenade launcher/grenade machinegun or 20 mm automatic cannon. THeMIS would support the squad with additional intelligence information that is provided by the observation sensors of the system and transmitted to the squad leader and, depending on the level of digitalisation of specific unit, to other members of the squad.

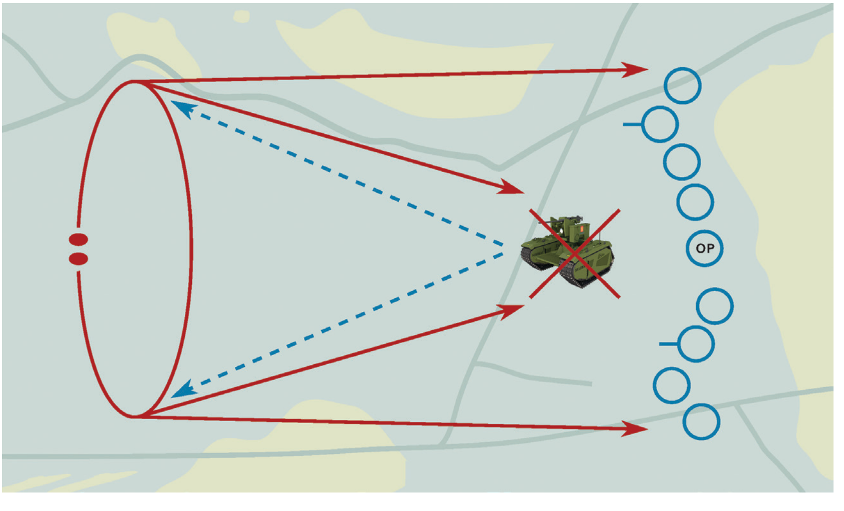
Tactical use of THeMIS on the battlefield has one constitutive limitation. To survive on the battlefield, UGVs need to move on the terrain from one observation/fire position to another. THeMIS is forced to move on the battlefield in such a way since the system operator could manage only one functional activity at a time, either moving the UGV on the terrain or observing the terrain and engaging adversaries' targets. It cannot effectively engage the adversary while on the move. Hence, the system, by definition, can move on the terrain, but it is not capable of manoeuvring on the battlefield.[3]

THeMIS is constructed in a way that each track is powered by an independent engine. While it is a good technical solution, it also has one deficiency. If one of the engines gets damaged during the battle, or simply malfunctions, THeMIS would not be able to move from the spot without help from a special technical and recovery personnel.

An adversary's unit will defend dug-in fortified and specially prepared positions that are most appropriate for the specific type of terrain and tactical arrangement. Breaching of the obstacles located in front of the adversary's unit will be excluded from this evaluation.

The first tactical situation will assess attack of the light infantry squad supported by THeMIS fitted with RWS on an open terrain. The THeMIS system will be placed in front of the attacking squad formation.

The squad attacks in a line formation, using a fire team wedge formation.[4] THeMIS is located and moves in front of the Squad formation. The Squad and the THeMIS operator have good fields of observation and fire. It is important to note that THeMIS can provide an early warning to the squad personnel, since it, compared to the dismounted light infantrymen, can carry better quality and more capable observation sensors and day/night and thermal optical sights. The adversary's section is defending its dug-in fortified positions with open and good fields of observation and fire. Upon contact with the adversary THeMIS would be engaged into fire exchange with the opponent's fire systems. While moving in front of the squad formation on the open terrain THeMIS might be easily spotted by the adversaries' observation systems and quickly destroyed or critically damaged by all adversary's available fire means. Since THeMIS is not foreseen as a fully up-armoured and protected system, it could be destroyed or damaged not only by heavy weapons or artillery and mortar fire, but also by adversaries' small arms. One additional disadvantage in this particular tactical situation is the inability to effectively reload the RWS by own forces, since it requires either movement of the system's operator up-front to THeMIS or return of the system back to the operator behind the line of our troops. For the duration of time when the system retreats for reloading, it would not be able to support its infantry unit. In both cases it would be done under a heavy enemy fire and would be lethal to either the operator or the system itself.

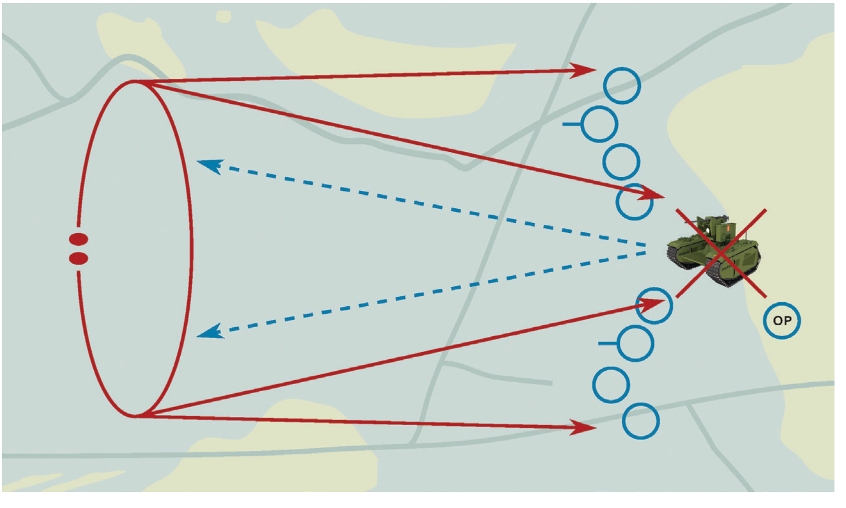


Sketch 1. An attack of the Light infantry squad on an open terrain supported by THeMIS fitted with the RWS moving in front of the unit formation

The use THeMIS in support of the attacking squad on an open terrain in that way is ineffective unless the problems with the UGV's protection, manoeuvrability, management and reloading of the RWS are resolved. In that situation, THeMIS would increase the squad's initial situation awareness and reconnaissance capabilities, but when the unit would close-in with the adversary, the UGV will be quickly spotted and easily destroyed or critically damaged by the adversary's fire. The low protection level of both THeMIS and the RWS makes them vulnerable to all types of enemy fire, including small arms. When the system is controlled by only one operator, it reduces THeMIS' capabilities from manoeuvre and fires that is usually provided by the infantry fighting vehicles to a simple movement from one firing position to another. Hence, it reduces the supporting effect of the platform. Placing THeMIS in front of the attacking unit poses the challenge of sustaining fire support to the attacking squad. It is impossible to reload the RWS under enemy fire without putting at risk the system's operator or significantly degrading fire support provided to the unit.

The second tactical situation will evaluate the attack of the light infantry squad supported by THeMIS fitted with the RWS on open terrain. THeMIS will be placed behind the attacking squad formation, in a place where infantry fighting vehicles are usually supporting attacking infantry units.[5]

The squad attacks in a line formation, using a fire team wedge formation.[6] THeMIS is located and moves behind the squad formation. The adversary's section is defending dug-in fortified positions with open and good fields of observation and fire. The squad also has good fields of observation and fire. Contrary to that, THeMIS has restricted fields of observation and fire, due to the fact that two fire teams are located in front of the system, and that narrows the system's ability to see the battlefield and engage the adversary. Also the system's low silhouette doesn't allow to observe the battlefield and engage the adversary over the heads of the infantry unit. THeMIS is able to provide early warning to the squad and support it with additional intelligence information that is provided by its observation sensors, but that information is limited due to the fact that such positioning of the system in combat formation restricts its observation and fire abilities. THeMIS moves on an open terrain from one observation/fire position to another. Because of its low silhouette, the THeMIS operator would be forced to choose specific "high-ground" positions that aren't always available, or move forward, close to the attacking unit, to increase its observation and/or fire engagement capacities. Such actions would even more expose the system to the adversary's observation and further engagement with weapons' systems. Upon contact with the adversary THeMIS would be engaged into fire exchange with the opponent's fire systems. In that situation, THeMIS would be in a disadvantageous position, because of the specifics of its movement on the open battlefield, it would be exposed to the adversary's fire when taking high-grounds or moving forward to the line of attacking troops. Since it lacks protection that is comparable with the Infantry fighting vehicles, THeMIS would be destroyed or critically damaged by all available fire means, not only by heavy weapons or artillery/mortars fire, but also by the adversary's small arms systems. The system operator has better possibilities of reloading the system, since it's located behind the attacking unit's formation. However, that is a marginal advantage, since both the unit and the UGV are moving on an open ground, and could be easily detected and destroyed by the adversary.

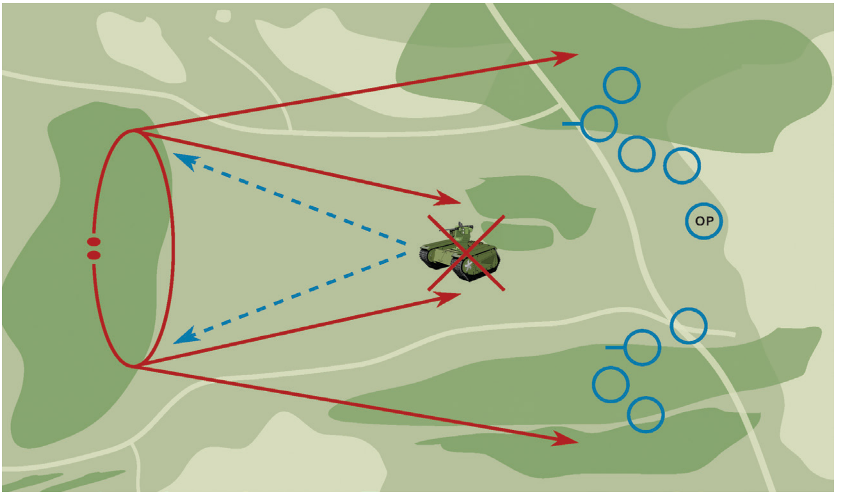


Sketch 2. An attack of the Light infantry squad on an open terrain supported by THeMIS fitted with the RWS moving behind the unit formation

The use of THeMIS in support of the attacking squad on an open terrain, placing it behind attacking troops, is even less effective than placing the system in front. THeMIS would increase the squad's initial situation awareness and reconnaissance capabilities to a lesser extent than in the first situation. Similarly to the previous situation, when the unit would close-in with the adversary and would engage with it in a firefight, the UGV would be quickly spotted and easily destroyed or critically damaged by the adversary's firepower. And the low protection level of both THeMIS and the RWS remains a major vulnerability. Control of the system by one operator reduces the supporting effects of the platform, allowing it to move from one firing position to another only. The reloading of the system would pose less threat to the system and its operator; however, an open terrain would not provide much advantage or protection.

The third tactical situation will assess attack of the light infantry squad supported by THeMIS fitted with the RWS on a restricted terrain. The THeMIS system will be placed in front of the attacking squad formation.

The squad attacks in a line formation using a fire-team wedge formation,[7] maximising cover and concealment advantages of the restricted terrain. THeMIS is located and moves in front of the squad formation. The squad and the THeMIS operator have limited fields of observation and fire, especially at the beginning of the operation. The operator of THeMIS system is in the rear of the squad formation, in between two fire teams and close to the squad leader. THeMIS moves in front of the unit formation from one observation/fire position to another using the restricted terrain to its advantage. The squad is supplied with additional intelligence information that is provided by the observation sensors of the THeMIS system. When the unit makes contact with the adversary, THeMIS engages in a fire exchange with the opponent's fire systems. While moving in front of the squad formation on the restricted terrain THeMIS would expose itself and would be spotted by the adversary's observation systems, quickly getting destroyed or critically damaged by all available fire means. Reloading of the RWS on restricted terrain remains disadvantageous, since it requires either movement of the system's operator up-front to THeMIS or return of the system back to the operator. While restricted terrain provides some degree of concealment from the adversary's observation and protection from its fires, such action is not speedy or efficient and still increases lethal risks to the operator.

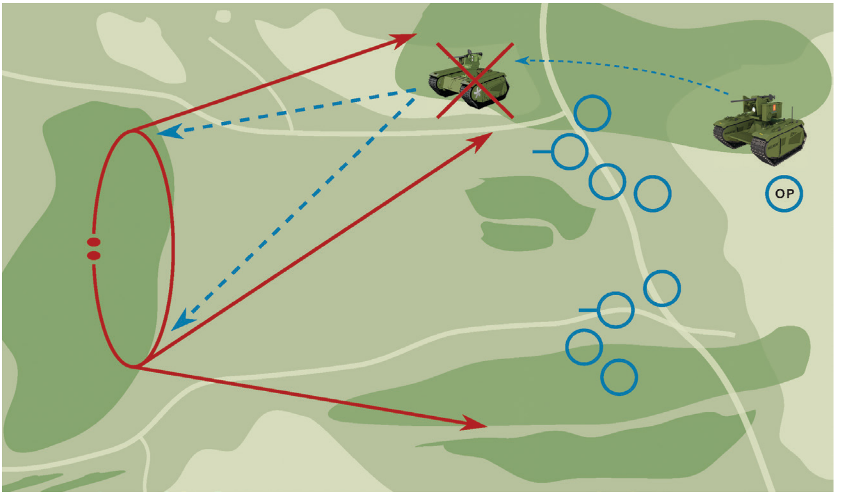


Sketch 3. An attack of the Light infantry squad on a restricted terrain supported by THeMIS fitted with the RWS moving in front of the unit formation

The restricted terrain, when used properly, provides some degree of concealment and passive protection to THeMIS, but it does not make the use of the system more effective. Similarly as before, THeMIS would increase the squad's initial situation awareness and reconnaissance capabilities, but when the unit would close-in with the adversary, the UGV would be quickly spotted and destroyed or critically damaged by the adversary's firepower, because of its low protection level. Placing THeMIS in front of the attacking unit still poses the challenge of sustaining fire support to the attacking squad. While the restricted terrain is more advantageous for UGV operations, it is still difficult to reload the RWS without putting at risk the security of the system's operator or significantly degrading the level of fire support provided to the unit.

The fourth tactical situation will evaluate attack of the light infantry squad supported by THeMIS fitted with the RWS on a restricted terrain. The THeMIS system will be placed behind the attacking squad formation and will move to new advantageous positions on the battlefield.

The squad attacks in a line formation, using a fire-team wedge formation[8] and has limited fields of observation and fire. THeMIS is located and moves behind the squad formation and has very restricted fields of observation and fire, due to the fact that restricted terrain provides concealment also to the adversary, and the unit that is located in front of the system narrows its ability to see and engage the adversary on the particular battlefield. The operator of the THeMIS system is located behind the squad formation and close to the squad leader, and simultaneously controls the systems movement and engagement of the adversary by fire of the RWS. The adversary's section is defending dug-in fortified positions with somewhat limited fields of observation and fire. Since THeMIS has very restricted fields of observation and fire due to the terrain, as well as due to its own unit and its low silhouette, it has a very limited capacity to support the attacking squad concerning both situational awareness and fire support. To gain benefits from THeMIS, the only possibility for the operator is to use the advantages of the restricted terrain and move the system forward to a specific flanking position, where it could ensure the necessary observation and fire support. When assuming a new position on the flank of the squad, THeMIS would be able to support the unit with intelligence information about the location of the adversary's positions. However, upon the beginning of a firefight, it would be destroyed or severely damaged by the adversary's fire systems. As previously, THeMIS would not manoeuvre, but would move on the battlefield from one fire position to another. In that situation, the reloading of the RWS is possible, if the operator is following the system to the new position and moves it to a concealed and protected position for reloading.



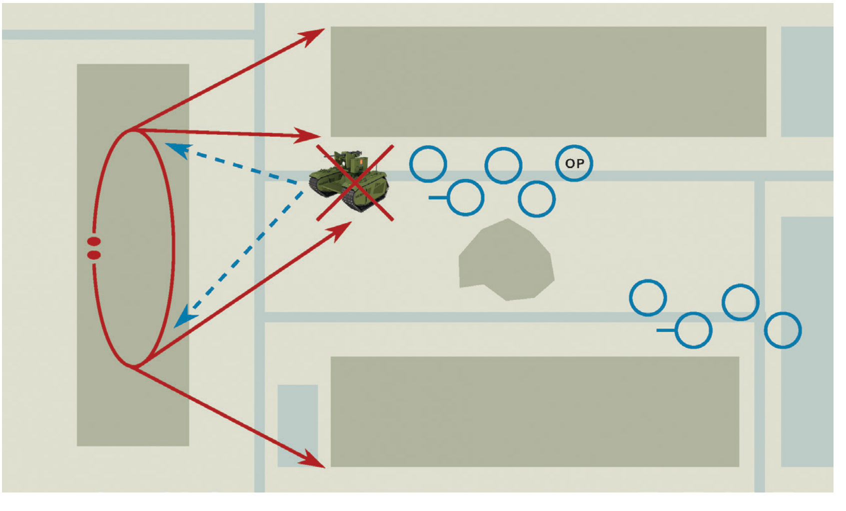
Sketch 4. An attack of the Light infantry squad on a restricted terrain supported by THeMIS fitted with the RWS moving behind the unit formation

THeMIS on the restricted terrain, when placed behind the formation of attacking troops, is ineffective against the dug-in adversary's unit. Moving the system to a flanking position would be the only possibility to achieve any advantage from THeMIS. But even in that situation, the UGV would be quickly spotted and easily destroyed or critically damaged by the adversary's fires. Reloading the system and sustaining fire support to the squad is possible, if the operator physically follows THeMIS and conducts proper reloading procedures on the spot. One of the possible solutions to the situation is reorganisation of the structure and organisation of the light infantry squad and its operational tactics, techniques and procedures. The infantry squad might integrate the UGV into the infantry squad as the third manoeuvre element and that would significantly increase the squad's firepower. This new type infantry squad would be able to conduct independent tactical operations by establishing three separate teams:

1. The fire team, i.e., the UGV;
2. The assault team – the infantry fire team Alpha;
3. The supporting team – the infantry fire team Bravo.

The fifth tactical situation will assess the attack of the light infantry squad supported by THeMIS fitted with the RWS in an urban environment. The THeMIS system will be placed in front of the attacking squad formation.

The squad attacks in a squad file formation that allows good control, manoeuvre and dispersion.[9] The urban setting contains a large number of obstacles, man-made barricades and rubble that severely limits the movement of the light infantry and especially the UGV. The operator of the THeMIS system is located in the rear of the leading fire-team formation, close to the squad leader. The squad and the THeMIS operator have limited fields of observation and fire, especially at the beginning of the operation. As explained previously, the THeMIS operator unilaterally controls movement and the fire of the system. The adversary's section is defending prepared fortified positions with acceptable, but limited, fields of observation and fire. The support to the squad with intelligence information is limited since the urban environment comprises many obstacles that hamper observation. Equally, the low silhouette of THeMIS prevents such deficiencies without exposing itself to the adversary. As in the other situations, when the UGV is moving in front of the squad's



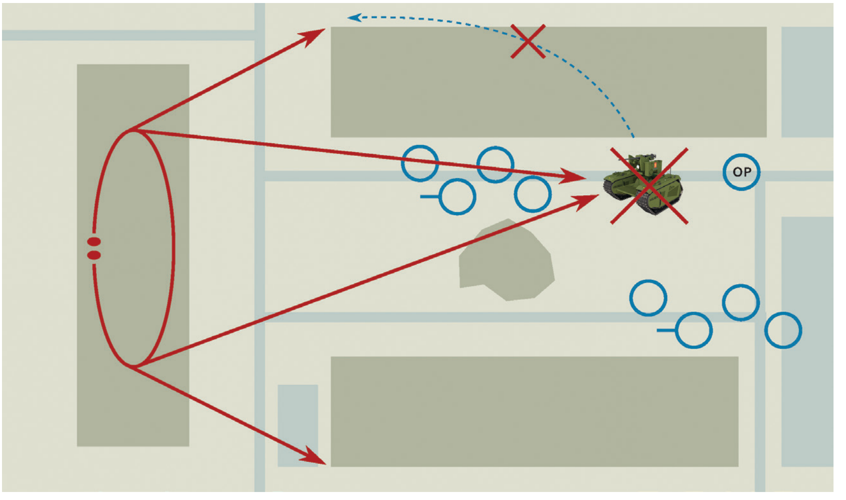
Sketch 5. An attack of the Light infantry squad in an urban environment supported by THeMIS fitted with the RWS moving in front of the unit formation

formation, it would be easily spotted by the adversary and destroyed. Effective reloading of the system for sustained fire support also remains a problem, while operating in an urban environment.

The use of THeMIS in the urban environment is very limited. The built-up environment from one side provides some degree of concealment from observation and protection from fire, but from the other side restricts movement of the UGV and limits the possibility of finding suitable fire positions. THeMIS would increase the squad's initial situation awareness and reconnaissance capabilities, but when the unit closes-in with the adversary, the UGV would be quickly spotted and destroyed. Control of the system by one operator remains a significant weakness. Placing THeMIS in front of the attacking unit still poses the challenge of sustaining fire support to the attacking squad.

The sixth tactical situation will evaluate attack of the Light infantry squad supported by THeMIS fitted with the RWS in an urban environment. The THeMIS system will be placed behind the attacking squad formation to provide the necessary fire support.

The light infantry squad attacks in a squad file formation that allows good control, manoeuvre and dispersion.[10] The urban environment contains a large number of obstacles, man-made barricades and rubble that severely restrict movement of the light infantry and the UGV. The adversary's section is defending prepared fortified positions with acceptable, but limited fields of observation and fire. The squad has limited fields of observation and fire, especially at the start of the operation. The THeMIS operator has a very limited view of the battlefield. THeMIS moves behind the attacking unit and has no possibility to support the squad with intelligence information and fire unless it moves to a suitable forward or flanking position, which is a complicated movement in the urban environment. The movement of the system is severely restricted, and THeMIS in many situations cannot move to a flanking position either, because buildings, man-made barricades and rubble create significant obstacles for it. The operator of the THeMIS system is located in the rear of the leading fire-team formation, close to the UGV and the squad leader.



Sketch 6. An attack of the Light infantry squad in an urban environment supported by THeMIS fitted with the RWS moving behind the unit formation

When operating in an urban environment, THeMIS should not be placed behind the attacking infantry squad, because in that situation it cannot support the unit to the required level. The environment and the attacking unit would significantly limit observation of its sensors and engagement abilities of its weapon systems. The movement of THeMIS would then be significantly influenced by the environment, which would create many insurmountable obstacles.

To summarise, six tactical situations in the offensive operations have just been reviewed, assessing the possibility and effectiveness of using THeMIS fitted with the RWS placed in different parts of the attacking formation. The assessment shows that the use of UGVs in support of attacking light infantry squads is largely ineffective. The main deficiency that limits the use of UGVs on an open terrain is its low level of protection. A restricted terrain provides some degree of flexibility for use of THeMIS, but it has its limitations too. Control of the system by only one operator reduces the THeMIS' capabilities and supporting effects of the platform from manoeuvre and fire to a simple movement from one firing position to another. Reloading the system is problematic, since it either puts at risk the security of the system's operator or significantly degrades fire support provided to the attacking unit.

To improve the use of THeMIS in offensive operations, the following recommendations should be considered:

- THeMIS should be placed in front of the attacking unit, thus increasing the squad's situational awareness and supporting it with additional intelligence information that is provided by the observation sensors of the system;
- The UGV should mainly be used on a restricted terrain that provides some degree of concealment and passive protection to the system, allowing THeMIS the possibility to move to proper observation and firing positions;
- Consider integration of a fully up-armoured version of the RWS that would increase the system's protection and in-turn its survivability on the battlefield. THeMIS has enough payload reserve to allow such improvement;
- Increase the armament of the RWS by adding an anti-tank capability and smaller calibre (7.62mm) automatic weapon. The third generation anti-tank weapons would significantly increase the firepower and engagement range of the RWS. An additional smaller machinegun would allow the system to engage an adversary's softer targets, whose destruction would not require use of the main weapon system. It would also decrease the usage of bigger calibre ammunition and reduce the number of reloads for the heavy weapon system during the engagement;
- Upgrade the RWS to increase the ammunition load beyond use of standard boxes for the cartridges. The RWS Ammunition supply system should supply larger amount of ammunition that will require lesser reloading iterations;
- Increase the number of system operators from one to two, where each operator would be responsible for one functional activity – moving the system on the ground or firing its weapons. That would enhance THeMIS' performance on the battlefield. However, a back effect of increasing the number of soldiers in the manoeuvring unit would also need to be considered;

- Introduce a back-up system for powering both tracks of THeMIS to increase its survivability and effectiveness;
- Change the infantry squad's organisation by integrating the UGV into the infantry squad as the third manoeuvre element. The new type of infantry squad would be able to conduct independent tactical operations by establishing three separate teams: the fire team, i.e., the UGV and the assault team; the infantry fire team Alpha and supporting team; and the infantry fire team Bravo.

Defensive Operations

This part of the paper will review defensive operations. Employment of THeMIS fitted with the RWS will be assessed in mobile and area defence operations that will be split into different tactical situations that will be executed in different environments. The defensive operation will include operations on an open terrain, on a restricted terrain and in an urban environment. THeMIS will be integrated into the light infantry squad's operations.

The first sub-part of the paper will review usability of the light infantry squad supported by THeMIS fitted with the RWS during mobile defence operations. In general, mobile defence is defined as "a defensive task that concentrates on the destruction or defeat of the enemy through a decisive attack by a striking force."[11] So, it is envisaged that the striking force will be able to conduct a strike and destroy the adversary. Armoured or mechanised units are naturally suited for such tasks,[12] because they possess all necessary prerequisites for that: mobility, firepower and shock effect.[13] Under certain circumstances "striking force" tasks could be accomplished also by an attack helicopter unit.[14] On the other hand light infantry units are better suited for static defence from well-prepared positions.[15] While describing mobile defence, the NATO doctrine identifies three important factors that enable the conduct of successful mobile defence: "depth, time and the ability to manoeuvre".[16] The depth and time are concerns for execution of an operation in a specific tactical situation, whereas ability to manoeuvre should be directly attributed to the unit's ability to conduct certain type of tactical tasks. The light infantry unit is not capable of manoeuvring on the battlefield, while executing mobile defence tasks. Reinforcing the light infantry squad with THeMIS will not change this situation, because THeMIS is not a direct replacement of the combat infantry fighting vehicle, but rather a new fire support platform that enhances performance capabilities of the light infantry units.

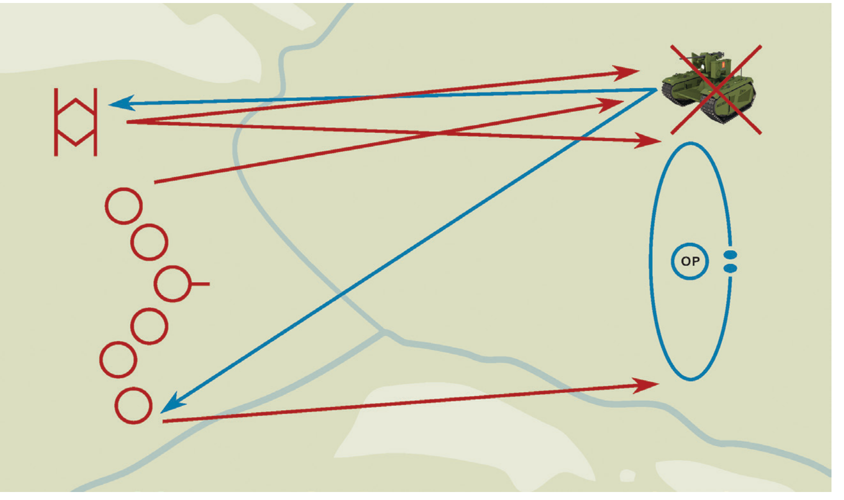
The combat power of fighting units consists of five essential elements: manoeuvre, firepower, protection, leadership and information.[17] This paper is focusing on the assessment of measurable aspects of performance of light units supported by an armed UGV. Leadership and information are very important factors indeed, and their importance could not be underestimated. However, they are "soft" elements of combat power that are hard to measure objectively. On the other hand, manoeuvre, firepower and protection of the combat units is easy to measure and compare and will be addressed here. The NATO doctrine identifies major limitations of light forces, stating protection, firepower and flexibility. Flexibility is described as an inability to execute "rapid re-grouping or redeployment due to the "lack of integral transport.""[18] In other words, they lack mobility. Light infantry lacks firepower, since it needs to carry all its weapons, so the weapons must be light and therefore provide inadequate fire support. It does not have an acceptable armour protection and is vulnerable to all types of firepower, including small arms. And finally, the mobility of the light unit is not sufficient to accomplish an assigned tactical task.[19] So, it could be concluded that the light infantry units lack all major elements of combat power for successful conduct of mobile defence operations. THeMIS certainly can increase the firepower of the defending unit, since it carries a heavy weapons system. But it also lacks mobility and protection that is comparable to a standard infantry fighting vehicle or tank. So, it will not be able to mitigate all the deficiencies of the light infantry forces.

Summarising all these factors it could be concluded, that the light infantry units are not suited for the mobile defence operations and even when they are supported by an armed UGV they will not be able to successfully conduct such a tactical task. The use of THeMIS in area defence operations will be reviewed through tactical actions on three selected types of environment: open, restricted and urban. The next tactical situation will assess the light infantry squad supported by THeMIS fitted with the RWS conducting the area defence on an open terrain.

Since all the tactical situations will review the same type of operation conducted by the same unit that is supported by the same UGV fitted with the RWS, they all will have a number of similarities. The light infantry squad will be tasked to defend a battle position to block an adversary's movement in a certain direction and defeat its forces in front of the squad's position. The squad will defend dug-in fortified and specially prepared positions that are most appropriate for the specific type of terrain and tactical arrangement. The low silhouette of the THeMIS system works to its advantage in defensive operations, since it reduced exposure to the adversary's observation and fire. It will also allow to significantly decrease the amount of necessary preparations of combat positions, compared to the infantry fighting vehicles. The operator of the THeMIS system will be located within the squad formation and close to the squad leader. The THeMIS operator will simultaneously control and manage: movement of the system on the ground; observation of terrain, situation and adversary; and engagement of adversary by fires of the RWS. The RWS will be equipped with one of the following weapons: 12.7 mm heavy machinegun, 40 mm automatic grenade launcher/grenade machinegun or 20 mm automatic cannon. THeMIS will support the squad with additional intelligence information that is provided by the observation sensors of the system and transmitted to the squad leader and, depending on a level of digitalisation of the specific unit, to other members of the squad. The adversary's mechanised unit will be tasked to seize an objective that is defended by the light infantry squad and destroy any forces at the position. The adversary's mechanised unit would attack in a line formation with the infantry fighting vehicle supporting attack from behind the formation. The fighting vehicle would be located on the flank of the attacking squad.[20]

The squad defends the battle position. THeMIS is located on the flank of the squad's formation in a dug-in fortified position. The squad and the THeMIS operator have good and open fields of observation and fire. The adversary has open and good fields of observation and fire. THeMIS would be able to provide an early warning to the squad personnel, since it, compared to dismounted light infantrymen, can carry better quality and heavier observation sensors and day/night and thermal optical sights. The defensive position provides THeMIS with additional passive protection and coverage from observation systems. However, since the RWS is not foreseen as a fully up-armoured and protected system, it could still be destroyed or damaged not only by heavy weapons or artillery/mortars fire, but also by the adversary's small arms systems. Generally, the light forces are not very effective on open terrain and therefore would be vulnerable when forced to fight a superior heavy or medium adversary.[21] Open terrain doesn't offer much possibilities for successful manoeuvring and change of the battle positions. Engineering capacities required to prepare proper defence positions, including the main and alternate battle positions and retreat routes, is far beyond the capabilities of the light infantry unit. Upon contact with the adversary THeMIS would be engaged in a fire-fight with the opponent's fire systems. Sooner or later, the position of THeMIS will be spotted by the adversary and then it will be destroyed or critically damaged by its fire assets. Effective reloading of the RWS remains an issue that needs to be solved. While a fortified battle position offers a good protection to the system; to reload it, the operator needs to raise above the protection level of the position and expose himself to the adversary's fire. The signature of the operator reloading the RWS would additionally expose the system.

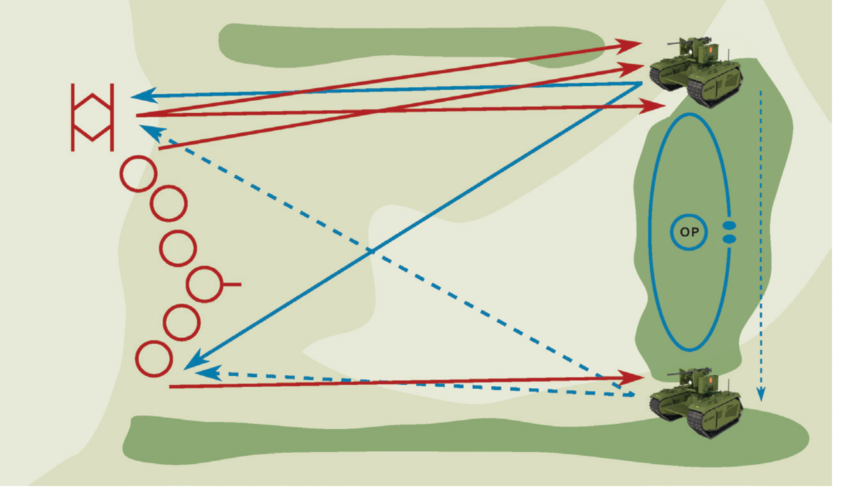
Since, the light forces are not well suited for operations on open terrain and are vulnerable when forced to fight a superior heavy or medium adversary, the light infantry should avoid fighting such battles. Additional fire support provided by the armed UGV will not change the situation significantly. In the early stage of engagement THeMIS would improve the squad's initial situation awareness. The low protection level of the RWS remains a challenge, since it could not be protected against all types of the adversary's fire. Reloading of the system on the open terrain is also problematic, since open terrain offers no good solutions for this problem.



Sketch 7. An area defence of the Light infantry squad on an open terrain supported by THeMIS fitted with the RWS

The following tactical situation will evaluate the light infantry squad supported by THeMIS fitted with the RWS conducting the area defence on a restricted terrain.

The squad defends the battle position. THeMIS is located on the flank of the squad's formation in a dug-in fortified position and alternate battle positions are available and prepared. The squad and the THeMIS operator have good, but slightly limited fields of observation and fire. The adversary's mechanised unit is attacking in a line formation with the infantry fighting vehicle located on the flank of the attacking squad and supporting attack from behind the formation.[22] The adversary has good, but limited fields of observation and fire. THeMIS is supporting the squad with additional intelligence information and providing an early warning. The restricted terrain favours the light forces, as they are optimised for dismounted operations and operations in a closed terrain.[23] The defensive position on a restricted terrain provides THeMIS with an additional passive protection and good coverage from the adversary's observation systems. The restricted terrain also facilitated successful movement and change of the battle positions for the UGV. There are always plenty of opportunities to choose primary and alternate battle positions, and retreat ways. Still, the RWS is not a fully armoured and protected system and the risk of its destruction or damage by the adversary remains high. THeMIS could start engagement with the adversary early and switch the position, when spotted by the adversary. The UGVs could conduct successful firefight with the opponent on a restricted terrain. The reloading of the weapon is not an issue, since the THeMIS operator can always choose concealed and protected positions for such activity.



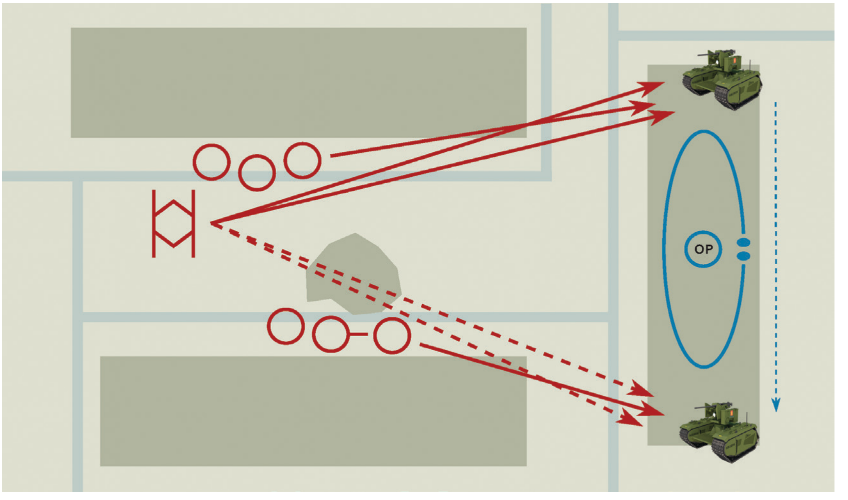
Sketch 8. An area defence of the Light infantry squad on a restricted terrain supported by THeMIS fitted with the RWS

Contrary to the open terrain, the restricted terrain favours the use of the Light forces and UGVs. THeMIS could not only provide an early warning to the squad and increase its situational awareness, but also successfully engage the adversary's targets and avoid the return fire by conducting survivability moves from one position to another. Reloading of the system could happen in a safe and secure way and pose a very small risk to both the operator and the system. The low protection level of the RWS remains a challenge, since it could not be protected against all types of adversary's fires.

The final tactical situation will review the light infantry squad supported by THeMIS fitted with the RWS conducting the area defence in an urban environment. The squad defends the battle position. THeMIS is located on the flank of the squad's formation in a dug-in fortified position and an alternate battle position is available and prepared. The squad and the THeMIS operator have good, but limited fields of observation and fire. The adversary's mechanised unit is attacking in a two column formation with the infantry fighting vehicle supporting attack from behind the formation.[24] The adversary has restricted fields of observation and fire. The squad receives early warning from the THeMIS' operator. That knowingly improves the overall situational awareness of the unit on a complex urban terrain. The built-up environment with its large number of buildings, obstacles, man-made barricades and rubble favours the defending unit and severally limits movement of the attacking force. THeMIS' defensive positions in built-up areas provide a good protection and excellent coverage from the adversary's observation systems. When prepared in advance, the defensive positions in an urban terrain allow movement and change of the battle positions for the UGVs. THeMIS could start engaging the adversary early, switch the position when spotted by the adversary, and continue engagement from a new place. The urban terrain allows safe and secure reloading of the system, without putting THeMIS and the operator at risk. All those factors combined ensure good opportunities for the UGVs to successfully conduct firefight with the adversary. The only remaining major shortfall is the protection level of the RWS – it still keeps the risk of destruction or damage of the system by the adversary high.

An urban environment, the same way as a restricted terrain, favours the light force and THeMIS. UGVs increase the early warning and situational awareness of the supported infantry unit and provide the required fire power. When defensive positions for the vehicle are carefully selected and thoroughly prepared, an urban terrain increases concealment and protection of the UGVs and enhances their survivability options.

This part of the paper reviewed two different types of defensive operations and evaluated the possibility and effectiveness of using THeMIS fitted with the RWS in support of defending the light infantry unit. The



Sketch 9. An area defence of the Light infantry squad in an urban environment supported by THeMIS fitted with the RWS

evaluation shows two different results for different types of operations. Light infantry units are not suited for mobile defence operations. The light infantry lacks all major elements of the combat power and cannot accomplish the task even when they are supported by armed UGVs. THeMIS increases firepower of the defending unit, but it also lacks mobility and protection, so it cannot replace a standard infantry fighting vehicle. The use of THeMIS in area defence operations in support of the light forces shows different results on different terrains. The light infantry is not well suited for operations on an open terrain and is vulnerable when forced to fight a superior heavy or medium adversary. Additional fire support provided by armed UGVs is not changing the situation considerably. Low protection level of the RWS and reloading of the system on an open terrain remains a challenge that is difficult to overcome. Contrary to an open terrain, a restricted terrain and an urban environment favour the light forces and UGVs. THeMIS can successfully support the light forces and ensure early warning and situational awareness, effectively engage the adversary's targets and avoid the return fire by conducting survivability moves from one position to another. The only remaining major shortfall is the protection level of the RWS that keeps risk of destruction or damage of the system by the adversary at a high level.

To increase the effectiveness of THeMIS in defensive operations the following recommendations could be given. Some of the previously mentioned recommendations are repeated for the offensive operations.

- Use UGVs in support of the light infantry units on a terrain that favours a dismounted force namely: restricted and urban terrains. Such environments facilitate proper use of UGVs, provides a certain degree of concealment and protection to the system and increases the survivability options of THeMIS. Operations on an open terrain should be avoided;
- While operating on restricted and urban terrains, ensure proper preparation of defensive positions that will allow for a safe, protected and uninterrupted movement of THeMIS between battle positions;
- Consider integration of a fully up-armoured version of the RWS that will increase system's protection and in-turn its survivability on the battlefield. The payload of THeMIS allows such improvement and overall increase of the weight of the system;
- Increase the armament of the RWS by adding an anti-tank capability and a smaller calibre (7.62mm) automatic weapon. The third generation anti-tank weapons will significantly increase the firepower and engagement range of the RWS. An additional smaller machinegun will allow the system to engage the adversary's softer targets, whose destruction would not require use of the main weapon system. It would also decrease usage of a bigger calibre ammunition and reduce the number of reloads for the heavy weapon system.

Delaying Operations

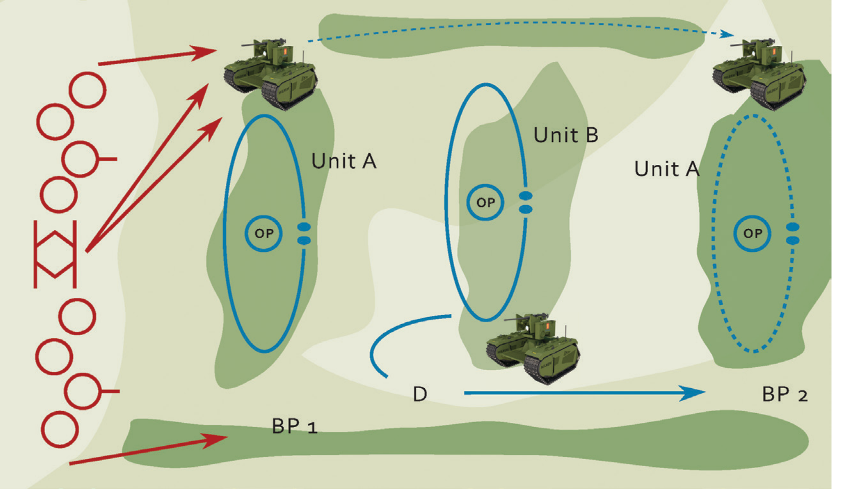
Employment of THeMIS, fitted with the RWS, will be assessed in two types of delaying operations: delay from alternate positions, and delay from successive positions. Delaying operations are operations where the engaged force is trading space for time to prepare defensive positions on a well-prepared defence line, or preparing a decisive counterattack against the adversary. During the operation the unit strives to slow down the adversary's pace of advance, inflict maximum possible damage to it and at the same time avoid a decisive engagement.[25]

The delay from alternate positions operation usually involves two fighting units. When the first unit is fighting the adversary, the second unit occupies and prepares the next defensive position in depth. Then the first unit disengages from the adversary, passes through/around second unit, hands over the battle to the second unit and moves to occupy and prepare the next defensive position. At the same time the second unit by fire disengagement supports the first unit from the adversary, and takes over the battle. This sequence of action continues until the mission is accomplished.[26] The best force to fight a delaying battle is a well-protected, mobile unit that can engage the adversary at a maximum range from mutually supporting battle positions. It should be capable of withdrawing quickly before being engaged in a decisive battle.[27]

The light infantry can potentially conduct delaying operations from alternate positions. When positions of the units are carefully chosen, mutual support by fire is prepared and rehearsed, and disengagement from the adversary and hand-over of the battle from one unit to another is comprehensively synchronised. The first fighting unit engages the adversary and sustains the fight for a specified period of time. When the situation allows, the first unit starts to disengage from the battle. Its disengagement will be supported by mutually coordinated fires from the covering unit and by the organic THeMIS system. When the first unit is disengaged, the UGV can also disengage from the firefight and withdraw to the next position. Since there are multiple firepower platforms engaged in covering the battle, THeMIS has a good chance of surviving and continuing the battle.

Under certain circumstances the light infantry squad could successfully conduct delaying operations from alternate positions when it is supported by armed UGVs. However, the best units for such operations are still well-protected, mobile units with significant firepower.

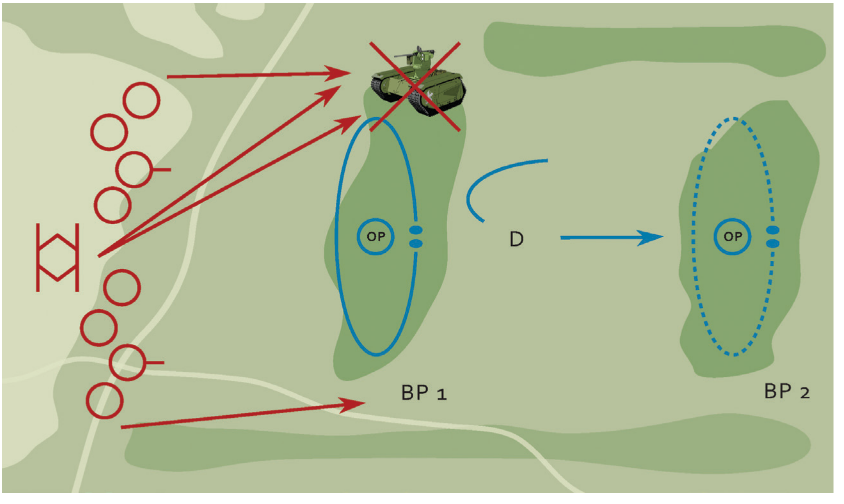
The delay from the successive position is usually conducted by one unit, because the delaying sector is so wide that all available forces cannot occupy more than a single line of positions at a time. The



Sketch 10. A delay from alternate positions conducted by the light infantry squads supported by THeMIS fitted with the RWS

delaying process is dynamic when the unit must continuously delay in a sector, fighting from one position to another. The fighting unit must be capable of single-handedly inflicting casualties to the adversary from the defensive positions, breaking the contact with the adversary, and moving to, occupying, and preparing the next defensive positions.[28]

This type of a delaying operation is very difficult to conduct with a light force, because it requires significant firepower, superior in respect to the adversary, mobility and worthy protection. As previously outlined, the light forces lack all of those capabilities. The only capability that the THeMIS system is bringing to the fight is an increased firepower that could be dispersed in the battle space by establishing a remote combat position, from which it is possible to engage the adversary. The weakest point for the light infantry unit during a delaying battle is disengagement from the attacking adversary. It is very difficult to break the contact with the adversary, who would have a better mobility. However, when the light Infantry squad is supported by THeMIS, it is possible to leave the UGVs armed with the RWS behind to cover withdrawal of the light infantry from one battle position to another. Such a tactical decision has one significant risk: that THeMIS most likely would be lost during the covering operation. That risk remains high, since THeMIS would be the only system engaged in a fire exchange with the adversary and it lacks an appropriate protection. A lack of the protection and reduced firepower (infantry squad withdraws) would likely end in destruction or critical damage of the UGVs. So, the infantry squad would be further forced to fight a delaying battle without the support of THeMIS, which would likely end with a failure and inability to accomplish the mission.



Sketch 11. A delay from successive positions conducted by the Light infantry squad supported by THeMIS fitted with the RWS

It could be concluded that light infantry units are not very well suited for delaying operations from successive positions and that they should avoid such operations. THeMIS could potentially support the disengagement of the unit from the adversary, but it would likely result in the loss of the UGVs, while the light infantry squad would be forced to continue fighting the battle alone with a reduced firepower.

The light infantry force is not particularly well suited for delaying actions. The evaluation results showed two different outcomes for different types of delaying actions. The light force lacks mobility, protection and fire power to conduct the delay from a successive position, hence, this type of operation is not recommended for the unit. Those deficiencies, to a certain extent, could be reduced during the delay from alternative positions, when THeMIS' firepower and covering force capabilities could be properly used for support of the disengagement operation. However, THeMIS' support would be unlikely to overcome all the deficiencies of the light force.

To increase the effectiveness of THeMIS in delaying operations, the pattern of other combat operations should be followed, i.e., improving the protection and firepower. In particular:

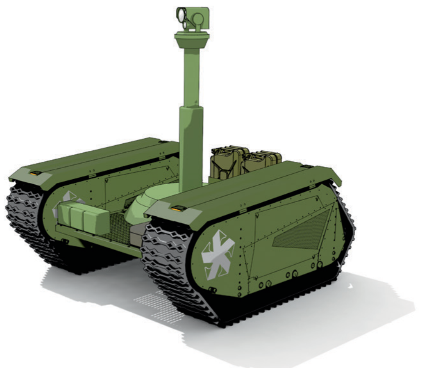
- Use UGVs in support of the light infantry units to cover the withdrawal of the unit, even if it will result in the loss of the armed UGVs, since it will facilitate the unit's disengagement from the battle and will allow it to continue the battle;
- Consider the integration of a fully armoured version of the RWS, which would increase the system's survivability on the battlefield and increase the armament of the RWS by adding an anti-tank capability and a smaller calibre (7.62 mm) automatic weapon.

UGVS FITTED WITH THE SPECIAL PAYLOAD FOR COMBAT SUPPORT TASKS

The THeMIS platform is a successful UGV that has a large selection of integrated equipment outfits for different types of the Combat Support Missions. Each integrated equipment set is tailored towards a specific tactical task. A variety of Combat Support Tasks will be assessed in this part of the paper. Each sub-part of the paper will review the usability of specific equipment installed on THeMIS. Since it is an open platform, it is also possible to integrate other equipment that is not currently integrated or available. This additional equipment could be easily integrated with the platform, thus enhancing the range of capabilities of the THeMIS system.

Tactical Reconnaissance Operations

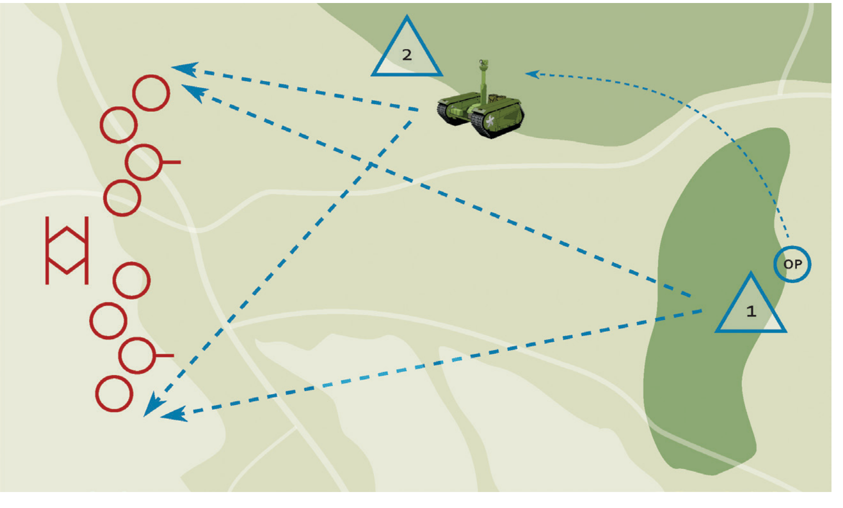
THeMIS is a universal system and it could serve as a platform for integration of a wide variety of the Intelligence, Surveillance and Reconnaissance (ISR) equipment. The most important would be: observation sensors, special communication and signals intelligence equipment, ground surveillance radars, and other equipment. It could also be used as a platform for launching the Unmanned Aerial Systems (UAS).



Picture 2. The THeMIS system with an integrated equipment suit for the Intelligence, Surveillance and Reconnaissance (ISR) operations

THeMIS with an integrated intelligence equipment would certainly enhance the capabilities of reconnaissance units. Due to its speed and mobility, UGVs are perfect for use during the ISR missions. THeMIS can easily follow an assigned unit and carry the main equipment and additional cargo. Its low silhouette and silent movement mode, complements the covert and stealthy mode of operations of the reconnaissance units. THeMIS has a sufficient payload, so in addition to the specialised intelligence equipment, it could carry some parts of the individual and collective gear of the unit. The additional carried payload would enhance either the variety of tasks that the reconnaissance unit could perform or the duration of the ISR operation. Both are positively increasing capabilities of the particular unit. Increasing the capabilities of the unit is an important factor, because a dismounted reconnaissance element would be able to carry with it not only a lightweight manpack type of the special intelligence equipment, but a heavier version that increases the distance at which the intelligence information can be gathered. Such equipment is usually installed on specialised reconnaissance vehicles. A selection of and placement on the position is easier with the THeMIS system. The handy technical construction of the UGV allows it to covertly move forward from the reconnaissance unit's position to a remote forward or flanking position to gather intelligence information more effectively. Use of THeMIS in such a way also reduces the reconnaissance unit's risk of being detected and destroyed by the adversary. If needed, THeMIS could conduct survivability and move to the new position to avoid detection and destruction by the adversary. Furthermore, THeMIS could perform the Battle Damage Assessment (BDA) to determine if the actions of the units are creating the desired effect on the battlefield.[29] In a combat situation, in case of a contact with the adversary's unit, the ISR THeMIS platform's position could be spotted. Under such circumstances, the system becomes vulnerable and a retreat from the position is not always possible. Therefore, to increase its survivability, the UGVs should be furnished with integrated active or passive (or combination of both) protection systems.

The use of the ISR version of THeMIS during reconnaissance missions would certainly increase the capabilities of the reconnaissance unit. The UGV fitted with a special ISR suit is fully capable of conducting different types of intelligence information-gathering tasks. A variety of tasks is



Sketch 12. THeMIS fitted with a special ISR suit conducting Reconnaissance operations

limited only by the type of special equipment installed on THeMIS, and of course the payload of the system.

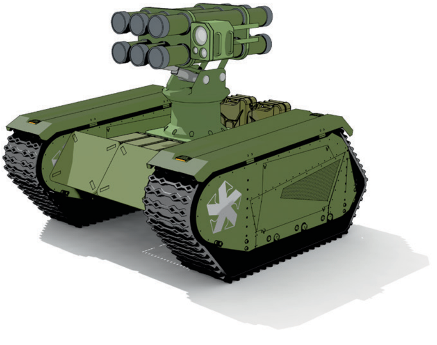
To increase the effectiveness of the ISR version of THeMIS during reconnaissance operations, the following recommendations should be considered:

- The placement of a combination of sensors on the single platform to enhance the effectiveness of the ISR UGV;
- The integration of a small RWS and smoke grenade launchers for self-defence purposes. The ISR THeMIS with such weapons will have increased self-protection capabilities, and, in case of a contact with the adversary, will be able to return fire, destroy small targets, and successfully disengage from the contact without damage to the system.

Anti-tank Operations

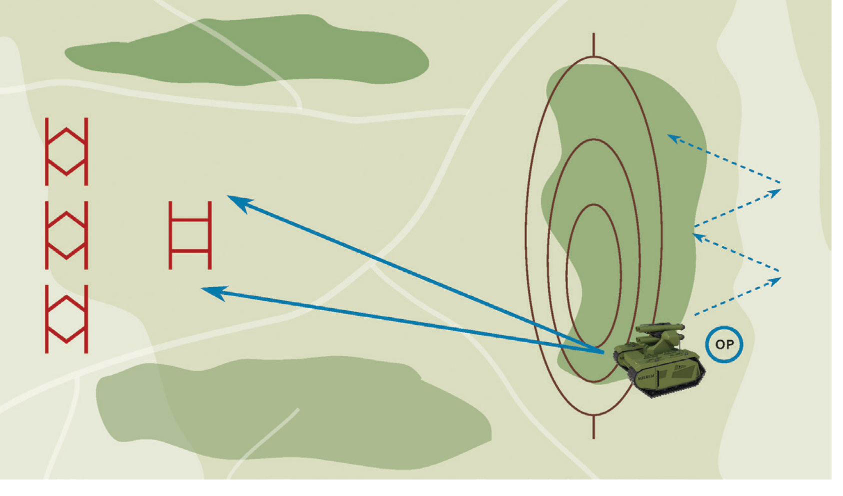
Currently, THeMIS has developed two configurations specific for anti-tank (AT) operations. Other versions of the AT weapons could be fitted onto the platform too. All additional sensors, day/night and thermal sights could be installed to enhance tactical performance of the system.

Current modification of the AT THeMIS system suits very well for anti-tank operations. An integrated anti-tank suit is capable of defeating all major tanks that it would meet on the contemporary battlefield. The low silhouette of the system decreases the possibility to detect it on the terrain and increases its survivability. The anti-tank modification of the UGV would allow it to conduct anti-tank operations in the same way as manned platforms can. When deployed on the battle position, THeMIS would be controlled by an operator, who would manage



Picture 3. The THeMIS system with an integrated suite for anti-tank operations

it from the same position in the rear. Usually anti-tank units take their positions on a specific terrain that allow effective use of their weapons. The adversary's armoured vehicles would be detected, recognised and identified at maximum distances and then engaged by the anti-tank system. After the launch of the missile and hitting the target (if not firing in a "fire-and-forget" mode), THeMIS will conduct a survivability move to a new position to avoid detection and destruction by the adversary. If needed, a designated observer would conduct a BDA. Than all the actions are repeated until the adversary's unit is defeated. The system has one potential shortfall – slow mobility on the battlefield that denies its quick and effective deployment to a different firing position. Usually, the anti-tank units are located in the waiting area and have assigned multiple firing positions throughout the battlefield. The unit requires robust mobility to move from the waiting area to the firing position and between the firing positions. The anti-tank unit is assigned to cover gaps between the major manoeuvre units' positions or countering the adversary's units that broke through the main defensive line. The speed of the system is insufficient for such a rapid deployment and, therefore, THeMIS requires additional transport assets to move effectively over the battlefield.



Sketch 13. THeMIS fitted with an Anti-tank suit conducting Anti-tank operations

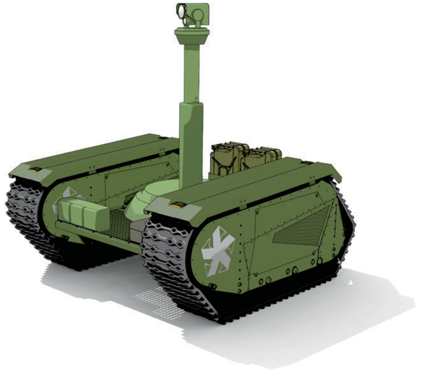
The anti-tank version of THeMIS is fully capable of performing tasks of an anti-tank unit on the battlefield. Its technical parameters improve its performance on the firing positions compared to its manned counterparts. An issue of slow deployability on the battlefield could be solved by assigning additional transport assets to the anti-tank unit.

The following recommendations will increase the effectiveness of the anti-tank version of THeMIS during anti-tank operations:

- Integration of improved third generation anti-tank weapons would significantly increase the firepower and engagement range of the system;
- The allocation of additional transport assets, specifically designed for rapid loading and off-loading of the THeMIS system, would improve the anti-tank unit's deployability on the battlefield.

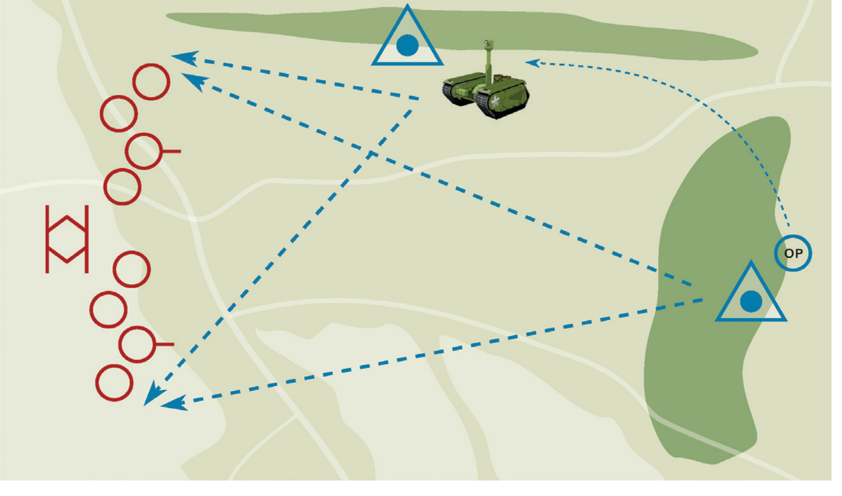
Fire Support Operations

Properly equipped THeMIS would be capable of supporting Fire Support (FS) operations. The UGV could be attached to the Forward Observer (FO) (Joint Forward Observers (JFO), the Fire Support Team (FIST), and the Combined Observer Liaison Team (COLT)) to enhance capabilities of the FOs. The following special equipment as a minimum should be fitted on the platform: day/night observation sensors; thermal sight; laser rangefinder; micro ponder; distress marker strobe light; and an infra-red pointer. This equipment could be supplemented by other gear that is envisaged for the conduct of the operation.



Picture 4. The THeMIS system with an integrated equipment suit for surveillance and target acquisition operations

THeMIS fitted with an integrated FS set of equipment would increase operational capabilities and security of the FO team. The UGVs can follow the assigned units on the battlefield and carry not only specially fitted equipment, but also individual soldiers' gear. The technical characteristics of THeMIS favour tactics and techniques that are used by the FO team. A low silhouette, quiet movement mode, and cross-country mobility all contribute to that. The FO team, which is equipped with THeMIS, can conduct operations from a distance, and that in-turn increases the team's survivability. The FO team is usually located within front-line units or separately positioned close to the line of contact with the adversary. The observers are responsible for identifying targets and requesting fire. The UGVs can always move forward and provide necessary information from remote up-front positions. In this situation, the FO team can choose safer and more secure positions and still deliver the required effects. The FO team equipped with THeMIS has more flexibility in a modern battle. If the adversary obscures visibility on the battlefield, or the fields of observation from the position of the FO team become limited, the team can move the UGVs to a more advantageous position and continue execution of the mission without endangering itself. That would not be possible without support from THeMIS. Moreover, THeMIS



Sketch 14. THeMIS fitted with a special Fire Support and ISR suit conducting Fire Support operations

could perform the Battle Damage Assessment (BDA)[30] to determine if the fires of the units are destroying the targets and creating the desired effects on the battlefield. As in the other tactical supporting tasks, where contact with the adversary is likely, the UGV should be equipped with a protection system that provides minimal self-defence capabilities.

Use of the FS modification of THeMIS during the FS missions will increase effectiveness, flexibility and survivability of the FO team.

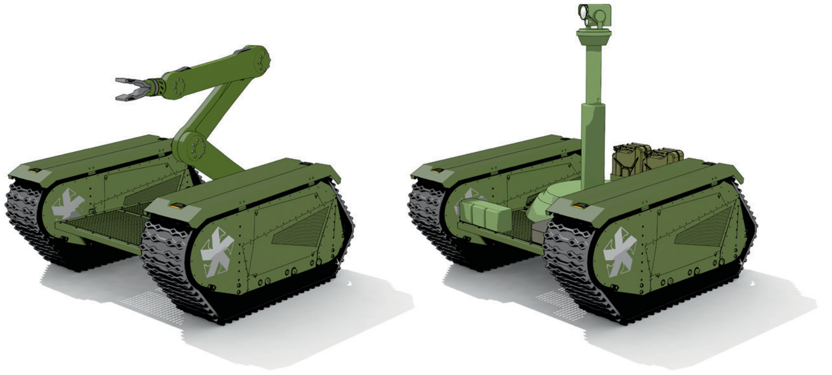
In order to increase effectiveness of the FS version of THeMIS during the FS operations, the following recommendations should be considered:

- installation of a combination of sensors on a single platform will enhance effectiveness of the FS UGV;
- integration of a small RWS and smoke grenade launchers for self-defence purposes.

Combat Engineers Operations

THeMIS could be fitted with different special equipment suits tailored to perform multiple engineering operations. The UGVs equipped with special engineering ISR sensors could successfully conduct Engineer Reconnaissance operations, the same way as the ISR modification. Additional, obstacle breaching equipment mounted on the same UGV will allow it to conduct not only scouting of the obstacles, but also breaching operations at the same time. As many other UGVs, THeMIS is able to conduct bomb disposal operations, including detection, identification, onsite evaluation, rendering safe, recovery and final disposal of an unexploded explosive ordnance[31] and improvised explosive devices.

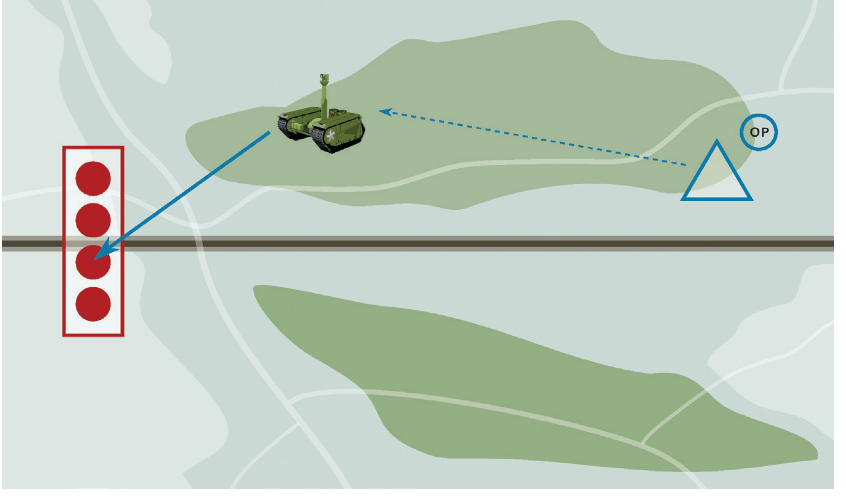
THeMIS, with an integrated engineer ISR equipment, would enhance the capabilities of the engineer reconnaissance units. The payload of the UGV is sufficient for installation of different types of intelligence sensors and obstacle breaching kits. The system's speed and mobility are suitable for conducting such tasks. Its low silhouette and silent movement mode contribute to the successful conduction of the mission. THeMIS can easily follow the assigned unit and carry the main



Picture 5. The THeMIS system with integrated suites for Combat Engineers and bomb disposal operations

equipment and additional cargo. When arriving at the spot where the adversary's obstacles are spotted, THeMIS is moved forward to recognise the obstacle. It could move forward as much as necessary without endangering personnel from the engineering unit. When an obstacle is identified, the operator could choose the way how to overcome that specific obstacle. The obstacle could be either bypassed or breached. If the operator decides to bypass the obstacle, THeMIS will find a bypass route. If a decision is taken to breach the obstacle, it could be accomplished on the spot, using different types of Mine-clearing line charges. Again, it could be conducted remotely, without endangering the operator and other personnel of the engineering unit. Additionally, THeMIS could perform a BDA to determine if the required effect is achieved. Since the engineer modification of THeMIS, while conducting obstacle reconnaissance and rupturing it, would operate in front of its own troops it may become exposed to the adversary's fire. Hence, to increase its survivability, the UGV should be furnished with an integrated active or passive (or combination of both) protection system.

Abilities of THeMIS to conduct explosive ordnance disposal (EOD) and improvised explosive devices disposal (IEDD) operations does not require detailed explanation, since a large variety of different kinds of UGVs have been efficiently accomplishing these tasks for decades.



Sketch 15. THeMIS fitted with a special Engineer equipment suit conducting obstacle reconnaissance and breaching operations

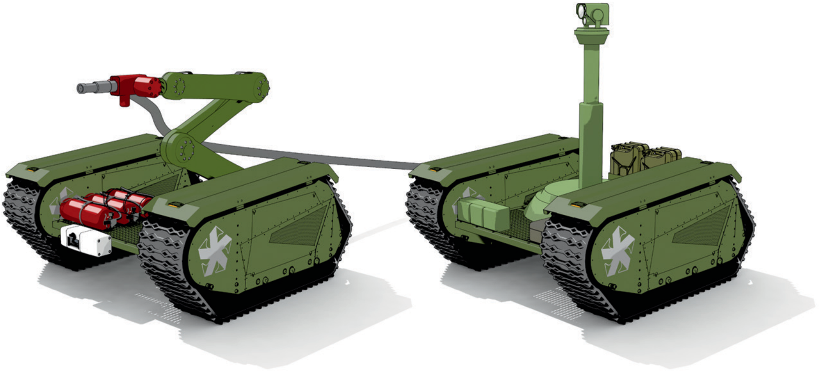
The engineer and EOD/IEDD modifications to THeMIS are fully capable of performing a wide range of engineering tasks. Its technical configuration and capabilities make it an excellent platform for fitting different kinds of specific engineer and bomb disposal equipment, starting with reconnaissance suit and ending with the EOD/IEDD equipment. The use of the Engineer UGV will significantly reduce unnecessary risks to the personnel of the Engineer unit.

The following recommendations should increase the effectiveness of the engineer platform of THeMIS during engineering operations:

- Combination of different types of equipment on a single platform to enhance the effectiveness of the Engineer UGV;
- Integration of small RWS and smoke grenade launchers for self-defence purposes.

Chemical, Biological, Radiological and Nuclear (CBRN) Defence Operations

Specifically designed UGVs could conduct different types of the CBRN operations. THeMIS, equipped with an integrated suit for the CBRN reconnaissance, must be capable of detecting, identifying, marking, sampling and reporting all chemical, biological and radiological contamination and providing forecast information to the units deployed around operations.[32] The modified decontamination operations' UGVs are capable of decontaminating personnel and equipment to reduce or eliminate the risk to personnel and to make the equipment serviceable again.[33]



Picture 6. The THeMIS system with integrated suites for CBRN

The CBRN reconnaissance operations are usually conducted by three to five (depending on a country and structure) CBRN Reconnaissance teams that operate from special CBRN vehicles. Those CBRN Reconnaissance teams are operating on a perimeter of large units and provide the CBRN detection and surveillance for battlefield hazard visualisation. The equipment detects and collects the CBRN contamination in its local environment on the move through a point detection and at a distance through the use of a standoff detector. Modern CBRN equipment automatically integrates contamination information from sensors and disseminates digital CBRN warning messages through the Battlefield management system. Nearly all of this equipment can be integrated on THeMIS to ensure its semi-autonomous activity. The frontal line vehicles from the CBRN Reconnaissance unit, also face the threat of the adversary's direct and indirect fires. In order to reduce the risks to the CBRN unit's personnel and increase the effectiveness of the actual reconnaissance it is reasonable to replace those vehicles and personnel with the CBRN THeMIS that is equipped with the appropriate sensors and equipment. All the UGVs will be controlled by personnel on the standard CBRN vehicles that are located in the rear. As in the other tactical supporting tasks, where contact with the adversary is likely, the UGV should be equipped with the protection systems that provide minimal self-defence capabilities.

THeMIS could also perform the CBRN Decontamination tasks.[34] Specially equipped UGV can decontaminate vehicles at the established decontamination points, where it will remove chemical, biological or radioactive materials from the equipment. Since it is remotely operated, it automatically reduces the potential contamination risks to the CBRN Decontamination unit's personnel and increases its survivability.

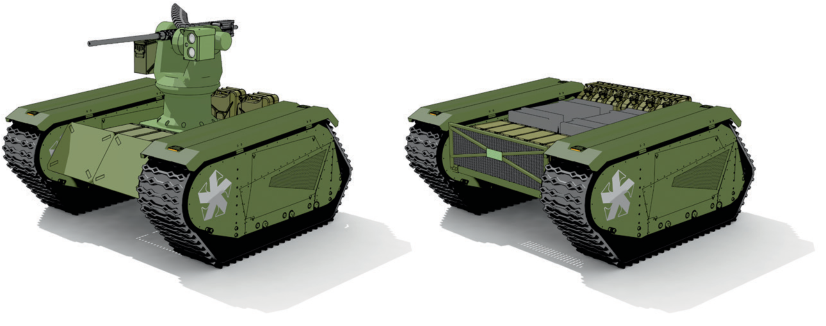
THeMIS can effectively perform different types of the CBRN operations, and all the required detectors and other equipment could be easily integrated onto the platform. Use of the UGV that is providing remote operations capability significantly reduces contamination risks to the CBRN personnel and manned equipment.

It is recommended to consider further improvement of the THeMIS CBRN modification to improve efficiency of the system by:

- installation of multiple types of detectors that can automatically perform the CBRN reconnaissance tasks without direct involvement of the personnel;
- integration of small RWS and smoke grenade launchers for self-defence purposes.

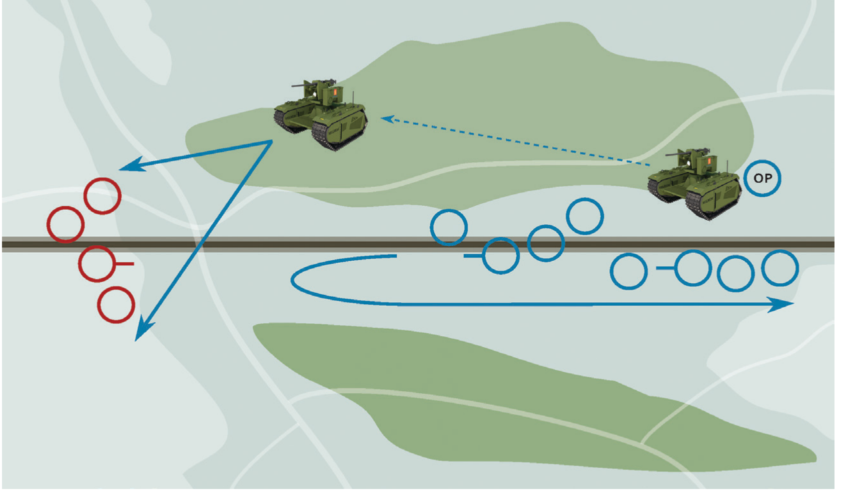
Patrol Operations

Two modifications of THeMIS can be employed during the patrol operations in support of the Light infantry squad. The UGVs equipped with the RWS could support patrolling units with additional fire power or independently conduct patrolling on a predefined patrol route. The Multifunctional Utility/Logistics and Equipment Vehicle (MULE) or cargo modification of THeMIS can support the Light infantry unit by carrying additional load, significantly increasing possible duration of the patrol, and expanding the area of operations.



Picture 7. The THeMIS system with an integrated suite for Patrol operations

The light infantry unit that is tasked to conduct a patrol can use THeMIS for its advantage in different ways. The observation sensors and sight of the UGV certainly increases situational awareness capabilities of the units. THeMIS will play an important role should the patrolling units suddenly contact the adversary. The significant fire capabilities of the RWS, compared to the light infantry squad, would permit the unit to generate substantial firepower and would facilitate breaking contact with the adversary and a safe disengagement. Remotely operated THeMIS with the RWS could “stay behind” and suppress the adversary with fire as long as it is required for the patrolling unit to assume a new advantageous position, and then it could be pulled out to join the main force. After completion of this manoeuvre, the unit could continue the operation as planned.



Sketch 16. The THeMIS fitted with the RWS supporting a patrolling operation

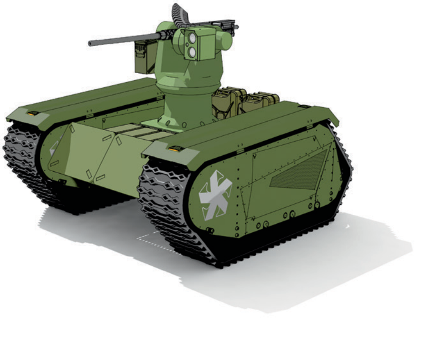
THeMIS with the RWS could conduct semi-autonomous patrol tasks. The installation of specific command and management systems is required for accomplishment of the assignment. Additional equipment may include infrared cameras, radars, high-sensitivity microphones, visible sensors, and hostile fire indicators. Appropriately equipped UGVs will be able to conduct patrolling on a predefined route and engage the adversary's targets in pre-planned fire sectors. Such operations would still require the operator, who would remotely control the UGV. The operation would be conducted in a similar way as by other UGVs, like the Guardium autonomous observation and target intercept system that was developed by the G-NIUS Autonomous Unmanned Ground Vehicles joint venture established by a consortium of Israeli companies.[35] These UGVs are currently operational and in the inventory of the Israeli Defence Forces.[36]

The MULE modification of THeMIS can carry up to 750 kg of cargo, which is a significant increase in weight that can be carried in support of a patrolling operation. The amount of additional armament, equipment and supplies significantly exceeds the weight that is normally carried by the light infantry squad. With more equipment and supplies the patrolling unit can cover much longer distances and sustain independent patrol operations for extended periods of time. The mobility and speed of the UGVs are more than sufficient to support dismounted infantry operations. Additionally, MULE has a capacity to recharge all types of rechargeable batteries for different kinds of electronic equipment that the Light infantry squad is normally using in patrol operations.

Those two THeMIS modifications are very well fit for the patrolling operations and do not require any significant upgrade. The UGVs with the RWS can effectively support patrolling units by providing an improved situational awareness and fire support. The MULE modification considerably enhances the operational range of a patrolling unit. For the conduct of independent patrolling tasks, THeMIS would require installation of an advanced command and management system that would control movement of the UGV on predefined routes and control the use of the weapon systems.

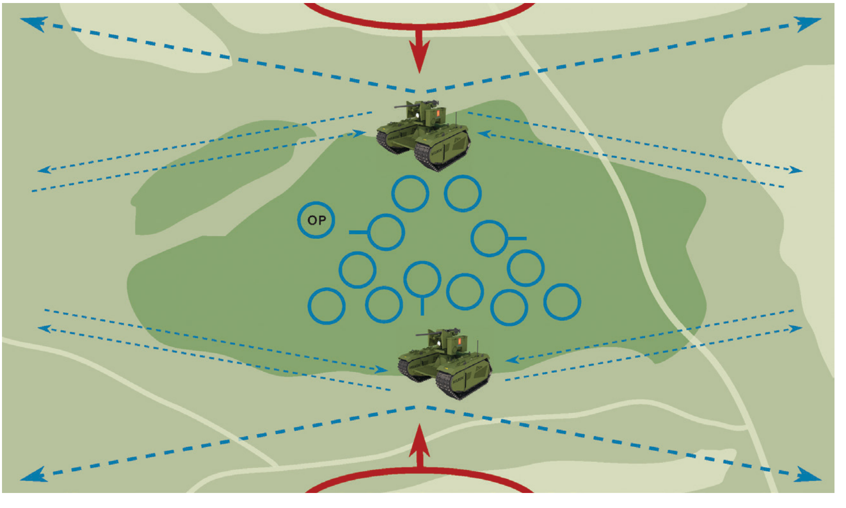
Security Operations

The THeMIS modification equipped with the RWS can be used for security purposes, when it is necessary to ensure protection of an objective or a unit that requires regeneration or rest. This modification will require the installation of additional tasks-specific equipment that was discussed previously in Patrol operations. Such equipment will include, but will not be limited to, command and management systems, infrared cameras, radars, high-sensitivity microphones, visible sensors, and hostile fire indicators.



Picture 8. The THeMIS system with an integrated suite for Security operations

When the unit, reinforced by THeMIS, specially equipped for security operations, is tasked to provide the security for an objective or a unit, it must find, prepare, and if necessary programme special routes for the UGVs that would ensure proper observation and fields of fire for the RWS. Appropriately equipped UGVs would be able to conduct the security operations in their prepared sector. The UGVs would identify, engage and destroy the adversary's targets in prepared fire sectors. The operations could be conducted under the full control of the system's operator or, under certain circumstances, THeMIS could act autonomously. When contact with the adversary is made and the UGVs have started fire engagement, it would be immediately reinforced by the strengthening unit. Small elements of the adversary's forces could be defeated by the UGVs, but a larger adversary's attack could be repealed only by a combined effort of the UGVs and the unit, which is a normal practice during security operations.



Sketch 17. The THeMIS fitted with the RWS conducting a Security operation

For the conduct of the security operation tasks, THeMIS would require the installation of an advanced command and management system that could control both, the movement of the UGVs on predefined routes and the use of the weapon systems. An appropriately furnished THeMIS would be able to successfully conduct assigned tasks. The UGV with the RWS would be able to secure the assigned objective and/or unit and provide an improved situational awareness and fire support.

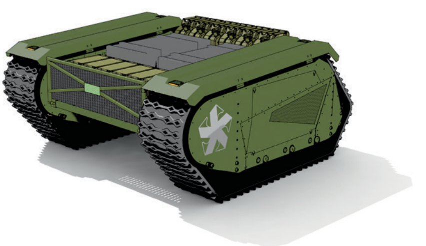
UGV FITTED FOR COMBAT SERVICE SUPPORT TASKS

An ability to conduct support tasks is definitely one of the strongest qualities of the THeMIS platform. Modifications that are specifically designed for combat resupply and casualty evacuation (CASEVAC) can perform their support tasks very well. With additionally installed equipment, THeMIS could perform multiple support tasks on the battlefield. Those Combat Service Support tasks will be evaluated in this part of the paper. Each sub-part of the paper will review usability of a specific modification of THeMIS.

Combat Resupply Operations

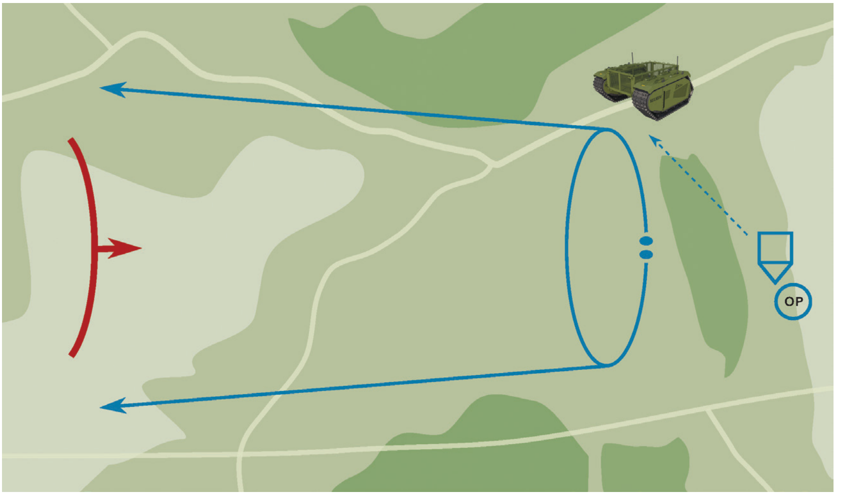
The MULE or cargo modification of THeMIS can successfully conduct routine resupply of the manoeuvre units and, more importantly, resupply units that are in a direct contact with the adversary's forces.

The supplying and the supplied units must carefully select resupply routes from the supply points to the combat units. Such routes should provide a natural cover and concealment to the UGVs. The technical characteristics of THeMIS are very beneficial for this kind of operations. The qualities that were discussed previously, i.e., low silhouette of the UGV, its mobility and speed, and very silent movement mode will all contribute to the successful accomplishment of the resupply mission. The MULE modification of the THeMIS could carry up to 750 kg of cargo. Even the heaviest ammunition that needs to be delivered to the light infantry unit



Picture 9. THeMIS' cargo transportation modification

– mortar rounds, when placed on a pallet will not exceed the payload of the UGV. All other types of supplies to the manoeuvre unit could be easily accommodated on the platform. The load itself could be preconfigured for the specific manoeuvre unit and all the necessary resupplies could be placed on standard pallets. That would significantly speed-up the resupply operation since the only requirement will be to move the preconfigured pallet from logistical truck to THeMIS, which will deliver the necessary supplies straight to the unit.



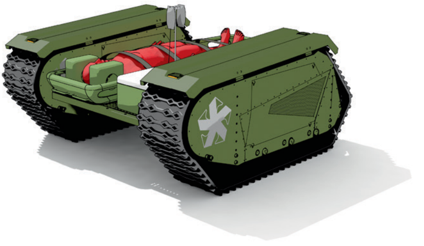
Sketch 18. The THeMIS conducting a Combat resupply operation

The cargo modification of the THeMIS is a well-developed system that can effectively execute resupply operations, even in the cases where supplied units are in a direct contact with the adversary.

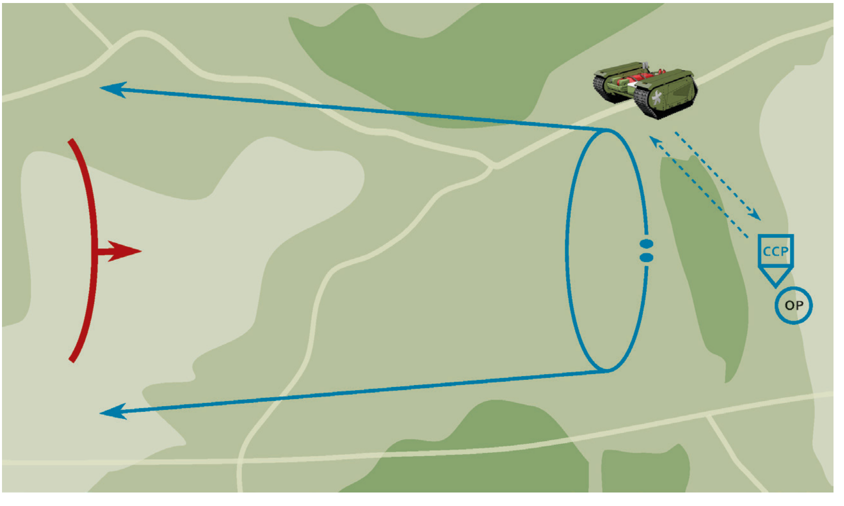
Casualty Evacuation Operations

Special modification of THeMIS was developed for conducting the CASEVAC operations. It is specially designed and equipped for transportation of casualties at the battlefield and, when used properly, it can evacuate wounded soldier from the unit that is in a direct contact with the adversary.

The CASEVAC operations must be carefully planned and evacuation routes must be wisely selected by both the supporting and supported units, thus maximising the effect from a terrain's natural features that provide cover and concealment. The technical characteristics of the UGVs, which were explained in the combat resupply operation, work the same way for the CASEVAC operations and the CASEVAC modification of THeMIS can successfully accomplish this mission.



Picture 10. THeMIS's Casualty evacuation modification

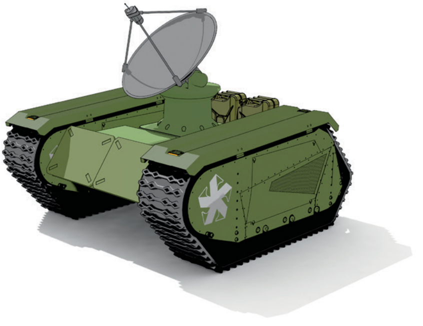


Sketch 19. THeMIS conducting a CASEVAC operation

The CASEVAC modification of THeMIS is a well-built system that can evacuate wounded soldiers from their combat positions back to the safety. It can execute the CASEVAC operations also when the units are in a direct contact with the adversary.

Communication Support Operations

The communication relay vehicles are specifically developed for narrow supporting tasks, such as the establishing of safe and secure communication within a certain area of operations. This THeMIS modification is fully capable of quickly and stealthily establishing, operating and relocating communication relay points. This task could be accomplished remotely without endangering the personnel of a signal unit.



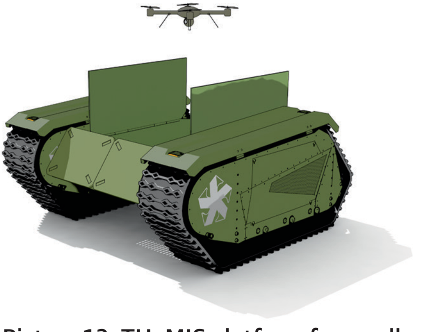
Picture 11. The THeMIS communication relay vehicle

The signal section is responsible for establishing network coverage within the area of operations and establishing safe and secure communications with all units. When the position for the relay station is identified, THeMIS is remotely moved to the position and the radio relay station is established. After completion of the task, the UGV can return to the unit and stay there until the establishment of a new relay station is required. The possibility to establish the point remotely reduces risks posed to the signal unit's personnel by the adversary's forces.

The communication relay vehicle can perform the task it was designed for. Use of the UGVs during the operation enhances survivability and protection of the personnel from the signal unit.

USE OF THE UGVS AS PLATFORMS FOR SMALL UNMANNED AERIAL SYSTEM (UAS) OPERATIONS

THeMIS has developed as a platform for a small UAS system. Use of the UAS in military operations vastly increases the situational awareness for the manoeuvre unit; and it is expected that such capability will be fielded in many armies. The use of specific UGVs, in addition to the obvious intelligence advantages, offers at least two additional benefits to the unit that operates such system. Firstly, in a tactical situation, the UGVs can provide the remote launch capability that in turn increases survivability of the UAS operators' team by allowing it to assume operational positions in a more remote zone outside of the main combat area. It also potentially provides a more comfortable operational environment for the operating crew by placing it into better tactical settings. Secondly, THeMIS serves not only as a launch and landing emplacement, but also as a quick recharging platform. It allows to prolong the independent UAS operations and enhance the usability of the UASs in support of the light infantry unit.

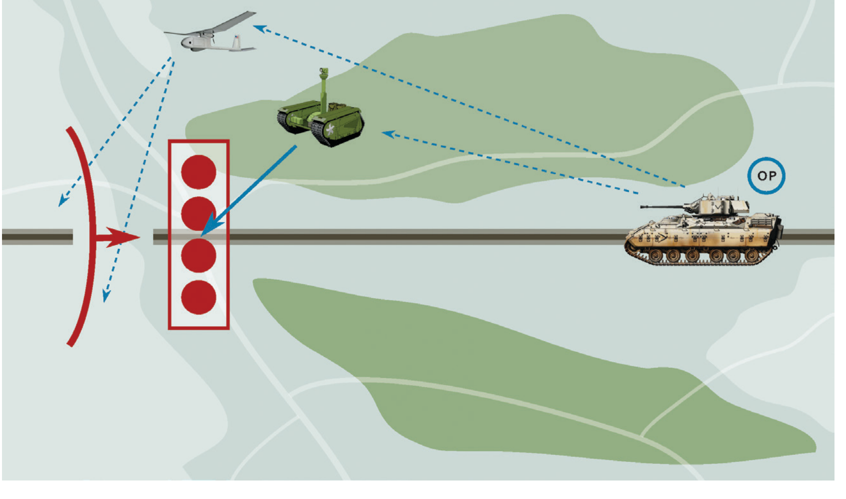


Picture 12. THeMIS platform for small UAS

USE OF UGV IN COMBINATION WITH THE LEGACY SYSTEMS

Potentially, THeMIS could support a mechanised infantry units too. A combination of the legacy systems represented by the infantry fighting vehicles and new unmanned platforms that are represented by the UGVs and the UASs have a very promising potential for the future use on the battlefield. Combining firepower; protection and the mobility of the infantry fighting vehicle; ability of the UASs to provide a real-time battlefield picture and early warning to the unit; and ability of the UGVs to conduct a detailed reconnaissance of objects on the spot, to breach obstacles, and conduct a BDA creates a very powerful amalgamation of capabilities. This, when used properly, could significantly enhance the engagement capabilities of the mechanised infantry. When THeMIS is operating together with the mechanised infantry unit, it should be attached to a larger force than a squad - the most appropriate is a platoon or a company-size unit, where the use of the UGVs and the UASs would be most effective. Larger size units can better handle use of additional assets, because their command element is bigger in size and therefore more capable to organise and coordinate effective use of different types of unmanned vehicles. The command element usually is not in a direct contact with the adversary and functions in a safer and more secure environment, so it can operate more effectively with additionally assigned assets.

In tactical situations, the mechanised infantry unit closes with the adversary in a combat formation. When operating on a restricted terrain, the unit commander must use all the available assets to clarify the situation and collect the maximum possible information about the location of the adversary's positions and its obstacles. It is more appropriate to firstly use the UASs to detect the location of the adversary. When the possible positions and obstacles are detected, it is appropriate to send forward the UGVs to collect more information on the ground. THeMIS that is specially equipped with an appropriate ISR suit and a Mine-clearing system is the most suitable modification for that task.



Sketch 20. THeMIS operating together with the Infantry fighting vehicle and the UAV

The identified obstacle could be either bypassed or breached – THeMIS can support both tasks. If the decision is taken to breach the obstacle then it can be accomplished on the spot. Breaching of the obstacle is conducted remotely, without endangering the operators of the UGVs and other personnel of the infantry unit. The Mechanised infantry is moving forward through the obstacles and attacks the adversary. Both unmanned systems provide the BDA and situational awareness to the attacking unit. In addition, THeMIS could support the attacking unit by fire, if required. Upon seizing the objective and accomplishment of the task, the mechanised infantry re-groups, collects all unmanned systems and moves forward to a new objective.

The use of THeMIS in support of the attacking mechanised infantry unit in combination with UASs has a good potential. More detailed tactics, techniques and procedures for such operations should be developed in the future. The UGV, when used in a combat support role, has more probability to be effective on the battlefield, while combat tasks are better fit to the mechanised or armoured units.

CONCLUSION AND RECOMMENDATIONS

Multiple tactical situations were reviewed, assessing usability of THeMIS in different tactical roles during combat, combat support and combat service support operations. In general, the UGVs show a noticeable potential for use in the future actions. They are especially well suited for logistical support activities and operations that do not require a direct engagement with the adversary's manoeuvre units. Overall usability and effectiveness of THeMIS varied, depending on the type of operation, environment, tactical set-up for operation and the battle formation used.

The efficiency of the UGV acting in support of the light infantry squad conducting combat operations was low; and the assessment showed that the use of UGVs equipped with the RWS was largely ineffective. However, in some situations, under certain circumstances, THeMIS can successfully fight the adversary's forces and enhance capabilities of the Light infantry. THeMIS brought two very important capabilities to the light infantry – sensors and weapon stations. The sensors and the RWS provided very good observation and situational awareness capabilities to the systems' operators and supported units. The weapon systems increase the engagement capabilities of the unit, though further improvement of the armament is recommended.

In the current status, the UGV is better suited for conducting of the area defence operations on a restricted terrain, and delaying operations from alternate positions. THeMIS can successfully support the Light forces and ensure early warning and situational awareness, effectively engage the adversary's targets, and avoid the return fire by conducting survivability moves from one position to another. While operating on a restricted and urban terrain, the units, which are supported by UGVs, must ensure proper preparation of defensive positions that will allow for safe, protected and uninterrupted movement of THeMISs between the battle positions.

The unit equipped with THeMIS should avoid all kinds of operations on an open terrain; operations that require lengthy firefight engagements with the adversary's heavy and medium forces and rapid mobility on the battlefield. In general, the effectiveness of the UGVs is lower in offensive operations, in mobile defence and delaying from successive positions. The UGVs increase the firepower of the fighting unit, but lack adequate mobility and protection, hence they cannot fully substitute the support provided by standard infantry fighting vehicles. A protection of the UGVs was the main deficiency that limits their use in the offensive operations and on an open terrain. The light infantry units, even when they are supported by the armed UGVs, were not suited for mobile defence operations when units were assigned as a striking force. The light force lacks mobility, protection and fire power to conduct mobile operations and even the UGVs support could not overcome all the deficiencies of the light force. The system's deficiencies are restricted movement on the battlefield and reloading of the RWS. Control of the system by one operator reduces THeMIS' capabilities and supporting effects of the platform from manoeuvre and fires to a simple movement from one firing position to another. Reloading of the system is problematic, since it either puts at risk the safety of the system's operator or noticeably degrades fire support provided to the attacking unit.

Those deficiencies, to a certain degree, could be reduced by increasing the protection level of the UGV and armament of the RWS, and implementing new tactical solutions on the battlefield. Some upgrades of the UGV can potentially increase its usability and effectiveness. All recommendations could be grouped in three categories: technical, tactical and organisational. To improve the use of THeMIS during combat operations, the following technical recommendations should be taken into account:

- Increase armament of the RWS by adding an anti-tank capability and a smaller calibre (7.62 mm) automatic weapon. The third generation anti-tank weapons will significantly increase firepower and engagement range of the RWS. An additional smaller machinegun will allow the system to engage the adversary's softer targets, destruction of which does not require the use of the main weapon system. It will also decrease the usage of bigger calibre ammunition and reduce the number of reloads for the heavy weapon system;
- Upgrade the RWS to increase the carrying ammunition load beyond the use of the standard boxes for the cartridges. The RWS Ammunition supply system should supply a large amount of ammunition that will require fewer reloading iterations;
- Consider integration of a fully up-armoured version of the RWS that will increase system's protection and in-turn its survivability on the battlefield. THeMIS has enough payload reserve to allow for such improvement;
- Introduce a backup system for powering both tracks of THeMIS, as that will increase the system's survivability and effectiveness.

The tactical recommendations vary for different types of combat operations. For the offensive operations it is recommended to place THeMIS in front of the attacking unit in order to increase the situational awareness of the supported infantry squad; support it with the additional intelligence information that is provided by the observation sensors of the system; and the use of the UGVs mainly on a restricted terrain that provides some degree of concealment and passive protection to the system, allowing THeMIS to move to and assume proper observation and firing positions. The effectiveness of the UGV will increase, if during defensive operations the UGV will be used in support of the light infantry units on a terrain that favours dismounted force, namely, on a restricted and urban terrain. Such environment facilitates' proper use of the UGVs, provides certain degree of concealment and protection to the system and increases the survivability options of THeMIS. While operating on a restricted and urban terrain, the unit, which is supported by the UGV, must ensure a proper preparation of defensive positions that will allow for safe, protected and uninterrupted movement of THeMIS between the battle positions. Another possibility to improve the light infantry squad performance is to integrate THeMIS into the structure of the squad as a third manoeuvre element. That will increase the squad's firepower and will allow to divide tasks of the attacking unit into the fire team (UGV), the assault team (Fire team Alpha) and the supporting team (Fire team Bravo). During the delaying operations and any other operation, when breaking the contact with the adversary's forces is required, the UGV must cover withdrawal of the light infantry unit, even if it will results in the loss of the armed UGVs. Such action will facilitate the unit's disengagement from the battle and will allow it to continue the battle from the next alternate position.

To improve the performance of the UGVs on the battlefield it is recommended to consider increasing the number of the system operators from one to two. In such an organisation each operator would be responsible for one functional activity – movement of the system on the ground or firing its weapons; and that will considerably improve the combat capabilities of THeMIS. Yet, increasing the number of soldiers in the manoeuvring unit also needs to be considered, since all the forces nowadays face the resources' austerity.

Further use of THeMIS for execution of combat support tasks was assessed. Different modifications of THeMISs were used in support of specific functional units during reconnaissance, anti-tank, combat engineers, bomb disposal, CBRN defence, patrolling and security operations. Overall, the UGVs performed well and units supported by the system were able to perform their tasks better. All the used UGVs fitted with special equipment suits tailored towards performance of specific operations were capable of conducting different types of assigned tasks. The variety of tasks was mainly limited by the type of the special equipment installed on THeMISs. The units supported by the UGVs were able to perform different tasks remotely, and therefore significantly decrease the engagement, destruction and contamination risks to the personnel and the equipment.

Majority of the THeMIS modifications that were reviewed in this part potentially require two upgrades that might be considered by the future users of the system: firstly, the placement of a combination of sensors on a single platform to enhance the functional effectiveness of the UGVs for specific types of operations; secondly, the integration of small RWS and smoke grenade launchers for the self-defence purposes. THeMIS with weapon and smoke launchers would increase its protection capabilities and in the case of a contact with the adversary will be able to return fire, destroy small targets and successfully disengage from the contact without damage done to the system. Also, there are some recommendations that are applicable only for specific modifications of the UGVs. Integration of an improved third generation AT weapons will increase the firepower and engagement range of the AT modification of THeMIS. Furthermore, additional transportation assets specifically designed for rapid on- and off-loading of the UGVs could be assigned to the AT units in order to improve the UGV's deployability on the battlefield. For the execution of semi-independent patrolling and security operation tasks, THeMIS will require an installation of an advanced command and management system that would monitor the movement of the UGVs on predefined route/area and control the use of the weapon systems. Appropriately furnished THeMIS will be able to successfully conduct the assigned patrolling and security tasks.

The usage of THeMIS for execution of the combat service support tasks was evaluated next. Overall, the UGVs could perform very well and units supported by the system were able to perform combat service support and other tasks much better than the units without the UGVs. The combat service support modifications of THeMIS are well developed systems and they all can effectively execute resupply, casualty evacuation and communication support operations. An important advantage of the UGVs is that supporting units can execute support and supply tasks from a distance without endangering its personnel. Still, with THeMIS, it could execute supporting operations in case the supported units are in a direct contact with the adversary.

The THeMIS platform for small UAS systems, besides obvious intelligence collection advantages, can provide remote launch capability and at the same time serve not only as the launch and landing emplacement, but also as a quick recharging platform. That increases survivability of the UASs operators' team by allowing it to assume operational positions in more remote zone outside of the main combat area, prolongs the independent UAS operations, and enhances the usability of the UAS in support of the Light infantry unit.

Finally, the use of THeMIS in support of the mechanised infantry unit was reviewed. Potentially, THeMIS could support the mechanised units. A combination of the legacy system represented by the Infantry fighting vehicles and new unmanned platforms that are represented by the UGVs and UASs has a very promising potential for future use on the battlefield. Combining firepower; protection and mobility of the infantry fighting vehicle; ability of the UASs to provide a real-time battlefield picture and an early warning to the unit; ability of the UGVs to conduct a detailed reconnaissance of objects on the spot; to breach obstacles and conduct the BDA all together creates a very powerful combination of capabilities. These, when used properly, will considerably increase the fighting capabilities of the mechanised infantry unit.

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CONCLUDING REMARKS: TOWARDS ROBOTISATION OF WARFIGHTING IN THE 21ST CENTURY

Kuldar Väärsi

Robotic technologies have supported significant breakthroughs in various UGV fields. These units have become much more capable and reliable and the cost has a clear trend for decreasing. This has created a platform for new warfare systems which will change warfighting, primarily by enhancing the human capacity through better means of force protection, situational awareness and firepower. The introduction of robotics in warfare will have wide implications for the way wars are waged – robotic and autonomous technologies will open new opportunities throughout all combat functions.

Robotic and autonomous capabilities can significantly improve reaction speed and the range of logistics support, analysis of situational awareness, decision making processes, effectiveness and the availability of firepower. All factors will work as a force multiplier establishing significantly stronger capabilities with the same number of war fighters. Robotic technologies enable achievement of a significantly stronger defence with fewer resources (manpower and finance). In the very near future it is going to be just a matter of imagination how collaborative sensors and semi-autonomous unmanned vehicles (ground and aerial) will bring situational awareness and synergy of combat effects to a totally new level. We will still have a human in the centre of everything, but our war fighter will be better protected and equipped with better tools to overcome any adversaries.

Many countries have already taken a very clear approach to bring robotic warfare systems closer to fruition, though many are still hesitating. The main innovators of robotisation on the battlefield – the US and Russia – have taken different approaches. The US has established a step-by-step approach starting with logistic support, which will lighten the load of war fighters and extend the range and speed of small units. The weaponisation of unmanned systems will be implemented in the more distant future, when logistic units are already well embedded into doctrines and army units.

Russia's approach has been very assertive and focused on unmanned ground vehicles with extremely high firepower. The pace of development and the amount of resources spent on these developments has been growing. As one of the authors of this book has pointed out, Russia has a very ambitious goal to increase the significance of robotic systems up to one third of all military technology by 2025. It is a clear sign of high prioritisation of robotic and autonomous systems.

On the contrary, from my personal experience of being part of the European UGV development community for almost four years, it is noticeable that European countries are clearly scattered – the strategic approach and prioritisation of robotic and autonomous capabilities is very different country by country. Some European countries are more progressive and have started to develop unmanned systems; others are still dealing with legal and ethical considerations. It is clearly noticeable that there is a lack of collaboration – each country develops its own concept and doctrine. There is a necessity for Europeans to work jointly on robotic warfare capabilities and find ways for a fast development.

Europeans need a robotic warfare programme that would take into consideration the threats of the contemporary operational environment and aim to enhance the capabilities of the armed forces while reducing the need for increasing the amount of soldiers, thus minimising human contact with threatening situations. That will be achieved via using robotic solutions and cyber technology on the modern battlefield as an asymmetric force multiplier. The wider concept covers five domains – land, air, sea, space and cyber. However, primarily and first-hand it should focus on the land domain.

I would like to point out two major topics we will encounter in the development of robotic and autonomous warfighting technologies – autonomous capabilities on open terrain and user-friendly human-machine interfaces.

Autonomous technologies have made a huge progress over the recent years and we will certainly see a lot of self-driving cars on the streets soon. Roads and the urban environment are well structured and it is easier to create rules for artificial intelligence, which drives the vehicles in such an environment. It is much more challenging to create artificial intelligence which could fulfil similar tasks on an open terrain, which is not structured at all. It will require much more flexible and creative artificial intelligence to encounter the different situations on the open terrain.

The second area is human-machine interfacing solutions. It is clear that war fighters are more willing to use tools and equipment that are intuitive and easy to use. If it is complicated and takes too much attention, then it easily becomes a burden instead of providing assistance. There is already a long history and experience with Unmanned Aerial Vehicles (UAVs) and different Counter Improvised Explosive Devices' (C-IED) robots. Unfortunately, most of this experience will not help us if we equip small units (such as squads) with autonomous ground vehicles. This will be a totally different scenario – we will put unmanned vehicles into much more dynamic environment where war fighters cannot pay so much attention to controlling the vehicle. We expect that a vehicle operator is still able to move around with his squad, can maintain awareness of a situation and can still use his personal weapon if needed. If we compare it to a C-IED or bomb disposal robot, then it is absolutely a new situation. We need a very intuitive and organic human-machine interface which will make our war fighters feel safe and comfortable.

To sum up, I would like to reiterate that there is still hesitation in Europe on using robotic and autonomous solutions in the battlefield and even more when it comes to weaponised solutions. These hesitations are understandable, but we should not focus on questioning robotic solutions as such. We should focus on building up a safe and clear environment for implementation. Legislation and ethical rules are a necessary part of this environment of course. Our soldiers should feel themselves safe and comfortable with the new (semi-)autonomous technical solutions.

The European Defence Agency's CapTech Ground Systems (Land) is starting to work on UGV standardisation. It is an absolutely necessary effort, which needs to be done to ensure the interoperability of different European UGV systems. However, there is necessity for an extended strategic collaboration projects which would work on determination of capability gaps and opportunities throughout all combat functions. Implementation of robotic capabilities is not so much about capability gaps at the moment – it is more about the new opportunities it creates.

Sometimes, the discussion over development of robots for the battlefield reminds me of those who disputed the efficacy of introduction of armoured vehicles and battle tanks at the beginning of the 20th century. We all know how that ended.

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