Operational Impact of Unmanned Combat Systems with Autonomous Functions. Preliminary Observations and Challenges.

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ABSTRACT

Rapid technology development of unmanned ground systems with autonomous functions requires the operational and scientific community to study the operational impacts of autonomisation *on concepts and doctrine throughout the tactical, operational and strategic level. Proliferation of Artificial Intelligence and technology of unmanned platforms and the fact that technology development of autonomous systems is driven by academic and civil industry efforts, provides an opportunity for smaller forces to benefit from disruptive technologies in different way than before, when disruptive defence technology was more or less the monopoly of big military powers. Fast and flexible applicability could be the keyword for success. This paper provides an overview of preliminary observation, based on number of workshops, interviews and expert opinion, about operational impacts small forces could achieve when integrating unmanned combat systems with autonomous functions in the future.*

1.0 INTRODUCTION

The introduction and development of Artificial Intelligence (AI) enabled unmanned ground combat systems (hereby Systems with Autonomous Functions, SAF) is one of the most challenging areas in defence capability development. Other technologies may have an impact on the ways we will fight in a future, e.g. quantum computing, biotechnology and new materials or hypersonic missiles. However, none of them will probably have as wide range influence on the ground forces warfighting, as introduction of autonomous systems.

One of the specific characters of autonomy for defence is that the military autonomous systems technologies are based largely on civil technology development. This element will also change traditional settings of technical power balance where military super-powers such as the United State, Russia, United Kingdom, or Germany may have the visible technological advantage. Proliferation of Artificial Intelligence (AI) in civil society and its transitions to military structures, either into state actors as well as into non-state actors, cannot be controlled or denied. The basic technology exists but work on conceptualisation is still focused on fundamental aspects.

The introduction of SAF into capabilities can be divided into two major streams - technical and conceptual. Leaving the technological stream aside, all countries interested in effects of autonomous systems on warfighting struggle to envision and understand it. It might be argued that autonomous systems may provoke the next Revolution of Military Affairs[1]? Could the potential change be as radical that we will call it in future "*robocalypses*" [2]?

A number of other disruptive technologies, which existed for military forces previously, may have not initiated an immediate conceptual change. For different reasons, an innovation, in a meaning to use new technology in disruptive way, conceptually and doctrinally, has often remained pending, even for decades. [3] Today, extremely rapid technology development has also forced research institutions and operational community to understand, how SAF will change the way we accomplish our tactical, operational and strategic goals in future in comparison of our current concepts and doctrines.

It is challenging to understand potential changes. First, we are not sufficiently aware of the development of disruptive technologies and we do not understand complex impacts. For example, in order to challenge military thinking vis-à-vis future challenges, several countries have called upon Science Fiction writers to help the military to see outside of “traditional military box” (as for example United State Marine Corps[5], French Ministry of Defence[6] or Switzerland’s Defence Forces[7]). There are number of known and unknown unknowns to be discovered and analysed.

It is also necessary to take into account potential adversarial attempts to bring autonomous combat systems to the battlefield. Even though these systems may not yet have much AI integrated, the fact is that the purpose is to develop their autonomous capabilities to have a desired effect on the ground. [8] An example is the Russian development of autonomous ground systems and willingness to test them in operations even though the prototypes still lack necessary level of technological maturity[9]. These tests, for example, were seen in unmanned combat ground system Uran experimentation in Syria. Even they failed in tests, they gained experience in deploying these systems and collected valuable information to better understand operational opportunities.

2.0 SCOPE

This current paper is based on research which has an aim to better understand what kind of impacts autonomous combat systems will have on warfighting and how smaller forces could benefit and exploit autonomous systems *vis-à-vis* larger and symmetrically stronger adversary.

The research includes variety of potential autonomous combat systems, including lethal weaponry and different combinations of functionalities and systems, for example UAV-s. Importance of ethical, moral and juridical aspects is considered, but so called “grey areas”[10] in using autonomous systems are not excluded.

The future time perspective of the research looks 10-15 years ahead and is an attempt to project potential future technology to the battlefield. Exact technology forecasting is impossible in given timeframe, but increasing number of technologies, especially what comes to the weapon systems, sensors and platforms are partially available already today. What is most challenging is to predict how AI component will act to fulfil given missions and how it provides for systems ability to operate collectively.

In order to better understand the current and near future trends, subject matter experts from industry and academia evaluated present status and development trends of key technologies of autonomous systems (see Figure 1). There are several approaches to define key technologies for UGV, depending on purpose of the model. The one used in study[11], conducted by USA National Research Council’s Committee of Army Unmanned Ground Vehicle Technology is more generic and takes into account all key technologies providing to an UGV its operational and technical capabilities. [12] The model designed for current study is focused only on key technologies which are essential for UGVas unmanned ground combat system and which might have its proper specific nature once integrated to the UGV.

Following approach to technology development trends was used to design models of combat systems with autonomous function for further data collection. In the situation where it is not possible to evaluate enough precisely the development of defined key technologies, or describe future complex systems in technical details, this model provide an opportunity for military subject matter experts to understand overall capabilities and limitations of the autonomous systems and develop descriptions of potential operational impacts.

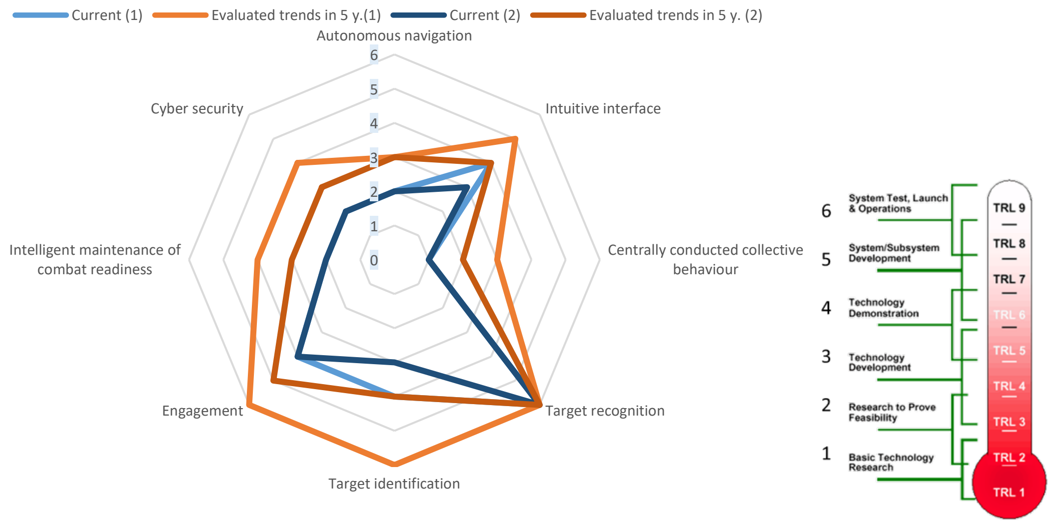

Figure 1: Technology development trends of autonomous ground systems.

The evaluation of technology trends indicates the most important deficits of technology for ground combat will be in the domains of navigation, swarming and combat readiness. Recent interviews and workshops revealed these considerations while keeping focus on realistic operational impacts.

Another aspect, which influences the evaluation of operational impact, is the level of autonomy we will designate to the systems in future. Popular “man in-, on-, or out of the loop”-approach is not appropriate classification to describe even currently existing technology because it is too simplified and does not reflect combinations of different autonomy levels.

3.0 CHARACTERISTICS OF SMALL FORCES

This study looks at the opportunities the autonomous systems could potentially provide for small forces. For that purposes, I have defined small forces having following characteristics:

- it’s adversary has larger conventional forces in terms of personnel, material and armament,
- it’s basic operational concept is based on defence in the well-known environment,
- it is lighter, having less fire power and protection than its adversary, ,
- it might be based on reserve forces (conscription during peace-time),
- it has shorter chain of command and more independence/responsibility delegated to lower command levels (extended mission command).

4.0 NATURE OF *AUTONOMISATION*

It is still unclear, how autonomous systems will change our way to fight. We do not know, how employment of autonomous systems will influence the input[13] to the capability development. How many men we can replace in our military structures? What kind of maintenance will new systems require? It is still to be discovered what is the output[14] of the employment of these systems. Does the tempo of operations increase remarkably? How will SAF increase readiness and deployability?

The first one who is able to integrate autonomous systems into operations, is most probably the one who has the advantage and unique knowledge of using them. Once we take into account the proliferation of unmanned systems, with increasing number autonomous functions, the power imbalance between classical military powers and smaller state and non-state actors will be probably be redefined. This is because smaller players can turn some of qualities of their nature, namely smallness and flexibility to advantages in applications of autonomous systems. The challenge with autonomy is not only and primarily the technology development, but also ability to execute rapid experimentation, adaptation and redesign of structures and doctrines.

To have an advantage over the adversary does not often require long leaps ahead of him, regarding technology, doctrines or relative strengths. Advantage is ability for “picking up low hanging fruits”: being a step ahead could be enough to gain the initiative and going faster and influencing the OODA-loop[15]. The speed of technology development, proliferation and permanent development of good-enough-new-solutions provides an opportunity for faster implementers. Of course, an army cannot be in permanent status of adaptation of never-ending introduction of new technical solutions. The bigger the system is, the harder it is to digest permanent change. Nevertheless, any armed forces will need to be sharp and understand new emerging opportunities.

Autonomous ground systems are environment-sensible. Other than in the air, the different natural or man-made type of terrains are extremely complicated environments for any system to operate autonomously. This is currently th biggest obstacle for larger employment of autonomous ground systems. The urban environment might prove easier for ground forces to use autonomous navigation by its more structured nature and thus may be easier for a machine to analyse and understand.

Another characteristic of autonomous systems is that they are and will be in permanent self-development. The challenge is that we often do not understand the development of AI, it’s still a “black box”. We do not fully understand of the future of its self-learning based development and we cannot anticipate comprehensively its behaviour. We are not able to fully understand its good or bad decisions regarding our expectations.

5.0 OPERATIONAL SHORTFALLS AND CONTEXT FOR AUTONOMOUS SYSTEMS

This section describes the operational shortfalls and which characterize Small Forces and are potentially areas to look for solutions for improvement provided by SAF. For classification purposes, all shortfalls are presented in generic manner. In addition, these characteristics cannot be directly applied on any specific existing forces. Nevertheless, as overall trends the description below provides relevant bases for further evaluation of preliminary impact of SAF. The Figure 2 illustrates the weaknesses in generic manner.

Less arms, thus less firepower leaves small forces into position where they lack strength for direct engagement with enemy. In addition to that, the level of protection of mobile systems (combat and other vehicles) is remarkably limited. Which, in combination with weak firepower limits remarkably their ability to conduct manoeuvers and use mobility for advantage. Instead of mobile tactics, they often rely on static means as fortifications and mine warfare. Lacking of freedom of movement reduces the potential for taking an advantage of their relative suppleness.

Small Forces have normally fewer high readiness forces and their principal fighting strength is based on low readiness forces from reserve. This makes timing crucial and top-most priority of different decision-making situations to increase readiness and mobilise forces.

With limited forces, the Small Force has normally significant gaps in controlling and influencing necessary battlespace and formations can be spread in large area without possibility to control space between fighting positions. At the same time, the areas of operations/responsibility of its units are remarkably large. This results large areas of empty space what blue force is not able to control and influence.

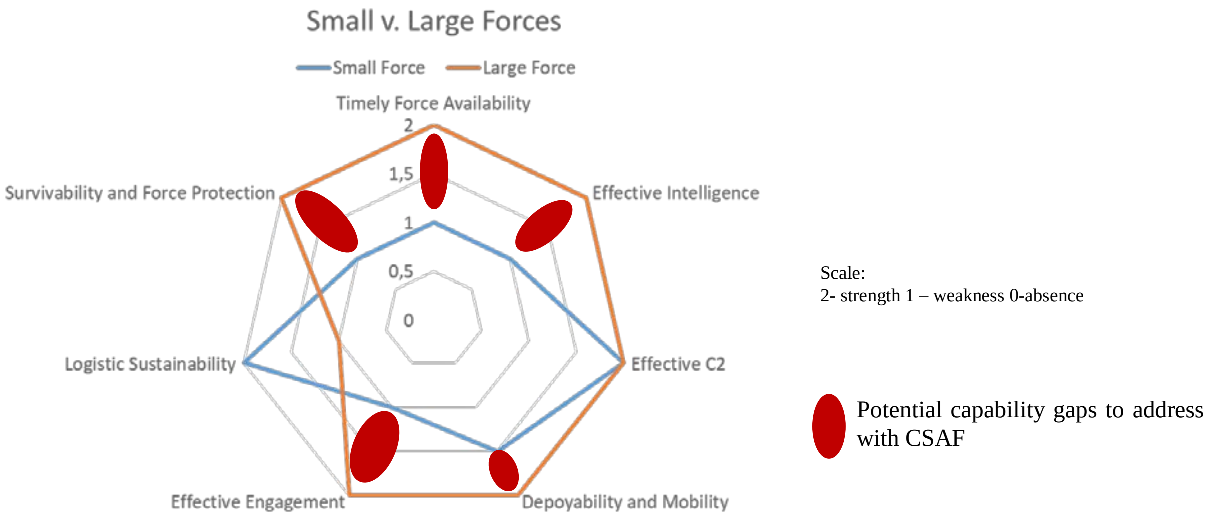

Figure 2: Capability comparison of small versus large forces.

6.0 PRELIMINARY OBSERVATIONS

Following preliminary outcomes, as presented in generic illustration on Figure 3, are results of expert interviews[16], field experiments[17], table-top enabled workshops[18] [19] and other analyses[20] about utilisation of combat systems with autonomous functions. [21]

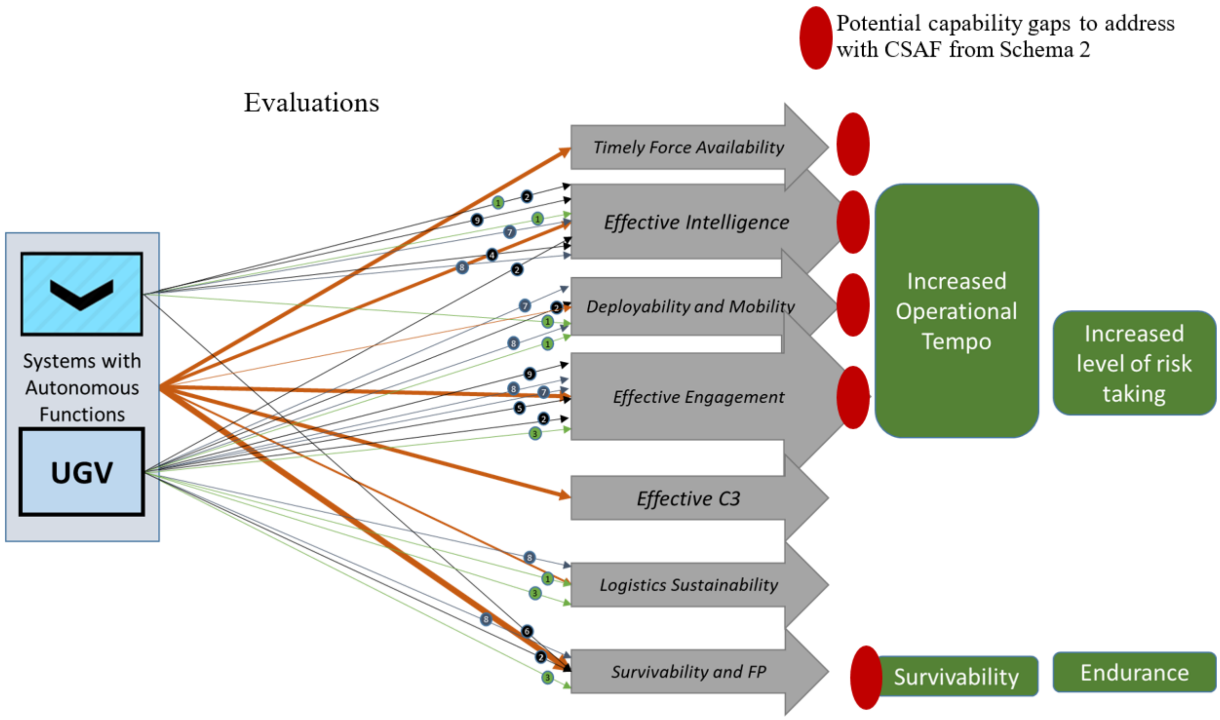

Figure 3: Overview of preliminary outcomes about operational impact of systems with autonomous functions on light infantry capabilities.

The base system for Unmanned Ground System (UGS) was medium[22] size unmanned ground vehicle (UGV), able to operate in different roles and with different sensor- and weapon systems. [23]

For supporting air systems, Unmanned Aerial Systems (UAS), a light mostly rotary wing UAV's are taken into consideration to operations of UGVs or co-operate in combination with UGV-s ISTAR.

For limited purpose and scope, this paper does not include different risks of employment of autonomous systems.

Current preliminary outcomes require further testing and analysing, but they describe already trends to understand the operational impact. The focus has been to understand, what is new conceptual approach the autonomy brings to the operations and what are potentially fundamental changes. There are number of cases where autonomous systems are available to reinforce current doctrines and concepts and it is often challenging to recognise "new" in comparison with "better".

Timely available forces - In order to stand up its principal military forces, the small forces have to execute mobilisation of personnel and formation of units, which is time consuming and reduces readiness. Autonomous systems could be an option to address this shortfall. They could be deployed as force multipliers to reinforce rapid reaction units and act in some cases as first responders.

Deployment of autonomous systems as first responders could decrease also threshold to set up first defensive postures. Mobilizing men-heavy units is more visible and thus might be politically sensitive in some situations.

Effective intelligence - UGVs are able to provide permanently situational awareness in their area of responsibility depending on sensor solutions. Via SAF, the mobile sensors can be dispersed in larger area than with manned systems and the endurance of employment exceeds manned options or unmanned aerial systems, depending on specific energy solution and consumption. Integrated systems of UGS and UAV-s provide data from areas which where permanently or partially out of the reach of ISR[24].

Effective C3 - Effective C3 is the most challenging and less understood capability area when autonomous systems (or systems of systems) are integrated into combat capabilities. For that reason, it is the less evaluated domain during the data collection of the study to facilitate discussions of other capability areas. Effective C3 is a key capability, but we do not fully understand the future behaviour of combat SAF in order to project new approaches to the C3 effects. We do know that the amount of data (about adversary, environment and own capabilities) will increase and there will be a requirement for interfaces to design the data into information to support military decision-making. Manned-unmanned teaming requires changes in planning and tasking; the opportunity to task machines as men (or vice versa) is still far ahead of us even though simple civil applications do exist and will be surely introduced in short term also to communicate with combat SAF.

Deployability and Mobility – SAF have potentially a double effect on the battlefield. The first is to enhance troops' existing capabilities and increase effectiveness in engagement, increase operational endurance and facilitate movement. The ability to move heavy weapon systems (machine guns, missiles, rapid mining devices), ammunition and other heavy weight equipment in unmanned and autonomous manner with troops while other transport means are not available provides opportunities to be more active, reactive and dynamic. It provides potential to create new tactical-operational approaches to achieve desired end state.

Another opportunity the combat SAF will provide is to survey, control and influence in areas without deploying men at all. It is easier to imply it in easier-to-understand-environments as urban areas.

SAF assets provide an opportunity to project firepower and sensors with less air-transport resources. [25]

Effective Engagement – The possibility to engage fully unmanned "units" or increased number of heavy weapons for dismounted light infantry unit diminish one of the most critical capability gaps. Heavy machine guns and anti-tank weapons, carried by unmanned systems and operated through man-machine teaming do provide compensation for lacking of regular combat vehicles. Flexibility, speed, rapid concentration and regrouping of heavy assets balance lack of heavy armour. Unmanned systems lack of fighting fatigue – proper limit for human – provides opportunity to keep high tempo to engage enemy and shape thus traditionally negative operational power-balance in regards of smaller forces to opposite direction. SAF provides also opportunity to engage enemy outside of the "manned" range, leveraging military presence to the extent otherwise not possible without autonomous systems. Better situational awareness makes engagement also more optimal and economic. Possibilities to take higher risks without putting man in danger enables new tactics; for example, engagements behind the enemy lines or making deep strikes between its formations.

Logistic Sustainability – Having unmanned Casualty Evacuation (CASEVAC) capability and delivery of supply classes, especially classes I, IV and V increases light infantry troops sustainability and increase their effectiveness. The troops is able to stay longer in necessary conditions to operate.

Survivability and Force Protection – Survivability and force protection is one of the key domains the combat SAF will have remarkable impact. The opportunity to replace manned systems with unmanned systems in situations of high risk will increase light infantry potential to survive against larger and more capable adversary. Combat SAF, if they are not meant to carry personnel (versions of Armoured Personnel Carrier (APC-s), but having unmanned capabilities), are smaller targets than usual platforms (APC, Infantry Fighting Vehicles (IFV)) to carry heavy weaponry and will have increased level of survivability even though their level of protection could be rather minimal. SAF provides also rapid decentralisation and centralisation of means reducing thus the effect of adversary's direct or indirect fire effects.

Previously described changes in light infantry essential capabilities offers a potential to have more capable and effective units to respond the challenges the small forces do have when facing larger and symmetrically stronger forces. Combat systems, which have autonomous functions seems to provide for light infantry troops possibilities to address their relative strengths as suppleness, short chain of command, readiness to use unusual tactics and routine to operate in concealed manner. In parallel, it reduces their existing shortfalls in capabilities such lack of firepower, lack of protection, static tactics, forced by previous shortfalls.

Through increased capabilities to manoeuver and having effects on enemy, the SAF equipped light infantry troops may be able to increase their operational tempo and avoid traditional static defensive posture. Mobile weaponised systems and ability to sustain troops without charging more personnel provides opportunity to better influence also on adversary's OODA-loop. Breaking the loop through flexible manoeuvring, precise engagement and unpredictable initiatives increases light infantry ability to counter otherwise stronger adversary.

Another new element combat SAF will most likely provide is an opportunity to plug-and-play with different systems. Traditional manned troops with the weaponry and equipment are fixed systems and rarely change their arms and equipment. All changes need time and could normally not executed on the battlefield. Contrary to that, autonomous systems and systems of systems, depending on basic platforms and core systems, could be modular thus giving an opportunity to design forces to respond the best way given mission. That means that there is possibility to a certain extent to tailor troops, even in low tactical level, to correspond operational challenges in the best way.

7.0 CONCLUSIONS

Employment of SAF will have influence on small forces capabilities throughout all spectrum of essential operational capabilities. The entire impact is complex and its different *sub-impacts* are in correlation to each other. Combat SAF as a system will introduce a number of new qualities to the battlefield. The careful evaluation of these impacts require considerations to keep results reasonable and feasible. In parallel, the evaluation has to be enterprising, even adventuresome, to be able to discover *unknown unknowns*.

New capabilities bring automatically countermeasures either by existing or new capabilities. For limitation of this article, the risks and possible countermeasures where outside of the focus but will remain as one of the key elements in the complexity of the combat SAF. Even though in considerations of larger vs. smaller forces this aspect is not taken into account at that phase of larger study, the adversary's counteractions are and will be an important part of continuing research. Not leaving aside the possibility, that the adversary could have initiative to field the combat SAF first.

Current results show that there is high potential for small forces to use these systems for their advantage. Small forces, vis-à-vis large forces, are in weak positions in many domains – for example, in firepower, manoeuvrability, protection. At the same time, there are potential strengths of smaller forces – like flexibility, shorter chain of command, concealed way to operate – which could be in benefit when using SAF. The preliminary results showed the potency the SAF could offer for small forces. Understandably, it is challenging – in doctrine, in resource allocation and cultural-wise – to be first to understand and then implement something nobody has experienced so far. However, that could be window of opportunity for small forces to become game-changer.

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[2] A term used by Paul Sharre, "Army of None: Autonomous Weapons and the Future of War", W. W. Norton & Company, 2018

[3] Adamsky, Dima, "The Culture of Military Innovation", Stanford University Press, California, 2010, p. 3-6

[4] Like Russian Unmanned Ground Systems Uran, Soratnik, Nerekhta, Virkh, Prokhod etc.

[5] https://www.c4isrnet.com/it-networks/2017/01/11/marines-study-sci-fi-to-plan-for-future-battlefield-needs/ as of 10.10.2019

[6] https://www.horizonspublics.fr/etat/emmanuel-chiva-la-science-fiction-va-nous-aider-nous-projeter-dans-le-futur as of 10.10.2019

[7] CH-2020. Future Soldier, Armasuisse Science and Technology, Thun, 2019

[8] Russia has deployed in Syria several unmanned ground systems for operational experimentation. https://www.c4isrnet.com/unmanned/2018/05/07/russia-confirms-its-armed-robot-tank-was-in-syria/

[9] https://nationalinterest.org/blog/buzz/russias-uran-9-robot-tank-went-war-syria-it-didnt-go-very-well-40677 as of 12.09.2019

[10] The term „grey area" is used for autonomous systems' use cases, where there is not yet clarity of how it respond to the international law of armed conflict or what are requirements for system to respond to this law. The purpose of including this perspective is to understand potential utilisation of autonomous systems and it does not reflect any attempt to question viability of current legislation.

[11] National Research Council 2002. Technology Development for Army Unmanned Ground Vehicles. Washington, DC: The National Academies Press.

[12] Ibis, p. 4-8. In this study, the list of key technologies consists Perception, Navigation, Planning, Behaviours and skills, Learning/adaptation, Human–robot interaction, Mobility, Communications, Power/energy, Health maintenance.

[13] Input as domains, which form up and design a capability. Author uses domains of DOTMILPFI (Doctrine, Organization, Training, Material, Infrastructure, Leadership, Personnel, Facilities, Interoperability).

[14] Output as operational capabilities as effects, in this study the 7 Essential Operational Capabilities: Timely Force Availability, Effective Intelligence, Effective C3 (Command, Control, Computers), Deployability and mobility, Effective engagement, Logistic Sustainability, Survivability and force protection.

[15] Observe-Orientate-Decide-Act

[16] Interviews conducted in July 2019, recordings of interviews at the custody of the author. Three expert interviews, officers with experience from company to battalion level leadership and tasks.

[17] Field experiments, conducted by Centre for Applied Research, National Defence Academy, Estonia, from May 2018 until May 2019, Report of Phase I, Project “Unmanned systems on the battlefield”, Academy of Defence Forces, Tartu, 2019 05.11.2019 nr KVA-0.7-1.1/19/42524

[18] Table-top enabled workshop conducted in Baltic Defence College in the framework of the Higher Command Study Course, sessions of Military Technology and Innovation on May 2019. Sixty participants, from captain to major. Worksop results at the custody of the author.

[19] Workshop conducted with the representatives of industry (six experts, two having military industry background and four military background from platoon-company level leadership and tasks) on September 2019, results at the custody of the author.

[20] Analyses about potential utilisation of unmanned/autonomous systems for Defence Development Plan 2021-2030, Estonian Defence Forces, dated 17.09.2019. Interviews and expert opinions from senior-officers from Headquarters of Estonian Defence Forces.

[21] As expected, is rather challenging to get persons who did participate in interviews, providing their expert opinions and participating in table-top enabled workshops out of their current doctrinal thinking. Easier way to evaluate new technology’s impact is just to add the new technology to the current tactical technical procedures and conceptual thinking in order to reinforce it. More challenging is to try to understand, how our current modus operandi changes when new technology is available. Considerations for changing structures are one of the most demanding ones and structures influence the deployment of forces.

[22] Systems from one to ten tonnes.

[23] Like ground SAF with Anti-tank missiles, 50 Cal heavy machine gun, mules, Casualty Evacuation (CASEVAC), Intelligence, Surveillance, Target Acquisition, Reconnaissance (ISTAR) etc.

[24] Intelligence, Surveillance, Reconnaissance.

[25] Squad Mission Equipment Transport (SMET)Lessons Learned for Industry, Power Point presentation, Annotated Version of Briefing at NDIA Ground Robotics Capability Conference, 02.03.2016