TECHNOLOGICAL DEVELOPMENT 2018

THE IMPLICATIONS FOR THE CAPABILITIES OF THE ARMED FORCES OF THE CZECH REPUBLIC

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INTRODUCTION

The aim of the analytical study is to evaluate the trends of technological development and their implications for the armed forces of the Czech Republic. The goal of the Centre for Security and Military Strategic Studies, University of Defence in Brno (CBVSS) is to provide an alternative view of the debate on the implications of the technological development for formulating and implementation of effective defence policy of the Czech Republic and the building of its armed forces. The paper should serve as an initial evaluation of the problem in question and provide basis for further research. The study is based on the analysis and comparison of open primary and secondary sources that are related to the nature of the current trends of technological development and its applicable examples. In terms of time, it is focused on the trends that may affect armed forces directly, taking into account, in particular, the events of 2017. The verification of the outputs has been carried out in the context of expert meetings with the participation of the Ministry of Defence of the Czech Republic, the armed forces of the Czech Republic and the representatives of the security community.

THE INCREASING IMPORTANCE OF THE 'NEW' STRATEGIC DOMAINS

In addition to traditional dimensions of strategic thinking and waging war (armed conflict) - the land, sea and air spaces, there is an increasing importance of the outer space and cyberspace.

The outer space

Based on the general level of technological development of mankind, which would allow not only short-term and economic bridging of vast distances between planets but also the pursuit of a permanent settlement, for instance, for the purpose of exploitation of natural resources, it is not feasible to propose conflicts comparable (using a certain degree of analogy) to fighting for the dominance over the shipping routes or overseas colonies. On the other hand, since the inception of the US-Soviet rivalry, individual states have 'recognised' further implications of this aspect. Any point on the surface of the Earth is directly accessible from its orbit, irrespective of the rugged topography, altitude or remoteness (not only from the rest of the 'civilisation', but also the mainland itself). Therefore, having relevant capacities in the outer space may have a crucial role in the ability of the various actors to project their power and their military strength on a global scale. This issue was highlighted, inter alia, in the *National Security Space Strategy* of the US in 2011, with the preparations of its amendment currently under way. The representatives of China, Russia and the United States of America, i.e., the leading states that focus on the development of their military programs and projects manifesting the current revolution in the military sphere, agree that the outer space plays a key role for the establishment of the military revolution (transformation).[1]

[1] Cf., e.g., NEARY, Michael. Space: The Next Revolution in Military Affairs? Journal of International Service. 2008, 18(1), 101-123.

In terms of the outer space, this claim is supported, among others, by the development of space policies of virtually all major actors of the international system (US, Russia, China, France, India, Iran, Israel, Japan, UK, etc.). In similar terms, the competition for the first place in reaching Mars with the human crew is sometimes referred to as the 'new space race', in an analogy to the US-Soviet rivalry in this area during the Cold War. The contribution of the outer space can be primarily seen in its location and practical size, or rather infinity. It represents the space in which, in addition to the Earth, other planets, stars, etc. are situated. In terms of security, it is not currently (so) important for individual actors in the international environment to overcome it and reach other astronomical objects.

In general, the potential offered by the open space and respective technologies can be divided into two groups - civilian and military - while the dividing criterion is the nature (purpose) of the activities or actual artificial bodies (satellites, etc.), operated or located in the outer space. The civilian group includes, for example, the establishment and use of satellite networks for monitoring weather or transmission of broadcasting signals, etc. The military group includes, e.g., spy satellite networks, satellite navigation for combat units or weapon platforms for intercepting ballistic missiles, etc. In accordance with the stated definition, we cannot exclude the so-called anti-satellite weapons (ASAT), which may be located on the surface of the Earth (e.g., systems used by the US, Russia, China), but their use is directly aimed at the outer space.

At the same time, it is necessary to state that the boundary between the two categories is very unclear and elements of both groups often overlap, thus, in practice they are often difficult to distinguish. We are faced with the phenomenon of the 'dual-use' (dual purpose) of the respective technologies or activities. The satellite navigation network may be used, for example, not only to determine the position of a civilian object, but also for the coordination of battlegroups or guidance of missiles or UASs (with reference to the American GPS or different types of services that will be provided through the newly built Galileo navigation system).

The outer space is becoming increasingly important for the ability to project (military) power of the state and plays a role in the field of providing national security. Its use is very closely connected with the phenomenon called dual-use, blurring the boundaries between civilian and military sectors.

Cyberspace

The growth of the strategic importance of the cyberspace is directly connected to the development of information technologies and their present use practically in all areas of human life. The interconnection of almost all the surface of the planet through an information network allows any actor (state or non-state) almost immediate and unhindered access to vast amounts of data and their subsequent processing and use for their own needs. The information, or 'raw' data, in this sense has gradually become a strategic raw material available both for building positions in this dimension and influencing the functioning of the real environment. From the point of view of state and non-state actors, ensuring stable access to this domain is effectively the primary prerequisite for effective pursuit of their own interests. In the event

of an (armed) conflict, the ability to deny access to the adversary represents an important tool for achieving the set objectives.[2]

An important element is the development of the so-called Internet of Things (IoTs), which not only offers much more effective use of the advantages associated with complex information connections (e.g., to ensure monitoring and decision-making in real time), but also deepens the overall dependence on a stable and effective operation of this area. Providing security at the present time, especially in terms of the critical information infrastructure, must necessarily take this trend into account, especially with regard to the large number of the items in question subject to the so-called botnets that perform targeted attacks against information systems of respective state or non-state actors (such as Mirai botnet[3] in 2016, Reaper botnet[4] in 2017, etc.).

Along with the increase of the interconnection of mankind in this area, there is also an increase in the numbers of networks that are created and used based on the principle of distribution, i.e., without having a central control or management 'node'. The resulting form of this trend is the increase in the significance of the so-called 'deep web', or, more specifically, 'dark web' and 'darknet'.[5] In particular, the dark web/darknet is directly associated with criminal activities across all areas (from illegal acquisition of information through trafficking in arms, drugs of abuse or people). In addition to the organised crime, similar means and possibilities are used by terrorist organisations and, in principle, the states themselves. In fact, there is a further weakening of state power, which is also linked to the conflict between the protection of national interests (as broadly understood) on the one hand and the usability of such networks on the other hand.

The interconnection of all areas of human society with the cyberspace further increases the mutual interdependence in terms of availability of information as such. The Internet allows an increase in the transparency of almost any activities in real environment. In particular, social media, such as Facebook, Twitter, YouTube, etc., allow almost constant supervision and monitoring of the activities of individual subjects. At the same time, they serve as an ideal instrument and a platform for implementing information operations by both state and non-state actors.

Information technologies are currently connected to all areas of human life. The Internet of Things is also gaining importance, which is connected with its abuse for implementing large DDoS attacks against state and non-state actors. At the same time, the state power becomes further weakened through illegal activities in the dark web/darknet. Social media/networks may be attractive from the point of view of information operations (spreading disinformation, etc.).

[2] Cf., e.g., NATO. Strategic Foresight Analyses. 2017.
[3] ANTONAKIS, Manos et al. Understanding the Mirai Botnet [online]. 2017. Available on: https://goo.gl/XkBp4T
[4] GOODIN, Dan. Assessing the Threat the Reaper Botnet Poses to the Internet – What We Know Now [online]. ArsTechnica, 2017. Available on: https://goo.gl/M1HjLz
[5] For a more detailed explanation of the terms, see, e.g., SUI, Daniel – CAVERLEE, James – RUDESILL, Dakota. The Deep Web and Darknet: A Look Inside the Internet's Massive Black Box [online]. Wilson Center, 2015. Available on: https://bit.ly/2FgxKW8

THE DEVELOPMENT AND SPREADING OF REMOTE CONTROL, AND AUTONOMOUS SYSTEMS

The armed forces of more than sixty countries of the world are using unmanned aerial systems (UAS) nowadays - for reconnaissance, survey or monitoring purposes. The number of states which employ offensive UASs is also gradually growing. It can be assumed that this general trend, i.e., the growing number of states which operate UASs of various categories, will only intensify. At the same time, it is possible to identify the increasing numbers of UASs of various types as well as expanding the range of tasks which they are used for, especially by the major superpowers of the international system. This trend can be well demonstrated by the example of the United States, whose armed forces had only two types of UAS in operation in 2000.[6]Today, they are at least eleven.[7] Since the period of Obama administrations, it has been possible to identify the ongoing trend of their intense use for attacking members of terrorist organisations (so-called targeted killings),[8] when lower acquisition and operational costs as well as the absence of direct threat to human 'crew' (operators) are given priority over the piloted aircrafts. Similarly, the Russian Federation has been intensively developing the projects of combat unmanned aircrafts, currently at the stage of testing individual prototypes (e.g., Altius-M).[9]

The numbers and variability of unmanned ground systems (UGS) used by the armed forces of individual countries are much lower compared to the UASs. Their role is often in the sector of disposal of booby traps and unexploded ammunition, handling of hazardous substances or short-distance reconnaissance (e.g., in urban areas). The Israeli military uses these resources (Guardium project) also for guarding activities in the border areas and for the protection of bases. In addition to the sensors to detect the enemy (intruder), the vehicles also carry weapon systems based on lethal or non-lethal principle.[10] In similar terms, the remotely controlled modification of the latest Russian armoured vehicles, based on the Armata platform, should be at the stage of development as well as individual projects in the US under the auspices of DARPA, which are directly linked to the needs/requirements embedded in the so-called Third Offset Strategy.[11]

In connection with the operation of the individual resources, significant attention is paid to the development of the capacities that would allow simultaneous deployment of a large number of different types of the respective (weapons) systems. In particular, in association with the UASs, this approach is associated with the ability to control the so-called swarms, i.e., high numbers of (small) items that would allow

[6] Office of the Secretary of Defense. Unmanned Aircraft Systems Roadmap: 2005-2030 [online], p. 3. Washington, D.C., 2005. Available on: https://goo.gl/RBfrij
[7] SICARD, Sarah. 11 Military Drone Names, Ranked [online]. Task & Purpose, 2017. Available on: https://goo.gl/Z3ExN7
[8] PURKISS, Jessica. - SERLE, Jack. Obama's covert drone war in numbers: ten times more strikes than Bush. The Bureau of Investigative Journalism, 2017. Available on: https://goo.gl/cfsqnU
[9] 9 DEAGEL.COM. Altius-M. 2017. Available on: https://goo.gl/2KEUJB
[10] ARMY-TECHNOLOGY.COM. AvantGuard Unmanned Groud Combat Vehicle, Israel [online]. 2016. Available on: https://goo.gl/knZqWb
[11] LOUTH, John – MOELLING, Christian. Technological Innovation: The US Third Offset Strategy and the Future Transatlantic Defense [online]. Armament Industry European Research Group, 2016. Available on: https://goo.gl/pvEHAc

congesting the (air) defence of the adversary. Intensive testing of these technologies takes place, for instance, in China, which is currently recognised as one of the leading countries.[12] Such use is foreseen for the implementation of individual tasks (including, e.g., destruction of targets) as well as in support of other units, or aircraft with human crew. In practice this means the development and strengthening of the functional ties between individual vehicles/systems in order to obtain the synergetic effect.

Compared to remotely controlled systems, the autonomous systems require no or only minimal involvement of the human operator. Individual systems should be able not only to obtain information about the environment but also to process (evaluate) this information and take appropriate decisions on their own. The motivation to establish those systems is directly based on their increased effectiveness in combat. Similar to remotely controlled systems, the idea of minimising the human losses on the part of the operator's own armed forces plays the key role.[13]

AI based systems also remove limits resulting from human physiology (such as the need for sleep, impact of fatigue or the influence of stress). On the other hand, serious questions arise that were previously attributable to the sci-fi literature, i.e., what degree of autonomy should be given to such systems and whether taking a decision on the killing of human beings made purely by these systems is acceptable from the ethical point of view.

This aspect is increasingly being discussed across the professional community and becomes the motivation for the efforts to establish and enforce a control system at the international level (e.g., under the auspices of the UN).[14] On the other hand, it is necessary to point out critically that based on the historical experience (e.g. with cluster munition, landmines, etc.), such a process would be at least problematic.

Certain elements of these technologies can be already identified, e.g., the Guardium vehicles able to operate in a fully automated (autonomous) mode.[15] These elements are also used by UASs during long flights, where the human operator takes over the control only in the destination of the mission, or by air defence systems (such as the Phalanx close-in weapons system).[16]

The development of unmanned as well as autonomous systems generally attracts significant attention. The armament of individual states includes especially reconnaissance UASs, however, based on the ongoing projects of combat UASs or UGSs, gradual expansion of this sector can be expected. Especially, the ability to deploy and control large numbers, in particular, of UASs is considered. The development of autonomous systems is directly dependent on the level of development of the elements of AI. At the same time, there is an intense debate

[12] Cf., e.g., TATE, Andrew. China launches record-breaking UAV swarm. Jane's 360, 2017. Available on: https://goo.gl/WCHry6

[13] Among others, STOJAR, Richard. Bezpilotní prostředky a problematika jejich nasazení v soudobých konfliktech. Obrana a strategie 2016 16(2) Available on: https://googl/dYJsZ2

[14] E.g., Autonomous Weapons: An Open Letter from AI & Robotics Researchers [online]. Future of Life Institute, 2017. Available on: https://goo.gl/X2N6CA

[15] ARMY-TECHNOLOGY.COM, ref. 10.

[16] 6 RAYTHEON. Phalanx Close-in Weapon System: Last Line of Defense for Air, Land and Sea [online]. Available on: https://goo.gl/Ky3RD1

over the moral/ethical aspects of the use of (not only) this type of technology for military purposes.

THE DEVELOPMENT OF THE HUMAN-MACHINE INTERFACE

Apart from the above described trend of 'robotisation of the battlefield', there are also ongoing projects aimed to achieve a more efficient interconnection of the human operator with the machine component. This should generally facilitate increasing the efficiency of the human potential, whether in relation to controlling other systems or skills/activities of the individual alone.

In the first case, it is possible to identify the effort to provide all the information from the sensors to the human operator in real time, the elimination of the delay between the response of the human and the controlled system, and at the same time to ensure the execution of various commands as if the human was the respective system on their own. It is the direction of the development and testing of sensor and control elements of the American F-35 fifth generation jet fighter that should, for example, transmit a comprehensive picture from six infrared cameras into the pilot's helmet and provide information about the entire surrounding scene and the position of the opponent.[17] This area is very closely linked with technologies allowing the use of augmented or entirely virtual reality and, if possible, full involvement of the individual in interaction therein.

Again, the importance of information technologies and cyberspace is accented as beneficial not only in the above described (combat) activities, but also for the planning of combat operations and training of troops. The development of virtual reality actually allows very faithful simulation, in this case, of combat situations and environments, in which the unit will operate, including the possible behaviour of the opponent.

In terms of the second topic (an increase in the performance of skills/activities of the human), in particular, the projects which aim to create robotic combat suits (called exoskeletons) should not be overlooked. The benefits can be seen not only in the increase in strength, endurance or speed of the individual (soldier) equipped with this device, but also in the improved protection, e.g., against hostile fire. Hydraulic systems, among other features, increase load bearing capacity and facilitate the handling of the 'armour' (if analogy to medieval fighting can be applied), which human individuals would not be able to carry, move, etc. on their own.

The current stage of development can be demonstrated with initial tests of exoskeletons developed by Lockheed Martin or Raytheon, not only taking over the weight of the mounted armament and equipment from the individual, possibly allowing them to handle much heavier loads, but also increasing the speed

[17] 7 LOCKHEAD MARTIN CORPORATION. The F-35 Helmet: Unprecedented Situational Awareness [online]. 2016. Available on: https://goo.gl/MD6gDK

of movement and distances to be covered.[18] A functional model of 'armour' has not been presented so far, even if it can be expected that this situation will change in the course of the coming years.

Apart from the exoskeleton projects, there are also projects addressing the technologies that are directly connected with the human organism and become its (integral) component. This concerns especially robotic limb prostheses, which can/could compensate, almost perfectly, for the respective types of (combat) injuries, or perhaps even vision or hearing substitutions.

On the other hand, the potential of these technologies cannot be limited to these situations and it can be very well assumed that along with the progress in the areas of cybernetics, neurobiology, etc., it will still 'more lucrative' to increase human capacities through various muscle, sensory, etc. implants or even substituting a healthy body part or extremity in order to achieve the above-described benefits.

The development of the human-machine interface is closely tied to the aspects of information technology. First of all, it concerns a more effective control of other systems - e.g. UASs - and the development of elements of augmented and virtual reality. The second topic is the increase of the capacities of human individuals through their 'reinforcement'. In addition to the development of exoskeletons, this includes also the possibilities of substituting individual parts of the human body - not only in the case when it is necessary to compensate for the consequences of (devastating) injuries.

THE DEVELOPMENT OF ENERGY TECHNOLOGIES

The development of energy technologies to allow not only obtaining a stable and efficient energy supply, especially as an alternative to fossil fuels, but also for the weaponisation and dedicated use in weapons systems, has also gradually become a principal trend. The first category is directly linked to the requirements, e.g., of the above-mentioned robotic exoskeletons whose use is currently significantly limited (in performance or time) mainly by this aspect. Especially the attempt to find effective replacements for fossil fuels is motivated in this sense (aside from the general approach of state and non-state actors to the issue of climate change) by the need to have mobile or easily transportable energy sources and to decentralise the production itself.[19] It also includes the rationale of limiting the dependence on external actors and increasing self-sufficiency.

Weaponisation of energy technologies can be divided into three main categories based on the form of their use, both with lethal and non-lethal effect. These are directed energy weapons (DEW), weapons using energy pulses (electromagnetic radiation) and electromagnetic weapons. In general, the development takes place in all of these

[18] E.g. ARMY-TECHNOLOGY.COM. Raytheon XOS 2 Exoskeleton, Second-Generation Robotics Suit, United States of America [online]. 2016. Available on: https://goo.gl/p9VcB2; MARINOV, Bobby. 19 Military Exoskeletons into 5 Categories [online]. 2016. Available on: https://goo.gl/6wW1q9

[19] Cf., e.g., FUTURE ASSESSMENT DIVISION. Notes from the Edge: Insights into Evolving Future, pp. 1–2. 2017.

categories, with the first and second categories involving the potential to replace 'traditional' small arms. The EMP category, on the other hand, is aimed against the electronic systems of the opponent in order to achieve their neutralisation/destruction. The principal attention is paid to the development of non-nuclear resources that could be deployed without the need to escalate the conflict, as implied by the nuclear weapons.

DEW and electromagnetic weapons are currently undergoing development especially under projects related to air and sea fighting or as alternatives to the elements of missile defence. An example is the deployment of the Israeli air defence system called Iron Beam[20] or completing the railgun tests by the US, with prospective testing on a dedicated vessel.[21] This orientation has been called for by the limits associated with obtaining an efficient source of energy and its use for executing required tasks (destruction of a vessel, missile in flight, etc.). In this respect, the usability for small arms is significantly limited, as the energy requirements do not provide higher efficiency compared to 'traditional' weapons (due to weight, mobility, destructive effect, etc.).

However, we cannot exclude the usability of these technologies in the non-lethal form, i.e., such means that would 'only' temporarily paralyse or neutralise the opponent. Its advantage is in generally minimising the losses of life among the civilian population; this becomes relevant especially for fighting in urban areas or executing tasks not directly related to the combat activities (such as public order enforcement).[22]

The development of energy technologies is aimed at finding/obtaining alternative sources of energy as well as their weaponisation and use in weapons systems. It is possible to identify three basic areas of weaponisation - weapons using directly emitted energy, weapons using energy pulses (especially the electromagnetic radiation) and electromagnetic weapons. DEW and electromagnetic weapons are currently undergoing development especially under projects related to air and sea fighting or missile defence. The fundamental limit is in obtaining a stable and efficient energy source that would fulfil the performance or mobility demands at the same time.

ADDITIVE MANUFACTURING

Additive manufacturing (especially the '3D printing') is a very quickly developing sector of industry. For example, in the US approximately two thirds of producers use 3D printing in one of the stages of development and production.[23] Universal expansion and use of this method of production is expected to happen in the next ten years. However, it already provides a very flexible and, in comparison with the traditional

[20] RAFAEL. Iron Beam [online]. Available on: https://goo.gl/NGYa6N
[21] OSBORN, Kris. U.S. Navy Rail Gun to Test Rapid Fire and Move Closer to Combat [online]. The National Interest, 2017. Available on: https://bit.ly/2FlGFFE
[22] In more detail, e.g., ARTICLE36. Directed Energy Weapons [online]. Discussion paper for the Convention on Certain Conventional Weapons, 2017. Available on: https://goo.gl/fiV7AW
[23] 3 NATO STO Sensors & Electronics Technology (SET) Panel. Flexible Displays Technology Watch Card. 2016.

way of production, also relatively easy method to create, e.g., spare parts for the weapons systems, thus reducing storage and transport capacity requirements. Although the example shows the importance for the segment of logistics, the actual usability has a much wider field of projection for the armed forces or production of the required (weapons) systems. [24]

Nanotechnologies represent a qualitative shift in the additive manufacturing in this context. This is an area that fundamentally affects the development not only of energy technologies, but also, for example, robotic technologies. The ability to create and control the structure of individual materials and objects at the level of one billionth of a meter brings along new opportunities both for durability and protection of the armed forces (e.g., in the form of active masking) and for the neutralisation of the opponent.[25]

The additive production allows very flexible production of almost any item, which is closely connected with a considerable potential for streamlining the logistics as well as other sectors. In this respect, nanotechnologies represent a qualitative shift based on the ability to create and influence the structure of individual materials and objects at the level of one billionth of a meter.

THE IMPLICATIONS FOR THE ARMED FORCES OF THE CZECH REPUBLIC

The pace of development of the above-mentioned as well as other technological areas is very difficult to predict. On the other hand, at least the already known projects have already had relatively significant military implications, which should not be overlooked by the armed forces of the Czech Republic. Of course, it cannot be expected that we would be able to focus on the complex set of capabilities, as it is in the case of major world powers - especially the US. It is nevertheless necessary to prevent the neglecting even of those areas which may seem irrelevant and distant with respect to the goals and possibilities, in particular, of the Army of the Czech Republic, as the tools for the pursuit of national interests. The impact on the armed forces of the Czech Republic will be evaluated using the main capability areas (MCA), defined by the methodology of NATO.[26] For each trend, areas of capability are defined that are directly affected by the respective development (for summary, see the final table).

The growing importance of the **outer space** as an operational dimension places new demands for the area of *Prepare/Train* of the armed forces to take into account the specificities of this domain. Although the approach to this dimension may look 'exotic' at first sight and distant to the objectives and capabilities, in particular, of the Army of the Czech Republic, the wider contexts of both the European Union and NATO should not be ignored. It is the membership in these institutions that represents the potential for gaining access to the various types of space systems (navigation,

[24] BAKER, Berenice. Made to Measure: The Next Generation of Military 3D Printing [online]. Army-Technology.com, 2018. Available on: https://goo.gl/jFKaRY
[25] In more detail, e.g., WONG, Wilson W. S. Emerging Military Technologies: A Guide to the Issues. Oxford: Praeger, 2013.
[26] 6 MC 400/3, MC Guidance for Military Implementation of Alliance Strategy. 2012.

communication or monitoring ones) and their use for the development of the respective skills. With regard to the nature of the Czech Republic, or its armed forces, respectively, attention should focus especially on the projects supporting the areas of *Project, Consult, Command and Control* (C3), *Protect*, and *Inform*.

As the fifth operating dimension, **cyberspace** also places higher demands on *training and preparation*, both in order to maximise the benefits and, at least, mitigate the negative impact of dependence on the corresponding technologies. Their importance for the AF CR can be further identified in the areas of *Project, Engage, C3, Protect,* and *Inform*. The development of capabilities in these areas will be associated with the systems for processing large amounts of data and also systems supporting operational changes in the level of centralisation and decentralisation of command and control.

At the same time, especially in the context of the *Protect* area, increased emphasis should be placed on providing cyber defence and security. This recommendation should be applied not only to the now traditional platforms, but to the area of the Internet of Things as well. Based on the experience, e.g., from the US, it can be reasonably assumed that this equipment will be used in the near future not only as the targets of cyber-attacks, but also as the means for their execution. Even the armed forces of a small country, such as the Czech Republic, should provide the A2/AD capabilities to allow a stable use of this environment, while denying access to the adversary.

The development of remote control, and autonomous systems will primarily affect the areas of *Prepare/Train* and *Protect*, not only in terms of their use but also the ability to respond to their deployment by the adversary (regardless of their nature). Based on the nature of the AF CR, it is necessary to point out the potential of swarms of UASs for the areas of *Project, Engage, Sustain,* and *Inform*; these could compensate for the size of the armed forces and cover a broad range of tasks (from reconnaissance to direct confrontation with the opponent). On the other hand, it is clearly essential to answer the above-mentioned legal and ethical issues associated with the use, in particular, of autonomous systems, in an ideal case still before their prospective acquisitions. The trends in the development of the **interconnection of the human and machine** allow for increased efficiency of training programs in the *Prepare/Train* area using augmented and virtual reality, thus creating conditions closely simulating the real combat deployment for the preparation of members of the AF CR. Similar implications arise also for the areas of *C3* and *Inform*, among others by creating a comprehensive picture of the battlefield and its mediation to concerned entities. More efficient control of other systems – such as UASs – and improved qualities of a human by exoskeletons or limb prostheses and organ transplants present a significant potential for the areas of *Project, Engage, Protect*, while especially the former category (system control) further supports the development of the trend mentioned previously.

In terms of **energy technologies**, especially the development of (new) alternative energy sources can be considered relevant for the AF CR at present. In the areas of *Project, Engage, Sustain, Protect,* they directly reflect the general efforts for securing self-sufficiency and independence of the armed forces, not only during their deployment. At the same time, there is a reduction of the so-called battlefield trace, i.e., the burden placed on logistics, for instance, which further contributes to more

effective use of (financial and other) resources. In the *Protect* area it is also necessary to point out the threat of use of the electromagnetic pulse by the adversary. In this respect, it is necessary to secure resilience of individual systems and prepare the reserves (back-up) for the event of their neutralisation, similar to the reaction to large-scale cyber-attacks.

The development of **additive manufacturing**, just like the previously introduced trends in the area of alternative sources of energy, reflects the efforts to secure self-sufficiency and independence of the armed forces not only in the time of deployment. The Army of the Czech Republic may benefit from the lower demands exercised on logistics or projection of forces using '3D print' (*Project, Sustain* capability areas). In the long term, there is a visible importance of miniaturisation through nanotechnology; this has impact especially on the further development of the trends of remotely controlled/autonomous systems, human-machine interface and energy technologies (under the areas of *Engage, Protect*).

Collectively, we should not ignore the need to ensure the mutual compatibility of the introduced systems (also outside the framework of cyberspace), not only with the NATO/EU allies, in particular, but also across different generations of the respective systems. The benefits that are associated with the ability to centralise and decentralise the structure of command and control flexibly and establish mutual connections among individual parts of the armed forces can be obtained in this respect only if the above described prerequisite is fulfilled. At the same time, interoperability also increases the strength of the entire structure (robustness, redundancy) and boosts efficiency of each of its elements.

With the unclear boundaries between the military and civilian dimensions, we can assume that Army of the Czech Republic (mainly in terms of the foreign operations) will be confronted with the use of, for instance, unmanned aircraft by a non-state actor. In this respect, it is clearly desirable to allocate resources to projects which focus on complex defence against such systems and possibly also assess whether, e.g., the current training also takes into consideration such a possibility. It can be also anticipated that this trend will affect the nature of suppliers, not only domestic, but also foreign ones. This, however, leads to a certain dependence on these entities, which may have negative features, such as the threat of espionage or unavailability of services in the event of discordant interests of the armed forces, or the Czech Republic in general, respectively, and such entities.

The impact of technological trends on the main capability areas of the Armed Forces of the Czech Republic

Trends/MCA	The outer space	Cyberspace	The development of remote control, and autonomous systems	Human-machine interface	Energy technologies	Additive manufacturing
Prepare/Train	X	X	X	X		
Project	X	X	X	X	X	X
Engage		X	X	X	X	X
C3	X	X		X		
Sustain			X		X	X
Protect	X	X	X	X	X	X
Inform	X	X	X	X		

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