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URBAN WARFARE

Report

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II. INTRODUCTION

1. Urbanisation is one of the most prevalent global trends of the 21st century. Already today an estimated 55% of the world's population live in urban areas. According to the 2016 United Nations World Cities report, two-thirds of the global population will live in cities by 2050 (Konaev and Spencer, 2018). By 2030, there will be 41 megacities (cities with more than 10 million inhabitants), mainly in poorly developed or developing countries. The increasing trend of urbanisation is most tangible in developing countries which often do not have the resources to develop the infrastructure and services necessary to match this increase. As a result, socio-economic inequalities will rise, as will the risks of instability and conflict with city centres and residential neighbourhoods becoming battlefields (ICRC, May 2017). Already today, more than half of the world's violent armed conflicts are taking place in cities, affecting some 50 million people (ICRC, June 2017).

2. The continuing instability on NATO's southern and south-eastern flanks and the trend towards urbanisation make it likely that the urban environment will be a relevant factor in many future conflicts involving NATO forces. Therefore, the ability to conduct urban operations will be indispensable. In the recent past, cities such as Mosul, Aleppo, Sana'a, or Donetsk have been subjected to sieges, air and artillery strikes, and violent street fighting. NATO forces have already been involved in urban combat in Iraq, Afghanistan, and other places and provided support to partner countries in urban combat operations. Moreover, major cities in Europe, Africa, and Asia have recently been targets of terrorist groups. These developments have raised awareness in Allied capitals for the need to prepare NATO forces for urban combat.

3. The situation is likely to continue as population growth, climate change and competition over natural resources, and sectarian and religious tensions will alter the international security environment and certainly challenge NATO Allies. In recognition of this general trend and their experience, NATO Allies, and NATO as an organisation, have begun to focus attention and resources on urban warfare and on building capabilities to facilitate urban missions.

4. This report provides a short, general overview of the threats that NATO forces are likely to face in urban warfare and how technology can help NATO Allies meet these challenges. As such, the report focuses on technological trends that will, or already do, have an impact on urban combat operations. The focus of the rapporteur is on implications for NATO Allies and NATO as an organisation, on the promises that emerging technologies will provide as well as the challenges these technologies are likely to pose for NATO forces.

III. SPECIFICS OF URBAN WARFARE

5. Urban warfare is defined as the conduct of military operations in cities (Spencer, 2019). Depending on the strategic objectives pursued, urban operations can take different forms, ranging from high-intensity conventional warfare to low-intensity combat, counterinsurgency, stabilisation, or humanitarian aid operations. The transitions between different stages of urban conflict can be very fluid and dynamic; actions of criminal paramilitary groups can very easily and quickly escalate into urban combat operations as demonstrated by the militarised fight against drug cartels in Mexico or the eruption of violent protests in Iraq.

6. Combat operations in urban areas are primarily defined by three factors: physical terrain, population, and infrastructure. Generally speaking, the physical terrain and infrastructure pose significant problems for movement and manoeuvres, the use of force, intelligence, and communications. The most important challenge in urban combat operations, however, is the presence of civilians. Conventional armed forces operating in urban areas are constrained by

human, legal, and military considerations relating to the presence of civilians at the heart of combat zones.

7. Urban warfare is not a new phenomenon. Since the beginning of warfare, the control of cities has always been of high strategic and psychological relevance. Cities are centres of a country's political, economic, technological, and cultural life; they are also hubs of a country's transport and communication networks. The concentration of critical infrastructure and the high population density increase risk of collateral damage and make urban combat extremely destructive. Damaging or destroying a city's essential infrastructure, like electric grids, water facilities, power supplies, hospitals, and sewers, affect the civilian population and can have disastrous consequences. Because of the density of the infrastructure and the interconnectedness of services damaged or destroyed, urban infrastructure has a massive and immediate impact on large numbers of people. In contrast to the population in rural areas, city dwellers are more vulnerable to disruptions in essential services as they cannot resort to alternatives to cope with their lost access to basic services (water wells, farmland, fishing, etc.) (Konaev, March 2019). By spreading disease or generating a high number of homeless and displaced people, the collateral damage can cause even greater harm than the combat operations themselves (ICRC, May 2017). The conduct of combat operations in cities therefore has profound consequences for a country as a whole. The destruction of a city in the course of combat will cause a disruption of trade and flows with perhaps regional and global consequences.

8. Dense urban areas are about the most complex operating environment for military forces. Urban terrain impedes situational awareness and degrades command and control (C2). Operations in urban areas also make manoeuvring, the movement of large troop formations, and heavy equipment difficult. Urban warfare, therefore, is high-intensity warfare which requires the command of small, flexible units. The difficult terrain, narrow streets, lack of open spaces, and high-rise buildings expose soldiers to ambushes and makes the evacuation of wounded more difficult. The features of urban terrains can vary with each presenting specific challenges regarding size, landscape, infrastructure, population, and other characteristics.

9. Urban combat favours the defender. Even armed forces which are technologically, materially, and numerically inferior compared to their opponents can take advantage of the urban environment. The complexity of the urban terrain makes detection, identification, selection, and prioritisation of legitimate military targets difficult (Konaev and Spencer, 2018). Urban infrastructure, such as roads, bridges, power stations, or waterworks can be used by enemy forces for military purpose and the city's residents could, willingly or not, provide cover to enemy forces. This complicates the differentiation between combatants and non-combatants (Konaev, March 2019). The high population density in cities increases the risk of killings and injuries among the civilian population. Seventy per cent of civilian deaths in the conflicts in Syria and Iraq occurred in cities (Keck, 2017). The proximity of civilians to military operations complicates military planning and targeting (ICRC, May 2017). These factors and the application of restrictive rules of engagement (ROE) are likely to strain the ability of NATO forces to operate effectively in hostile urban environments. Using modern technology can help NATO forces to achieve and maintain an advantage on such complex battlefields. In this context, your rapporteur wants to highlight the need to limit access to certain key technologies for potential NATO adversaries as stated in the 2017 report of the Science and Technology Committee by Thomas Marino (United States).

10. The main characteristics of urban warfare remain unchanged. Combat in urban areas is manpower and resource-intensive; it is a highly violent, decentralised type of combat conducted by relatively small units where infantry needs to cooperate closely with armoured vehicles and air power. This environment poses considerable challenges, particularly because NATO military forces, although generally agile and lethal as well as sophisticated technologically, are relatively small in size while cities are increasingly large and complex. Yet, while the challenges of urban warfare

generally remain the same, technological advances have led to an evolution of urban warfare (Konaev and Spencer, 2018).

IV. URBAN WARFARE – AND THE PRESENCE OF THE POPULATION

11. The NATO Strategic Foresight Analysis has identified urbanisation as a key security challenge that can have a significant impact on NATO (Bodnar and Collins, 2019). As stated above, the most important challenge in urban combat operations, however, is the presence of civilians.

12. Urban operations are complex and challenging, they are not only purely military but multifaceted as they need to take a city's economic, social, and other characteristics into account. Successful urban operations require specific strategies and training, and adapted weapons and equipment. Preparations for operations in dense urban areas must not only include training to fight in cities, but also to better understand a city's "flow". Flow is the interaction of people, and the flow, or exchange, of resources and information both inside a city as well as between a city and its surroundings. This flow is similar to the nervous system of a living organism. It is both physical, i.e. linked to the existing infrastructure network of a city like streets, canals, or train tracks, as well as non-physical. Effectively operating in an urban environment requires comprehension of how a city functions, i.e. how all flows of information, goods, people, energy, waste, and commerce into and out of the city shape the interaction between the various parts of the population with their formal and informal governance structures and actors. Some urban experts believe a city's social infrastructure is more important than its physical infrastructure (EIDib, 2018).

A. INTERNATIONAL HUMANITARIAN LAW

13. As an Alliance of nations that share the same values, NATO has always ranked adherence to International Humanitarian Law (IHL), which regulates the conduct of war, as top of its priorities in its combat operations. IHL requires respecting the principles of distinction, proportionality, and precaution. According to IHL, conflict parties are required to take precautionary measures to protect civilians, including doing everything possible to verify that targets are military objectives, and taking all feasible precautions in the choice of means and methods of warfare. The protection of the civilian population and avoiding collateral damage in urban combat areas has therefore been of crucial importance for NATO forces in the development of its urban operations framework.

14. In Afghanistan, for example, NATO's International Security Assistance Force (ISAF) adopted policies that restricted the use of certain air-delivered weapons, refined its collateral damage estimation methodology, and emphasised training to reduce civilian casualties. As a result, the number of civilian casualties attributed to ISAF operations decreased by almost 75% by the end of the ISAF mission in 2014 (Konaev, March 2019). The lessons learnt by ISAF were also integrated into a NATO Training Directive and civilian casualty prevention and mitigation training (Muhammedaly, 2016).

15. The Alliance has been adapting its policies and frameworks to protect civilians, prevent conflict-related sexual and gender-based violence during military operations, and provide a safe and secure environment for its forces and the populations in the areas of operations. Among others, NATO has integrated gender perspectives in its policies, public statements, and military strategy. At the Warsaw Summit in July 2016, NATO leaders endorsed the NATO Policy for the Protection of Civilians. The policy includes all efforts to avoid, minimise, and mitigate the negative effects that might arise from NATO military operations (NATO, 2016). This commitment also includes a pledge by NATO to facilitate access to basic needs for the civilian population and, if possible, to provide support to civilians in case of emergencies. NATO commanders on the ground are also required to limit the use of artillery, heavy weaponry, and airstrikes to avoid civilian casualties in densely

populated urban terrains. In December 2019, NATO formally reaffirmed its pledge to commit to the rules and principles of IHL. However, abiding by IHL is not only a goal in itself. The conduct in urban combat will have important implications for the credibility of a military force. Engaging with the civilian population will be a fundamental necessity and potential avenue of opportunities to enhance operational effectiveness.

16. In numerous armed conflicts on NATO's southern and south-eastern borders, civilians are deliberately attacked, displaced, starved, injured, and killed, and essential civilian infrastructure is damaged and destroyed (Konaev, March 2019). These conflicts generate further instability and refugee flows which impact the security of NATO Allies and Partners. For example, humanitarian agencies have repeatedly accused Russia of deliberate targeting of civilian objects such as schools, hospitals, and residential districts, or the use of sieges and the denial of relief efforts and aid in Syria and eastern Ukraine, leading to millions of internally displaced persons and refugees in NATO and Partner nations. Noting the mass exodus from Syria's urban battle zones, NATO's Supreme Allied Commander Europe has directly accused Moscow of "weaponising migration" through its deliberate use of imprecise weapons (Konaev, March 2019).

17. Having recognised the increasing likelihood of their forces being drawn into urban combat, NATO Strategic Foresight Analysis has been conducting research on the implications of urbanisation for NATO military operations since 2014. This research resulted in two NATO Conceptual Studies on Urbanisation; the first one was presented in April 2016 and an updated version of the study, which included the findings of a wargame conducted at the NATO Defense College, was presented to the Military Committee in March 2017 (Bodnar and Collins, 2019). In the same year, in 2017, the Science and Technology Board (STB) of NATO's Science and Technology Organisation (STO) decided to develop Operations in Congested Urban Environments (OCUE) to identify critical technologies that can deliver solutions for key military requirements. Based on these studies, the Military Committee tasked Allied Command Transformation (ACT) and Allied Command Operations (ACO) to produce an overarching Capstone Concept for "Joint Military Operations in an Urban Environment". The Capstone Concept was presented in November 2018 and approved by the Military Committee and the North Atlantic Council in 2019. It basically identifies the relevant factors, forces, and interactions that shape and influence urban combat operations and assesses the necessary future capabilities, tactics, and strategies that NATO needs to develop the conduct of urban operations successfully.

B. THE NEED FOR TRAINING AND EXERCISES

18. While emerging information and weapons technologies will play an important role in conducting future urban combat operations effectively, the most efficient way to limit casualties among their own forces and the civilian population is via training and exercise. NATO forces have conducted a range of urban operations in recent years and it is obviously important to evaluate and apply the lessons learned from past urban combat operations and to incorporate these into the institutions of NATO.

19. Reflecting the general recognition of the importance of training for urban operations, individual Allies have slowly started modifying their doctrines, training, material, leadership, and facilities according to the urban terrain (Konaev and Spencer, 2018). For example, the French Armed Forces have built the *Centre d'entraînement aux actions en zone urbaine* (CENZUB) to train their infantry for combat in urban environments. CENZUB is an essential part of Anglo-French military cooperation. In 2016, the U.S. Marine Corps participated in intense urban combat training hosted by French Army Centre for Urban Combat Training at Camp Sissonne, France.

20. To that end, NATO Allies need to expand existing urban warfare training facilities and tactical training systems to enable their armed forces to better familiarise themselves with the particularities of urban warfare. NATO's Military Committee considers that urban scenarios should be included in NATO Major Joint Exercises within the Military Training and Exercise Programme (NATO, March

2019). Moreover, exchange of expertise in the form of joint training and/or workshops with Partner Nations which possess recent first-hand experience in urban combat is worthwhile to pursue.

C. THE CHALLENGE OF SOCIAL MEDIA

21. Technological superiority enables information superiority over adversaries, that is, the ability to influence and control the flow of information going into and out of the operations area. Attaining information superiority and asserting control over the information environment is all the more critical in urban warfare, as it allows the state's force to cut off local hostile forces from their strategic leadership, prevent them from disseminating their message and from communicating with the city's civilian population and the outside world, shape public opinion in their favour and win the "battle of narratives" (Konaev, March 2019).

22. Public perception of the use of force is ever more important in the age of the internet. The use of force must be considered not only through military and legal compliance lenses but also through the lens of the enemy's potential to manipulate the public's perception of this very use of force. An adversary may manipulate that perception to its advantage and the detriment of NATO. Therefore, success in future urban operations will largely depend on the ability to maintain control of the information and cyber domains and on close cooperation with non-combat actors such as local governments and security forces as well as NGOs and the like. The presence of the media in urban conflict zones and the ubiquitous, internet-enabled access to social media effectively reduce the ability of government forces to control the information environment and shape public opinion.

23. Today, all conflict parties make use of social media like Facebook, Twitter, and YouTube to promulgate their version of events. Social media has become a new battlefield for the "war of narratives" (Konaev, March 2019). Armed non-state groups have proven highly capable in using social media for recruitment, propaganda, as well as to organise and coordinate combat operations. The proliferation of cell phone technology and unprecedented internet-enabled interconnectedness have seriously heightened this threat. According to estimates, social media has helped Daesh to recruit at least 30,000 foreign fighters from nearly 100 countries to the urban battlefields of Syria and Iraq (Konaev, March 2019).

24. Social networks have profoundly altered the way unconventional armed groups organise, mobilise, associate, and communicate (Konaev, March 2019). These tools provide armed groups with secure communication networks to share information, instructions, and to recruit civilians. Terror groups have already used communications technology and social media to organise and implement their operations. During the 2008 Mumbai attacks, members of the Pakistani terrorist group Lashkar-e-Taiba and their commanders in Pakistan used Skype, cell phones, and satellite phones for their communication. Because the Indian forces were unable to cut off adversary communications and separate the attackers in Mumbai from their command and control node in Karachi, these raiders managed to withstand the early loss of their team leader and evade Indian police and counterterrorism units. The Lashkar-e-Taiba terrorists were able to besiege one of the world's largest cities with attacks on civilians and public places for almost three days (Konaev, March 2019).

V. URBAN WARFARE – IMPLICATIONS OF TECHNOLOGICAL CHANGE

25. As stated above, three factors, the physical terrain, the presence of the population, and dense infrastructure are major challenges for the effective conduct of operations in an urban environment. Weapons development and technology has always played an important role in combat, including in densely populated areas. For example, Unmanned Aerial Vehicles (UAVs) and sensor technology have vastly expanded the quantity and the quality of battlefield information that is available to troops on the ground. As technology advances, it seems likely that it will play an even greater role for urban

operations in the future. The main areas where emerging technologies can help NATO forces mitigate the problems caused by the terrain, infrastructure, the presence of civilians, and improve their effectiveness in urban warfare are: Intelligence, surveillance, and reconnaissance (ISR); Force protection; Protection of the civilian population and limitation of collateral damage; Command and Control.

A. INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE (ISR)

26. Obtaining and maintaining situational awareness in a chaotic and rapidly changing urban environment is crucially important for the effective conduct of joint military operations. Sensors, which encompass an enormous range of technologies and devices, such as radar, acoustic, thermal, optics, seismic, and magnetic play a crucial role in achieving situational awareness. For example, wall-penetrating radar technology allows soldiers to see through walls and determine potential threats (South, 2019). Acoustic sensors can detect projectiles such as rounds fired from guns, rockets, and cannons (Vergun, 2015). The use of unattended ground sensors vastly increases ISR capabilities of NATO forces and limits adversaries' opportunities for cover and concealment (Keller, 2017). Low-cost, covert, and manoeuvrable micro- and nano-drones can be used for reconnaissance and surveillance. Wearable sensor technology can provide accurate location and navigation data and allow for uninterrupted communication between troops and unmanned aerial vehicles in areas where GPS signals are weak or absent (Konaev, March 2019).

27. The efficiency of sensors will be dramatically increased by the Internet of Things (IoT). For example, IoT can vastly improve battlefield situational awareness of forward-based soldiers by using small-sized, low-cost sensing and communications devices (Konaev, March 2019).

28. The U.S. Army is promoting IoT technology with its Nett Warrior integrated dismounted situational awareness and mission command system, and the Force XXI Battle Command Brigade and Below communication platform (Konaev, March 2019).

29. Unmanned Aerial Vehicles (UAVs) have been in use with military forces for many years already. They are being used for a broad range of purposes, including for conducting reconnaissance of urban areas where they play an important role. Drones have also been instrumental in counterterrorism and counterinsurgency operations. In Ukraine, drones have allowed Ukrainian forces and the OSCE Special Monitoring Mission to Ukraine to corroborate claims that Russia is actively supporting the illegally armed militants in the east of the country. Drones play a central role in precision targeting, which reduces collateral damage. Larger drones are currently limited by their radar observability, but stealth technology is set to change that. Small drones can provide battlespace awareness and target development. Drones are also part and parcel of DARPA's Urban Reconnaissance through Supervised Autonomy (URSA) project. URSA would allow to rapidly distinguish between civilians and combatants in urban environments (Russell, 2020). The drones deliver warning signals to any humans they encounter and forward information on the human's response, along with video and location data, to military staff which will decide how to respond to the situation. The URSA project is remarkable insofar as it has been accompanied by advisors on ethical questions from the start (Glass, 2019).

30. Moreover, swarms, i.e. large numbers of simple, low cost, expendable systems that are interconnected, can change how militaries fight. Drone swarms are large groups of drones flying and operating as a single unit and capable of autonomously altering their behaviour based on communication with one another (Kallenborn and Bleek, 2019). Communication allows the swarm to adjust behaviour in response to real-time information. Drones equipped with cameras and other sensors can identify potential threats or targets and relay that information to the rest of the swarm. The swarm may then manoeuvre to avoid the threat or attack the target with an armed drone. (Kallenborn and Bleek, 2019).

31. A number of Allies have been researching swarm technology. The United States pursues several projects which evaluate the military utility of using swarming Robotic and Autonomous Systems (RAS) to conduct urban reconnaissance in a manned/unmanned Advanced Teaming relationship. For example, in 2017 the U.S. Department of Defense conducted a test of a micro-drone swarm in California consisting of 103 drones collaborating in decision-making, adaptive formation flying, and self-healing. Moreover, DARPA has been working on a programme dubbed “Gremlins” which consists of micro-drones designed to be dropped from planes and perform reconnaissance over vast areas. The UK Ministry of Defence plans to deploy “swarm squadrons” in the coming years (BBC, 2019).

32. The use of drone swarms will improve situational awareness as they increase the coverage, persistence, and duration of ISR missions. For example, since 2016, DARPA has been developing tactical concepts in the OFFSET programme (OFFensive Swarm-Enabled Tactics), which are tested in computer simulations with up to 250 autonomous aerial and ground systems. However, because drone swarms are dependent on drone-to-drone communication, they are particularly vulnerable to electronic countermeasures and cyberattacks.

33. Augmented reality (AR) and virtual reality are other areas of consumer technology harnessed by the armed forces. AR headsets have long been deployed in the helmets of jet fighters but have not yet been incorporated into the equipment of ground forces, except for Special Operations Forces. That could soon change, however, as devices such as the ARC4 headset of Applied Research Associates allows sending location and tactical information to soldiers via a heads-up display. Rather than looking down at a 2D map or smartphone device, the user sees virtual icons overlaid on their real-world view. Thus, tactical augmented reality (TAR) improves situational awareness by allowing soldiers to locate their own and fellow soldiers’ positions, as well as enemy combatants without GPS and night vision goggles.

34. Anonymity, the ability to hide among civilians, is a key protective factor for hostile individuals and non-state actors, including terrorists or foreign fighters according to the NATO Strategic Concept and the 2014 Wales Summit Declaration. The use of biometrics can take away this anonymity. Biometrics is defined as the “automated recognition of individuals based on their behavioural and biological characteristics” (Lunan, 2018). Biometrics can be employed to support intelligence and threat identification. Characteristics that can be collected are topography – face, finger, and hand; structure – iris, DNA, and hand-vein; dynamics – handwriting, voice and keystroke, as well as gait. (Lunan, 2018).

35. The NATO Communications and Information Agency (NCIA) has been tasked with the development of a NATO Automated Biometrics Identification System (NABIS) under the Defence Against Terrorism Programme of Work (DAT POW) (NATO, 2014). Allied leaders endorsed a new biometric data policy to enhance threat identification in 2018 (NATO, 2018). NABIS allows to store biometric data and facilitate multiple-mode biometrics searches and to share these data among Allies in a controlled environment. This provides actionable intelligence and improves situational awareness at the strategic and operational levels. A Biometrics Enabled Watch List (BEWL) enables NATO commanders to provide specific guidance to operational and tactical forces on how to address specific individuals.

36. Military operations in an urban environment are particularly dynamic as combat can radically alter the terrain as buildings can collapse, or streets become impassable. Information that was accurate hours or even minutes ago can become irrelevant in a split second. AI applications will increase the accuracy and prioritisation of real-time, actionable ISR information, thereby improving decision making on all levels of the urban battlefield. As urban combat operations involve many small military units that need to coordinate their actions amongst each other and with armoured forces,

close air support, and other enablers such as engineers, AI can dramatically improve the effectiveness of command and control.

B. FORCE PROTECTION

37. Precision weapons: the widespread use of artillery, mortars, rockets, grenades, and other explosive weapons in urban warfare is a key factor for the high number of casualties among the civilian population (ICRC, May 2017). Advancing weapon accuracy can mitigate the risk to civilians and avoid or at least reduce the destruction of critical infrastructure in urban warfare. In addition, precision fire and targeting will also enhance combat effectiveness. NATO has further developed the Air-to-Ground Precision Guided Munition (PGM) project, which is a missile, bomb, or artillery shell equipped with a guidance system enabling increased accuracy (NATO, June 2019).

38. Several NATO Allies are investing in technological advances in ordnance, such as loitering munitions and weapons that can identify targets through artificial intelligence.

39. The U.S. Defence Advanced Research Projects Agency (DARPA) is researching self-guided bullets that “follow” and strike a moving target. DARPA is also working on the development of smart bombs which can guide themselves towards their targets by using sensors and cameras. Military forces are also increasingly using civilian technology to bolster urban combat effectiveness. For example, mobile devices like smartphones are being used for target acquisition or for urban combat training.

40. Loitering munition, first introduced by the Israel Defence Forces in the 1980s, has already been in use for years (Gao, 2019). As sensor technology continues to improve and drones become smaller, loitering munition will become increasingly important in urban warfare. Smaller loitering munition can be launched by soldiers on the ground and their low radar, visual, and thermal signatures make them difficult to track and defeat. These munitions are cheaper than missiles fired from drones and more accurate than radar-guided artillery. Moreover, as these weapons are already “loitering”, they have a faster response time than weapons which have to be launched.

41. The use of robotic systems is an effective way to improve force protection and to increase operational effectiveness. Robotic systems are already being used for many different tasks, including to search tunnels, caves, and buildings for enemy fighters and explosives (NATO, 2015). Moreover, robotic systems are particularly well suited for surveillance functions as their endurance exceeds that of human beings on sentry positions.

42. Israel and Russia already have obtained considerable battlefield experience with their Unmanned Ground Vehicles (UGVs). Israel’s Carmel Armoured Combat Vehicle is particularly suited for urban combat; the system integrates advanced artificial intelligence and autonomous capabilities to enhance mission effectiveness for the Israel Defence Forces (IDF) (Egozi, 2019). Russia has tested and employed a range of UGVs in Syria, including the Uran-6, a mine-clearing robot, and the Uran-9, a remotely controlled reconnaissance and fire support vehicle. Although the programmes encountered a number of shortcomings, such as low-level autonomy and low-level automation of C2, Russia has drawn valuable experience from their use (Bendett, 2018).

43. Past experience in places like Fallujah, Baghdad, or Mogadishu has shown that the casualty rate among soldiers in urban operations is very high, primarily due to IEDs, mines, and sniper fire. Unmanned vehicles can reduce such casualties during dangerous reconnaissance missions and patrols in hostile urban terrain. The U.S. Army is doing research on robotic combat vehicles that can “scout” and “escort” for its next-generation Infantry Fighting Vehicle (IFV) to prevent ambushes and protect the flank (Konaev, October 2019).

44. While autonomous systems have been limited in their application thus far as they depend on various levels of direct human control, the availability of digital data and advances in AI applications will soon allow for the production of autonomous ground vehicles which will vastly improve survivability and resilience of ground troops in an urban theatre. Similar trends can be expected for autonomous air and sea vehicles. As advances in the development of commercial self-driving cars have made sensors both much cheaper and better, several Allies are already researching robotic vehicles which could be used for ground supply and medical evacuation, which are both dangerous and resource-intensive.

45. Robotic systems can be used to provide faster casualty recovery and extraction from the battlefield. UAS are being tested that can bring telemedicine and other equipment to medics in the field and conduct casualty evacuation (CASEVAC) (NATO, 2015). As part of its Automated Ground Resupply (AGR) programme, the U.S. Army is testing autonomous trucks that will move in a “leader-follower” formation with manned vehicles in the lead that, with software improvements, should be able to navigate around obstacles and pull trailers (Konaev, October 2019).

46. Advances in technology are likely to make Improvised Explosive Devices (IEDs) more lethal and easier to use and conceal. As soldiers in urban combat zones are increasingly at risk from bullets, shrapnel, and improvised explosive devices, NATO Allies are investing in the development of innovative body armour to protect soldiers. In addition to providing a maximum of protection against bullets and fragment projectiles, current research into body armour focuses on reducing weight and increasing mobility.

47. Several research projects are being conducted that promise to produce a new generation of body armour that can protect soldiers better than currently available systems. One of the projects focuses on the development of liquid body armour based on sheer thickening fluids (STF). STF is made up of a liquid, polyethylene glycol, and hard silica particles. When an STF-soaked vest is impacted by a bullet, the liquid hardens. The U.S. Army is currently testing kevlar vests that are pre-soaked in STF liquid body armour. The US military is also looking into slime body armour. The U.S. Naval Surface Warfare Center Panama City Division, Florida, is studying hagfish slime that could be used to build bulletproof armour that is stronger and lighter than what is currently available. Another interesting research project, which is being developed at North Carolina State University, is foam body armour which is based on composite metal foams (CMF). In tests, CMF has shattered 7.62mm armour-piercing rounds into dust on impact. The U.S. Naval Research Laboratory is developing transparent polymer armour consisting of alternating layers of elastomeric polymer and a harder material substrate. This lightweight armour is nearly as transparent as glass and provides excellent protection. Moreover, if the body armour sustains some hits, it can be ironed back into shape thanks to its special characteristics. Crystallites, which also provide rigidity, give the polymer its transparency.

C. COMMAND AND CONTROL

48. The effective conduct of joint military operations requires a comprehensive understanding of the multi-dimensional, dynamic urban environment, and continuous interaction with the latter. Information about the capabilities, location, and activities of the adversary, as well as the city’s terrain, infrastructure, and population, is paramount to success in urban warfare. Due to the density of population, structures, and networks, cities generate an overwhelming amount of information. Advancements in sensor technology and IoT will further increase the amount of available data. As compiling, sorting, and prioritising this information for NATO forces will become ever more resource- and time-intensive, automated intelligence processing and AI will become indispensable to obtain accurate, relevant, and timely intelligence (Konaev, October 2019).

49. However, in contrast to military operations in the open field, urban terrain compartmentalises large units into small teams, which requires a more decentralised and fragmented command and

control structure. The dense terrain, the size and physical construction of buildings, or poorly maintained power distribution systems can make communication among units difficult or prevent it altogether. This challenge is compounded by the fact that a vast number of users in a dense urban environment will congest the electromagnetic spectrum, thereby degrading communications availability or quality. Moreover, adversaries can use countermeasures to disrupt or compromise the ability to communicate or conduct command and control functions.

50. As the number of autonomous systems in the urban battlefield will increase, so will the need to coordinate the myriad of different missions and activities. Moreover, as adversaries are likely to disrupt C2, the need for robust, rapid, and secure C2 will grow.

51. Continuing digitisation, miniaturisation, and decreasing costs will be major drivers for military technology that can be used for urban combat. Innovative forms of intelligence collection, including open-source information from non-military sources will have profound implications for urban combat capabilities. For example, increasingly intelligent and interconnected systems are likely to vastly improve situational awareness and precision strikes. New sensors (e.g., quantum technology-enabled) and the development of software that can integrate and make sense of data from many different sources will provide opportunities that can make urban combat operations of NATO forces more effective. IoT will vastly improve situational awareness, signals intelligence, and communication (Konaev, March 2019). The U.S. Department of Defense released a paper entitled, "DoD Policy Recommendations for the Internet of Things," which described the potential benefits that such technologies can bring to battlefield situational awareness.

52. At the same time, as information technology is primarily driven by commercial companies, the proliferation of items that can be used for electronic warfare like jammers and other devices can challenge the technological advantage of NATO forces. Therefore, NATO forces can come under attack from adversaries who exploit cybersecurity gaps. As sensors, communication devices, and weapons become more interconnected, the need for cybersecurity is increasing significantly. NATO forces must be able to communicate in increasingly congested environments, while keeping their assets safe (Konaev, March 2019). In this context, NATO should also include the lessons of Russian jamming and cyber-attack efforts against Ukrainian forces operating in the east of the country.

D. THE CHALLENGE OF PROLIFERATION

53. Unlike in the past, when the military was the main driver for technological developments advances in technology, particularly information technology, they are now spearheaded by the civilian sector. These technological advances in consumer electronics also benefit non-state actors as the proliferation of relatively cheap, commercial, off-the-shelf products allows armed non-state groups to incorporate these systems in support of their operations (Konaev, March 2019). The availability of cheap, commercial drones provides non-state actors with a limited air force capability, thereby undermining the traditional dominance of conventional forces in the air. These groups, particularly terror organisations, including Daesh, Hezbollah, the Houthi rebels in Yemen, or the Russia-backed illegally armed militants in eastern Ukraine have already used commercially available drones and even military-grade unmanned aerial systems for reconnaissance, surveillance, and even in combat missions in Syria, Iraq, and eastern Ukraine. As commercial technology advances non-state actors will become more dangerous, including for potential terrorist attacks in the West (Konaev, March 2019).

54. For example, Daesh used drones to reconnoitre battlefields in Syria and Iraq and to produce material for their propaganda videos (Erzse, 2018). During the nine-month offensive to recapture Mosul, Daesh aimed at inflicting the highest possible losses among Iraqi troops and the civilian population and used the video footage to exploit the battle for propaganda purposes.

55. As technology is becoming more and more relevant in urban warfare as combatants, including armed groups continue to adapt, innovate, learn, and copy tactics from one another, NATO Allies should also consider ways to control the proliferation of technologies, including commercial ones, that non-state actors like terrorist groups could use in urban combat operations.

56. The use of AI in warfare and the development of autonomous weapons systems will greatly enhance the effectiveness of NATO forces in urban warfare while limiting human and material costs. At the same time, however, the use of AI and autonomous systems raise series ethical and legal questions. Lethal Autonomous Weapons (LAWs) could, for example, independently search for and engage targets using lethal force¹. Whether or not LAWs can adequately distinguish between civilians and combatants is contested (Bird et al, 2020). In November 2019, United Nations Secretary-General Antonio Guterres called for a ban of LAWs, noting that “machines that have the power and discretion to kill without human intervention are politically unacceptable and morally despicable” (Brzozowski, 2019). Talks on a potential ban of these systems within the UN’s Convention on Certain Conventional Weapons in November 2020 have not yielded binding results (Brzozowski, 2019).

57. Recognising the need to address this issue, several Allies are looking into the ethical and legal implications of AI in warfare. For example, the US Department of Defense has issued a set of “Ethical Principles for Artificial Intelligence” in 2019. The release followed 15 months of consultation with AI experts from industry, government, academia, and the public. The guidelines call for responsible, equitable, traceable, reliable and governable use of AI. DoD personnel is to apply adequate levels of judgment and care and carry responsibility for the “development, deployment and use of AI technologies”, its use should be explicit and well-defined, and the design of technology should allow capabilities to fulfil their functions whilst maintaining the ability to “disengage or deactivate deployed systems that demonstrate unintended behaviour” (DoD, 2020). In September 2020, the Pentagon’s Joint AI Center convened a dozen partners, including Allied countries, to discuss the question of ethics and AI (Freedberg, 2020).

58. Similarly, the French Defence Ministry issued a report on “Artificial Intelligence in Support of Defence” in 2019, containing guidelines for a controlled defence AI. These guidelines recommend to set up a ministerial ethics committee, ensure a that an adequate level of trust and human control is maintained in technologies used, and to work towards international standards for AI (French Ministry of the Armed Forces, 2019). In 2018, the European Commission identified seven requirements for trustworthy AI: human agency and oversight, technical robustness and safety, privacy and data governance, transparency, diversity and non-discrimination, societal and environmental well-being, and accountability (European Commission, 2018). Drawing on these initiatives, Allies can jointly contribute to advance international standards for the ethical use of military AI.

¹ It should be noted, though, that there is no agreed-upon definition of lethal autonomous weapon systems and that no nation has yet publicly stated its intention to develop such systems.

VI. CONCLUSIONS

59. There is general consensus that NATO forces will be engaged in urban combat operations in the future. It is therefore essential for NATO Allies to strengthen capabilities that increase combat effectiveness and reduce risk to both NATO forces and the civilian population.

60. Technology can play a crucial role in overcoming the complexity of urban combat operations, which is primarily shaped by terrain, dense infrastructure, and the presence of many civilians. Advances in sensors and information technology will be pivotal to ensure situational awareness and command and control, while augmented and virtual reality will help to enhance training and exercises. Robotics and new materials will improve force protection and combat effectiveness, and the use of AI applications will vastly expand the ability to compile, sort, prioritise, and distribute actionable information. However, as technological progress also benefits the adversary, the future urban battlespace will also be more congested, more cluttered, and more contested.

61. Key to the mastery of the urban battlefield is sufficient situational awareness. A comprehensive understanding of the multi-dimensional urban operating environment (physical and human) is indispensable for successful urban operations. Technological superiority enables information superiority over adversaries, that is, the ability to influence and control the flow of information going into and out of the operations area. Therefore, NATO Allies should promote the development of new technologies that improve situational awareness and secure and fast C4ISR capabilities. NATO should also use communication platforms to its advantage and increase NATO information operations that win the hearts and minds of the population.

62. While technology can only help to address some of these areas, it can be instrumental as a key facilitator. Making NATO forces fit for urban combat operations will obviously be a longer-term process. However, there are some “low hanging fruit” related to technology that can be relatively easily and quickly achieved. An important step in preparing NATO for urban warfare is the identification of capability requirements – which should be done through the NATO Defence Planning Process (NDPP).

63. NATO’s Science and Technology Organisation will play a pivotal role in this endeavour as it can identify and formulate NATO priority research areas and expand the number of actors that can find solutions to problems of urban warfare. Allied nations should use the NATO S&T network to promote the development of technologies that increase urban warfare capabilities. NATO S&T programmes of work can make meaningful contributions to that end. Many cooperative research activities of the NATO Science and Technology Organisation are focussed on urban operations, ranging from symposia over specific research groups to demonstrations of technology. STO has also had a strategic initiative on Operations in Congested Urban Environments. STO is the central tool for NATO nations to do cooperative research leading to innovations for urban NATO operations, improving military abilities, and reducing military and civilian losses.

64. Other parts of the NATO S&T community also have important roles. For example, NATO’s Defence Against Terrorism Programme of Work (DAT POW) already covers topics such as the protection of forces and infrastructure and promotes interoperability among NATO forces. The S&T Board acts as a focal point for coordinating the S&T activities of NATO bodies through priority alignment, mutual awareness, and achieving synergies. The existing NATO S&T network might be expanded by including experts from the police and other organisations with responsibility for urban infrastructure and related issues in its activities on a regular basis. In addition, increasing cooperation with dedicated Partners can provide valuable experience in countering adversaries in urban combat operations. More generally, the NATO S&T culture nurtures cross-discipline collaboration and research which inspires innovative approaches, capabilities, and technology utilisation.

65. Finally, apart from the capability-related considerations linked to the use of modern, disruptive technology, NATO Allies also need to find common approaches to two central questions. The first concerns the increasing importance of AI and autonomous systems in warfare and the related ethical and legal issues. While these discussions are primarily taking place on a national level, it would be important that the Allies develop a common position. This would help advance an eventual international agreement on internationally binding ethical standards for the use of military AI and autonomous systems. This would be desirable, among others because it would help to prevent, or at least limit, the proliferation of these technologies. NATO would be a natural place for such a discussion as it can draw upon the military, technological, and academic expertise in its vast S&T network which includes Allies and Partner nations.

66. The second question is related to the proliferation of dual-use technologies. Closer Allied and Partner cooperation on the monitoring and regulation of the use and export of dual-use technologies is necessary. Devising suitable policy guidelines and enforcing them should be higher on the agenda of NATO member states as modern commercial technologies can be used in a highly disruptive manner on the battlefield.

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