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MULTI-DOMAIN OPERATIONS VERSUS "MOSAIC" WARFARE: THE LATEST TECHNOLOGICAL DEVELOPMENTS TO OPERATIONALISE THESE CONCEPTS

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The fierce struggle for international (High Tech) market cornering and dominance is constantly taking place in the global Competition Continuum. The dominance of the technological market fits perfectly into the broad political-military disputes regarding the change of the current world order, in which competition between the great powers is becoming increasingly acute.

While MDO has grown in popularity among the military after including two new operational domains − space and cyberspace −, "mosaic" warfare is viewed more condescendingly by defence researchers, being explained much more technically, as an art of assembling small pieces (of coloured glass, stone, sandstone or other materials), hence its name.

As a result, the present paper aims to analyse the progress and continue to present the cutting-edge technological achievements of today according with those competition for global and regional power.

Keywords: *Multi-Domain Operations (MDO); the Mosaic Warfare; High-Tech; Competition Continuum; operational domain; Space; Cyberspace.*

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Introduction

The outbreak of the Russian − Ukrainian war has posed and continues to represent a very huge threat to Europe's security and the maintenance of the current international order. In addition to being considered the largest conventional military confrontation since World War II, Russian President Vladimir Putin's repeated threats to use nuclear weapons may turn it into World War III.

In addition, the fact that this war began and continues to unfold in the midst of the Coronavirus pandemic, with serious economic, financial and social consequences, as well as in the context of a global trend towards green energy and digitisation, there is an amplification of its consequences on regional and international security. Thus, we are already witnessing the emergence of international and regional crises such as the energy crisis, the humanitarian crisis (the increase in the number of migrants at the European level and the situation of social of the local population in conflict zones), the social crisis (decrease in the standard of living and the increase in the number of social movements against war, as well as the drastic measures taken by officials at European and national level), the food crisis (as a result of not distributing grains in time), as well as increasing the effects of climate change (such as drought, floods and hurricanes).

It can also be said that in this war, new types of weapons have been tested and continue to be tested by both the Russian and Allied forces, and that an unprecedented competition to dominate the international market development of emerging and disruptive technologies (EDTs) and the sale of their products has begun. A similar situation occurred during the Cold War, with the so-called "Star Wars", when Soviet-American competition to weaponise outer space led to the disintegration of the former Union of Soviet Socialist Republics (USSR) and the fall of communism. What sets it apart now is the larger number of participants (emerging states have been added), and the more diverse fields of technological development being at competition (artificial intelligence, robotics, unmanned vehicles, human performance enhancement/modification, nanotechnology, quantum physics, etc.).

The mere possession and use of new types of weapons, some of them very technologically advanced, is not the decisive factor for the rapid success of any of the parties involved in the conflict. This is the case of the Russian Air Force, which, although clearly superior to the Ukrainian one, did not even manage to achieve air superiority in certain strategic directions. The same can be said about equipping the Ukrainian Army with NATO-standard weapons systems − such as the Javelin, Milan or NLaws anti-tank missiles, the Stinger anti-aircraft missile or the 35 mm Ghepard self-propelled anti-aircraft gun (aka the "Cheetah"), the Harpoon anti-ship missile, the Himars artillery system, the M777 155mm towed howitzers, or self-propelled Panzerhaubitze (PzH) 2000, Zuzana or Krab, the M113 or Bushmaster

armored personnel carriers (APC) and the Bayraktar TB2 combat drones (UAVs) –, which only managed to provide it with tactical advantages.

Hence the need to develop operational concepts for the most efficient use of these advanced technologies in future armed conflicts. Currently, American military theorists have developed the concept of "Multi-Domain Operations (MDO)", which was immediately embraced by other Allied states and even by NATO, this being at the level of experimentation within the US Armed Forces. Apart of this endeavor, US researchers from the government's Defence Advanced Research Projects Agency (DARPA) have launched the concept of "the Mosaic Warfare" to outclass Russian Anti-Access and Area Denial (A2/AD) systems that prevent the US from intervening in regions controlled by Moscow and Beijing.

We have discussed and described these two operational concepts (MDO and Mosaic Warfare) in detail in articles previously published in the Strategic Impact journal, as well as in the specialised study entitled "Post-Industrial Society and Artificial Intelligence. Challenges and Opportunities from the Perspective of National Security and NATO Regarding the Development of the Multi-Domain Operation Concept", published in 2022 by the "Carol I" National Defence University Publishing House. As a result, this article analyses the latest conceptual approaches developed both at the level of the North Atlantic Alliance and of some member states and presents the new technological developments applicable to both concepts.

1. The Latest Conceptual Approaches of the Two Operational Concepts

The increase in existing threats and risks at European and Euro-Atlantic level and the emergence of new ones, caused by unprecedented technological developments in the civilian life but also at military level, have caused military strategists and defence researchers to rethink the way future armed conflicts are planned and conducted. The free access of state and non-state actors to advanced technological products, as well as the possibility to develop sophisticated weapon systems that restrict the freedom of action of Allied forces at a strategic level, or capabilities that act at the edge of legality, have amplified this necessity, accelerating the development of new operational concepts to make the use of new technologies more efficient and minimise those effects of adversary systems.

Within the Alliance, the term MDO has become extremely popular in recent years, starting with the US Army[1] and ending with the main Allied forces, even though there are still many member states and partners that have not defined the concept at the national level. In simple terms, the MDO represents the approach to future warfare (for the period 2025-2050) beyond the level represented by joint operations

[1] At the US Air Forces level the term used is *"Joint All-Domains Operations (JADO)"*, instead of *"Multi-Domain Operations (MDO)"*.

(Land, Air and Maritime) by incorporating two new recognised operational domains (Space and Cyberspace). Thus, MDO requires coordination of joint, interagency, and multinational military activities beyond campaign planning, where individual effects are combined at the boundary between the tactical and operational levels. And the specific degree of differentiation compared to joint operations is given both by the level of integration with the other instruments of power (in an authorised inter-agency approach) and by the level of expertise in the use of capabilities from all operational areas. (LTC Grest and LTC Heren 2019)

In essence, MDO is the synchronisation of the actions, forces and means of platforms (vehicles, satellites, ships, etc.), their Command and Control (C2) systems and all data sources to constitute a "complete picture of the operating battlespace" (see Figure no. 1) and to ensure the ability of warfighters in the Theater of Operations (ToO) and command staff to "rapidly make decisions that lead to action". (Tunnicliffe 2022)

Figure no. 1: The US approach for integrating all platforms into a large Command and Control network (Source: US DoD)

In future MDOs, the Artificial Intelligence (AI) and Machine Learning (ML) will play a critical role in helping staff personnel to manage large volumes of data (Big Data) and quickly decipher the most important information, and determine its operational relevance and then presenting informed options for shared decision-

making at all levels of C2. The ultimate goal is to overcome the adversary's strengths by presenting them with multiple operational and/or tactical dilemmas through the combined application of calibrated force posture, the employment of multi-domain formations, and the convergence of capabilities across domains, environments, and functions. As part of the implementation of this concept, all Services, but especially the Air Force and the Navy, are working on new technologies and capabilities through Research-Development-Innovation (CDI) programs, such as *"Project Overmatch"* and "*Advanced Battle Management System"*, respectively. Together, both force categories have developed more than a dozen collaborative technology projects, bringing together all operational domains to share and use intelligence, and assess and respond synergistically. Within the Ministry of Defence, the UK is developing the "Digital Backbone" transformation programme, which will enable information sharing and communication regardless of the hardware used. "We need to make sure that all the data we collect from every platform we have — whether it is satellite, aircraft, drone, ship or ground system – can be brought together to produce the most complete picture of what is happening". (Tunnicliffe 2022)

The North Atlantic Alliance has moved on to the definition of the MDO Concept and its development from September 2021. The development of the Allied MDO Concept was done in two phases–in June, NATO's definition and vision for Multi-Domain Operations were approved and, in September 2022, the Military Committee (MC) approved the original concept itself. Thus, according to the Allied approach, Multi-Domain Operations are defined as "the orchestration of military activities, in all domains and environments, synchronised with non-military activities, to enable the Alliance to produce convergent effects at a relevant speed". (The ACT Team 2022) In the Allied approach, effective implementation of the MDO can only be achieved through a cultural change within both the member states and the Alliance. This change involves moving from a traditional joint approach to one that is more broadly focused on all five operational domains, i.e. a fundamental shift of mindset towards Multi-Domain Operations.

At a conference jointly organised with the British Ministry of Defence in London a month later, some priorities for the development of this new concept were identified. The first priority is the development of the MDO as part of a broader integrated approach (diplomatic, informational, military and economic) at all member states level, complemented by partner education. Secondly, the question arose that the digital transformation of the organisation is understood by all Allies as a critical factor in developing the new concept by learning lessons from the Russian-Ukrainian conflict and continuing to develop capabilities, which they integrate into the "long-term approach to war". This long-term approach is carried out in accordance with the 20-year vision for the development of the Allies' military instrument of power, as part of the NATO Warfighting Capstone Concept (NWCC). Last but not least, it is intended to issue a development and implementation approach in phases, which

evolves towards achieving full interoperability of Allied forces and capabilities, with particular emphasis on the rapid development of those in the cyber and space domains. More specifically, "it is about ensuring that every part of defence can work seamlessly with other government departments, Allies and partners to achieve the desired outcome and to defend our NATO and nations." (Tunnicliffe 2022)

The most advanced allied state in the MDO is the US, which has already moved, at the level of the Army, to the concept operationalisation, by transforming it into a unified doctrine and testing "Multi-Domain Task Force (MDTF)" type of a force structure. After five years of development and experimentation, in June 2022, the United States Joint Doctrine on Multi-Domain Operations was approved, which has applicability in an anticipated operating battlespace for the year 2035 and an assessment of the security environment from 2025 to 2050. (Judson 2022) After testing the first MDTF in an operational-strategic exercise in the Pacific, the US Army developed a concept in March 2021 for operationalising five MDTFs to act in all phases of Competition Continuum (see Figure no. 2), including competition, crisis, and conflict. Two of these MDFTs will be deployed in the Indo-Pacific ToO (the first is already stationed at Lewis-McChord Joint Base in Washington D.C.), one in Europe and one in the Arctic. The fifth MDTF will be kept in reserve. As the document states, "each MDTF will be designed and adapted to operate at the necessary level to meet the needs of the supported Joint Force Commander. From the beginning, each MDTF will be assigned or tasked in support of a Strategic Commander (Combatant Commander), who will organise and train it according to the assigned missions." (Judson 2022) This new type of force structure will be coordinated by an MDTF All-Domain Operations Center (ADOC), which, once operationalised, will allow to ensure permanent contact with the adversary in all operational domains.

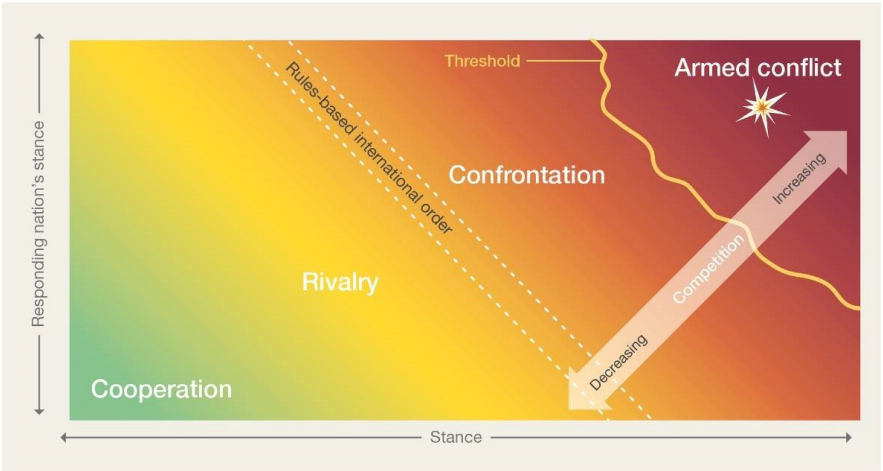

Figure no. 2: The specter of Competion Continuum
(Source: MCDC MD-MNU Project Report Nov 2022)

The second concept developed, this time by American defence researchers in the form of a strategy called "mosaic warfare", represents, in essence, an application of military art in the conduct of rapid military actions with measurable and tailored effects of a multi-domain lethal approach in future armed conflicts. Like the conglomerate from which it derives its name (mosaic), this new concept involves the use of a package of forces in which actions of individual combat platforms are fused in an artistic, innovative approach to the conduct of multiple attacks, in parallel and on a front wide, which ensures massing of fire and not forces to overwhelm the opponent. (Grayson 2018)

In the view of DARPA researchers, the mosaic warfare strategy incorporates the following areas of interest: technologies to operate in mosaic warfare, mosaic web services (EWS), experimentation with mosaic conceptual approaches, and the necessary fundamental strategic technologies and systems. Thus, the technologies that could operationalise this new strategy will need to provide solutions or automate functions such as: planning and organisation (e.g. software and automated decision tools to establish the core force structure or to increase the planning speed of commanders from theaters of operations), interoperability (a new global interoperability architecture applied to mission speed), and execution (for combining battle management decision support with machine autonomy). EWS involves the development of an advanced system-of-systems (SoS) incorporating new surveillance and search sensors and electronic warfare assets, particularly for the detection and capture portion of the kill chain and for achieving non-kinetic effects in offensive actions. Within the necessary fundamental strategic technologies and systems, it is foreseen to incorporate disruptive technologies that reduce the weight, volume, power or costs of some weapon systems, ensure their adaptability and quick refresh and ensure their advanced performance. (Strategic Technology Office 2018)

In the understanding of military researchers and technicians, "mosaic warfare" is a theory of war that involves forcing an adversary to fight with an unexpectedly large number of weapon systems and platforms of different classes, sizes and types, asymmetrically and variably arranged, where each acts distinctly like pieces of a mosaic, and which can create an overwhelming advantage compared to using systems and platforms similar to its own. (The Bae Systems Team 2021) The new strategy is also a multi-domain approach, in which the individual platforms of each operational domain (Air, Land, Maritime, Cyberspace, or Space), like pieces of a jigsaw puzzle, would together create a thorough picture of a large and overwhelming force, while making it more difficult for the adversary to identify an effective way to fight such a mixed and confusing force package.

To function effectively and bring a distinct strategic advantage to its user, the flexible nature of the new strategy requires flexibility in achieving communications

connectivity of all combat platforms and in planning their deployment and action in a coordinated, concentric and synergistic effort. Communications links and data sensors must be reliable and adaptable to interconnect state-of-the-art electronic warfare technologies (e.g. radio frequency/RF integrated analogue/digital mixed-signal electronics for high-capacity communications and electronic sensors precision systems that can increase situational awareness of own forces, improve weapons accuracy, and maintain communications flowing safely even in highly congested areas). In fact, this new approach represents the concept of using the most advanced technological products in the Decision-Centric Warfare[2].

At the same time, the asymmetric effects it propagates depend on the ability of the new strategy to introduce high-efficiency elements such as autonomous/remotely piloted aerial vehicles (UAVs), underwater (AUVs/UUVs) or ground-based vehicles (UGVs) and robots into the operating space, in an unexpected and amalgamated manner. These new means will increase the survivability of forces by considerably reducing the risks of human casualties.

As can be see, the two new concepts intertwine and represent a conceptual approach to the use the latest military technological developments in future armed conflicts. Thus, MDO is a pure military theory approach, in which the two new operational domains – Space and Cyberspace – are integrated within joint operations, as well as with the other instruments of power (see Figure no. 3).

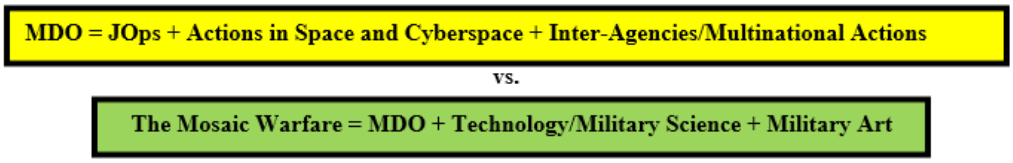

Figure no. 3: Multi-Domain Operations vs. the Mosaic Warfare

In turn, mosaic warfare strategy represents a multi-domain approach, but from the point of view of military art, in which the latest high-tech products are used in an innovative and unpredictable way to obtain asymmetric advantages over the adversary. Thus, the two new operational concepts bring attention to the development of multi-domain capabilities that include the highest technology products and that can act, interchangeably, in any operational domain or produce effects in domains other than the one for which they were established. At the same time, they also represent an innovative way of planning and conducting future armed conflicts, but the approach to each is different – MDO from the perspective of Military Theory and Mosaic Warfare from the perspective of Military Art.

[2] "The Decision-Centric Warfare" Concept replaces, in the US approach, the old "Network-Centric Warfare", used to increase the efficiency of the decision-making process through centralising it and it focuses on "the Mission Command" philosophy.

2. New Technological Developments within the Two Operational Concepts

At present, there is a real consensus among military specialists and policy makers that emerging and disruptive technologies (EDTs) have the potential to change the character of future wars. This desideratum is not a novelty because, throughout history, many newly introduced weapons have produced surprises or shocks at the strategic or operational level and influenced the outcome of wars. Such was the case with the use of fighter aircraft and chemical weapons (chlorine) in the First World War, the only means that brought an active approach to the static actions of all belligerents. Or the involvement of submarines and the tank-aircraft binomial by the German army to carry out the "Blitzkrieg", at the beginning of the Second World War. Not to mention the end of that war, when German V1 missiles, Japanese kamikaze tactics or the nuclear bombs launched by Americans at Hiroshima and Nagasaki were used. The Cold War began with the arms race for dual-launch ballistic missiles (nuclear and conventional) and continued with the competition to conquer outer space in the so-called "Star Wars".

But the biggest technological developments came after the end of the Cold War, when a new world order entered into force (the unipolar world) and the competition for world dominance reached its peak, leading to a possible change in the current international order (bi-polar or pluralism). Indeed, rapid advances in Artificial Intelligence, robotics, Big Data, quantum computing, and other emerging technologies may take future armed conflicts in new and unexpected directions. By developing new operational concepts for the use of advanced technological products, military organisations are expected to evolve, adapt and innovate to maintain a competitive advantage over state or non-state adversaries. In a future operating environment characterized by dimensional expansion, convergent domains and sensor proliferation, as well as an increase in weapon system range, speed, autonomy, lethality and compressed time horizons, the transformative impact of these technologies is likely to manifest itself across the entire spectrum of military engagement. That means, from major armed conflicts between great powers, to hybrid or hyper-war[3], to memetic warfare[4].

[3] The hyper-war was defined by General (ret.) John R. Allen and AI specialist Amir Husain in the science material *"On Hyper-War"* delivered at the US Naval Institute in July 2017 as *"a type of conflict in which human decision-making is almost entirely absent from the observation-orientation-decision (OODA) loop, being replaced by artificial intelligence. Consequently, the time associated with an OODA cycle will be reduced to almost instantaneous responses."* That is why it is also called *"the AI-fueled, machine-triggered conflict"*.

[4] NATO's Center of Excellence on STRATCOM in Riga, Latvia, defined memetic warfare as *"competition over narrative, ideas and social control in a social media battlefield; a subset of 'information operations' tailored to social media."* Information operations involve gathering and disseminating information to establish a competitive advantage over an adversary, and memes are like improvised explosive devices (IEDs) for information warfare – they are natural tools of an insurgency, very useful for throwing things in the air, but capable of sabotaging desired effects when used by the largest actor in an asymmetric conflict.

To implement the new operational concepts presented in the previous chapter, scientists and representatives of private defence companies investigated over 1,000 start-ups and emerging companies and established, according to Figure no. 4, the main trends in the transformation and use of advanced technological products to develop multi-domain capabilities, mapping the top 10 military technological innovations and their degree of impact in the near future. These technologies used in defence will bring changes to the military domain regarding connectivity (adversary detection and location, communication and conduct of direct operations), lethality (innovations in missiles and other attack platforms), autonomy (use of AI and robots to execute decisions with zero or minimal human involvement) and sustainability (strengthening the defence industry by adding 3D printing technologies and electrification) (The StartUs Team 2022).

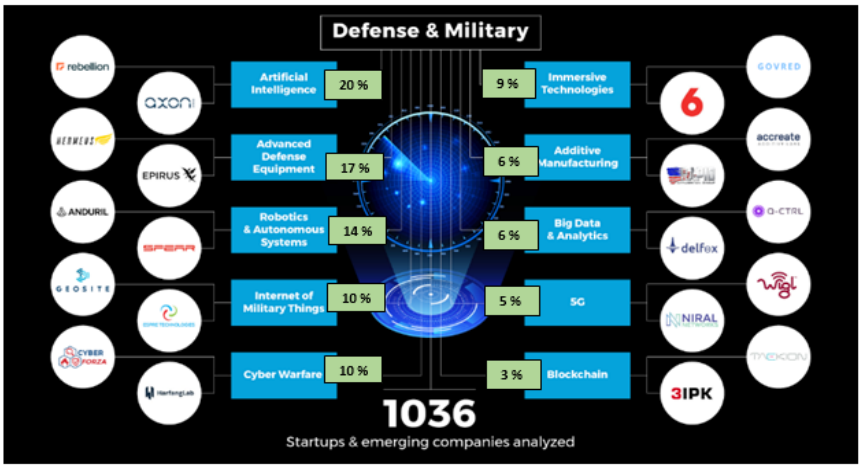

Figure no. 4: Top 10 of future trends in technological developments and their impact in the military field
(Source: Copyright@2021 StratUs Insights)

Topping these trends is Artificial Intelligence (AI). The implementation of the main AI products such as "digital twins" and "machine learning" in the military field will lead to improved algorithms and software for intelligence, surveillance and reconnaissance (ISR) missions. Computer vision will enable equipment safety management and provide a degree of empowerment for autonomous systems, thereby reducing military casualties (see Figure no. 5). But it should also not be forgotten that when AI can beat us at any kind of game, with the ease with which we beat chimpanzees today, the consequences can be catastrophic. This conclusion was reached at the same time by researchers from Google DeepMindo and the University of Oxford, stating that if advanced AI is left autonomously to use its own methods to achieve the set goals, allowing it to create their own tests and hypotheses, then

"an existential catastrophe is not only possible but probable." And AI software could intervene in providing information about the objective, with major consequences for the conduct of the attack phase (Mazilu 2022).

Figure no. 5: The possible Artificial Intelligence supremacy
(Source: https://Playtech.ro/2022)

Moreover, former Chinese Vice Minister of Foreign Affairs, Ms. Fu Ying, stated, in a scientific paper at Tsinghua University in December 2020, that "AI has limitations, including the inability to interpret intuition, emotion , responsibility and value. In the process of human-machine collaboration, the shortcomings of the machine could lead to the escalation of international crises." (Ying and Allen 2020) And her claim was reinforced by Chinese military analysts who argued that unmanned combat systems could encourage major military powers to use force, further dehumanise the enemy, and make the act of killing a simple game, which produces great collateral damage. Even a highly intelligent system would have difficulty discerning intentions on the battlefield when dealing with enemies who have been wounded or disarmed or who are using civilians as human shields. (Moriyasu and Fang 2021) As a result, leaving such decisions to machines can seriously undermine the distinction between civilians and combatants in international humanitarian law, as well as the rule that soldiers who have laid down their arms will not be subject to attack.

Despite all these inconveniences, China launched the world's first artificial intelligence-piloted drone carrier named "Zhu Hai Yun" in May 2022, which can transport 50 drones and unmanned aquatic and underwater systems on board (see Figure no. 6). Expected to enter service at the end of 2022, this unmanned vessel is 88 m long, 14 m wide and 6 m high, capable of developing a speed of 32 km/h and

is piloted by the AI "Intelligent Mobile Ocean Stereo Observing System", developed by the Southern Marine Science and Engineering Guangdong Laboratory. (Shoaib 2022)

Figure no. 6: China lauches the "Zhu Hai Yun" drone carrier
(Source: @venkatesh_Ragu)

The next place is occupied by the development of more sophisticated and technologically advanced defence equipment to deal with all types of threats and risks. Within this trend, innovations range from hypersonic flights to directed-energy weapon systems, including the advanced research in biotechnology and nanotechnology. Thus, in the field of hypersonic weapons[5], the competition is between Russia, China and the USA. As the deputy head of the US' Joint Chiefs of Staff, General John E. Hyten, stated in an interview with the Washington Post in February 2022, hypersonic missiles "...are the threats the future. This is not only because they can fly so fast, but also because their trajectory is so unpredictable. When tracking a ballistic missile, US surveillance systems can predict immediately after launch where it will land. But a hypersonic, low-altitude cruise missile can zigzag, avoiding detection and targeting and presenting a strange, perhaps unstoppable, hazard." (Ignatius 2022)

[5] Hypersonic weapons are of two kinds: a) hypersonic cruise missiles (HCMs), which are powered by high-performance air-propellans engines, known as scramjets (a hypersonic cruise missile is boosted by a hypersonic speed missile and then uses an air propellant engine to sustain that speed; b) hypersonic glide vehicles (HGVs), which comprise a manoeuvrable glide vehicle launched on a ballistic missile or booster rocket (an HGV is propelled by a high-altitude rocket and then glides towards its target, maneuvering along the way). Both types of weapons are notionally pre-programmed to fly to a specified target.

For now, a tangible advantage seems to be held by Russia, which has announced the existence of these hypersonic weapons systems since 2018 and has already tested and used in the Russian - Ukrainian war - the Avangard hypersonic glide vehicle (a 2-tonne strategic intercontinental ballistic missile, equipped with a UR-100NUTTH hypersonic vehicle flying at Mach 27 in low Earth orbit), as well as several types of hypersonic missiles, such as the 3M22 Zircon anti-ship/land target cruise missile (SS-N-33 in NATO, having a speed of Mach 9 and a range of 500-1,000 km, which can be launched from submarines or battleships) and the Kh-47M2 Kinzhal ('Dagger' in Russian lb. or RS) air-to-surface ballistic missile -AS-24 Killjoy in NATO, having a speed of Mach 12 and a range of 2,000 km, which can be launched from Tu-22M3 bombers and MIG-31K and Su-57 Felon interceptors). The Russian Air Force has had, since 1995 but upgraded in July 2018, a 53T6 hypersonic interceptor missile, called ABM-3 Gazelle by NATO, with a speed of Mach 17 and a range of 80-100 km, being kept in special silos . (The IISS Team 2022, 164-175)

For its part, China has joined the hypersonic arms race, testing on July 27 and August 13, 2022, its first Dong-Feng DF-ZF glider vehicle (designated by the US as WU-14, which has a speed of Mach 5 and can have a unpredictable trajectory in low Earth orbit up to a distance of 2,500 km, being built to be mounted on ground vehicles DF-17) on board of the Long Mach 2C space missile, as well as the anti-ship/anti-satellite ballistic missile DF- 21D (CSS-5 in NATO, having a speed of Mach 10 and a range of 1,770 km, which can be launched from submarines and DF-17 vehicles), developed jointly with Russia. (Makichuk 2022)

Recognising that it is lagging far behind, the US has accelerated testing of its supersonic weapons programs – the Air Force has an Air-Launched Rapid Response Weapon (ARRW) program in development for 2023, the Navy is developing two such "Conventional Prompt Strike" programs and "Hypersonic Air-Launched Offensive Anti-Surface Warfare" for 2028, the Army is working on the "Long-Range Hypersonic Weapon" programme and DARPA has the "Glide Breaker", "Tactical Boost Glide" and "MoHAWC" programmes in research and development. For its part, the US Missile Defence Agency (MDA) is considering the development of a system to destroy a hypersonic missile in the glide phase, which includes an interceptor as part of the Aegis system and the creation of a constellation of satellites (tracking hypersonic missiles on the flight path and guiding the interceptor to hit them) within the "Hypersonic and Ballistic Tracking Space Sensor (HBTSS)" programme. Thus, in mid-March 2022, it made the first flight of a hypersonic missile, called "Hypersonic Air-breathing Weapon Concept (HAWC)", produced by Lockheed Martin, with a speed of Mach 5 and being launched from a B-52 bomber. Four months later, the US Air Force tested two ARRW hypersonic missiles, also manufactured by Lockheed Martin, having a speed of Mach 6 and also being launched from aboard a B-52H, and DARPA carried out the first test of its hypersonic weapon

"Operational Fires". Furthermore, the US, UK and Australia announced on 6 April 2022 that they will collaborate under the newly created AUKUS Security Alliance (launched in September 2021) to jointly develop new types of hypersonic missiles to counterbalance de-escalation against China and Russia, through the hypersonic project "Southern Cross Integrated Flight Research Experiment". (Hamlin 2022)

As far as directed energy weapons systems[6] based on lasers are concerned, it can be said that there are only few countries in the world that have achieved some conclusive results in this field. This is because atmospheric thermal refraction still represents a difficult problem to solve. There is also the effect of permanent blindness under certain conditions of use, and its use as a non-lethal incapacitating weapon has been banned by the Protocol on the Prohibition of Laser Weapons that can cause Blinding, entered into force on July 30, 1998 and to which up to 109 UN member states have acceded. Currently, the most advanced laser system is the High-Energy Laser (HEL), which allows detection and engagement of a wide range of targets depending on its power, including unmanned vehicles, missile threats, ISR systems, missiles, ships, artillery and grenade launchers. The system's modular, adaptable design provides significant reductions in size, weight and power consumption to suit air, land and maritime platforms. Recent developments in laser weapons include: English "Dragonfire" strike system, Israeli "Iron Beam" anti-aircraft laser system, US naval anti-drone systems "Technology Maturation Laser Weapon System Demonstrator (LWSD)" and "AN/SEQ-2 Laser Weapon System (LaWS)", US naval anti-ship system "High Energy Laser and Integrated Optical-dazzler and Surveillance (HELIOS)", the US anti-RAM system "High Energy Liquid Laser Area Defence System (HELLADS)", which can be mounted on aircraft or combat vehicles, the US "Boeing Laser Avenger" land-based anti-drone system, installed on the AN/TWQ-1 Avenger combat vehicle, or the Russian "Almaz HEL" land-based system. (Spender 2022)

The US is currently working on a high-powered, 100-kilowatt laser weapon system, called HEL TVD, to be tested in 2023. This system will be able to inter-react with the Athena and Aladin laser systems designed for the US Air Force and Navy. At the level of the Russian Federation, it has been decided to build a new generation of powerful laser weapons, called "Zadira", already tested in Ukraine for the destruction of drones. And China is in the process of experimenting with high-powered electromagnetic pulse (EMP) weapon systems for multiple point defence and kinetically selected effects.

The unprecedented developments to date in robotics and autonomous weapon systems, with their tendencies towards full autonomy and the ethical implications of artificial intelligence, have caused certain states and multinational companies to

[6] Directed energy (DE) weapons include high-energy lasers, high-power radio frequency or microwave devices, and active or neutral particle beam weapons. In turn, microwaves and lasers are part of the electromagnetic spectrum, which includes light energy and radio waves.

question the degree of permissiveness and responsibility given to these so-called "killer robots". Seen as having an increasingly important role in future armed conflicts, robots and autonomous weapons systems are being developed to replace their own forces in tense or dangerous areas, and the idea of keeping the human factor in the decision-making equation is supported by most programmes developed. The biggest problem to be solved, apart from ethics, is the short response time, which sometimes exceeds the human capacity to react. As a result, the US Department of Defence (DoD) has developed some principles to focus on the responsible use of operating autonomous weapons systems in armed conflict, in a way that maintains human judgment and accountability over the use of force and helps minimize the likelihood of losing control over its system of inadvertent employment, particularly against non-combatants. These principles are based on the understanding of system autonomy in the military context as specified in DoD Directive 3000.09[7].

Internationally, it is increasingly being said that we are witnessing a veritable race to develop increasingly powerful robots and autonomous weapons systems, including, in addition to the US, great powers such as Great Britain, the Russian Federation and China. They are leading the development and testing of mobile robots, unmanned aerial systems (UAS or drones), marine autonomous vehicles, counter-explosive ordnance countermeasures (C-EOD) robots, surveillance and situational awareness, and material handling, humanoid/skeleton robots, swarms of drones or unmanned ground vehicles. The international market in this field is expected to grow to $52.16 billion by 2027, with a CAGR of 12.8% between 2020 and 2027. (After 2021)

A conclusive example of the use of autonomous drone weapon systems is the war between Azerbaijan and Armenia in 2020, when it was found that about 40% of Armenian tanks and armored vehicles, as well as over 90% of artillery and missiles were destroyed by drones acquired by Baku from the Turks and Israelis. (Moriyasu and Fang 2021) The same can be said of the use of the Turkiyesh Bayraktar TB2 drone by the Ukrainians against Russian forces, which literally changes the fate of the war, adding greater strike accuracy to Ukraine's airborne capabilities.

However, it is safe to say that the US continues to maintain its leadership position in the development of advanced military robots. To compete in the future robotics and autonomous weapons systems market, the Pentagon invested, last year, about 379 million dollars and continues to invest in the development of high-tech robots such as: The robot bee "The Robobee", a tiny static energy research or non-lethal

[7] DoD Directive (DoDD) 3000.09 "Autonomy in Weapon Systems" implements, along with "DoD's Artificial Intelligence (AI) Principles", the DoD's formal policy directives on autonomous weapon systems developed in 2012. The Directive is also consistent and with the 11 guiding principles established in 2019, in the framework of the Meeting of the High Contracting Parties to the Convention on the prohibition or restrictions on the use of certain conventional weapons that can be considered to be excessively harmful or to have non-discriminatory effects.

attack flying robot developed by the Harvard Microbiotic Laboratory that is capable of hovering for a short time or diving and being recharged via an electrical cable; The "DOGO" operative dog, a lightweight anti-terrorist combat robot that accompanies the military in combat, made by General Robotics and equipped with eight vision cameras, two audio negotiation systems and armed with a Glock 26 mm pistol or non-lethal weapons; The autonomous naval firefighting robot "SAFFIR" autonomous robot for fighting fires on board, developed by students at Virginia Tech University, which is equipped with stereo infrared vision sensors and a rotating laser, and equipped with extreme mechanisms claw-like grippers. (The RoboticsCareer Team 2021)

For its part, China has not let itself down and presented in Guandong, at the Zuhai Air Show of November 2022, the world's largest drone, called "Wing Loong-3", capable of transporting two tonnes of UAVs. At the same time, it tested a ground-based drone launch vehicle to be presented at the same air show, which was able to simultaneously launch 18 suicidal combat drones and which is produced by China Ordnance Equipment Group (CORG) to launch a so-called "barrage of drones" (see Figure no. 7). The catapult launch system on this vehicle will improve the survivability of swarm drone systems, such as the ASN-301/JWS-01 anti-radiation drone (modeled after Israel's Harpi loitering ammunition), being similar to the American "SwitchBlade 600". Apparently, this new system resembles the drone attack sequence in the American movie "Angel Has Fallen" and is inspired by the US naval drone attack project called "LOCUST" that started in 2015. (Hambling 2020)

Figure nr. 7: The "Hummer" − type vehicle with 48 UAV launching tubes
(Source: https://youtu.be/QamGaDNczJw)

Turkiye as well wants to be among the leading states in the development of unmanned combat aircraft, through its company Baykar, which announced, on

20 November 2022 that it had completed testing of its invisible supersonic drone "Kizilelma" (see Figure no. 8). This new drone can be classified as a 6th generation fighter aircraft, thus surpassing 4th generation aircraft, such as F-15 and F-16 (US), Rafale (France), Gripen (Sweden), SU-35 (Russia) and Eurofighter (EU), but also 5th generation ones, such as F-35 (US), SU-57 (Russia) and J-20 (China). Having the engine manufactured in cooperation with the company Ivchenko-Progress from Ukraine, the drone can carry 1,500 kg of ammunition, can reach an altitude of 10,000 m, has a range of 926 km and can stay in the air for up to five hours. These characteristics allow it to perform both air-to-ground and air-to-air missions, just like the latest generation manned combat aircraft. (Gheja 2022)

Figure no. 8: The Bayraktar Kizilelma supersonic invisible drone
(Source: Twitter - Baykar / Aktual24.ro)

Also, in the other technological trends – IoT, 5G, Cyber Warfare, imersive technologies, aditive manufacturing, Big Data or blockchain – research, developments and acquisition efforts are constantly changing and evolving. While they represent amazing technologies, they still require human effort to understand and employ them in future armed conflicts. As a result, they require special education and a special degree of training to be able to use them efficiently in the future operating space and work effectively in "man-machine" teams.

Conclusions

It is very true that the current competition between the great powers to acquire and deploy cutting-edge technologies has the effect of resuming the arms race and is

very similar to the Cold War-era's wining the space supremacy through the so-called "Star Wars". Now, when the world is facing numerous economic-financial, socio-humanitarian, energy and food crises, billions of euros/dollars are being spent to invest in state-of-the-art technological products to be used in future armed conflicts.

Using the latest and most advanced developments in military science and technology will create amazing and unique opportunities for the winner of the global technology competition to develop military capabilities that are difficult to counter. How to use these advanced technology capabilities will be conceptualised by new operational concepts in various stages of development or implementation, such as "Multi-Domain Operations (MDO)" or Mosaic Warfare. If MDO can be described as a synchronisation of the actions of platforms, forces and assets, their command and control systems and all data sources to constitute a complete picture of the operating battlespace and to ensure the ability to make rapid decisions that leading to action in a future operational space, mosaic warfare represents an application of Military Art in the conduct of rapid military actions, with measurable effects and adapted to a lethal multi-domain approach in future armed conflicts. Thus, both concepts aim at how to use advanced technological products in a future armed conflict, in a multi-domain, inter-agency and multinational approach. The main difference between the two operational concepts is the development framework of each − MDO is developed by military thinkers through the lens of Military Theory, to which they have added products of the Military Science, while the mosaic warfare is designed by defence researchers, combining Military Art with Military Science.

In the last decade, discussions have been gaining momentum at European and international level on how to use advanced technological products, especially lethal autonomous weapon systems (LAWS), in an attempt to solve the ethical aspects and legal restrictions according to the International Humanitarian Law. The lack of a unanimously agreed definition of LAWS has made these discussions difficult. However, a consensus was reached in 2019 to maintain human responsibility for decision-making on the use of these weapons systems and force through their use. Discussions are currently ongoing regarding the type and degree of involvement of human intervention required to ensure compliance with the provisions of International Humanitarian Law and resolve ethical interference. Ultimately, it is hoped that a Convention on the use of LAWS in combat will be adopted at the UN, respecting legal, ethical and moral principles.

Also, the forces intended to participate in future conflicts will be reorganised and tailored differently to achieve the effectiveness and teamwork of the "man-machine" binomial in the multidimensional operating space. But replacing fighters or human-manned systems with robots and autonomous weapons systems, as well as removing commanders from the decision-making cycle by introducing AI/ML software, will challenge the core philosophy of human existence − "Dubito ergo

cogito. Cogito ergo sum". And this is because machines, however advanced, will not have a degree of doubt in making technological decisions, but will act quickly and directly, as they have been programmed.

In such a fierce international competition, states with less economic power, such as Romania, will not be able to keep up and will become mere spectators, having to place themselves on one side or the other of the great competitive powers. This is why, at the level of the Romanian Armed Forces, the process of equipping with advanced technological products and developing an operational concept such as MDO, which would bring us among the modern Allied armies and counteract the possible threats and risks brought by the degree technology of potential adversaries. Especially since, as Elon Musk stated in his latest prophecies in November 2022, all forms of transport, including planes and ships, will become fully electric and largely autonomous, and tunnels will play an important role in the future of transport by 2030 (such as the electric sleds and cars on electric skates). The American billionaire's intention ist o use his SpaceX company to take people to Mars, by 2025, to colonise the planet. The American space agency NASA has already announced that the most powerful rocket in the world, the Space Launch System (SLS), has taken off on November 15, 2022 for the Moon, resuming the "Artemis" programme to colonise the Earth's natural satellite after 50 years.

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