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Land Forces Academy Review
Vol. XXIX, No. 2(114), 2024

THE FUTURE OF WARFARE IN THE VOLATILITY, UNCERTAINTY, COMPLEXITY AND AMBIGUITY CONTEXT

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ABSTRACT

The war of the future represents an increasingly difficult concept to model through the implementation of emerging and disruptive technologies in a Volatility, Uncertainty, Complexity and Ambiguity (VUCA) context. The study of wars is essential in conflict prevention and peace building. In our paper we analyze the determining parameters of the contemporary operational environment against which we estimate possible directions of evolution of this phenomenon. The technological approach to war allows the identification of indicators of the development of emerging and disruptive technologies in an ethical framework and reinforces the strategies of forming a security culture through the mass education of citizens. The results of the research and the conclusions formulated can also constitute priorities for the strategies to strengthen the resilience of the national security and defense infrastructures.

KEYWORDS: emerging and disruptive technologies, management in VUCA context, national security, warfare

1. Introduction

The complexity of contemporary conflicts results in hybrid developments taking place in complex environments, from interpersonal disputes to wars with global effects, making it almost impossible to establish a pattern. The clues that allowed the establishment of a determining model are so numerous in the VUCA context that requires a military analyst to establish a frame of reference, a methodology and, last but not least, specifying the limits of his scientific research. VUCA is a common concept in the business environment and is an acronym for Volatility, Uncertainty, Complexity and Ambiguity (Bennett & Lemoine, 2014). It is usually used to develop strategies to deal with struggles for profit, efficiency and markets. Understanding specific indicators allows a leader to develop decisions adapted to the challenges of the operational environment through clear visions of the realities that surround them.

In this paper, we present the results of an analysis of the contemporary operational environment where traditional wars take place, in their hybrid form, but also other conflicts in a VUCA context. Thus, through a technological approach we will identify possible directions of evolution of the future war, accepting that the analysis of the main specific indicators of this environment represent references for the identification of possible directions of evolution of the security systems relations, in the short term, as well as a forecasting the long-term impact of future conflicts on society.

DOI: 10.2478/raft-2024-0024
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Overall, the study of wars is critical research for understanding humanity, for promoting peace, and for preventing conflict and the human suffering associated with it. Being an extremely complex phenomenon, wars have had a major impact on history, politics, economy, culture and many aspects of human life, favoring the shaping of borders, the development of military technologies, the shaping of political and diplomatic instruments, the creation of influential economic and social security infrastructures (Petre & Ciupercă, 2019). In addition, the study of wars enables a deeper understanding of human behavior in critical situations, the psychological and social impact on communities and other global effects, under a systemic approach.

In order to carry out this analysis, we used a series of tools on open access resources under a technological approach, on specific maturity stages. The importance of knowing the stages of technological maturity of a system is essential for achieving success in a competitive market, where diverse relationships are established between entities in constant change and innovation. Knowing and understanding these stages allows organizations to plan their innovation strategies, anticipate changes, prioritize investments, establish strategic partnerships and alliances, promote innovation and competitiveness by identifying gaps and technology and developing innovative solutions to cover them. Moreover, in the academic and technological environments, a standardization of them was achieved through Technology Readiness Levels (TRL).

Originally established by NASA (in 1970), they have been introduced and currently used in common strategies for the development of European technologies, since 2009 (Futuro Perfect, 2024). Through this approach, the level of maturity of a technology can be measured, on a scale from 1 to 9, level 9 being corresponding to the phase of confirmation and validation of functionality in the operational environment (Commission Decision C(2014)4995). Completion of TRL 9 corresponds to confirmation that the respective technology is fully developed and available to be distributed to the market.

Why is such an approach useful in military science? According to the Collins dictionary, military science represents a series of studies about military practice and the strategic, tactical and logistical theories derived from this practice (Collins, 2024). In situations where the use of a military system is desired, regardless of the user's experience, a technological approach will allow him to understand its stage of development and the limits of the relationships it can establish within a military operation. Extrapolating the experience of development programs, financed through international competitions, we can appreciate that the academic environment and government funding sources focus, as a rule, on TRL 1-4 levels and the private sector requests an implementation of TRL 7-9 level for a possible support of its development. A possible explanation is determined by the fact that the private sector does not prioritize investments to support the academic environment and military structures in order to continue the development from TRL 4-7 to TRL 9 (TWI Romania, 2024), which would require verification of projects in environments controlled and under laboratory conditions. Thus, a number of new concepts and technological models, although promising, end their evolution before the implementation stage, sometimes being unadopted to the new security risks and threats identified.

Following only the economic return equations at the institution level, the private sector does not pay enough attention to the global state of security, except in the field in which it has economic interests to ensure its prosperity. But, most of the time, national and international security is maintained by adopting measures to deter a possible aggressor, which do not involve the direct armed forces actions. Military structures are

used in operational conflict environments only in warfare. This does not imply their abolition and establishment in the conditions preceding the outbreak of war. That is why they are maintained, modernized and prepared to be able to act only when needed, which requires economic and social efforts on the part of the whole nation.

The TRL classification of military systems also has some limitations. These may be due to the fact that some military leaders and politicians, in their official positions, use a vague expression that generates ambiguous interpretations and confusion. Without a standardization of public communication, important factors related to the degree of preparation for the use of military technology may be omitted, such as those related to the understanding of the military system architecture, the role of specific structures in the operational environment relationship, the different wear of some components, weapons and equipment, the quality of the human component etc. That is why it is recommended that parallel to the inclusion in TRLs a clear strategy of promotion and audience analysis should be carried out, all of which contribute essentially to the consolidation of success in innovation, in a similar way to any technological process.

The theory presented is taught in management programs related to all areas of economic and social studies. Adaptation to a military system, as a part of any society, is imperative for the real knowledge of the military system quality and for estimating the directions of warfare approaching in any parameters of the security operational environment.

2. The General Framework of Technological Analysis of Contemporary War

Today, warfare is hybrid, complex and ambiguous. It is characterized by a multitude of factors including technology, information, cultural particularities of non-state actors, multi-dimensional battles, mobile, flexible and timely logistics assurance. Innovative and integrated systems approach capable of managing the hybrid relationships that are formed between the entities involved are needed to resolve a contemporary war. To reach a sub-stage in the evolution of war, any of the entities involved can establish mutual relations, regardless of the antagonistic position they occupy. Thus, Gibson's war model (Kuehl, 2002) is increasingly visible in the contemporary geopolitical context. A contemporary war is unthinkable without the combination of conventional and unconventional tactics. They are used by state and non-state actors to conquer territories, in manipulation and disinformation actions, in subversive actions and proxy wars, in terrorist attacks etc. The involvement of non-state actors in direct conflicts, such as terrorist groups, militias, organized crime structures, corporate entities in combat and support missions require a radical reform of traditional military tactics.

Contemporary wars are characterized by simultaneous attacks in several fields such as military, economic, political, informational, psychological etc., establishing its multidimensionality. Their effects are presented persuasively to justify the extensive local, regional and global repercussions. Thus, the interconnectedness of economies, technologies and communications generates a significant impact in any part of the world, a fact that can allow a rapid expansion of the conflict but also a polarization of undecided entities. The relation of war-specific events to the rise and fall of stock markets fully justifies these aspects.

War contains a vast and inexhaustible field of engagement of all existing technologies. Such an approach is useful to understand which factors contribute to obtaining advantages in achieving superiority or dominance in the space or environment where the respective conflict takes place. Thus, support requirements and strategies can be outlined to sustain progress or to

force the technological gap between belligerent forces, so that an advanced technology cannot be exploited to the maximum level for which it was created. Advances in technology are known to have shaped the environment in which military operations are conducted and influenced tactics, strategies and even the nature of war itself.

We present some key aspects for current military conflicts:

1. Cyber evolution has influenced communications and decision support technologies: Cyber solutions have improved communications, surveillance, monitoring and decision support technologies to observe, compromise and destroy critical enemy infrastructures. This is how strategies for cyber-attacks, information manipulation, online propaganda etc., appeared.

2. Use of drones for military purposes: UAVs and drones have become essential vectors for surveillance, reconnaissance and striking enemy targets without exposing the human component to the risk of exposure to direct enemy fire.

3. Artificial intelligence (AI) and Big Data analysis: The use of machine learning algorithms and data processing systems to analyze information obtained in real time and quickly propose solutions to solve critical situations have increased the precision of military operations (Stanciu, Florian, Ciupercă & Cîrnu, 2021).

4. Autonomous weapons and robots: The rapid development of autonomous systems and robots in military applications has facilitated the creation of systems that can act independently in conflict environments. Thus, drones with autonomous target engagement capability, autonomous tanks, land and sea combat robots etc., appeared.

5. Space technologies: Initially, if satellites were used to optimize military communications, today they have become useful in support of military operations, in surveillance, navigation, fire control and logistical support missions (Botezatu & Vevera, 2023).

6. Directed Energy Weapons, Lasers, and Hypersonic Missiles: Breakthroughs in the fields of lasers and directed energy have enabled the creation of new weapons that can destroy targets, thus increasing the arsenal of direct-hit weapons and electronic warfare. Missiles in flight, planes, tanks, trucks, even enemy drones can be destroyed. In addition, hypersonic missiles reach unimaginable speeds which make them very difficult to intercept (Ciupercă & Vevera, 2022).

7. Last but not least, the so-called non-lethal devices such as sponge bombs, rubber bullets, electroshock weapons, painful electromagnetic/high powered sonic weapons etc., increase the arsenal of individual weaponry used in complex environments, where it is very difficult to discriminate a human target from a group of non-combatants civilians.

These are just a few examples drawn from contemporary conflicts where modern technology is influencing the way military operations are planned, lead and involved, not excluding traditional weapon systems and equipment intended to address a conflict.

In the macro-economic analysis of the phenomenon of war, it is important to mention the ethical implications for the use of these technologies in war. Even if they have not yet been fully determined and included in norms of international law, it is recognized that they can generate new types of risks and vulnerabilities, especially in the fields of diplomacy and international relations. Moreover, in some situations, the disproportionate implementation of new emerging and disruptive technologies (Ilinca, 2022) allows the deepening of the technological gap with the entities (institution, organization, society etc.) dependent on a certain technology. In the long term, these solutions can become harmful, as the technologically unadapted system is no longer able to identify the new

types of security risks and threats to which it is subjected. From a military point of view, an army's dependence on certain weapons and equipment makes it vulnerable to innovations or strategic changes by an enemy (Vevera & Ciupercă, 2019).

The most relevant example is the arms race of World War II. Thus, if the Axis Powers invented an aviation navigation system intended to bomb London, the Allied Powers invented radar and radio jamming systems. If the Axis used small submarines to attack shipping convoys that provided Allied logistics, their adversaries improved their sonar and systems for intercepting and decrypting radio communications. Within the Air Forces of both forces, the rate of technological development of aircraft determined by performance in speed and in precision strike systems is well known as a reactive relationship for airspace dominance. The examples can go on. From the point of view of technological progress, this period represents an exaggeration of the war industrial effort, which determined a huge consumption of resources (raw materials and labor) for the creation of weapons and military equipment.

Specific to contemporary warfare are the operations to combat a very poorly developed technologically, unstructured and non-military opponent. We are referring to the fight against international terrorist organizations, where their tactics are based on the use of individual weapons and improvised explosive devices with limited destructive effects. For them, information technology is only a platform to promote terrorist messages. The production costs of new technologies are disproportionate to the direct effects of combating a terrorist organization. However, identifying entities and their treacherous activities is extremely difficult to achieve using only traditional equipment. Obviously, a strict interpretation of the budget numbers allocated to the endowment of belligerent forces is favorable to terrorists. But will it really be like that? The analysis of the effects of a terrorist attack on the global economy contradicts this conclusion, which is correct for the geographical attack-area related.

A technological approach to war, reinterpreting the tactics and strategies of using the armed forces to make them capable of anticipating risks and developing contingency plans may represent an optimal strategy against the background of minimizing excessive dependence on technology in some directions. However, strategies take time to develop and observe the effects of their adoption. A strategy follows the maturity stages of the model based on TRLs. The development of a strategy through a technology approach can be stopped at TRL 4-6 levels, when it can be shelved or abandoned. But it exists, is verified and can be implemented as needed. Otherwise, it will produce an increased consumption of resources through the research and technological transfer exercise, against the background of society's reactions at the time of its adaptation to the conditions of the operating environment. Moreover, the ad hoc adoption of several parallel strategies to achieve the same objective is nothing more than a stubborn, very resource-consuming policy that reflects ineffective management.

3. Critical Analysis of the Global Operational Environment in a VUCA Context

Knowledge of the operational environment is a critical condition for understanding strategic opportunities as well as a basic principle of effective military management. In our analysis we considered as reference elements the reports of the World Economic Forum as an environment of public-private cooperation in which the opinions of some political, business, cultural and other important leaders of society are brought together. The resulting conclusions shape global,

regional and industry agendas in order to form a unique institutional culture.

The Alliance for AI Governance report, with reference to emerging technologies, states that the collective global future is based on generative AI governance (World Economic Forum, 2024a). The report highlights the potential to increase global gross domestic product (GDP) by 7% over the next 10 years through the implementation of generative AI, but also the fact that this direction generates complex challenges with impacts on employment, education, the environment and online harm. To deter a potential aggressor requires increased requirements for data security, human rights protection, intellectual property protection and online safety, all as hybrid responses to a potential attack. Many of the emerging tensions are seen to be rooted in governance issues that require an improved legal framework to ensure digital identity security, data protection and information systems security amid labor migration and social upheavals generated by rapid deployment of generative AI systems. It is possible for a non-state actor to encourage some grievances, through deep-fake techniques, and create local conflicts that may subsequently escalate into a war. Amid rising inequality, many citizens believe the system is rigged. Populist forces amplify the feelings of separation and individualism, one in the decrement of others, persuasively presenting the extremist forms of liberalism generated by economic globalization (Wintour, 2023).

Quantum technologies have the potential to revolutionize financial services not only by improving computing systems, but also for detecting fraud and blocking support for terrorist organizations and organized crime structures. But these new technologies can generate significant cyber security risks by disrupting industrial systems and connections. To neutralize them, unified, global and cross-sectoral quantum security policies adopted only through collaborative dialogue between regulatory authorities, banks, industry and academia are needed (Rusu & Jurgens, 2024). Thus, complex solutions can be identified to inform and educate society about the benefits of the quantum future, in order to ensure the transition to a quantum-secure economy.

Mass migration due to local conflicts, climate change and increasing inequality of income and economic opportunity can undermine international security and generate new conflicts. The terrorist attack of the Hamas organization generated the war in Gaza. The threat of Iran and Russia to use nuclear weapons causes a rise in risk indicators at the level of G7 countries (MSC, 2024a).

Another direction of global institutional commitments aims to promote sustainability policies. It is observed that precisely green finance and technology are the missing links in achieving sustainability (World Economic Forum, 2024b). The different application of climate objectives, as a rule, due to the evolution of national economies according to their performances, can become environmental security risks with major influences for the generation of conflictual states. Autocratic regimes are seen using digital tools to oppress their own citizens and destabilize the democracies of other states. In addition, the competition between China and the US for dominance in artificial intelligence (AI) is causing repercussions with effects on international security, as more countries seek to implement emerging and disruptive technologies in industrial and military equipment. For example, the strategy of the US and its allies to control China's exports of advanced semiconductors has produced a crisis in the development of supercomputers, AI technologies and modern military capabilities (MSC, 2024b).

Last but not least, approaches focused only on cautious domestic policies are insufficient for a nation's resilience. Most countries need better preparation and proactive investments to control demographic

changes, access to their own resources, education and new technologies. Increasing global interdependence for the development of peaceful relations produces a number of economic disadvantages. For example, the development of trade routes did not make more developed states responsible for establishing democratic relations, but rather, for creating dependencies on autocracies, a state that manifested itself by establishing relations of influence in the internal order of dependent states, through the unequal distribution of the benefits. For example, Russia's invasion of Ukraine determined European states to adopt deterrence policies against cooperative security in them international relations with Russia.

In terms of ensuring the control of the escalation of local conflicts, usually of low intensity, but also to deter an offensive military operation carried out by a powerful actor, we observe extensive maneuvers of forces and military means and the repositioning of some military bases in advanced positions. The effects of these policies are felt in measures of global inclusion accepted by those states, reasoning that their own security systems are not capable of dealing with a major war. In the long term, these effects will cause economic losses, political compromises, decrease in national budgets etc., which will lead to geopolitical tensions, mistrust and military risks. Even such a strategy can be a short-term solution, the only ways to face new risks and threats are cooperation and dialogue in broad coalitions.

4. Results and Conclusions

Following what has been briefly presented, we claim that the future war will no longer represent a continuation of the policy achieved by other means (the Clausewitzian view) but a complement to the strategies of the alliances, and its forms of manifestation will be complements to the policies of the actors involved, in order to achieve some global economic and security objectives in various fields. Through this vision we support opinions such as that the war has gone far beyond the military sphere. A future war does not make a clear distinction between what is and what is not the environment for military operations. The spaces where the struggles take place can be of any nature: physical, social, economic, virtual, ideological, etc. The battles will be fought by human entities or robots, in military, quasi-military or non-military structures. Professional soldiers can fight each other or with non-military entities, the battles can be between specialists, totally unprepared and opportunists who don't want to lose everything.

In conditions where no one can anticipate the place, the moment of the trigger, as well as who will achieve the victory, the adequate training of the security and defense structures, collaboratively with civil entities, against the background of a good education of the population for security, will be the main assets for the maintenance of national identity and for the defense of its values and assets.

War based on emerging and disruptive technologies, in the VUCA context, is a central theme in the contemporary international security agenda and in multinational cooperation. These technologies have a great potential to change the way the entire society works, creating new opportunities for development. In this context, the technological impact on civil but also military domains is essential through the economic and social transformations they impose to ensure national and international security.

AI systems with self-learning functions will be able to make decisions in a short time and the synergy between the human and technical factors will be essential. At the same time, their malicious use represents a major challenge for national authorities and international organizations with attributions in the field of security and defense.

Domestic and international disputes must be resolved in such a way that international peace and security are not endangered. The use of force and interference in the internal affairs of another country must be condemned at the global level, with peaceful settlement representing the sure form of ensuring national identity and sovereignty. Any type of intervention in any economic and social field must be analyzed as a serious threat to global security. The emergence of non-state actors and the rapid globalization of the economy have rapidly diluted the power and control of state administrative entities, but even so, a defragmentation into diverse objectives and strategies will increase the amount and type of emerging risks and threats that will erode international trust. Against this background, it will be very easy to adopt wrong strategies in the name of law enforcement, in which the coercive forms adopted will increase the polarization of the entities involved, will justify the use of armed force for self-defense, new dissensions will appear for which there is no international legal framework regulation.

In the near future, we estimate that war will simultaneously take various forms based on the timely exploitation of feelings of mistrust that can be easily observed within any society. As words become weapons and silence and suspicion are considered tactics, the battles will no longer be just between troops and tanks but also between data, algorithms, propaganda and other forms of mind control. In these conditions, trust will be an exchange value and the distance between people will increase, communication being carried out only through blockchain technologies.

The effort of an aggressor will be to implement ideas that stimulate mistrust. Thus, the dialogue will turn into a fight, the truth becomes a victim, the words will be the ammunition that will support the provocation of material destruction and the stimulation of social dramas (loss of human life, injuries, social blame etc.). Under these conditions, open communication and human empathy will be the only forms of combating mistrust.

For all these, new technologies will be developed based on emerging and disruptive applications, the Internet of Things (both IoT and OT forms), blockchain, NFT, quantum computing, virtual and augmented reality, renewable energy and energy storage, biotechnology and personalized medicine and other technologies determined by the interest of the global security systems market. People are the only ones who will decide how they will use them.

In conclusion, there will be wars in the future as well. The evolution of emerging and disruptive technologies will shape the stages of conflict operations and require continuous adaptation of military strategies and capabilities. This requires highly qualified specialists, resources and appropriate policies. Social resilience solutions through education, which represent much more than the diversity of university education programs, should be a national priority that, in a relatively short time, will also stimulate the stabilization of labor force migration, demographic development and the strengthening of national security.

We are convinced that this topic is inexhaustible and has the potential to generate numerous directions of scientific research that go beyond the TRL4-6 level and generate added value through technology transfer to production. At the same time, the rapid establishment of a solid legislative framework is required to stimulate their ethical use.

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