Disruptive Technologies and Challenges to Arms Control Regimes

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Abstract-

The research aims to determine the disruptive technologies and the challenges to existing arms control regimes. The paper has discussed the emergence of fourth industrial revolution and its military implications. However, the major focus of the research is the impact of counter-space capabilities, AI-based cyberwarfare, and hypersonic weapons on the arms control regime. The study has used the case study of ongoing Russia-Ukraine War where both the parties have used counter-space capabilities and AI-based cyberwarfare. The research indicates that new technologies offer states the potential to increase their capabilities in a wide range of areas, from intelligence gathering to military operations, moreover emerging technologies also pose a risk to international stability, and enable states to act in ways that may be seen as aggressive and destabilizing. This could lead to greater armed conflict and increased risk of miscalculation. Moreover, these technologies have the potential to create an arms race or a situation of unequal power between states. The study has separately discussed the complex challenges of these technologies. Finally, it has suggested potential solutions for mitigating the challenges posed by new technologies.

Keywords: *Disruptive Technologies, Regimes, Counter-space, AI-based cyberwarfare, Hypersonic, Arms Race*

INTRODUCTION

The United States' explosion of the world's first atomic bomb in a New Mexico desert as part of the Manhattan Project in 1945 marked the beginning of the 'Atomic Age', The first nuclear bomb, known as "Little Boy," was dropped on Hiroshima, Japan on August 6, 1945, killing thousands of people. Three days later, a second nuclear bomb, known as "Fat Man," was dropped on Nagasaki, Japan. These two bombs are thought to have been the only nuclear weapons used in warfare. These events demonstrated the extraordinary destructive power of nuclear weapons, a fact that has had long-term consequences for international peace and security.[1]

In 1949, the Soviet Union successfully tested its first atomic bomb; this marked the beginning of the nuclear arms race, in which both countries competed to build the most powerful and destructive weapons. Both superpowers recognized that the first requirement of an effective deterrent was that it should survive or "ride out" a surprise "counterforce" targeted attack without being decimate a task made difficult by the ever increasing numbers of accurate delivery systems, "penetration aids," and multiple warheads. This led to the foundation of the nuclear triad, or use of three different types of delivery systems. Those are; first, long-range manned aircraft carrying nuclear bombs land-based. Second, Intercontinental ballistic missiles with nuclear warheads, and last nuclear-powered submarines armed with nuclear ballistic missiles to assure that a second-strike capability existed able to cause massive destruction to the attacking nation.[2]

Since then, basic nuclear technology that can be used for either civil or military purposes has diffused widely across the globe. Nuclear weapons themselves have spread much more gradually, with four additional nuclear powers by 1965, and only nine today: the five nuclear weapons states, plus India, Pakistan, North Korea, and Israel. In addition, a number of countries, including Iran, are suspected of

[1] History.com Editors, "Atomic Bomb History," *HISTORY*, last modified September 6, 2017, https://www.history.com/topics/world-war-ii/atomic-bomb-history.

[2] Council on Foreign Relations, "U.S.-Russia Nuclear Arms Control," *Cfr.org*, last modified May 1, 2017, https://www.cfr.org/timeline/us-russia-nuclear-arms-control.

seeking to develop nuclear weapons. Several other countries have developed or inherited nuclear weapons arsenals, but have chosen to relinquish them.[3]

The world has recognized the destructive capabilities of the Nuclear weapons right after the US nuclear attack on Japanese population. Thus, the development of nuclear weapons spurred a number of international initiatives to control their proliferation. Several formal and informal nuclear non-proliferation and disarmament regimes. The Nuclear Nonproliferation Treaty (NPT) signed in 1968 is the core component of the global nonproliferation regime, and establishes a comprehensive, legally binding framework based on three principles: prevent the spread of nuclear weapons, to promote peaceful uses of nuclear energy and to move towards nuclear disarmament. Others prominent regimes include IAEA, CTBT, FMCT, SALT, START, NSG, PSI, Wassenaar Arrangement, Australia Group, and Zangger Committee. A number of additional treaties and agreements have been signed to help limit the proliferation of nuclear weapons. [4]

However, The Fourth Industrial Revolution (4IR) is a term referring to the rapid digital transformation of the global economy, society, and culture. It is driven by advances in the digital technologies of artificial intelligence (AI), the internet of things (IoT), robotics, nanotechnology, biotechnology, quantum computing, Counterspace capabilities, Hypersonic Weapons and other emerging technologies. 4IR have a profound impact on the global military landscape.[5]

The emergence of the Fourth Industrial Revolution (4IR) presents a unique set of challenges and opportunities for the development and deployment of such technologies. The 4IR is driven by the development of new technologies such as artificial intelligence (AI), autonomous systems, big data analytics, and the Internet of Things (IoT). These technologies are being used to create powerful and destructive weapons, such as autonomous drones, laser-guided missiles, and even autonomous tanks. The implications of these technologies for the development of military capabilities are far-reaching. These technologies can used to create weapons that are more powerful and destructive than ever before, which could be used to cause mass destruction and loss of life. These technologies has created further challenges to existing arms control regimes.[6]

This research focuses on current debates on nuclear risk in the world and looks into the threats emanating from disruptive technologies under the nuclear overhang. The major focus of the study is the impact of counter-space capabilities, hypersonic weapons, and AI based cyber warfare on the arms control regime. It provides policy recommendations for the practitioners and academicians to mitigate the emerging threats from these new technologies.

Counter-Space Capabilities

Counter-space weapons designed to target and destroy spacecraft, satellites, or other targets in space. Examples of counter-space weapons include ground-based missiles, kinetic kill vehicles, directed energy weapons, radio-frequency jammers, and space-based missiles. Ground-based missiles are used to launch a projectile into space, usually with the intention of intercepting and destroying an enemy satellite. Kinetic kill vehicles are small, maneuverable spacecraft that can be used to ram an enemy satellite and destroy it. Directed energy weapons emit radiation or particles in a focused beam, which can be used to disrupt or destroy a satellite's electronics. Radio-frequency jammers are used to block signals to and from a satellite, rendering it useless. Space-based missiles are used to launch a projectile into space, usually with the intention of intercepting and destroying an enemy satellite.[7]

[3] Sheena Chestnut Greitens, "Nuclear Proliferation," *in The Globalization of World Politics: An Introduction to International Relations* (New York: Oxford University Press, USA, 2020), 373.

[4] International Institutions and Global Governance Program, "The Global Nuclear Nonproliferation Regime," *Council on Foreign Relations*, last modified March 21, 2012, https://www.cfr.org/report/global-nuclear-nonproliferation-regime.

[5] Klaus Schwab, "The Fourth Industrial Revolution: What It Means and How to Respond," *World Economic Forum*, last modified January 14, 2016, https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/.

[6] David Barno and Nora Bensahel, "War in the Fourth Industrial Revolution," *War on the Rocks*, last modified June 28, 2018, https://warontherocks.com/2018/06/war-in-the-fourth-industrial-revolution/.

[7] Tyler Way, "Counterspace Weapons 101," *Aerospace Security*, last modified June 14, 2022, https://aerospace.csis.org/aerospace101/counterspace-weapons-101/.

Counter-space capabilities of the world's militaries

The counter-space capabilities of the world's militaries vary significantly. The United States, Russia, and China are generally considered to have the most advanced and capable counter-space capabilities. These countries have developed advanced antisatellite weapons, as well as capabilities to jam, deceive, and disrupt satellite communications. They also have a range of other counter-space capabilities such as cyber operations, electronic warfare, and directed energy weapons. Other countries such as India, France, and Japan have also developed counter-space capabilities, albeit at a lower level than the United States, Russia, and China.[8]

Use of Counter-space capabilities in Russia-Ukraine War

The Russian-Ukraine War has been one of the most complex and multifaceted conflicts of recent times. Counter-space capabilities have played an important role in both sides' strategies. The following are some of the ways in which counter-space capabilities have been used in this conflict:

Jamming and Deception: Both sides have used jamming and deception techniques to disrupt the other's satellite systems. This includes jamming of GPS signals, jamming of satellite communication systems, and spoofing of satellite imagery.

Counter-space Surveillance: Both Russia and Ukraine have sought to gain an advantage through monitoring of the other's space assets. This includes use of ground-based radar and optical systems to track satellites, as well as use of cyber capabilities to gain access to and monitor satellite data.

Anti-Satellite Weapons: Both have tested and used anti-satellite weapons, such as kinetic kill vehicles, to disrupt and disable the other side's satellite assets.[9]

Challenges to Arms Control Regimes

Counter-space capabilities used to target other countries' satellites or missile defense systems, deny access to or disrupt communications, or even jam or destroy other countries' space assets. This can create an asymmetric advantage in conflict and undermine the effectiveness of arms control regimes.

One of the biggest challenges to arms control regimes posed by counter-space capabilities is the fact that they can be used to conceal and deny information. Counter-space capabilities can be used to jam or deceive sensors, making it difficult to verify compliance with arms control agreements. Moreover, counter-space capabilities can be employed to deny access to space assets, which can prevent the use of satellites for verification and monitoring. This can make it difficult to verify compliance with arms control agreements and increase the risk of violations.

Lastly, counter-space capabilities can also be used to target other countries' space assets, potentially leading to an arms race in the space domain. This arms race can create an environment of mistrust and an increased risk of conflict. Moreover, the development and deployment of counter-space capabilities can be seen as a destabilizing factor in international relations, as it can give states an advantage in conflict and undermine the effectiveness of arms control regimes.

AI based Cyberwarfare

AI-based cyberwarfare is the use of artificial intelligence (AI) to conduct cyberattacks. AI-based cyber warfare techniques are used to automate the process of cyberattack planning, reconnaissance, and execution. This type of warfare is especially dangerous because it allows attackers to launch sophisticated attacks on a large scale with little to no human involvement. AI-based cyber warfare can be used to launch distributed denial of service (DDoS) attacks, steal sensitive data, and manipulate or disable critical systems. AI-based cyber warfare also has the potential to cause significant physical damage if attackers are able to access and manipulate critical infrastructure.[10] Moreover, AI-based cyberwarfare can involve a variety of strategies, including the use of machine-learning algorithms to detect and respond to malicious activity, or the use of autonomous agents to

[8] Amanda Miller, "New Report Tracks Counterspace Capabilities of World's Militaries," *Air & Space Forces Magazine*, last modified April 2, 2021, https://www.airandspaceforces.com/new-report-tracks-counterspace-capabilities-of-worlds-militaries/.

[9] Victoria Samson and Brian Weeden, "Insight - Ukraine Highlights The Threat of Counterspace Capabilities In Future Conflicts," *Secure World Foundations*, last modified April 5, 2022, https://swfound.org/news/all-news/2022/04/insight-ukraine-highlights-the-threat-of-counterspace-capabilities-in-future-conflicts.

[10] David Cotriss, "AI-Driven Cyberwarfare: The Future of Conflict?," Nasdaq, last modified April 7, 2022, https://www.nasdaq.com/articles/ai-driven-cyberwarfare%3A-the-future-of-conflict.

launch and manage offensive operations. AI-based cyberwarfare could potentially revolutionize the way in which countries and organizations defend against cyber-attacks, as well as how they launch their own offensive operations. [11]

A new generation of AI-augmented offensive cyber capabilities will likely exacerbate the military escalation risks associated with emerging technology, especially inadvertent and accidental escalation. Examples include the increasing vulnerability of nuclear command, control, and communication (NC3) systems to cyber-attacks.[12]

Use of AI based Cyberwarfare in Russia-Ukraine War

Russia has been at the forefront of AI based cyberwarfare and has been using it in its military operations, including the ongoing conflict in Ukraine. Russia has been suspected of having used asymmetric warfare by using AI-based cyber-attacks, electronic warfare and information weapons on Ukraine's infrastructure like electrical grids and communication systems before the incursion. Russia has in the past also used this discreet use of technology for destabilizing its opponents' infrastructures.[13] Moreover, Russia's invasion of Ukraine was preceded by several weeks of cyberattacks, including that use AI to impede Ukrainian weapon systems, an attack that posted a fake ransomware note and then destroyed data. These attacks were part of a multi-year campaign of cyber warfare against Ukraine, which included attacks on portions of the country's power grid.

On the other hand, a rapid response team of cybersecurity experts in the European Union has mobilized to assist Ukraine in defending against cyberattacks by detecting when attacks are occurring. The Ukrainian government has also called on the Ukrainian hacker community to help defend the country, by protecting computer systems that control critical infrastructure like the power grid.[14]

Challenges of AI-based Cyberwarfare to Arms Control Regimes

AI-based cyberwarfare poses significant challenges to existing arms control regimes. As cyberwarfare becomes increasingly reliant on AI-based technologies, it becomes increasingly difficult to determine the source of a cyberattack, making it difficult for states to respond in a timely manner. Moreover, AI-based cyberwarfare is highly decentralized and distributed, providing an advantage to attackers who are able to launch large-scale, coordinated attacks from multiple points. This makes it difficult to identify the attacker and gives them the ability to launch attacks quickly and without detection. Furthermore, AI-based cyberwarfare is highly automated, making it difficult to track and attribute cyberattacks to a specific state or individual. This makes it difficult to hold attackers accountable under existing arms control regimes.[15]

Hypersonic Weapons

Hypersonic weapons travel at extreme speeds, typically five times the speed of sound or higher. These weapons can include missiles, torpedoes, and artillery shells that have been designed to travel at extreme speeds. These weapons are capable of delivering payloads to distant targets in a matter of minutes, creating an increased potential for destruction and damage. Hypersonic weapons can also be used to penetrate existing air defense systems and to evade missile defense systems. Hypersonic weapons are much harder to detect and counter than traditional ballistic missiles, making them a potentially powerful weapon of choice for militaries around the world. The development of hypersonic weapons is a relatively new field, and many countries

[11] Firas Sassi, "Artificial Intelligence/Machine Learning and Cyber Command As a Tool of War: A New Method in the Mediterranean Battlefield?," *IEMed*, last modified August 2021, https://www.iemed.org/publication/artificial-intelligence-machine-learning-and-cyber-command-as-a-tool-of-war-a-new-method-in-the-mediterranean-battlefield/.

[12] James Johnson and Eleanor Krabill, "AI, Cyberspace, and Nuclear Weapons," *War on the Rocks*, last modified January 31, 2020, https://warontherocks.com/2020/01/ai-cyberspace-and-nuclear-weapons/.

[13] Sanur Sharma, "Russia's AI Enabled Military Ecosystem and Its Algorithmic Warfare," *Manohar Parrikar Institute for Defense Studies and Analyses*, last modified March 16, 2022, https://www.idsa.in/idsacomments/russias-ai-enabled-military-ecosystem-ssharma-160322.

[14] Justin Pelletier, "Intelligence, Information Warfare, Cyber Warfare, Electronic Warfare – What They Are and How Russia is Using Them in Ukraine," *The Conversation*, last modified March 1, 2022, https://theconversation.com/intelligence-information-warfare-cyber-warfare-electronic-warfare-what-they-are-and-how-russia-is-using-them-in-ukraine-177899.

[15] Thomas Reinhold and Christian Reuter, "Cyber Weapons and Artificial Intelligence: Impact, Influence and the Challenges for Arms Control," in *Armament, Arms Control and Artificial Intelligence* (New York: Springer, 2022), 154.

are currently working to create such weapons. Currently, the United States, Russia, China, India, and France are the only known countries to have hypersonic weapons.[16]

Challenges of Hypersonic Weapons to Existing Arms Control Regimes

The development and deployment of hypersonic weapons pose significant challenges to existing arms control regimes.

First, hypersonic weapons are difficult to detect. They travel at high speeds, making them difficult to detect until they are already in the target area. This makes it difficult to determine whether a nation is preparing to launch a hypersonic weapon and to respond in a timely fashion. Second, hypersonic weapons can be used to bypass existing arms control agreements. Hypersonic weapons can be used to deliver nuclear weapons with greater accuracy and speed than existing ballistic missiles, potentially allowing nations to circumvent arms control agreements that limit the number or type of nuclear weapons deployed.[17] Third, hypersonic weapons can be used to target civilian populations. Lastly, Hypersonic weapons can be used to deliver conventional as well as nuclear weapons, allowing states to target civilian populations with greater accuracy and speed than existing weapons systems. Their development and deployment could lead to a new arms race among nations, as each seeks to develop and deploy more advanced weapons in order to outpace its rivals. This could lead to increased tensions and a heightened risk of conflict.[18]

In light of these complex challenges, it is essential that states must work together to develop a new arms control regime that considers hypersonic weapons and should aim to limit the development and deployment of hypersonic weapons, as well as to ensure that existing arms control agreements are not undermined. [19]

Recommendations and Conclusion

This research aimed to identify the threats emanating from disruptive technologies under the nuclear overhang and the challenges to arms control regimes. Based on a quantitative and qualitative data, it can be concluded that disruptive technologies in military domain like counter-space capabilities, AI-based cyberwarfare, and hypersonic weapons alongside with nuclear weapons is creating lethal phenomenon. The research indicates that new technologies offer states the potential to increase their capabilities in a wide range of areas, from intelligence gathering to military operations, moreover emerging technologies also pose a risk to international stability, and enable states to act in ways that may be seen as aggressive and destabilizing. This could lead to greater armed conflict and increased risk of miscalculation. Moreover, these technologies have the potential to create an arms race or a situation of unequal power between states. Furthermore, these technologies have created new, and most complex challenges to existing arms control regimes. In addition, counter-space capabilities, and AI-based cyberwarfare has massively used in ongoing Russian-Ukraine War which has provided the practical implications of these technologies.

Therefore, states must work together to develop new arms control regimes that effectively address the challenges posed by emerging technologies or develop a comprehensive arms control and disarmament framework that is tailored to the unique challenges posed by emerging technologies. This framework should also consider emerging technologies within the wider context of disarmament and non-proliferation agreements. Develop a comprehensive strategy for mitigating risks posed by emerging technologies. This strategy should include measures to monitor and assess the potential misuse of such technologies and to identify and prevent potential violations of arms control regimes. Moreover, invest in research, development and implementation of technology-based arms control and disarmament initiatives, such as verification and monitoring of weapons systems and

[16] Jeff Seldin, "What Are Hypersonic Weapons and Who Has Them?," *VOA*, last modified March 22, 2022, https://www.voanews.com/a/what-are-hypersonic-weapons-and-who-has-them-/6492459.html.

[17] John Borrie, Amy Dowler, and Pavel Podvig, "Hypersonic Weapons: A Challenge and Opportunity for Strategic Arms Control," *United Nations*, last modified February 2019, https://www.un.org/disarmament/publications/more/hypersonic-weapons-a-challenge-and-opportunity-for-strategic-arms-control/.

[18] Shannon Bugos and Kingston Reif, *Understanding Hypersonic Weapons: Managing the Allure and the Risks*, (Washington: Arms Control Association, 2021), https://www.armscontrol.org/sites/default/files/files/Reports.

[19] Emmanuelle Maitre, "Arms Control and Delivery Vehicles: Challenges and Ways Forward," *Journal for Peace and Nuclear Disarmament* 5, no. 1 (March 2022): 143, https://doi.org/10.1080/25751654.2022.2047360.

disarmament verification regimes. Also, Increase efforts to strengthen international cooperation and collaboration on arms control and disarmament, in particular through the use of technology. Furthermore, develop international standards for the development, testing, and deployment of emerging technologies, in order to ensure that their use complies with international arms control regimes. In addition, establish an international forum to discuss the implications of emerging technologies for arms control and disarmament. Work with industry to develop and implement measures for regulating the development and use of emerging technologies, such as export controls and reporting requirements, and lastly, Foster dialogue between states on the challenges posed by emerging technologies and their implications for arms control and disarmament.

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