



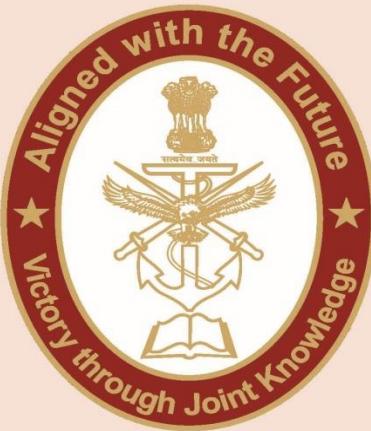
WEB ARTICLE

CENJOWS

AUTONOMOUS COMBAT DRONES: THREATS, CONCERNS AND WAY AHEAD

LT COL RENGARAJAN G

CENTRE FOR JOINT WARFARE STUDIES



CENJOWS

**AUTONOMOUS
COMBAT DRONES:
THREATS, CONCERNS
AND WAY AHEAD**



Lt Col Rengarajan G got commissioned in Indian Army to Corps of EME on 12 Dec 2009. The Officer has served with Infantry, Rashtriya Rifles battalion and also with two EME battalions in field, modified field, CI & CT operations environment in addition to an active association with technology intensive projects of simulators and drones at SDD.

Introduction

The rapid development of autonomous combat drones has transformed the concept of "killer robots" from fantasy to reality. These drones have the capability to operate independently, selecting targets and engaging in lethal actions without human intervention. While the technology for autonomous drones is largely in place, the deployment of such systems raises significant political and ethical concerns. This article explores the threats posed by autonomous combat drones, the associated concerns, potential ways forward, and concludes with a summary of key points.

Autonomous combat drones are revolutionizing the landscape of modern warfare, presenting new possibilities and challenges. These drones, operating with a high level of autonomy, are capable of carrying out military missions collectively as swarms. Swarms are groups of individual systems that interact and work together towards a common goal. While the military potential of swarms is a subject of great interest, there are significant concerns regarding the extent of human control over these autonomous systems.

Although swarm technology is still in its early stages, research in swarm robotics provides valuable insights into their operation and the challenges of human control. Swarms offer scalability, adaptability, and robustness, allowing for complex missions to be accomplished by a collection of simple units. However, the decentralized nature of swarms and their reliance on local information pose difficulties for human control.

The broader focus is on "human control," encompassing the mechanism for achieving a human commander's intent and the level of human influence on mission outcomes. It recognizes that autonomy raises fundamental questions about the evolving relationship between humans and machines, including concerns about the loss of human control over weapon systems.

Human control over machines, including swarms, presents various challenges. Factors such as cognitive demand, stress, and trust in machines can erode human control. Design choices and control structures also play a significant role in determining the level of control achievable. Additionally, legal and ethical implications arise from the use of swarms, including concerns about compliance with international humanitarian law, protection of civilians, and the erosion of moral responsibility.

Threats

Autonomous combat drones have the potential to revolutionize military operations, but they also present numerous threats. These threats include the risk of indiscriminate killings, collateral damage, and the violation of international humanitarian laws. The introduction of autonomous drones in warfare raises concerns about their ability to distinguish between combatants and non-combatants accurately. The lack of human oversight in decision-making processes increases the potential for errors and the possibility of civilian casualties.

Furthermore, the use of autonomous drones may lead to an escalation of conflict due to their inherent capabilities, such as flying at high altitudes and collecting extensive information. The ability of autonomous drones to operate in communications-degraded or -denied environments adds a new dimension to military operations. However, this also raises concerns about the legality of their actions and the potential for misuse or unintended consequences.

The emergence of autonomous combat drones brings with it a range of potential threats and challenges. While these drones offer enhanced capabilities and military advantages, they also pose significant risks that must be carefully considered. This section explores the key threats associated with autonomous combat drones, encompassing both technological vulnerabilities and strategic implications.

Technological Vulnerabilities

One critical concern is the susceptibility of communication systems to cyber attacks. As swarms heavily rely on communication and coordination among individual units, any disruption or manipulation of these communication channels could severely impact their effectiveness. Adversaries could attempt to jam or hack into the communication links, disrupting the swarm's ability to carry out missions or even gaining control over the drones themselves.

Another technological vulnerability lies in the sensor systems of autonomous drones. These sensors, such as cameras and radar, provide crucial situational awareness for the drones. However, they are susceptible to interference and manipulation. Adversaries may employ tactics such as spoofing or jamming to deceive or disable the sensor systems, rendering the drones blind or leading them into hostile situations. Furthermore, the reliance on GPS for positioning and navigation introduces a vulnerability to spoofing attacks that could misdirect the drones or cause them to collide with unintended targets.

Moreover, the increasing complexity and sophistication of autonomous systems introduce the risk of software vulnerabilities. Malicious actors could exploit these vulnerabilities to gain unauthorized access or control over the drones, potentially causing them to deviate from their intended missions or engage in unauthorized actions. Ensuring robust cybersecurity measures and regular software updates is crucial to mitigate these risks.

Strategic Implications

The deployment of autonomous combat drones also raises significant strategic implications that necessitate careful consideration. One primary concern is the potential for an escalation of conflicts. The autonomous nature of these drones, especially when operating as swarms, could reduce the threshold for engagement and increase the likelihood of rapid, large-scale military actions. The speed and efficiency of swarms in executing missions could lead to an accelerated tempo of operations, leaving less time for human decision-making and diplomatic efforts. This heightened pace and reduced human involvement may increase the risk of miscalculations and unintended escalations, potentially leading to uncontrollable conflicts.

Another strategic threat posed by autonomous combat drones is their potential to disrupt the balance of power. The widespread adoption and deployment of these drones could potentially provide a significant advantage to states or non-state actors that possess superior technological capabilities. This technological asymmetry could lead to destabilization, as those without access to advanced autonomous systems may feel compelled to seek alternative means to counterbalance the drone threat. This may result in an arms race, further exacerbating global tensions and undermining stability. The use of these drones raises questions regarding the proportionality and discrimination of force. Without direct human involvement in the decision-making process, there is a potential for disproportionate or indiscriminate use of force, leading to civilian casualties and violations of international humanitarian law. The complexity of swarms further compounds these ethical challenges, as the collective behaviour of a swarm may result in unintended consequences or excessive use of force.

Impact on Warfare and Defence Strategies

The introduction of autonomous combat drones fundamentally alters the landscape of warfare and defence strategies. The enhanced capabilities of these drones, such as

rapid deployment, advanced sensor systems, and coordinated attacks, provide new tactical options and force multipliers. However, they also necessitate adaptations in defence strategies to effectively counter these threats.

One primary concern is the development of effective countermeasures against autonomous combat drones. Traditional defence systems, designed to counter manned aircraft or single unmanned systems, may prove inadequate against swarms of autonomous drones. The sheer number, speed, and agility of swarms present challenges in terms of interception and defence. New technologies and strategies, such as advanced anti-drone systems, electronic warfare capabilities, and networked defences, must be developed to counter these evolving threats effectively.

The proliferation of autonomous combat drones also raises the level of asymmetric warfare. Non-state actors or rogue states, with access to relatively low-cost and easily obtainable autonomous systems, may be able to employ these drones in unconventional ways. This could include targeting critical infrastructure, launching terrorist attacks, or conducting asymmetric warfare against traditional military forces. Such asymmetric tactics may pose unique challenges for conventional defence forces, requiring innovative approaches and cooperative defence efforts.

Furthermore, the deployment of autonomous combat drones challenges existing legal frameworks and norms governing armed conflicts. The applicability of international humanitarian law, pertaining to principles of distinction, proportionality, and precautions in attack, must be carefully assessed in the context of autonomous systems. Ensuring compliance with these legal obligations in the face of rapidly evolving technologies and novel modes of operation is a complex and pressing task for policymakers and military planners.

Autonomous combat drones introduce a range of threats and challenges that must be addressed to ensure responsible and effective deployment. Technological vulnerabilities, including cyberattacks, sensor manipulation, and software vulnerabilities, require robust cybersecurity measures.

Strategic implications, such as the risk of conflict escalation and disruption of the balance of power, necessitate careful considerations of global stability and arms control. The impact on warfare and defence strategies calls for the development of effective countermeasures and the adaptation of legal frameworks to address the ethical and legal implications of these autonomous systems. By proactively addressing these threats, policymakers can promote the responsible and secure use of autonomous combat drones in the evolving landscape of modern warfare.

Concerns

The deployment of autonomous combat drones raises a range of ethical and legal concerns. The main concern lies in determining responsibility for the consequences of their actions. With reduced human involvement, questions arise regarding who should

be held accountable for any unlawful or unethical outcomes. The potential for drones to make decisions based on complex algorithms and artificial intelligence algorithms poses challenges in defining liability.

Additionally, there are concerns about the ability of autonomous drones to make ethical judgments and comply with international humanitarian laws. Current technology struggles to replicate human cognitive functions, such as creativity and pattern recognition, necessary for distinguishing combatants from non-combatants. The potential for civilian casualties and collateral damage remains high, particularly if autonomous drones are unable to assess the proportionality of an attack.

Ethical Concerns

Erosion of Moral Responsibility. With the increasing complexity and autonomy of these systems, the traditional understanding of responsibility centered around a human operator's full control over their actions becomes blurred. Operating a high number of systems simultaneously, especially in a networked environment, risks diffusing the sense of human responsibility for mission outcomes. This diffusion of responsibility can undermine ethical accountability and raise questions about the attribution of blame in case of unintended consequences or errors.

Burden on Operators. Controlling autonomous combat drones and swarms is a cognitively demanding task. Operators are responsible for the outcomes of missions, yet the increasing complexity of systems with autonomous functions places a significant burden on them. Holding operators fully accountable for mission outcomes in such challenging circumstances raises ethical dilemmas and questions about fairness. It becomes essential to strike a balance between the system's autonomy and operator's ability to exert meaningful control over them.

Legal Concerns

Compliance with International Humanitarian Law (IHL). Autonomous combat drones and swarms present legal challenges regarding compliance with International Humanitarian Law (IHL). The principle of precaution, which requires assessing the proportionality and necessity of an attack, becomes more complex when swarms are involved. Due to the latency and bandwidth challenges, as well as the reliance on simplified sensors, assessing the situation for swarm operators becomes more difficult. If swarms autonomously develop a mission strategy, ensuring compliance with all principles of IHL becomes uncertain.

Violation of the Principle of Distinction. The principle of distinction, which requires distinguishing between combatants and civilians and avoiding harm to the latter, is also at risk. During swarm engagements, some individual nodes may be shot down and left on the battlefield, potentially posing risks to civilians. Swarms can also create hazards by rendering land unavailable and causing environmental pollution if they contain

unexploded ordnance or toxic materials. Ensuring the proper application of the principle of distinction in swarm operations presents a considerable legal challenge.

Strategic Concerns

Reliance on Technology. The increasing reliance on autonomous combat drones and swarms introduces strategic concerns. Over-reliance on technology carries inherent risks, as it may lead to vulnerabilities exploited by adversaries. If the control systems or communication networks of autonomous systems are compromised, there is a potential for adversaries to disrupt or manipulate the drones or swarms, potentially causing detrimental effects on military operations.

Escalation and Proliferation. The proliferation of autonomous combat drones and swarms can also contribute to the escalation of conflicts. The accessibility and affordability of this technology may lead to a proliferation of these systems among state and non-state actors, reducing the threshold for engagement and potentially escalating confrontations. Unintentional escalation or miscalculations resulting from the deployment of autonomous systems could have far-reaching consequences for regional and global security.

Arms Race and Unintended Consequences. The development and deployment of autonomous combat drones and swarms may trigger an arms race among nations. As countries invest in this technology to gain a military advantage, there is a risk of unintended consequences and a lack of control over the trajectory of such races. Rapid advancements in technology can outpace the development of regulations and international norms, leading to a potential security dilemma and strategic instability.

Public Perception and Accountability. The introduction of autonomous combat drones and swarms raises concerns regarding public perception and accountability. Widespread deployment of these systems without adequate understanding or transparency could lead to public mistrust and fear. Lack of public acceptance and oversight mechanisms may hinder accountability and transparency in the use of autonomous drones, necessitating clear guidelines and frameworks to address these concerns.

Addressing Concerns and Mitigating Risks. Given the complexity of concerns surrounding autonomous combat drones and swarms, addressing these issues requires a comprehensive approach. International cooperation, dialogue, and the establishment of clear legal frameworks are crucial to ensuring the responsible development, deployment, and use of this technology. Enhancing human control and oversight mechanisms is of utmost importance. Striking the right balance between autonomy and human involvement, while upholding ethical standards, can help mitigate concerns related to erosion of moral responsibility and burden on operators.

Adequate training and guidelines should be provided to operators to enable them to make informed decisions and maintain control over mission outcomes. Additionally,

developing and enforcing regulations that ensure compliance with international humanitarian law is imperative. International bodies, such as the United Nations, can play a vital role in facilitating discussions and agreements on the ethical and legal use of autonomous combat drones and swarms. Regular legal reviews and assessments of new weapons and means of warfare, including swarms, should be conducted to identify and address any major strategic, ethical, and legal risks associated with their development and deployment.

Transparency and public engagement are essential in shaping public perception and addressing concerns related to accountability. Establishing mechanisms for public consultation, oversight, and awareness campaigns can foster trust and ensure that the use of autonomous combat drones and swarms aligns with societal values and expectations.

Way Ahead

To address the threats and concerns associated with autonomous combat drones, a way forward must involve a comprehensive approach. One potential path is the establishment of a human-machine partnership, where humans and artificial intelligence work together. This approach combines human creativity and decision-making abilities with the advanced data processing and sensor capabilities of autonomous drones. The human-machine partnership allows for a division of labour, with the drone handling data collection and processing, while critical decisions, including the use of lethal force, are made by human operators. This approach ensures that ethical boundaries are considered, and responsibility for the drone's actions lies with the human operator.

Furthermore, ongoing research and development should focus on enhancing the capabilities of autonomous drones to accurately distinguish between combatants and non-combatants and assess the proportionality of an attack. Advancements in artificial intelligence and sensor technologies can contribute to the ethical and lawful use of autonomous drones in military operations. However, it is crucial to consider potential strategies and actions that can pave the way for responsible and effective use of this technology in the future. This section explores various aspects and offers recommendations for the way ahead.

International Norms and Regulations. Establishing international norms and regulations is essential for governing the development, deployment, and use of autonomous combat drones. Collaboration among nations is crucial to ensure consistency and address the potential risks associated with this technology. Efforts should be made to engage in meaningful discussions and negotiations within existing frameworks, such as the United Nations and relevant disarmament conventions.

The ongoing debates surrounding Lethal Autonomous Weapon Systems (LAWS) provide an opportunity to address the challenges of human control over swarms. The

concept of "Meaningful Human Control" (MHC) should be further explored and defined to establish a clear standard for human involvement in decision-making processes. The international community should work towards a consensus on the parameters of MHC, ensuring that autonomous systems are subject to human oversight and accountability. Additionally, states should consider the development of national regulatory frameworks that align with international norms. These frameworks should address issues such as transparency, accountability, and compliance with international humanitarian law (IHL). Legal reviews should be conducted throughout the development and deployment stages to assess the strategic, ethical, and legal risks posed by autonomous combat drones.

Human-Machine Interface and Training. Improving the human-machine interface and training programs is crucial to enhance human control over autonomous combat drones. Operators must receive comprehensive training that encompasses both technical understanding and ethical considerations. Training programs should focus on developing critical thinking skills, situational awareness, and the ability to make informed judgments in complex and dynamic scenarios.

Human-machine interfaces should be designed to facilitate effective human control. This includes providing operators with clear and intuitive displays, decision-support tools, and real-time feedback on the status and actions of the autonomous systems. The interfaces should prioritize transparency, enabling operators to understand the decision-making processes of the drones and intervene when necessary.

Moreover, research and development efforts should be directed towards creating advanced control systems that enhance human-machine collaboration. This includes the development of adaptive autonomy, where the level of autonomy of the drones can be adjusted based on the mission requirements and the operator's preferences. By providing operators with flexible control options, it becomes possible to strike a balance between human control and the efficiency of autonomous swarms.

Testing, Evaluation and Verification

Thorough testing, evaluation, and verification procedures are essential to ensure the reliability, safety, and compliance of autonomous combat drones. These procedures should encompass both technical aspects and adherence to legal and ethical principles. This should not only be limited to controlled environments but should also include realistic operational scenarios. This involves conducting field tests that mimic real-world conditions, taking into account communication disruptions, adversarial interference, and unexpected contingencies. Field tests can provide valuable insights into the challenges of human control and the performance of autonomous swarms in dynamic and complex environments.

Verification mechanisms should be established to assess the compliance of autonomous combat drones with international humanitarian law. Independent oversight and auditing bodies can play a crucial role in conducting reviews and ensuring that the drones meet the necessary legal and ethical requirements. Additionally, international

collaboration in sharing testing methodologies, lessons learned, and best practices can contribute to the overall improvement of verification processes.

Ethical Considerations and Accountability. Ethical considerations should be at the forefront of the development and use of autonomous combat drones. A thorough analysis of the ethical implications should be conducted, encompassing considerations such as proportionality, discrimination, and the protection of civilian lives. The principles of just war theory and human rights should guide the ethical framework for the use of autonomous systems.

To ensure accountability, clear lines of responsibility and liability should be established. Operators should retain ultimate responsibility for the actions and outcomes of autonomous drones, even when the level of autonomy is high. Mechanisms for monitoring, auditing, and reviewing the actions of the drones should be implemented to address any potential violations or unintended consequences.

Transparency in the development and use of autonomous combat drones is vital for building trust among the public and the international community. Efforts should be made to promote openness and engage in public discourse on the implications and risks associated with this technology. This can include initiatives such as public consultations, ethical guidelines, and mechanisms for receiving feedback and addressing concerns.

International Cooperation and Confidence-Building Measures. These are crucial for addressing the challenges of autonomous combat drones collectively. States should engage in information sharing, dialogue, and joint research projects to enhance mutual understanding and trust. Platforms for multilateral discussions, such as expert forums and workshops, can facilitate the exchange of knowledge, experiences, and best practices.

Furthermore, confidence-building measures can contribute to reducing the risks associated with the deployment of autonomous combat drones. Measures such as notifications of military exercises involving drones, sharing of technical specifications, and establishing hotlines for communication during incidents can foster transparency and reduce the potential for misunderstandings or miscalculations.

Collaborative efforts should also be directed towards capacity-building and technology transfer to ensure that the benefits and risks of autonomous combat drones are shared equitably among nations. By promoting responsible development and use, international cooperation can help prevent the misuse or proliferation of this technology.

Conclusion

Autonomous combat drones represent a significant advancement in military technology, but they also raise critical ethical, legal, and security concerns. The introduction of fully autonomous systems challenges the traditional understanding of accountability and responsibility in warfare. The potential for indiscriminate killings and

the violation of international humanitarian laws necessitates careful consideration of the ethical implications of deploying autonomous drones.

Autonomous combat drones, particularly in the form of swarms, present both tremendous military potential and significant challenges regarding human control. Ultimately, the development and deployment of autonomous combat drones should be guided by a commitment to international humanitarian laws, ethical principles, and the protection of human life. As technology evolves, it is crucial to strike a balance between leveraging the advantages of autonomous systems and upholding fundamental ethical and legal standards in military operations in the future. The international community's debates on LAWS and the concept of MHC have highlighted the importance of maintaining human involvement in decision-making. However, achieving a consensus on the definition and implementation of MHC remains a challenge. Clarifying the concept of human control, encompassing the mechanism for achieving a human commander's intent, can provide a broader perspective for addressing human control concerns.

Furthermore, legal and ethical implications arise from the use of swarms in combat scenarios. Compliance with international humanitarian law, including the principles of precaution and distinction, must be ensured to prevent harm to civilians and avoid legal complications. Ethically, the use of swarms risks diluting operator's moral responsibility, as the increasing complexity and scale of swarm operations can make it challenging for operators to maintain full control over mission outcomes. To navigate the way ahead, it is imperative to foster interdisciplinary collaboration between experts in swarm robotics, defence, policy, and ethics. This collaboration can help shape comprehensive frameworks and guidelines for the development, deployment, and use of autonomous combat drones. By emphasizing transparency, accountability, and adherence to international legal standards, we can mitigate the risks associated with the increasing autonomy of these systems. A way forward lies in the establishment of a human-machine partnership, where humans and artificial intelligence collaborate to maximize the strengths of both. This approach allows for effective decision-making while ensuring human operators maintain responsibility for critical judgments. As we move forward, policymakers must remain vigilant in assessing the evolving landscape of autonomous combat drones. By proactively addressing concerns surrounding human control, we can ensure the responsible and ethical utilization of these powerful technologies in the interest of global peace and security.

DISCLAIMER

The paper is author's individual scholastic articulation and does not necessarily reflect the views of CENJOWS. The author certifies that the article is original in content, unpublished and it has not been submitted for publication/ web upload elsewhere and that the facts and figures quoted are duly referenced, as needed and are believed to be correct.

References

1. Arkin, R. C., 2020. Altmetric article – ‘The Case for Ethical Autonomy in Unmanned systems’.
2. D. Mendes, N. Ivaki and H. Madeira, "Effects of GPS Spoofing on Unmanned Aerial Vehicles," *2018 IEEE 23rd Pacific Rim International Symposium on Dependable Computing (PRDC)*, Taipei, Taiwan,.
3. Etzioni, A., Etzioni, O., 2017. ‘Pros and Cons of Autonomous Weapons Systems’, <https://www.armyupress.army.mil/Journals/Military-Review/English-Edition-Archives/May-June-2017/Pros-and-Cons-of-Autonomous-Weapons-Systems>.
4. Ryan, M., 2018. ‘Integrating Humans and Machines, The Strategy Bridge’, conference paper/
5. Scharre, P., Horowitz, M., 2015. ‘An Introduction to Autonomy in Weapon Systems, Center for a New American Security’, February 2015, pp. 6- 7.
6. Cummings, M., ‘Human supervisory control of swarming networks’, Paper presented at the 2nd Annual Swarming: Autonomous Intelligent Networked Systems Conference, 2004.
7. Karyoti, V., 2021. ‘9/11’s Legacy of drone warfare has changed how we view the military’.
8. Anna Konerta & Tomasz Balcerzak, 10th International Conference on Air Transport – INAIR 2021, Military Autonomous Drones (UAV) from fantasy to reality.