Eurasia Journal of Science and Technology
ISSN: 2663-1016
DOI: 10.61784/ejst240112

OPPORTUNITIES AND CHALLENGES OF FUTURE INTELLIGENT UNMANNED CONFRONTATION

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Abstract: With the rapid development of electronic and information science and technology, the development and application of intelligent unmanned systems has become the main axis of the world's technological innovation and development, and the era of intelligent unmanned systems is quietly coming. This article analyzes and discusses what opportunities and challenges will be faced in intelligent unmanned confrontation represented by drones in the future intelligent era, and puts forward some understandings and insights into the development of intelligent unmanned confrontation technology and equipment suggestion.
Keywords: Intelligent unmanned aerial vehicle; Drone; Robot; Directed energy; High-power microwave; Network electromagnetic space; Energy confrontation; Military intelligent technology

1 BASIC UNDERSTANDING

With the development of electronics and information science and technology, information systems based on computers and networks are rapidly developing in the direction of intelligence. The emergence and widespread application of intelligent unmanned systems will once again change the rules of combat and the shape of war. In the report "20YY: Preparing for War in the Robot Age" released in January 2014 by the Center for a New American Security, an American think tank, it was stated that "war in the robot age is no longer science fiction" and emphasized that for the United States and its allies, partners and opponents, It is said that in a new era, unmanned and autonomous weapons systems will play a central role in future wars, and the United States must be prepared for this. Intelligent unmanned warfare is coming to us. Intelligent unmanned systems, typically represented by unmanned aircraft, will become the protagonist of combat confrontations. Effective countermeasures against intelligent unmanned systems will be the new commanding heights for winning future wars. How to welcome the arrival of the intelligent and unmanned era in the future is a question that must be considered in depth.

1.1 Unmanned Systems are not Really Unmanned

Whether it is unmanned aircraft, unmanned boats, unmanned cars or robots, they are not truly "unmanned". The control of humans lurking behind them is indispensable. It just separates humans and machines in space and time. After separation, there must be information communication and connection between machines and humans. In order to reduce the dependence of unmanned systems on humans in the loop, unmanned systems will inevitably develop in the direction of intelligent unmanned systems [1-3], but in any case it is impossible to completely get rid of human control.

1.2 The Lifeline of Unmanned Systems is the Information Chain

Unmanned systems are essentially systems where humans and machines are separated in time and space. It is precisely because of the separation of humans and machines that unmanned systems need to be equipped with various sensors to obtain real-time external information. They must have reliable information links connected to the command center, and may also be equipped with wireless power transmission links in the future. It can be said that the information chain is the lifeline of the unmanned system. Without the information chain, the unmanned system is like a kite with a broken string. Without the acquisition, processing, sharing and decision-making of information, the unmanned system has no vitality.
Sensors and communication links are like invisible "windows", "nerves" and "backdoors" on unmanned systems. They are the most critical and most vulnerable parts of the normal operation of unmanned systems, which leaves many opportunities for anti-unmanned system operations. Space.

1.3 The Development Trend of Unmanned Systems is Intelligent Clusters

The intelligence of unmanned systems is an inevitable development trend [1-3]. Since humans have far better intelligent creativity than machines, and machines are far better than humans in terms of strength, speed, precision, endurance and repeatability [4], therefore, artificial intelligence researchers are committed to developing intelligent autonomous systems. Human systems make unmanned systems "smarter" and more autonomous, minimizing dependence on rear command personnel, thereby reducing dependence on information links. The clustering of unmanned systems is another important development trend [1-3]. In the future, intelligent unmanned systems will develop from independent operations to "cluster and collaborative" operations, including swarm cooperative operations of unmanned systems and

swarm coordinated operations of unmanned systems and manned systems, such as loyal wingmen, unmanned swarms and unmanned swarms. Wolves etc.

1.4 Unmanned Systems will Make Great Achievements in Replacing Manned Systems

Unmanned systems have the characteristics of specialization, speed, endurance, flexibility, strong autonomy, and recyclability [1-2]. They have demonstrated unique advantages in several local wars that have occurred in recent years. It is foreseeable that in the future multi-dimensional battlefields of land, sea, air, space and electricity, network electronic information and intelligent unmanned battlefields, unmanned systems will make great achievements in replacing manned systems.

First of all, unmanned systems have a wide range of uses and can be used on various unmanned platforms (such as aircraft, vehicles, boats), unmanned equipment (such as guns, missiles, radars, electronic warfare), and unmanned facilities (such as outposts, monitoring and listening stations) , communication relay station) and various robots.

Secondly, unmanned systems come in various forms. They can be multifunctional integrated intelligent unmanned systems or highly targeted special unmanned vehicles; they can be large unmanned systems or micro unmanned vehicles; they can be Unmanned aerial vehicles operating alone can also form unmanned formations operating in groups, such as "unmanned swarm", "wolf pack", "shark swarm", etc.

The most important feature of unmanned systems is their outstanding advantages. These advantages mainly include [1-2, 5]: 1) Super endurance, which can greatly improve the continuous operation time of the system. 2) Super mobility allows for wide space coverage with few restrictions. 3) Super adaptability, especially suitable for hazardous and harsh environments such as poisonous and harmful environments. 4) Better concentration and stability can make specific functions and tasks more targeted, and the continuous operation can be more repeatable and stable. 5) Renewable and low cost. Machines can be easily reproduced, and the machine's knowledge and skills can replicate binding and quickly form capabilities. 6) Have better consistency and synergy. Large-scale homogeneous unmanned aerial vehicles can ensure extremely high consistency. Different types of unmanned aerial vehicles can have fine division of labor and precise coordination, which is conducive to giving full play to the advantages of clusters and can even form disruptive capabilities to complete tasks that cannot be completed by a single unmanned aerial vehicle. arduous task.

1.5 The Main Battlefield for Unmanned System Confrontation is the Cyber Electromagnetic Space

With the development of science and technology, the form of war has undergone profound changes: from face-to-face fighting between people, fighting for physical strength; to confrontation with gun and shell firepower, fighting for energy; to full coverage of land, sea, air and sky, fighting for platforms; to cyber electromagnetic space confrontation, fight for information; with the development and application of artificial intelligence, future intelligent unmanned combat will directly fight for intelligence. The main battlefield of the battle has also undergone profound changes: from the one-dimensional frontline position to the three-dimensional physical space of earth, sea, air and sky, and then from the three-dimensional physical space to the network electromagnetic virtual space with electromagnetic information as the main body. In information networked and intelligent unmanned wars, once the electronic information confrontation in the cyber electromagnetic space fails, then the opportunity to use firepower in the physical space is completely lost, and the cyber electromagnetic space will definitely become the main determinant of victory or defeat. battlefield.

As a typical system for future operations, intelligent unmanned systems are highly informatized and intelligent electronic information equipment. The confrontation of intelligent unmanned systems is formally a confrontation of platforms. The core is the confrontation between information and intelligence. The main battlefield of the confrontation is the cyber electromagnetic space.

1.6 The Biggest Threat to Unmanned Systems is Electronic and Information Attacks

Unmanned systems are the integration of information systems, mission systems, control centers and platforms. The most prominent feature is a high degree of informatization and intelligence. Electronic information systems are spread throughout every key link. Attacking and destroying these electronic information systems can put unmanned systems under fatal threat. The most effective means of attack are electronic and information attacks and high-power microwave and strong electromagnetic pulse disruption and damage attacks. Among them, electronic and information attacks include information deception, signal interference, communication suppression and other electronic information countermeasures. Electronic and information attacks are the biggest threats to unmanned systems, and disruption and damage attacks from strong electromagnetic pulses such as high-power microwaves may be a fatal threat to unmanned systems.

2 CURRENT STATUS AND EXISTING PROBLEMS OF COUNTER-UNMANNED SYSTEMS

In recent years, various unmanned systems, typically represented by unmanned aircraft, have emerged one after another and are increasingly widely used. At the same time, unmanned systems have quickly become a new threat to national security. The armed forces of various countries around the world are vigorously developing and using drones to directly participate in combat. Drones have been widely used in surprise attacks and assassination operations; especially the large-scale popularization of civilian drones has provided important military and political sites and major events in various countries around the world. On-site security control poses a serious threat. On January 6, 2018, a Russian military base in Syria was attacked by a swarm of 13 simply modified small fixed-wing drones. Although the Russian

army effectively disposed of most drones using anti-aircraft fire interception and electronic interference, many drones still successfully carried out attacks and caused certain damage. On August 4, 2018, while delivering a speech at a military commemoration event in the capital, Venezuelan President Maduro was attacked by multiple multi-rotor drones, injuring many people. Effectively controlling and countering unmanned aircraft has become an urgent problem in the world today.

The three key links to effectively counter UAV moving targets are timely and reliable early warning detection, real-time and accurate tracking instructions, and accurate and effective intersection strikes. For different unmanned aircraft, the capability requirements of these three links are very different. The offensive and defensive operations of large and medium-sized unmanned aircraft and micro-unmanned aircraft, single unmanned aircraft and unmanned swarms are completely different. Among them, the countermeasures of large and medium-sized unmanned aircraft belong to the category of traditional air defense operations, and existing air defense means are capable of covering them; while the countermeasures of micro-unmanned aircraft and swarms are a new problem, which requires early warning detection, tracking instructions and The three links of intersection and attack all face many difficulties and challenges.

Since the targets of micro-UAVs are small, low in altitude, and their movement characteristics change rapidly, the first difficulties faced in effectively countering them are difficulty in early warning detection, difficulty in stable tracking, and short effective interception distance. Secondly, it is greatly affected by the interference of terrain and ground objects. Whether it is a radar or an optoelectronic system, it is difficult to maintain stable locking and accurate tracking. Especially when facing unmanned swarm targets, it is necessary to accurately and stably track and lock a large group of similar targets. One of the goals is a very challenging puzzle. Thirdly, due to the small targets of micro-unmanned aircraft, it is difficult to accurately coordinate the projectile-target intersection and ignition during anti-aircraft fire strikes. Finally, the cost of micro-UAVs is low and the number is large. Not only is it too late to intercept and strike one by one, but it also consumes a lot of firepower and has low offensive and defensive efficiency.

At present, countries around the world are actively promoting the application of unmanned aircraft, and at the same time vigorously developing capabilities and means to counter unmanned aircraft and swarms. On the one hand, we have strengthened the construction of early warning, detection and tracking indication capabilities for low-slow and small targets such as unmanned aircraft, and launched a variety of miniaturized radar and photoelectric early warning detection test devices on the basis of existing equipment; on the other hand, we have also explored A variety of methods and means have been developed to attack and deal with unmanned aircraft and swarms, mainly including anti-aircraft fire strikes, net capture, electronic jamming of measurement and control communications, navigation and positioning deception jamming and suppression jamming, and laser weapon strikes. Preliminary test results show that although these methods and means have certain combat effects, they all have obvious limitations.

Countering unmanned systems through anti-aircraft fire strikes, net-throwing arrests, and other methods positions the confrontation with unmanned systems at the level of "fire confrontation and platform confrontation." Not only is the interception efficiency low, the associated risks are high, but also the cost of use is high. The effectiveness is also poor. Even if traditional anti-aircraft artillery forms a fire network, the probability of intercepting micro-unmanned aircraft is very low; when faced with a large number of clusters of micro-unmanned systems, methods such as anti-aircraft missiles and net-throwing captures are basically unable to cope.

From the perspective of electronic information confrontation in network electromagnetic space, it is a reasonable choice to use various electronic interference methods to counter unmanned systems. Once electronic information interference is effective, it will not only have a long range and large coverage, but also can deal with cluster targets at the same time, resulting in high combat effectiveness and cost-effectiveness. However, due to the highly targeted nature of electronic information interference, it is difficult for a single interference device to interfere with electronic systems of different frequencies and systems at the same time, and it needs to continuously interfere with the target. The use of omnidirectional interference will also lead to long-term and large-scale collateral effects; if directional interference is used, the targets can only be tracked and interfered in batches. When faced with multiple consecutive batches of different targets, one will lose sight of the other. , difficult to deal with effectively.

Laser weapons can shoot down small unmanned aircraft at the speed of light, and have fast reaction speed, strong combat concealment, strong universality, and relatively low strike cost [6]. However, laser weapons have high requirements for target tracking and aiming, and can only hit targets one by one. It is also difficult to effectively deal with unmanned swarms.

In short, in the face of the harassment of micro-unmanned aircraft and swarms, there is currently a lack of effective countermeasures at home and abroad, especially in sensitive areas such as bustling cities, dangerous goods warehouses or military bases, to effectively combat micro-unmanned systems and Bee colonies also face many difficulties and challenges.

3 THOUGHTS AND SUGGESTIONS ON THE FUTURE DEVELOPMENT OF COUNTER-UNMANNED SYSTEMS

The era of intelligent unmanned systems is bound to come, with both opportunities and challenges. To take the initiative and win in the future confrontation of information networking and intelligent unmanned systems, we must have the ability and means to effectively counter intelligent unmanned systems.

3.1 The View of Space should be Updated and Great Attention should be Paid to the Confrontation in the Cyber Electromagnetic Space

Although the cyber electromagnetic space is an artificial virtual space, it is already a real existence. Moreover, through electronic information technology and platforms, it has been closely connected with the familiar three-dimensional physical space, forming a new space world together. In the cyber electromagnetic space, people have not only recreated a new virtual world, but the virtual world is increasingly widely and closely supporting the operation of the physical space. With the development and application of electronic information technology, the higher the degree of informatization, the higher the utilization and dependence on network electromagnetic space. In the future era of information networking and intelligent unmanned, the three-dimensional physical space and network electromagnetic space will Interactions will definitely become closer; moreover, the operation mode of network electromagnetic space based on electromagnetic energy has unique and huge advantages, which is very different from the operation mode of physical space. Therefore, the role and status of cyber electromagnetic space will become more prominent.

Intelligent unmanned systems are a highly integrated complex of platforms, firepower, electronic information, and artificial intelligence. They are typical equipment supported by both the 3-dimensional physical space and the network electromagnetic space. When studying effective countermeasures against intelligent unmanned systems, one's vision cannot only be limited to In addition to traditional three-dimensional physical space, we must also see the advantages and importance of network electromagnetic space.

This article believes that the first confrontation between intelligent unmanned systems is the confrontation between network electromagnetic space information and intelligence, and then the confrontation between physical space platforms and firepower. Therefore, it is recommended to focus on developing combat methods and means to counter unmanned systems from the perspective of electronic and information confrontation in network electromagnetic space.

3.2 High-Power Microwave Weapons may be the Best Choice for Anti-Intelligent Unmanned Systems and Swarms

High-power microwave (HPM) weapon is a new concept weapon. It directly attacks the target electronic system through high-power microwave beam with directional radiation, disrupts and damages the target's sensitive electronic components, thereby making the enemy's informatized and intelligent weapon system or The performance of the ammunition is reduced or the combat capability is completely lost. Different from the "hard damage" of traditional chemical and kinetic energy weapons such as bombs and missiles that destroy equipment and personnel in physical space, and also different from the "soft damage" of electronic warfare equipment in the network electromagnetic space that interferes with and deceives electronic information systems, HPM weapons It uses electromagnetic energy to destroy electronic information systems in enemy weapons and equipment with beam damage. It is a "hard-kill" weapon for cyber electromagnetic space operations. The targets, modes, and effects of HPM damage and destruction subvert the concept of traditional weapons. It is a disruptive technology. It is likely to become a "game rule" changer in the future information networked, intelligent and unmanned system confrontation, and will become a counter-attack. The core weapon of electronic information networks and the "nemesis" of intelligent unmanned systems.

After more than 30 years of development, military and technological powers represented by the United States and Russia have made significant progress in high-power microwave technology research and weapon development and testing. They have proposed and developed and tested anti-electronic information equipment, precision-guided weapons, intelligent Various high-power microwave weapon prototypes such as ammunition, drones and swarms. For example, in the 1990s, the United States proposed the "Warning Eagle" system to intercept anti-aircraft missiles, mainly to prevent terrorists from using small anti-aircraft missiles or shoulder-fired missiles to attack civil aircraft. On October 16, 2012, with the support of the Counter-Electronic System High-Power Microwave Advanced Missile Program (CHAMP), the United States conducted a CHAMP missile flight test at the Utah Test and Training Range, successfully implementing high-power microwave missiles on computer networks and surveillance equipment. Damage attack. In 2013, the United States developed and tested the vehicle-mounted "Phaser" high-power microwave weapon system, which is mainly used to counter UAVs and swarms [6-8]. From September to October 2013, the U.S. Army successfully used the Phaser high -power microwave weapon developed by Raytheon Company to conduct air defense tests to intercept small UAV targets at the Army Fires Center of Excellence at Fort Sill, Oklahoma. Successfully shot down 2 types of small drones. According to reports, in June 2019, the U.S. Air Force Research Laboratory spent US$15 million and took 18 months to develop the anti-drone tactical high-power microwave weapon (THOR). Testing of THOR began in the spring of 2019. The device is vehicle-mounted and mobile, and the installation and debugging work can be completed within a few hours [9].

Russia's high-power microwave weapons are also developing rapidly, and are even ahead of the United States in some technologies. The focus of development is ground-based and space-based high-power microwave weapons. In 2001, at the Lima Maritime and Aerospace Exhibition, Russia demonstrated the concept design of the Ranets-E air defense high-power microwave weapon system. In 2013, Russia released two models of high-power microwave electronic warfare equipment, "Krasuha-2" and "Krasuha-4", which can interfere with electronic systems within hundreds of kilometers and destroy manned and unmanned weapons within several kilometers. The complex electronic guidance and navigation systems of aircraft and precision-guided missiles render the system ineffective. In 2015, at the Moscow Military Equipment Exhibition, Russia demonstrated a high-power microwave weapon called a "microwave gun" with

anti-missile and anti-drone combat capabilities at a distance of 10km. In 2016, the Russian Radio Electronic Technologies Company (KERT) disclosed plans to install high-power microwave weapons on sixth-generation unmanned combat aircraft. The weapons in this plan can disable the electronic equipment of enemy aircraft and have an attack radius of up to dozens. km.

Domestic and foreign research results have shown that high-power microwave weapons can disrupt and damage electronic information systems and carry out effective and devastating attacks on multiple clusters of intelligent unmanned systems in a wide range at the same time, with fast response speed and interception efficiency. It has high combat effectiveness and cost-effectiveness, can carry out short-term and precise attacks within seconds, and has little collateral impact. It is the best choice for anti-intelligent unmanned systems. It is recommended to strengthen the application research of high-power microwave anti-UAV and swarm, develop practical equipment and form capabilities as soon as possible.

4 CONCLUSION

The era of intelligent unmanned systems is coming. Whoever can make full use of and effectively counter intelligent unmanned systems will win the future. Military powers such as the United States and Russia are stepping up their deployment of innovative development plans for smart technology. Unmanned armies and smart warfare are not too far away, and our country must be prepared to respond.

Since intelligent unmanned systems are highly dependent on the cyber electromagnetic space, effectively attacking and containing the cyber electromagnetic space will be an important way to win the intelligent unmanned confrontation. Based on the good development trend of my country's high-power microwave technology, we should coordinate national efforts, coordinate innovation and development, accelerate the research and development of high-power microwave countermeasures for intelligent unmanned applications, and strive to play a greater role in future intelligent unmanned confrontations.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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