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Analysis on the development trend of future UAV equipment technology

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ABSTRACT. *UAV equipment has the advantages of low loss, zero casualties, reusability and high maneuverability. The world's military powers are actively developing unmanned aerial vehicles (UAVs) adapted to domestic needs. This paper introduces the development and application of UAV equipment technology in military aspects, and then analyzes the future development trend of UAV equipment technology from new power technologies, stealth technologies, artificial intelligence and new manufacturing technologies. n the future, UAV equipment will be integrated into various military fields, such as aviation, shipwreck, reconnaissance, etc., and even change the human combat mode.*

Keywords: *drone; long battery life; electronic skin; stealth technology.*

1. Introduction

At the beginning of the Vietnam War, the US military killed and injured more than 5,000 pilots[1]. Faced with tremendous pressure from the battlefield and the country, the US military finally thought of using a reconnaissance plane instead of a manned aircraft to perform reconnaissance missions, making the UAV rise rapidly . At present, as a typical combat force in modern warfare, UAV have become increasingly effective in combat effectiveness. Their enormous military application value has prompted the world's military powers to actively develop UAV that adapt to their domestic needs [2]. Compared with traditional combat forces, UAVs have the advantages of low loss, zero casualties, reusability and high maneuverability. According to the classification of execution tasks, At present, UAVs are mainly used in target drones, reconnaissance surveillance, communication relay, electronic countermeasures, fire guidance, war evaluation, harassment temptation, ground (air and sea) attacks, etc. With the wide application of hi-tech in UAV systems, future UAVs will have breakthroughs in terms of endurance, stealth capability, autonomous

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intelligence and manufacturing processes, and their operational effectiveness will be greatly improved, and may even be reshaped the new combat mode.

2. New power unit

The old-fashioned UAVs have short air-times and low flight altitudes. They cannot fit the needs of modern warfare. In 2015, the Northrop Grumman X-47B drone has Completed the feasibility verification of unmanned aerial loading and receiving oil[3]. However, compared with the aerial refueling technology, the US Global Army's follow-up “Global Hawk” super-altitude and long-endurance are more combative. The whole airspace and long battery life have always been an important trend in the development of UAVs. The power plant of the UAV system is the key to determining the endurance. The requirements of the UAVs for different purposes are different, but in terms of economy, reliability and other considerations, it is hoped that the power plant will save fuel, light weight, small size, high reliability, low cost and convenient maintenance. From the current technical development trend, the new technologies that may be adopted in the future UAV power plant have the following aspects.

2.1 Small nuclear power propulsion device

In theory, the energy released by a pound of enriched uranium can drive an airplane to fly 80 times around the Earth. As early as the Cold War, the United States and the Soviet Union began to study nuclear-powered aircraft. It is speculated that this aircraft can guarantee that a country's strategic bombers carry nuclear weapons in the air for a very long time, thus forming an effective nuclear deterrent tactic. Subject to radiation protection, weight issues and the inherent dangers of this technology, with the development of intercontinental ballistic missile technology, the plans have been cancelled, but its advantages still lead NASA's Marshall Space Flight Center to continue the development of nuclear-thermal propulsion (NTP) technology [4]. The application of a nuclear power propulsion device to an unmanned aerial vehicle system does not require radiation protection for personnel, and only the protection of electronic equipment needs to be considered. In recent years, with the wide application of small nuclear power propulsion devices in space probes, the miniaturization of nuclear power propulsion devices, radiation protection and other technologies have made breakthroughs, and the conditions for applying nuclear power to UAV have matured.

2.2 New technology of battery

Since the invention of lead-acid batteries by the Frenchman named Plant in 1859, people have been pursuing batteries that are lighter in weight, higher in energy density, longer in life and more stable and safe. However, the reality is that the development of

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battery technology has already entered a bottleneck period, and no breakthrough battery technology has been produced so far. Battery-powered UAVs have a poor endurance and limited working time. The average aerial UAV flight time is only about half an hour. With the emergence of new battery technologies such as liquid hydrogen batteries, graphene batteries [5], biofuel cells, super capacitor batteries, quantum batteries, solid-state batteries, etc. It is very likely that there will be breakthroughs in the power battery. These new battery technologies are used in drones to make drones lighter, smaller, and longer lasting.

2.3 Long-range wireless energy supply technology

The basic principle of this type of technology is to use lasers, sunlight, microwaves, ultrasonics and radio frequency carriers to provide energy for UAVs over long distances [6]. Lockheed Martin of the United States has started the laser long-range functional test as early as 2012, providing energy for any multi-rotor helicopter through a laser charging system called a stealth tower. In the future, Long-range power can be supplied to UAVs using laser-enabled devices deployed in space, to ensure uninterrupted flight of UAVs in the case of sufficient energy source. Micro-energy technology can be used in medium and short distances, using directional microwave towers mounted on vehicles or ships to provide energy to UAVs,reducing the weight of the drone's powertrain, and improving functional loads and endurance.

3. New stealth technology

Stealth technology is highly valued by the military powers of the world in the military, and the stealth UAVs formed by the combination of stealth technology and drone technology have strong survivability. The United States is the first country in the world to use stealth technology for UAVs. In the early 1960s, the United States adopted stealth technology on the Q-2 drone, enabling such drones to survive the enemy's defense zone. From a modern perspective, the new stealth technology is an important direction for the development of future UAVs.

3.1 Plasma Stealth Technology [7]

In October 2014, the UAV named "Zidian" developed by Nanjing University of Aeronautics and Astronautics was amazed at the "China Aviation Industry Cup" National Drone Grand Prix. The Massachusetts Institute of Technology developed a UAV propulsion system with ion wind in November 2018. For the "Ion Wind" drone propulsion system, these two UAVs, which are still in the experimental prototype stage, use the "plasma stealth technology", this technology use high-pressure ionized air to generate plasma, and gain power suddenly by controlling the flow of plasma. Due to the complex electromagnetic properties of plasma, objects covered by plasma

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clouds have natural radar stealth. In the future, the UAV with plasma stealth technology can unify the power propulsion and stealth of the drone. At the same time, this technology has no special requirements on the shape of the drone, and can be upgraded to make the traditional drone have stealth capability.

3.2 New stealth material

The demanding design of the UAV's stealth shape is bound to reduce the aerodynamic performance of the drone. The application of stealth materials can reduce the radar cross-sectional area without changing the shape. Therefore, the research and application of new stealth materials have become an important supporting technology for the development of stealth technology. Currently, the more popular new stealth materials divided into chiral material, nano-steal materials, conductive polymer materials, polycrystalline iron fiber absorbers, power-on coatings, etc. The basic characteristics of such materials are absorption and attenuation of incident electromagnetic waves, and the conversion of electromagnetic energy into heat energy, or disperse electromagnetic energy in other directions to avoid detection by enemy radar.

3.3 Bionic technology

Experiments show that although the shape of the seagull is similar to that of the swallow, the seagull's radar reflection cross section is 200 times larger than that of the swallow starling. Although the bee's volume is smaller than the sparrow, its radar reflection cross section is 16 times larger than the sparrow. It can be seen that the size of the volume is not the only factor that determines the ability of concealment. The body shape is the key to determining stealth. Therefore, by adopting bionic technology and changing the shape of the drone, it becomes an important direction of the stealth of the UAV. In July of 2018, China developed a new type of drone, whose shape and movement are no different from real pigeons. By mimicking birds flapping wings to generate lift, thrust and steering, it only produces very low noise. Make them almost impossible to find. At the same time, this drone has excellent radar stealth. Such UAVs have changed the shape of traditional UAVs, not only with radar stealth, but also with visual stealth.

4. Artificial intelligence technology

From the history of the development of air vehicles, drones are only born more than ten years later than manned machines, but their initial development speed and popularity speed are far less than those of manned machines. The development of UAVs is mainly limited by the backwardness of intelligent control technology. However, with the breakthrough of the new round of information technology

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revolution represented by artificial intelligence, UAVs will usher in the historical moment of rapid development and application.

4.1 Capsule network technology

Currently, Artificial intelligence technology such as neural networks and PID control are often applied to UAVs. The literature [8] has applied neural networks to the aerodynamic parameter identification, nonlinear flight control and flight fault diagnosis of aircraft. In addition, according to the literature [9], Wu Jiande and others of Kunming University of Science and Technology have applied the single-neuron-based PID control method to the speed control of light unmanned helicopters. to improve the autonomous hovering performance of unmanned helicopters. While in the future ,Capsule networks (CapsNets) [10] will become a new trend in the development of drones: it is a new type of neural network architecture, which may have a profound impact on deep learning, especially in the field of computer vision. The basic principle is Constructing a multi-layered neuron module in a deep neural network to discover and store information such as the detailed spatial position and attitude of the object. This technique enables the machine to quickly identify the same object in different situations with less sample data. In the application of UAVs, the computational power requirements can be greatly reduced, and the functional recognition of the target graphics can be realized under a small number of training samples.

4.2 Cloud artificial intelligence

Cloud manpower can only refer to the technology that integrates the operation mode of cloud computing with artificial intelligence in the cloud to centrally use and share machine learning tools. With the rapid development of communication technology, future UAVs can be equipped with advanced communication means, such as broadband satellite communication, laser communication, etc. Under the support of large-capacity communication, the huge artificial intelligence operation cost can be transferred to the cloud platform, which can effectively reduce the threshold for the use of artificial intelligence by the drone, and is beneficial to reducing cost and large-scale deployment.

4.3 Brain machine interface technology

Brain-computer interface technology refers to the establishment of a direct connection path between human cranial nerves and external devices with high biocompatibility, for realizing information interaction and function integration between nervous system and external devices.The technology uses artificial brain-controlled brain-computer interface to accurately analyze the working state of the human brain, to achieve the effect of intelligent integration of brain-computers,

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and to make human communication and communication more diversified and efficient. In March 2017, researchers at the NASA Armstrong Flight Research Center completed a flight test of an Advanced Data Acquisition and Telemetry System (ADATS) on a NASA Air King[11] . In the future, the brain-computer interface technology applied to the UAV can completely subvert the remote control mode of the traditional UAV, enabling the UAV to complete more complex tasks.

5. New manufacturing technology

With the development of manufacturing processes, materials science and open source hardware, the types of UAVs will become more numerous in the future. The hardware of the drone can be customized according to the specific mission, operational use and battlefield environment.

5.1 New material technology

New material technologies, such as composite materials, memory metals, self-healing materials, self-growing materials, biodegradable materials, etc., can be used to impart special capabilities that are unimaginable to traditional drones, For example, a drone using biodegradable materials can self-decompose after performing a task. This technology can be applied to the delivery of biological and chemical weapons, etc. with the enemy unable to verify. Another example, the drone working at sea, due to high temperature and humidity and high salinity, the body is susceptible to corrosion and damage, The use of self-healing materials and self-growing materials gives the drone a longer life and more stable performance.

5.2 Electronic skin technology

Electronic skin technology [15] uses polymer materials as the body to selectively deposit precision metal on the surface, so that devices such as antennas and circuits can be directly assembled on the surface of the UAV, and then the absorbing and wave-transparent materials are sprayed to form electrons skin. In the future, UAVs can use this technology to embed the onboard electronic system into the surface of the drone's body, providing more space for functional loads.

5.3 open source hardware

At present, open source unmanned projects are in the ascendant. As far as the core flight control technology of the drone is concerned, including closed source flight control and open source flight control, due to the limited developers of closed source flight control, it is often necessary to invest a lot of manpower and material resources and events for research and development, which is time consuming and laborious.

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Based on the open source thinking, the control can be a group strategy and a virtuous circle of “co-development and sharing”, which can be iteratively improved more quickly. In the future, the UAV system can adopt an open source software and hardware framework and build a universal UAV platform. It can flexibly carry different functional modules and software systems according to the needs of combat missions.

6. conclusion

In the future, military UAVs will present a trend of diversification of tasks, blurring of platform boundaries, and modularization of mission products. With the development of artificial intelligence, unmanned cluster technology, and hypersonic technology, unmanned combat will be more integrated into existing equipment systems. It will bring new combat modes and creat an upgraded combat system. Unmanned systems have become the weaponry system pursued by national military hotspots.

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