Research on Intelligentized Anti-UAV Command Control Scheme Technology

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Abstract：In view of this situation, our research project aims at accurately locating UAVs in detection mode, effectively damaging UAVs in defensive means, and constantly suppressing UAVs in key technologies. The optimal anti-UAV scheme is formulated. Combining with the above anti-UAV program, together with the control of relevant monitoring ZTE and decision-making center, the anti-UAV prevention and control command system is set up in the camp. According to the characteristics of different types of UAVs, the system can formulate effective anti-UAV plan for deployment, and also can play a significant role in the defense of key protected areas.

1 Introduction

With the global blowout development of unmanned aerial vehicles (UAVs), various countries are pushing ahead the researches on the anti-UAV technologies, and developing the anti-UAV schemes, the breakthrough research progress regarding the anti-UAV technologies has been achieved, and the pertinent striking of UAV of any single type can be realized with niche-targeting weapons. However, it is far from enough to resist the simultaneous invasion of UAV cluster and multi-type UAVs just by relying upon several technologies. An anti-UAV defense system should be established to cope with the multilevel, multi-type, and multi-directional UAV invasion at the same time. The system, which integrates multiple UAV detection modes and UAV striking modes, and can formulate the anti-UAV scheme according to the characteristics of different types of UAVs, is called an anti-UAV command & control system. With the accelerated development trend of UAVs, the planned and targeted UAV invasion will certainly become a normalcy, and the anti-UAV command & control system is bound to become the future development trend.

2 Current Situation of Anti-UAV Command Control Technology

2.1 Characteristics of anti-UAV command control technology

From the current practical situation, the UAV threat targets are mainly manifested by the following characteristics: The reflected cross section of the target is too small to be discovered. The modern UAVs are of evident stealthiness, especially miniature UAVs already have considerable radar stealth capacity without needing any specialized technical measure, and moreover, they are hard to be discovered by radar, acoustic and optical detectors, etc. by virtue of extremely weak noise and IR characteristic. Secondly, the UAVs execute diversified missions, which are hard to judge. The modular design is mostly applied to the modern UAV-borne systems, which can carry different mission equipment according to the mission demand to execute different missions such as intelligence reconnaissance, battlefield surveillance, electronic countermeasure, target indication, and ground striking. Moreover, different equipment can be reloaded on the UAVs with the same appearance so that they can be modified into UAVs with different uses. When these UAVs do not transmit electromagnetic wave, their functions can be hardly distinguished. Therefore, the recognition of target type becomes even more difficult when the UAV threat target appears in the air. Thirdly, the miniature UAVs will be regarded as major confrontation targets. With stealthiness and low cost, they can be turned into attacking systems just through slight modification, and moreover, it is difficult to detect them, so miniature UAVs confrontation will become the emphasis of troops in different countries.

2.2 UAV confrontation through traditional anti-air weapon system

Large UAVs can be stricken by the traditional anti-air weapon system. However, the anti-UAV method using guided missile and cannonball is susceptible to extreme cost asymmetry. Furthermore, these systems cannot resist the invasion of miniature and cheap UAV clusters due to the enormous volume. Besides the traditional anti-air weapon systems are used to execute the anti-UAV missions, the anti-UAV combat has been vigorously carried out by means of electronic warfare, network

warfare, etc. all over the world.

2.3 UAV confrontation by means of soft kill

The anti-UAV combat by means of soft kill has natural advantages in the field of UAVs. Compared with antiaircraft gun, air defense missile, catch net, etc., the soft kill is featured by low cost, high precision, low collateral damage, high technical maturity, and good effect on coping with UAV cluster. Nowadays most UAVs conduct the navigation and control by relying upon the electromagnetic frequency spectrum. The UAVs ability in effectively utilizing the frequency spectrum can be deprived of by means of soft kill, which then destructs the control and communication link or GPS signal between UAV and operator, so the UAVs cannot complete the normal flight operation and lose the combat capability, thus realizing the effect of soft kill. The soft kill can deprive the UAVs of the ability to execute the missions, and even control the enemy UAVs in turn. Various soft kill systems with different models have been developed successively at both home (China) and abroad, with the maximum effective range from hundreds of meters to tens of thousands of meters, etc. The anti-UAV combat system based on soft kill has become the development mainstream of the current anti-UAV equipment thanks to simple operation and mature technology.

2.4 Domestic and foreign existing anti-UAV systems

The existing anti-UAV systems in the globe vary a lot with the used technical route, but the main technical proposals include acoustic wave interference, electromagnetic signal interference, hacker technology, laser strike, UAV catcher, etc., all of which have different characteristics and effects. However, according to the differences in interference and suppression technology, the existing anti-UAV systems can be generally divided into three major types: interference blocking, damage catch, and monitoring control.

(1) Interference blocking-type anti-UAV system

Represented by the Drone Defender anti-UAV gun of American Battlelle Corporation and CounterUAV electronic anti-UAV system of European Airbus, the interference blocking-type anti-UAV systems transmit the directed high-power interference radio-frequency signal to the target UAV to cut off the communication link between UAV and remote-control unit, and force it to land voluntarily, or return under controlled state. As the GPS satellite navigation system is usually integrated with the inertial navigation system in most UAVs, the UAV is cheated to reach the preset position by simulating its GPS signal, the UAV will conduct the signal switching and insertion when flying in the protected area, so it is located to the preset position through the fraud navigation information, deviates from the preset planning route, and breaks away from the control of the controller, thus realizing the goal of enticing.

Another type blocks the interference and reaches the preset goal via the down link between UAV and ground station. Through the directed emission of large-beam radio-frequency interference signal to the target UAV, this type realizes the abnormal operation of down data link between UAV and ground station, the UAV is then divorced from the control of the ground station, handles this situation according to specifical circumstance, and then makes a return voyage according to the preset program.

The electronic interference resistance of UAVs is corresponding enhanced with the development of electronic technology; the ordinary signal interference contributes to the flight failure of UAVs, but it is difficult to judge the follow-up motion of the interfered UAVs, so the expectation for safety protection cannot be satisfied.

(2) Damage catch-type anti-UAV system

Represented by the high-energy laser mobile display system of American Boeing Company, “low-altitude guard” anti-UAV laser defense system of China Academy of Engineering Physics, SkyWall100 system of British OpenWorks Company, and UAV catcher of Dutch Delft Dynamics Company, this type directly intercepts, destroys, or captures the low-altitude UAVs, and realizes the prevention, control, and suppression of non-cooperative UAV targets mainly by means of laser weapon, ground-to-air missile, attacking UAV, etc.

The damage catch-type means of defense focuses on destroying the target, and according to the variety of striking weapons, it can be divided into the following types:

Traditional conventional anti-air weapons. As the existing combat targets of traditional anti-air weapons are applicable to large UAVs, the weapons of this type are only suitable for large-scale UAVs, and they have the shortcomings of high strike cost and excessive damage for miniature UAVs.

Laser strike weapons. Different from the traditional conventional weapons which destroy UAVs using kinetic energy or chemical energy, through the photons moving at speed of light or by adding the particles approaching speed of light, the laser weapons make the abovementioned photons or particles act upon and damage the UAV. The laser weapons are also applicable to the small-scale miniature UAV cluster by virtue of short reaction time and combat preparation time, and minor damage.

Microwave weapons. Similar with laser weapons, the microwave weapons belong to directed energy weapons. Nevertheless, compared with the laser weapons, they present broader range of transmitted wave velocity, and enlarged transmitted energy, which makes it easier for them to accept long-range air attenuation. Moreover, they only need to roughly direct at the target, but not need to accurately track the UAV target just like the laser weapons. By destructing the electronic equipment in the weapon system, the microwave weapons make the UAVs lose their operational effectiveness, and reach the goal of fire control.

(3) Monitoring control-type anti-UAV system

The monitoring control-type anti-UAV systems implement the real-time monitoring of the airspace within effective range by means of photoelectricity, radar,

etc., and control the UAVs and guide them to make return voyage by intercepting the transmission code used by the UAVs. Represented by the AUDS system of British Blighter Company, and UAVX system of American Black Sage Technologies Company, the anti-UAV systems of this type are developed by combining the electronic surveillance and photoelectric detection device with high maneuverability and integration level. They can detect, identify, and track the UAV target with multi-mode detection information, and implement the interference or destroy. As efficient and advanced anti-UAV systems, they have great development potentials in both military field and civilian field.

The detection radar will transmit electromagnetic waves to the UAV to acquire the target information. The transmitted electromagnetic waves vary with the UAV variety and signal. After receiving the electromagnetic echo, the equipment conducts the computational analysis via the computer, and realizes the identification and detection of UAV targets. The imaging mode of photoelectric devices is mainly divided into visible light imaging and IR imaging, and the two may be combined for the detection as required. The photoelectric device can realize the tracking and detection of UAV target, and moreover, provide accurate target information such as range, azimuth angle, and pitch angle through the image processing in cooperation with the laser range finder. When it comes to the satellite reconnaissance, the satellite collects the target information via the photoelectric remote sensing technology, and transmits the information through the radio reception technology. This type of reconnaissance method is featured by broad reconnaissance area, fast speed, and favorable effect, it can realize the regular continuous reconnaissance of one area, but the orbit coordination is required, which results in the high use cost.

3 Construction of Coordinated Anti-UAV Command Control Center

3.1 Construction of coordinated anti-UAV command control center

The anti-UAV command & control system consisting of "level I organization and command, regional detection, and distribution control of intercept disposal" is constructed in the air defense center. According to the function, the command control system is divided into wartime main control unit, and wartime slave control unit. A multi-directional anti-air combat system architecture covering multiple areas is built to cope with the possible threats. Based on the comprehensive recognition of the invasive targets, the prevention & control situation is formed, a scheme is formulated, and the prevention and control missions are allocated and transmitted to lower levels.

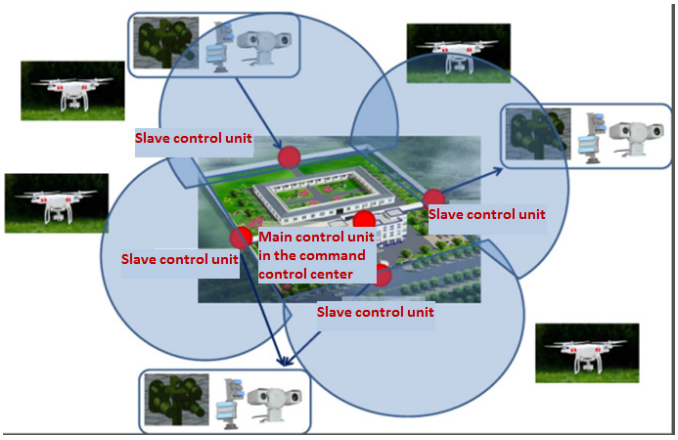

Figure 1 Schematic Diagram of Coordinated Anti-UAV Command Control Center

3.1.1 Prevention and control scheme for defense-penetrating low-altitude miniature UAVs

At present, the low-altitude defense-penetrating miniature UAVs will attack the same target from different directions and levels within a short time, so the enemy anti-air system is under saturation state for a short time, which cannot be handled. If the traditional anti-air weapon system is used under this circumstance, enormous asymmetry problem will be caused, just like striking mosquitos with a cannon. To avoid this problem, the anti-air scheme should center on the interference. To be more specific, the silent protection of low-altitude UAVs can be realized based on the electronic fence technology with directed electronic interference, namely, the signal transmission is interfered by the directional antenna to realize the signal interference for the miniature UAVs in designated direction within the designated range, suppress the remote control navigation information of the UAVs, and protect the target area.

3.1.2 Prevention & control scheme for large and medium-sized UAVs focusing on medium and high-altitude reconnaissance

The large and medium-sized UAVs are assigned mainly to acquire the intelligence information on our part. They

carry complicated and diversified mission payloads for the reconnaissance, including aerial camera, laser, or IR detector, etc., and moreover, they can realize strikes with the attacking weapons they carry. Based on the above features, the precondition for establishing a prevention & control scheme is always ahead of the enemy, namely further perfecting the prevention & control reconnaissance system. The air situation can be timely discovered, and the strategic depth of defense can be expanded by building an air observation post combining high and medium altitude, and far, medium, and short range in the course and direction where the enemy UAVs often appear. Miniature UAVs can be arranged beyond the radar exploration range and within the transmission distance of relaying data link in the air as the sentinels to conduct the reconnaissance. After the related reconnaissance information is acquired, the prevention and control can be conducted using the direct destroy technology. When a UAV invades, camouflage & deception technologies (including optical, thermal IR, acoustic, and electronic camouflage & deception technologies) can be used in important areas and nearby important targets, in order to avoid the disclosure of important information of our own side. Meanwhile, the position of this UAV can be determined under the joint action of sentinel UAV, radar detection and tracking technology, airborne early warning technology, and satellite reconnaissance technology, the information is then processed to form a control command, which is transmitted to the fire control system, and then the target is stricken and destroyed using the conventional anti-air weapon or laser weapon.

3.2 Research and formulation of prevention and control combat command process

The threat situation of UAV prevention and control is mainly divided into external invasion and internal invasion of the defense area. The prevention and control combat command process generally includes three phases: pre-war planning, wartime disposal and intercept, and postwar summary. In the prewar planning, the sentinel UAV, electronic interference weapon, anti-air missile, and ground forces lightweight weapon are integrated to form a coordinated defense system according to the abovementioned pertinent weapons, and invasive UAV discovered will be intercepted and stricken using air-to-air missile, ground-to-air missile, and artillery successively based on the distance. The low-altitude low-speed UAVs are destroyed by means of electronic interference, along with lightweight weapons. Two prevention and control authorization modes—prewar authorization and wartime authorization—are studied and formulated according to the regional level of protection.

The prewar authorization is used for the area with high level of protection, where the target should be intercepted immediately after discovery and confirmation, and the information will be reported to the command system. For the area with high level of protection, the command center should delegate the power to lower levels in advance. If an enemy UAV invades an important target, the information safety of the important target should be firstly guaranteed, and the prevention and control system should follow the principle of destroy upon discovery in order to ensure the nondisclosure of information. The target information is directly transmitted to the weapon system by various means of reconnaissance, and the target will be intercepted and destroyed after entering the attack range of the weapon.

The wartime authorization mode is adopted for the area with not high level of protection, the target should be discovered and confirmed, the target information should be reported to the command node of the prevention and control combat unit where it belongs, a disposal and intercept plan will be generated after the target information is finally confirmed by the main control unit, and the mission command will be allocated and transmitted to lower levels. For the area with not high level of protection, the strike priority of the command control system for the invasive UAV can be properly lowered. After the target reconnaissance information is uploaded to the main control unit, the commander can decide the strike opportunity according to the concrete defense situation in the subcamp, and formulate the optimal and relatively economical strike method based on the quantity, size, formation pattern, action attempt, and activity of the invasive UAVs. The mission will be allocated to each weapon system after the specific circumstance is analyzed, and the strike plan is confirmed.

3.3 Construction of anti-UAV combat system surveillance center

As the control center, the surveillance center is mainly composed of essential facilities like display and operation keys, all of which facilitate the operator to receive and process the real-time video and alarm information, and transmit the command to lower levels.

Figure 2 Configuration of Surveillance Center

The surveillance center plays an irreplaceable role as the brain commanding the anti-UAV command control system. After the reconnaissance information is uploaded to the surveillance center, the commander will make decisions, transmit the control command, complete the target strike plan according to the battlefield situation. Therefore, the surveillance center will become the key strike area for the enemy party. In order to guarantee the normal system operation, the destroy resistance of the surveillance center and its maintenance support capability will be the construction emphasis. Meanwhile, a fake surveillance center can be established to deceive the enemy.

3.3.1 Define the surveillance center as an area with high level of protection, and deploy major air defense forces around it

As the key strike target of the enemy, the surveillance center should be the primary protected area of our own side. While it is defined as the area with high level of protection, additional air defense forces are deployed around it. As the additional air defense guarantee of the surveillance center, these air defense forces will not be planned and dispatched by the surveillance center as a whole. An independent radar reconnaissance system is established around these air-to-air missiles and ground-to-air missiles, so as to form a reconnaissance and strike integrated air defense system together with the air defense forces. After the target is discovered by radar, the target information will be transmitted to the anti-air weapon, which will rapidly carry out firepower striking. This air defense system is used to realize the firepower striking of the enemy forces making a sudden and violent attack at our surveillance center under the emergency of paralysis, and win precious time for recovering the normal functions of the surveillance center.

3.3.2 Provide backup control link for the surveillance center, and establish its maintenance support capability

When the surveillance center is established with the anti-destroy capability, it is noteworthy that the surveillance center, if becoming the primary attacking target of the enemy air force, will unavoidably be damaged and even destroyed. To tackle the above possible circumstances, it is indispensable to equip the surveillance center with the maintenance support capability. The backup control link should be prepared for the guarantee while the surveillance center is built. During the wartime, the maintenance support team and vehicles should be deployed around the center in order to recover its functions.

3.3.3 Establish a fake surveillance center, and entrap the enemy to make firepower striking

A fake surveillance center can be established in the air defense area. This facility consists of electromagnetic wave transmitter. The generated electromagnetic waves simulate the frequency and waveband of the control link in the surveillance center, thus inducing the strike of hostile UAVs and other firepower. If attracting the enemy UAVs, the fake surveillance center can provide the real surveillance center with a safer survival environment.

4 Conclusion

No matter from the present development trend of war situation, or from the UAV threats faced by troops, the anti-UAV combat has been elevated to the level of national defense security protection in China. Single anti-UAV weapons only aim at the specific targets, but cannot handle different types of UAVs. Especially with the expansion of the field of UAVs application, the simultaneous combat of multi-type UAVs becomes inevitable. Therefore, the intelligent UAV command control system, which integrates multiple anti-UAV technologies and anti-UAV means of defense, is bound to play a dominant role in the future wars.

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