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Research on Uav Application Development and Airworthiness Standard Management in China

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ABSTRACT. *UAV technology is in high-speed development. It is a high-tech intensive product and belongs to high-tech vertical industry. China's UAV application is developing rapidly. The management is becoming more and more mature and standardized, and the industrial technology is at the international leading level. This paper studies the application development and industrial management of China's UAV, analyzes the role of UAV in promoting the development of related science and technology industries as well as promoting the innovation and development of science and technology fields.*

KEYWORDS: *China, Uav, Application classification, Airworthiness management*

1. Introduction

Thanks to the development of technology, the unit price of chips, batteries, navigation devices, communication chips and other hardware has been reduced. Unmanned aerial vehicles are widely used in the fields of logistics and transportation, agricultural and forestry protection, aerial photography, pipeline inspection, remote sensing detection and other fields. The UAV industry has a wide and profound impact on China's national economy and public life. However, the incidents of UAV intruding into no-fly zones and interfering with the take-off and landing of civil aviation flights have also been seen in the media for many times.[1] The safety management of UAV is a prominent issue. This paper starts from the perspective of airworthiness standards of UAV, and studies how to deal with relevant safety access issues from the source of manufacturing enterprises.

2. Classification and Characteristics of Uav Application

The unmanned aerial vehicle (UAV) is composed of a flight platform, the mission load and a ground control system. It is a non-manned aircraft controlled by radio equipment and airborne program control device. Through data link, the ground remote control station can track, locate, remote control, telemetry and transmit data to UAV. UAV can complete related tasks efficiently, improve work efficiency and

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reduce work intensity in business applications such as mapping, plant protection, line patrol and so on.

According to the application field, UAV can be divided into military aircraft and civil aircraft. Table 1 shows the details. Civil aerial vehicles are mainly multi rotor vehicles, which are mainly used in aerial photography, plant protection and mapping; fixed wing vehicles are mainly used in geophysical exploration, mapping, line patrol and other applications; unmanned helicopters are mainly used in agricultural and plant protection as well as engineering construction towlines. Unmanned airships are mainly used in air advertising. Civil UAV reduces the operation cost and risk of navigation, opens up new application scenarios, and plays an alternative role in the traditional general aviation business. There are many kinds of military unmanned aerial vehicle, ranging from small single soldier throwing tactical reconnaissance aircraft to large-scale strategic vehicles with long voyage. In recent years, UAV has become the most important means of non-contact combat attack.[2] This paper focuses on civil vehicles.

Table 1 Classification and Characteristics of Uav Application.

	field	classification	application (features)
UAV	civil	consumer	In large scale display activities, aerial photography entertainment, education and other aspects of large-scale application
		industry	It is applied to mapping and geological exploration, agricultural spraying, police patrol, electric power inspection, disaster prevention and emergency response, logistics and other applications
	military	investigation	Only perform monitoring and other work tasks; small size, easy to carry
		Investigation and attack	Long-endurance large, unmanned aerial vehicles carrying guided missiles and other weapons to attack enemy targets; strike target through human in the loop. When the combat mission is executed, the reconnaissance image obtained by the airborne sensor is transmitted to the ground station (satellite or wireless communication), and the ground station flight control or operator identifies the target according to the image, compares the image with acquired intelligence information, and makes the decision of attack.

3. Data of Uav Application in China and Analysis

China is a big country in UAV design, manufacture and application. According to the statistics of Civil UAV Real Name Registration Information System

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(hereinafter referred to as the “Real Name Registration System), as of 2019, about 285000 unmanned aerial vehicles have been registered, with 268000 UAV owners and 3720 UAV models; 1228 manufacturers and agents have been registered; as of the same period, 7113 manned aerial vehicles have been registered in China (hereinafter referred to as “MAV”).

Among all registered vehicles, there are 24471 with the maximum takeoff weight of 25 kg to 150 kg, 571 with the maximum takeoff weight of 150 kg and 49 with the maximum takeoff weight of 650 kg. Figure 1 shows the statistics of all unmanned aerial vehicles according to the takeoff weight in the real name registration system.

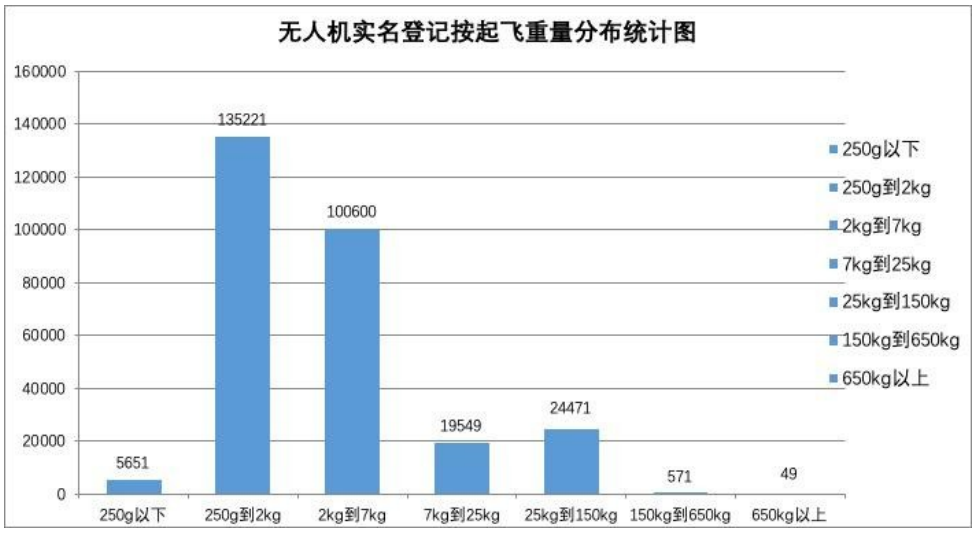

Fig.1 Statistical Chart of Uav in the Real Name Registration System According to the Takeoff Weight.

There are 1228 domestic UAV manufacturers and agents registered, and the top three regions are: South China, East China and North China. The top two cities are Guangdong (197) and Beijing (128). UAV manufacturers are different from the traditional MAV designers and manufacturers; they have more IT manufacturer attributes. The distribution of UAV manufacturers by region is shown in Figure 2.

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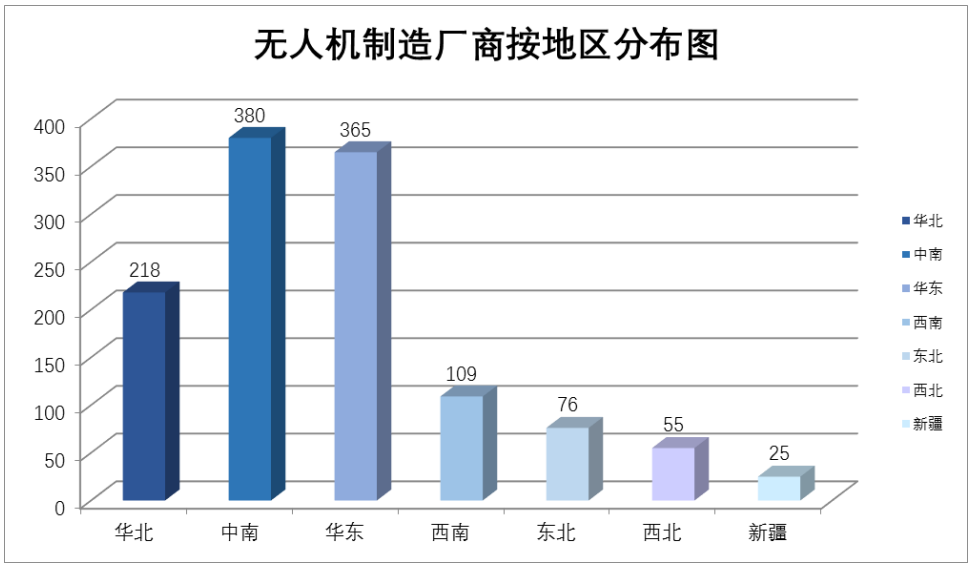

Fig.2 Distribution of Uav Manufacturers by Region.

According to system data, there are about 93000 unmanned aerial vehicles used for agricultural and plant protection, power line patrol, remote sensing and geophysical exploration, cargo delivery and other purposes. There are about 192000 vehicles for personal entertainment. Figure 3 shows the distribution statistics of UAV real name registration by usage and area.

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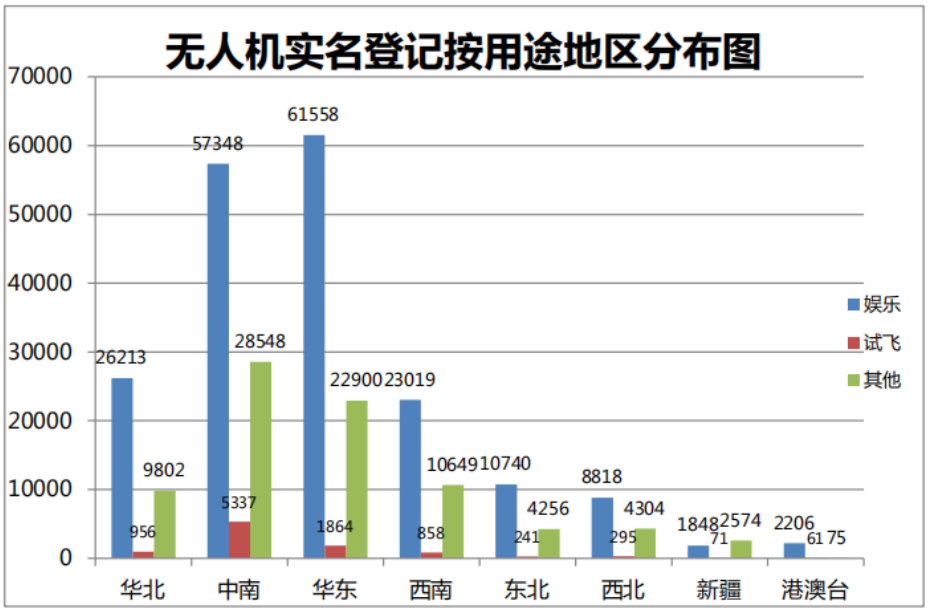

Fig.3 Distribution of Real Name Registrated Uav by Usage and Area.

According to above data, the number of unmanned aerial vehicles and manufacturers in China are higher than those of the same kind of MAV, and they have various uses, which puts forward new requirements for airworthiness certification from following perspectives.

First is the large quantity and diversified models.

The number of unmanned aerial vehicles is huge and there are many models. If we use the MAV certification mode, it will not meet the needs of UAV certification. We must innovate the UAV airworthiness management mode. [3]

Second is the diversified operational risks.

When UAV is used for different purposes, the usage scenarios and risk factors are different. The operation risks are different, so the airworthiness management should be classified.

Third is the new technical features

The operation mode of UAV is different from that of MAV, and its unique technology is distinct. Therefore, it is necessary to innovate the airworthiness standard and establish the unique standard system of UAV.

China's UAV manufacturing enterprises have basically mastered flight control, satellite positioning, multi rotor structure, composite materials and other

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technologies. China has a complete industrial chain of civil UAV, with many designing and manufacturing enterprises, extensive industry applications, and the largest industrial scale. In terms of small civil UAV, an industrial cluster with world leading level has been formed; in terms of large UAV, China's Wing Loong UAV, Rainbow series and other models have advanced performance.

There is a strong demand for UAV airworthiness standards in relevant industries, so it is urgent for CAAC to issue UAV airworthiness certification policies and standards. ICAO, the International Civil Aviation Organization and national authorities do not have complete and mature UAV airworthiness management methods or airworthiness standards, which is conducive for China to use our domestic technology accumulation and industrial experience to develop independent standards and promote China's standards to the world.

4. Airworthiness Management Based on Operational Risks

The purpose of airworthiness certification of civil UAV is to ensure that civil UAV can meet the minimum safety level acceptable to the public from the source of design and manufacturing. In the early stage, CAAC has established a real name registration system for UAV, and basically understood the industry situation; the real name registration system has realized the record of UAV and their owners, laying a good foundation for comprehensively mastering the overall situation of unmanned aerial vehicles in China, and providing strong support for the management and operation of UAV.

The airworthiness certification pilot of UAV was launched, and the airworthiness certification pilot was set up in relevant UAV manufacturing companies. The airworthiness standards and certification methods of cargo UAV, line patrol UAV and manned UAV were explored, which accumulated experience for the airworthiness certification of UAV. The civil UAV airworthiness management will innovate management method and carry out the management based on operation risks according to the characteristics of diversified UAV usage scenarios and operation risks.

The airworthiness management of UAV based on operational risk will establish an operational risk assessment method, so as to reasonably divide risk levels and carry out hierarchical management. The review mode of CAAC will change from clause review to manufacturer system review. It will guide manufacturers to establish and improve airworthiness system, and make UAV manufacturers take the main responsibility of airworthiness.[4] At the same time, it will implement the principle of positive validation, and establish the UAV airworthiness standard system according to the path of “industrial standard →professional standard → airworthiness standard”. After the manufacturer meets the system requirements and UAV meets the airworthiness standard, the airworthiness certificate can be issued. Thus, the airworthiness management mode of civil UAV based on operational risk is formed, which is composed of “a method, a system, a set of standards and a certificate”.

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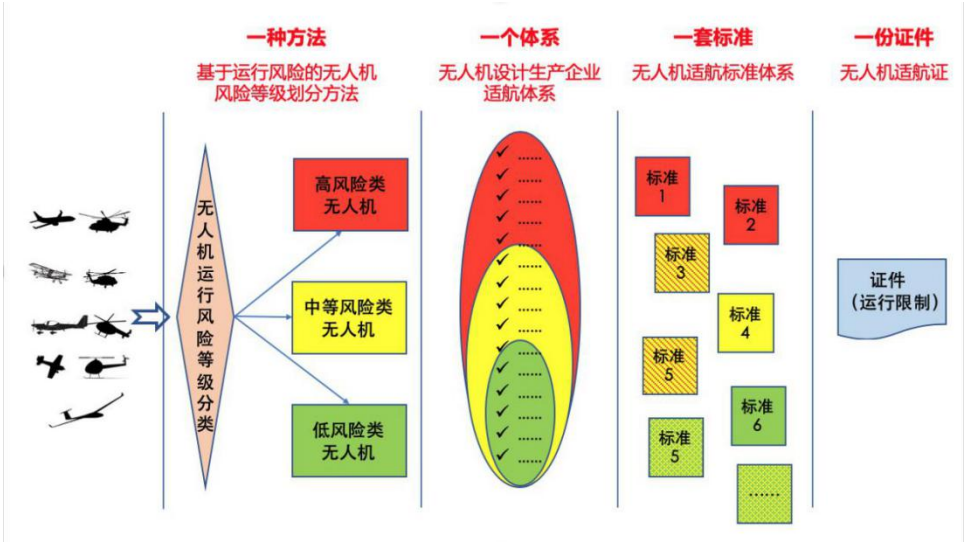

Fig.4 Airworthiness Management Framework of Civil Uav.

We need to establish an operation risk assessment method and divide the operation risk level of civil UAV into three levels: low, medium and high, as shown in the Figure 4. The operation risks of UAV mainly refer to collision caused by out of control, including the impact of UAV on the ground, and the impact of UAV with the third party vehicle irrelevant to the flight, such as personnel and facilities which causes injury. It also includes the impact of UAV with third party vehicle which is irrelevant to the flight, such as MAV and other UAV. In addition, there are also damages such as property damage, noise impact on the environment and people, and so on.

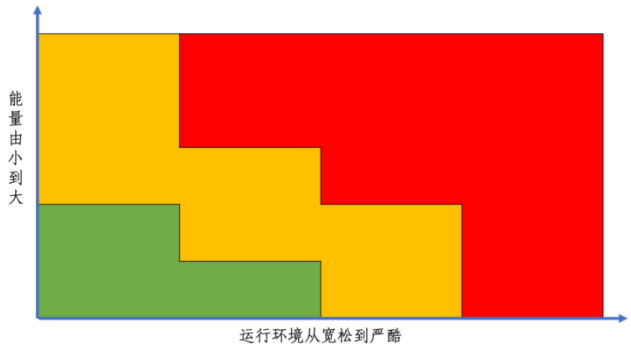

Fig.5 Uav Operation Risk Level Matrix.

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In Figure 5, the vertical coordinate represents the UAV energy; relevant data comes from the experience of military UAV model, the data of UAV real name registration system, and the feedback of industry research. The abscissa shows the environment of UAV operation scene; relevant information comes from the airspace classification and geographical environment of China.

Manufacturers of low, medium and high-risk UAV shall meet the airworthiness system requirements for the manufacturer, with the required content from less to more and the required degree from the shallower to the deeper . For manufacturers of UAV with low operational risk, after passing the system review of CAAC, and under continuous supervision, manufacturers shall show the conformity of their products to relevant standards, provide CAAC with declaration of conformity and supporting materials and put them on record. CAAC shall take post supervision as the main task.

For manufacturers producing high-risk UAV, after the system review of CAAC, and under continuous supervision, CAAC will evaluate specific projects and determine the degree of intervention. The manufacturer can complete part of the standard conformity determination, issue the conformity statement and submit it to CAAC, and CAAC will not intervene in the specific review of this part.[5]

For the manufacturers of UAV with medium operation risk, after passing the system review of CAAC, and under the continuous supervision, the involvement degree of CAAC review is between the above two cases.

In terms of international exchange, through participating in the work of ICAO's remote piloting aircraft expert group (RPASP), the UAV certification working group (UCWG) under the FAA Asia Pacific Partnership Framework and the UAV rulemaking Consortium (JARUS), the airworthiness certification policy and airworthiness standard of UAV can be discussed with authorities of various countries and regions. The views and experiences of China can be expounded and participated in international rule making.

5. Prospects of Key Technologies in the Future

Under the guidance of airworthiness technology, China's UAV industry will maintain orderly, healthy and sustainable development. China's future UAV technology will continue to lead the international level and drive the rapid development of science and technology industries which depend on following breakthroughs in key technologies.

From the perspectives of UAV itself, breakthroughs mainly include high-strength and lightweight structure, efficient power energy system, reliable mechanical, electronic software and communication system, and various loads and sensors for demand. The following links are weak.

Firstly, endurance is the biggest weakness. At present, lithium polymer battery is mainly used as power, which limits the practical performance. In the future, hydrogen fuel cell is expected to increase the endurance.

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Secondly, navigation and communication should also be improved; GPS and Beidou satellite navigation and positioning can be used. The horizontal positioning accuracy of satellite can reach decimeter level, but the vertical accuracy is still in meter level, and the cellular positioning is obviously limited by the environment and height. In addition, the navigation problem of indoor (closed) space has not been solved. The UAV uses radio communication command to control. The anti-interference ability of public radio communication is weak; the same frequency interference cannot be avoided. With the exponential growth of UAV, the anti-interference problem of communication system becomes increasingly prominent.

Thirdly, in order to ensure safety, we mainly rely on four technologies: infrared, ultrasonic, laser and visual sensor. The above obstacle avoidance technology cannot guarantee stable operation in special environment and weather conditions.

From the perspective of the UAV system, it takes responsible for data link technology of UAV communication and related ground control station equipment.

Firstly, ground control station is used to monitor and control the UAV flight platform and mission load, including equipment control the launching and recovery of UAV. The core of this technology lies in friendly human-computer interface design, one station multiple machine control, openness and publicity, as well as the training of operators.

Secondly, for the data link communication equipment, its core technology includes relay transmission, modulation, anti-interference transmission and coding. With the development of 5G technology and the breakthrough of key technology of network communication data link, it provides a huge development space for UAV clustering and intelligent application.

6. Conclusion

It is predicted that in the future, most UAV will use artificial intelligence and 5G technology. The operation of UAV increasingly relies on 5G communication network, big data processing, cloud computing, Internet of things and other new technologies, and can become mobile “space information receiving and transmitting control platforms”. UAV is also an appropriate application carrier of artificial intelligence technology. It is in the forefront of some applications of artificial intelligence technology, such as environment detection, perception and avoidance, communication, information fusion, sharing, environment adaptation and intelligent sensors. Some advanced unmanned aerial vehicles are trying to use advanced artificial intelligence technology, such as self-learning, self-coordination and autonomous intelligence. The development of UAV related technology has a significant role in promoting the development of high-tech technology represented by 5G.

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