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Comparative Study on the Legal Supervision System of Low-Altitude Aircraft in China and Europe Based on Key Risks †

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Abstract: In order to further ensure the safety of low-altitude activities, this paper takes the low-altitude aircraft regulatory systems that have been issued by the European Union and China as the research object and compares and analyzes the regulatory measures taken by the two regions for key risks and hidden dangers during low-altitude aircraft activities. Based on the analysis results, three improvement suggestions are put forward for China's future low-altitude aircraft regulatory measures: 1. Establish a complete risk assessment mechanism for the entire operation process of low-altitude aircraft, confirm flight activity authorization based on risks, and reduce operational risks; 2. Equip observers for special flight activities to reduce the workload of operators; 3. Establish a complete low-altitude aircraft information registration and monitoring system, monitor the entire process from production and sales to use, and avoid the phenomenon of "illegal flying".

Keywords: risk; legal system; supervision; low-altitude aircraft

1. Introduction

In March 2024, during the National People's Congress, the government work report clearly proposed "actively building new growth engines such as biomanufacturing, commercial aerospace, and low-altitude economy" and for the first time wrote "low-altitude economy" into the government work report. The newly released "2024 Shanghai Low-altitude Economic Development White Paper" defines the low-altitude economy as a comprehensive economic form that radiates and drives the integrated development of related fields, driven by various low-altitude flight activities of various manned and unmanned aircraft. As a representative of new quality productivity, the low-altitude economy has a long industrial chain and huge potential [1]. Its upstream includes research and development, key raw materials, and core components; the midstream includes payload systems, the design and manufacturing of low-altitude aircraft and other products, as well as ground systems; downstream applications include "low-altitude + transportation", "low-altitude + cultural tourism", "low-altitude + emergency", and other industries. The low-altitude economy uses low-altitude aircraft as the main carrier, is related to a variety of industries, involves all aspects of social life, and is more directly related to national security and people's safety. Therefore, in order to ensure the safe development of the low-altitude economic industry, it is necessary to establish an effective low-altitude aircraft supervision mechanism. Since both the EU and China have proposed a classification regulatory framework of "open category, specific category, and certified category" for low-altitude aircraft, they have certain similarities. However, the EU's low-altitude economic business has developed early, and the relevant regulations are complete. Therefore, this article intends to start with the regulatory laws and regulations of the EU and China and compare and analyze the regulatory measures taken by the two regions for key risk hazards during low-altitude aircraft activities.

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2. Development of Regulation of Low-Altitude Aircraft

2.1. EU's Low-Altitude Aircraft Regulation Mechanism

The EU has proposed a categorized regulatory framework of "open, specific, and certified" and has continuously improved various regulatory details through the formulation of relevant laws [2]. In 2015, the European Aviation Safety Agency issued the "Concept of Operations for Drones: A Risk Based Approach to Regulation of Unmanned Aircraft", which suggested setting up a corresponding classification regulatory framework based on operational risks and adopting the classification method of open category, specific category, and certified category. In July and December of the same year, the "Advance Notice of Proposed Amendment 2015-10 Introduction of a Regulatory Framework for the Operation of Drones" and "Technical Opinion: Introduction of a Regulatory Framework for the Operation of Unmanned Aircraft" were formulated and issued, respectively, which detailed the classification regulatory rules. In May 2017, the European Aviation Safety Agency issued the "Introduction of a Regulatory Framework for the Operation of Drones Unmanned Aircraft System Operations in the Open and Specific Category", which explained the adjustments to the open and specific categories [2].

The EU assesses the risk of harm to ground personnel, the risk of mid-air collision with traditional aircraft, and the risk of endangering critical and sensitive infrastructure during drone operations and sets differentiated regulatory rules based on the weight, size, complexity, and nature of specific activities of drones. The open category adopts post-regulatory measures, does not require prior authorization, and the pilot is responsible for the flight activities. In 2017, the EU subdivided the open category and put forward corresponding requirements for pilot capabilities and drone technical standards based on drone weight and flight area. The specific category requires prior authorization, and flight authorization can only be obtained when risk control conditions corresponding to the assessed risks are met. In the operation of this type of drone, the pilot can play a smaller role and needs to rely on safety equipment installed on the drone or specific operating procedures. The certification category means that when the risk level of drone operation is equivalent to that of traditional aviation operation, the operation will be deemed to require certification; that is, the airworthiness certification category. The regulatory method is handled in the traditional aviation regulatory method, and the traditional aircraft flight regulatory rules are applicable. The civil aviation authorities bear the main regulatory responsibilities. Each drone in the certification category needs to obtain a type certificate issued by the relevant agency before entering the airspace, including environmental certification, airworthiness certificate, and noise certificate. Pilots and operators must obtain approval from the organization; system support, such as airports and testing stations, should also meet the standards.

2.2. China's Low-Altitude Aircraft Regulation Mechanism

Chinese favorable policies in recent years have provided good legal and regulatory protection for the development of the low-altitude economy.

The scope of low-altitude aircraft flight airspace is constantly being refined. The "Interim Regulations on Unmanned Aircraft Flight Management" issued in June 2023 (effective on 1 January 2024) designates airspace above 120 m in true altitude, air restricted areas, air restricted areas and surrounding airspace, and ultra-low-altitude flight airspace for military aviation as controlled airspace. In November 2023, the "Regulations on Airspace Management of the People's Republic of China (Draft for Comments)", drafted by the Office of the National Air Traffic Management Committee, was officially released. Through the top-level design of the airspace management model, the scientific and fine configuration of airspace resources and hierarchical and classified management are realized. In December 2023, the Civil Aviation Administration of China issued the "National Airspace Basic Classification Method", which divides airspace into 7 categories, among which A, B, C, D, and E are controlled airspace, and G and W are uncontrolled airspace, providing a basis for the range of activities of low-altitude aircraft.

The country has established low-altitude economic industry standards and proposed a full-process supervision method. In June 2023, the "Safety Requirements for Civil Unmanned Aircraft System" was approved, and applies to micro, light, and small unmanned aerial vehicles other than model aircraft [3]. It stipulates 17 mandatory requirements such as electronic fences, remote identification, emergency response, structural strength, body structure, whole machine fall, power energy system, controllability, error prevention, perception and avoidance, data link protection, electromagnetic compatibility, wind resistance, noise, lighting, signs, instruction manuals, etc., and proposes corresponding test methods, further improving the existing civil unmanned aerial vehicle standard system, which can effectively guide the work related to the whole life cycle of civil unmanned aerial vehicles.

The Interim Regulations on Flight Management of Unmanned Aerial Vehicles, in accordance with the classification management approach, have established a full-chain management system for unmanned aerial vehicles covering production and manufacturing, sales and operation, operation qualifications, airspace use, flight activities, supervision and management, and emergency response, and has clarified the management departments and relevant responsibilities of each link, filling the gap in China's drone management regulations. The Civil Unmanned Aerial Vehicle Operation Safety Management Rules, published in December of the same year, divide the operation of civil unmanned aerial vehicles into three categories: open, specific, and certified, based on the principles of operation scenario-oriented, operation risk-based, and hierarchical and classified management. It also explains the corresponding management requirements for operators, registration, airworthiness, air traffic, and operation for different types of situations. The Several Provisions on the Production Management of Civil Unmanned Aerial Vehicles clarify specific management systems such as the unique product identification code management process, radio transmission equipment, and frequency of use; stipulate the network security and data security responsibilities of civil unmanned aerial vehicle manufacturers; and require the Ministry of Industry and Information Technology to establish a civil unmanned aerial vehicle product information system to share civil unmanned aerial vehicle manufacturer information and product information such as unique product identification codes with relevant departments and the integrated supervision service platform for unmanned aerial vehicles.

3. Key Operational Risks of Low-Altitude Aircraft

Although China has issued a series of laws and regulations, they have not been tested in practice, and the existing literature mostly analyzes from the macro level of laws and regulations, industry standards, management entities, etc., but there is less risk analysis from the operational level. Therefore, it is necessary to start from the actual operation process of low-altitude aircraft, summarize the risk factors of the entire process of aircraft operation, and analyze the key risks. Hao Weiqian (2023) sorted out the risks of the entire process of aircraft operation and classified all risks into five categories through the hierarchical analysis method, summarizing a total of 15 unacceptable risks(as Table 1) [4].

Table 1. Details of key operational risks of low-altitude aircraft.

Risk Type	Risk Factors
Human risk factors	No pilot license
	Insufficient preparation before flight
	No/Inadequate pre-flight inspection
	Maintenance errors by maintenance personnel
	Illegal operation
Drone system failure	Unregistered drone system

Table 1. *Cont.*

Flight environment factors	Magnetic field interference
	No network (communication and navigation) environment
	Low-altitude obstacles (terrain, buildings)
Drone traffic management	Flight plan review management error
	Drone fence data (update) management error
	Traffic management failure
	Emergency management failure
Communications, navigation, and surveillance	Communication, navigation, and monitoring equipment failure
	Communication network signal loss/delay/blockage
	Communication network information security (cyber attacks/interference/eavesdropping on radio signals)

4. Methodology

The Text Comparison method has been applied in this article [4]. Based on the key risks and hidden dangers during low-altitude aircraft activities by Hao [5], a comparative analysis was conducted on the existing low-altitude economic regulatory laws and regulations in the EU and China. With the EU's relatively complete low-altitude economic laws and regulations and policies as experience, China's current low-altitude economic safety regulatory legal system was further improved and supplemented to promote the safe and orderly development of the Chinese low-altitude economic industry.

For the analysis of relevant EU regulations, the main reference is the European Commission Implementing Regulation (EU) No. 2019/947 and its revised version translated by Ruan (2024) as a reference [6].

5. Results and Analysis

5.1. EU Regulatory Regulations Based on Key Risk

5.1.1. Remote Operator Qualifications and Operation Supervision

The EU stipulates that remote operators operating unmanned aircraft systems in the "open category" must be familiar with the user manual provided by the unmanned aircraft system manufacturer, complete an online training course, and then successfully complete an online theoretical knowledge test conducted by the competent authority of the Member State where the unmanned aircraft system operator is registered or an entity recognized by that competent authority.

In addition to being familiar with the user manual and obtaining a qualification certificate, remote operators operating unmanned aircraft systems in the "specific category" should also comply with the operation authorization issued by the competent authority and should have at least the following capabilities:

- Ability to perform operational procedures (normal, emergency and contingency procedures, flight planning, pre-flight and post-flight checks);
- Capabilities to manage aeronautical communications;
- Managing flight paths and automation of unmanned aerial vehicles;
- Leadership, teamwork and self-management;
- Problem solving and decision making;
- Situational awareness;
- Workload management;
- Coordination or handover of work (if applicable).

In addition, the EU has also made detailed regulations on the relevant operations of remote operators before and during flight, such as observing the environment before flight, ensuring the normal operation of the drone, and no drug effects. If necessary, an unmanned

aerial vehicle observer can be arranged next to the remote operator to provide assistance. The observer does not use auxiliary visual observation to observe the unmanned aerial vehicle and assist the remote operator in conducting the flight safely.

5.1.2. Systematic Registration and Supervision of Low-Altitude Aircraft in EU

The EU stipulates that each member state should reward and maintain an accurate registration system and explains the information that unmanned aircraft system operators should provide. During the drone operation authorization period, the EU also requires the registration number of the unmanned aircraft system operator, which once again provides protection for the registration and supervision of drone systems.

5.1.3. Traffic Supervision, Communication, and Navigation Supervision of Low-Altitude Aircraft in EU

The EU has established rules for conducting operational risk assessments, which set requirements for the description of unmanned aircraft system operations, including the operating environment (the operating environment and geographical area of the expected operation, in particular the population, terrain distribution, airspace type, in which airspace the operation will be carried out, and which airspace will be reserved as a necessary risk buffer), operation plan (the complexity of the operation, in particular the planning and execution of preparations for the operation, the capabilities, experience, and composition of the personnel, and the required technical means), and UAV performance characteristics (whether there are means to reduce the risk of collision, whether there are systems to limit the impact energy or brittle failure of the unmanned aircraft, whether it is designed in accordance with recognized standards, and whether there is an automatic fault protection design), etc.

Regarding the communication and navigation of low-altitude aircraft, the EU requires unmanned aircraft system operators to ensure that all operations use the radio spectrum effectively and support the efficient use of the radio spectrum to avoid harmful interference, and take measures to prevent illegal interference and unauthorized access to unmanned aircraft systems.

5.2. Chinese Regulatory Regulations Based on Key Risk Factors

5.2.1. Remote Operator Qualifications and Operation Supervision

China has also made clear provisions on the qualifications and operating specifications of operators. The "Civil Unmanned Aerial Vehicle Operation Safety Management Rules" require that personnel who operate various types of civil unmanned aerial vehicles in unmanned aerial vehicle controlled airspace should be proficient in the operation methods of the relevant models, understand the risk warning information and relevant management systems, have full civil capacity, and pass the theoretical training and examinations prescribed by the authority to obtain the corresponding safety operation theory training certificate.

At present, China divides the operator's license into small, medium, and large civil unmanned aircraft operator licenses. Applicants for civil unmanned aircraft operator licenses, and corresponding levels must meet the following conditions:

- Full civil capacity;
- No history of disease that may affect the operation of civil unmanned aerial vehicles, and no record of drug abuse;
- No record of intentional crimes or criminal penalties in the past five years;
- A medical certificate that meets the requirements;
- Complete the corresponding aviation knowledge training and pass the theoretical examination;
- Complete the corresponding control skills training and pass the practical test.

Regarding flight operations, the "Civil Unmanned Aircraft Operation Safety Management Rules" also require operators to confirm airworthiness standards, weather conditions, aircraft status, emergency plans, geographic location, and other information before takeoff.

5.2.2. Systematic Registration and Supervision of Low-Altitude Aircraft in China

The "Civil Unmanned Aerial Vehicle Operation Safety Management Rules" also set requirements for the real-name registration of civil unmanned aerial vehicles. The owner of a civil unmanned aerial vehicle shall register with the civil unmanned aerial vehicle integrated management platform in accordance with the regulations and may activate and use the civil unmanned aerial vehicle only after obtaining the registration mark. The real-name registration information shall include the legal identity of the owner, the owner's contact information, the information of the civil unmanned aerial vehicle, the purpose of the aircraft, and the validity period of the real-name registration.

5.2.3. Traffic Supervision and Communication and Navigation Supervision of Low-Altitude Aircraft in China

The "Civil Unmanned Aircraft Operation Safety Management Rules" stipulate that civil unmanned aircraft air traffic services shall be provided by the air traffic management agency responsible for the relevant area or the civil unmanned aircraft navigation service provider entrusted by it. Civil unmanned aircraft air traffic services are divided into control services, collaborative services, and information services. Control services include, but are not limited to, separation services and flow management services; collaborative services include, but are not limited to, flight activity application services, airspace risk assessment services, and air traffic management agency collaborative services; information services include, but are not limited to, operation identification services, traffic situation information services, operation environment information services, recording and statistical analysis services, and flight plan design services.

The "Safety Requirements for Civil Unmanned Aircraft Systems" have established corresponding standards for electronic fences, remote identification, and emergency response and proposed corresponding experimental methods. The "Civil Unmanned Aircraft Operation Safety Management Rules" require that, except for micro-civilian unmanned aircraft or those approved by the authority, civil unmanned aircraft operating within the territory of the People's Republic of China must install and use unmanned aircraft electronic fences. Civil unmanned aircraft must be equipped with aircraft status information detection equipment that is compatible with flight rules, and emergency or life-saving equipment that is compatible with the operation scenario must be installed for the case of manned and cargo operations.

The "Interim Regulations on Unmanned Aerial Vehicle Flight Management" also require that the application for flight activities must include necessary information such as the operator's qualification certificate, flight plan, communication and navigation capabilities, and emergency response procedures.

6. Discussion and Conclusions

In summary, both the EU and China have adopted a classified regulatory framework and have implemented more regulatory measures on key risks. However, in comparison, there are still areas that can be supplemented in China's regulatory methods for key risks.

From the overall operation of low-altitude aircraft, the EU has introduced a relatively complete operational risk assessment mechanism. By evaluating information on various aspects of aircraft operation, it confirms the operational risk of the flight activity and determines whether it is authorized, which provides a guarantee for the safety of aircraft operations.

From the perspective of operator supervision, both the EU and China have established requirements for the qualifications of operators and pre-flight preparations, but the EU has further proposed the capabilities that operators should have in operational activities

and refined the assessment methods for operators; at the same time, it has proposed the use of "observers", who can help operators share part of the workload and improve the safety of operation. Observers play an important role in general aviation. They are able to supervise civil aviation enterprises and institutions in their jurisdiction and have achieved good supervision results. This may also be applicable to low-altitude flights [7].

In terms of drone system supervision, both the EU and China require real-name registration of civil unmanned aerial vehicles, but neither mention specific regulatory methods. In terms of aircraft flight environment supervision, both the EU and China have adopted risk avoidance methods, including prior assessment and operator inspection before takeoff.

In terms of traffic supervision, communication, and navigation supervision, the EU conducts prior supervision through a risk assessment mechanism. China has categorized different flight services for different types of flight activities, which are uniformly supervised by the Aviation Administration. At the same time, China has also issued the "Safety Requirements for Civil Unmanned Aircraft Systems" to set national standards for communication, navigation, and emergency devices.

In order to further improve the regulatory mechanism of low-altitude aircraft in China, by comparing the regulatory measures of the EU and China on key risk factors, the following suggestions are put forward for the future regulation of low-altitude aircraft in China:

- Establish a sound operational risk assessment mechanism. Establish a sound risk assessment mechanism for the entire operation process of low-altitude aircraft, confirm flight activity authorization based on risks, and reduce operational risks.
- Assign an observer for special flight activities. For medium-sized or large low-altitude aircraft, or flight activities under special conditions, the operator can be assigned an observer to reduce the operator's workload.
- Establish a complete low-altitude aircraft information registration and monitoring system. Make good use of the product's unique identification code, establish a real-name registration system for drone sales, develop a drone monitoring system, and monitor the entire process from production to sales to use to avoid "illegal flying".

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