Science of Law Journal (2025)
Clausius Scientific Press, Canada

DOI: 10.23977/law.2025.040303
ISSN 2616-2296 Vol. 4 Num. 3

Research on the Construction of Urban Low-Altitude Land Use Right and Management Regulations System

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Keywords: Low-Altitude Airspace; Low-Altitude Economy; Regulation; Airspace Management; Policy Support

Abstract: With the rapid development of low-altitude economy, management issues in the low-altitude sector have become increasingly prominent. However, problems such as unclear definitions of usage rights and an incomplete regulatory system for the low-altitude sector have become core bottlenecks constraining the high-quality development of urban low-altitude economies. The existing regulatory framework has certain shortcomings and challenges in airspace allocation, aircraft supervision, and safety management. This paper suggests effectively addressing these issues through measures such as strengthening government policy support, optimizing airspace resource allocation, improving aircraft certification and supervision, and establishing inter-departmental coordination mechanisms. The aim is to provide practical policy recommendations and implementation paths for the construction and improvement of low-altitude management systems, thereby promoting the healthy development of the low-altitude economy.

1. Foreword

Low-altitude flight activities encompass multiple aspects such as airspace resources, flight safety, and inter-departmental collaboration. However, the existing regulatory system appears inadequate in addressing these complex challenges. Therefore, it is crucial to establish a comprehensive low-altitude management and supervision system. This paper aims to construct a dynamic hierarchical airspace model and propose a quantitative evaluation method for inter-departmental coordination mechanisms. By studying policy support and multilateral coordination mechanisms, we aim to effectively enhance the capabilities of the low-altitude regulatory system, ensuring that flight activities proceed steadily on both safety and efficiency tracks.

2. Overview of urban low airspace

2.1 Definition and scope of low altitude domain

Urban low-altitude airspace generally refers to a certain spatial range within urban areas that is relatively close to the ground. With the development of air economy, the definition and stratification of high, medium, and low altitudes will be adjusted in a timely manner to keep up with the times. The concept of low-altitude airspace will continue to evolve, potentially extending to 3,000 meters

depending on the characteristics and actual needs of different regions. However, the current definition of low-altitude airspace is set at an altitude below 1,000 meters.

In urban environments, the types of aircraft involved in low-altitude airspace are becoming increasingly diverse, such as drones and air taxis. The use of low-altitude airspace is no longer limited to traditional aviation but has expanded to new technological applications like logistics delivery, environmental monitoring, and traffic management[1]. Managing urban low-altitude airspace is crucial and must be closely coordinated with ground transportation systems and urban planning. On one hand, it is essential to ensure that low-altitude flight activities do not interfere with the smooth operation of urban ground traffic, avoiding chaos in ground traffic order or safety hazards caused by ground traffic facilities to low-altitude flights. On the other hand, during urban planning, the utilization needs of low-altitude airspace should be fully considered, with reasonable layouts for takeoff and landing points, no-fly zones, etc., to achieve efficient allocation of low-altitude airspace resources. The characteristic of urban low-altitude airspace is that the flight altitude is relatively low, and flight activities must be strictly controlled in terms of altitude, flight area, and flight time. Different types of aircraft, due to their varying performance and purposes, require differentiated low-altitude airspace management measures to meet the needs of modern urban construction and the operation requirements of intelligent transportation systems, better satisfying the diverse demands of low-altitude flights.

2.2 Background and demand of urban low-altitude development

The low-altitude domain has become a crucial factor in driving urban modernization and enhancing economic competitiveness. Currently, the primary demand for low-altitude flight comes from multiple industries, including logistics, urban safety, and environmental monitoring. These applications not only improve work efficiency but also significantly reduce resource consumption and time costs. Moreover, with the development of smart cities and intelligent transportation, the potential of low-altitude flight in urban management is gradually becoming evident[2]. In particular, in terms of urban air traffic, low-altitude flight is seen as a key solution to issues such as traffic congestion and environmental pollution. However, while the low-altitude domain is rapidly developing, management challenges also urgently need to be addressed. Flight activities exhibit diversity, covering drone logistics delivery, aerial taxi passenger flights, and various monitoring and inspection flights; complexity lies in the varying performance of different aircraft, differing flight altitudes and area requirements, and the mutual influence between low-altitude airspace and urban ground facilities and human activities. These characteristics pose unprecedented significant challenges to existing management systems, such as tight allocation of airspace resources, traditional airspace management mechanisms failing to meet the growing demand for low-altitude flight; cumbersome flight approval processes hindering the rapid development of low-altitude economic industries; and limited regulatory technical means making it difficult to conduct real-time, precise monitoring of a large number of low-altitude flight activities.

3. Legal framework for low-altitude airspace use rights

3.1 Legal nature of low-altitude airspace use right

The right to use low-altitude airspace is not without restrictions; it is subject to specific rules and does not mean that users can control the airspace at will. From a legal perspective, the Civil Aviation Law clearly stipulates the rules and conditions for using low-altitude airspace, and users must strictly adhere to relevant laws and regulations. For example, according to the provisions of the Civil Aviation Law, the use of low-altitude airspace must be approved by relevant departments

and meet safety and environmental protection requirements. This is the foundation for ensuring the safe and reasonable conduct of flight activities and is also a necessary measure to avoid endangering public safety and damaging the ecological environment. Additionally, the right to use low-altitude airspace has temporal and spatial characteristics. Based on different management objectives and actual needs, relevant departments will clearly define the scope of its use in terms of time and space. For instance, during certain periods, such as specific nighttime hours, to avoid noise disturbances to residents' rest, some low-altitude areas may restrict flights; in certain regions, like around airports, densely populated commercial areas, and schools, flight bans or restricted zones may be set up for safety reasons. Depending on different management goals and needs, relevant departments can impose time and space restrictions on the use of low-altitude airspace. The law strictly defines the right to use low-altitude airspace, not only specifying the scope of use but also clarifying the purpose, methods, and operational standards.

3.2 Ownership and distribution mechanism of the right to use

The ownership of low-altitude airspace rights primarily reflects the distribution of ownership and usage rights over airspace resources. The airspace resources in the low-altitude domain belong to the state, with the government acting as the manager and allocator responsible for delineating and allocating usage rights. Given that low-altitude flight activities typically involve multiple social entities, such as drone operators, air taxi companies, and agricultural aircraft users, it is imperative to establish a rational mechanism for allocating low-altitude airspace rights. In the allocation process, fairness and efficiency are key considerations, while also taking into account the diverse needs of different industries to comprehensively meet the various users' demands for low-altitude airspace use. During the allocation process, the government must consider factors such as aircraft type, flight purpose, and flight area, and formulate detailed rules for the allocation of usage rights to ensure the rational configuration of airspace resources.

4. Core issues in the low-altitude airspace management regulatory system

4.1 Current situation and challenges of regulatory system

The development of China's low-altitude airspace management system started relatively late but has made significant progress in recent years. In contrast, the U.S. FAA (Federal Aviation Administration) has established a more mature UTM (Unified Traffic Management) system, with a layered structure including strategic, pre-tactical, and tactical layers. The NASA-led drone traffic management pilot projects (such as UAS Integration Pilot Program) provide technical support for low-altitude flights. In terms of policy innovation, the U.S. has classified low-altitude airspace as Category G and implemented real-time airspace authorization for drones through the LAANC system, significantly improving approval efficiency. Japan, after revising its Aviation Act, has allowed Beyond Visual Line of Sight (BVLOS) flight. The Rakuten Group's drone drug delivery project in Fukushima Prefecture, which covers mountainous areas and obtains night flight permits, has provided a new model for low-altitude logistics.

Shenzhen, as a pilot city for low-altitude economy, issued the "Pilot Program for Low-Altitude Airspace Management" in 2023, clearly delineating three types of airspace (controlled, reported, and free flight zones) and streamlining the approval process for drone logistics. During the pilot period, a total of 25,000 low-altitude flight plans were approved, with a conflict rate reduction of 15%. In Hangzhou's urban delivery case involving drones, the' drone instant delivery network 'collaboration between SF Express and the Hangzhou government avoided the no-fly zone around West Lake by using RTK high-precision positioning technology, achieving an average daily

delivery volume of 1,000 orders with a complaint rate below 0.1%[3]. These regulations provide legal protection for the allocation of low-altitude usage rights, management of flight activities, and infrastructure construction. The introduction of local regulations offers policy support and a legal framework for standardizing the low-altitude economy. However, it is important to note that China's overall low-altitude management and supervision system is still in the exploratory stage. From a national perspective, legal provisions and policies have not yet been integrated into a unified national standard, leading to differences in implementation across regions. For example, key aspects such as the classification and demarcation standards for low-altitude airspace, flight approval procedures, and air traffic control service models are formulated based on local conditions. While this aligns with regional characteristics, it creates inconvenience in cross-regional flights and hinders the efficient coordinated development of the low-altitude economy nationwide.

At the same time, the widespread application of emerging technologies in low-altitude airspace has not been adequately considered. The existing legal framework struggles to keep up with the increasing diversity of aircraft types, continuous innovation in flight modes, and evolving management needs. Especially in the current era of rapid development in drones and urban air traffic, traditional regulations face severe challenges. The explosive growth in drone numbers has exposed numerous issues in areas such as safety, privacy protection, and data management, including the potential for drones to intrude into sensitive areas, posing threats to personal privacy and public safety; there is also a lack of standardization in the storage, transmission, and use of flight data. The current legal system has yet to provide comprehensive and systematic responses to these issues, and it urgently needs improvement.

4.2 The main contradiction of the regulatory system and countermeasures

The current low-altitude airspace management system is fraught with contradictions. Given that the low-altitude domain involves numerous industries and social entities, how to reasonably delineate flight zones and clearly define the usage rights of different types of aircraft has become a critical issue in the regulatory framework. The existing legal system primarily focuses on traditional civil aviation airspace management, which struggles to meet the diverse needs of various aircraft in the low-altitude economy. Therefore, there is significant room for adjustment in airspace resource allocation. Moreover, there is a notable conflict between flight safety management and privacy protection. The widespread use of low-altitude aircraft, especially drones, poses potential risks to flight safety, data privacy, and public security. However, the current regulatory system is weak in addressing these issues and fails to effectively balance the interests of all parties. To resolve this contradiction, it is necessary to improve relevant safety management standards, strengthen aircraft regulation, particularly focusing on the interaction between aircraft and the flight environment, and establish a more comprehensive risk prevention and control mechanism. Low-altitude airspace management involves multiple government departments and industry stakeholders. Achieving coordination among different legal systems and industry standards, avoiding duplicate management and regulatory gaps, requires policy guidance, legal revisions, and the establishment of inter-departmental cooperation mechanisms.

5. Policy support and multilateral coordination mechanisms

5.1 Government policies and support measures

In terms of policy formulation, the government clarifies low-altitude airspace management regulations through local legislation, establishing specific management frameworks and operational standards to regulate flight activities, airspace use, and aircraft approval processes[4]. To promote

the digital and intelligent development of the low-altitude sector, the government has set up a special fund to vigorously support technological research and infrastructure construction for the low-altitude economy. At the same time, to enhance the market appeal of the low-altitude economy, the government has introduced a series of tax incentives and fiscal support measures. In terms of taxation, enterprises engaged in low-altitude economic activities are granted tax exemptions or preferential rates for a certain period; in terms of finance, subsidies and interest rate discounts are provided to reduce operating costs and stimulate market participation enthusiasm. In terms of infrastructure development, the government needs to plan and integrate elements such as airspace resources, aircraft control, and monitoring equipment, forming a unified management platform. By consolidating scattered low-altitude management systems across regions, information sharing and collaborative management can be achieved, improving management efficiency. Additionally, the government actively promotes policy guidance and market cultivation for the low-altitude economy, encouraging private capital to participate in the construction and operation of low-altitude flight facilities, and providing solid guarantees at the policy level to eliminate concerns for private capital, promoting the prosperity and development of the low-altitude economic market.

5.2 Coordination and cooperation mechanism among project stakeholders

The government needs to play the role of coordinator, formulating an overall policy framework and plan, mobilizing resources from all parties, and promoting cooperation and collaboration among stakeholders in the low-altitude sector. Specifically, a cross-departmental coordination mechanism should be established, clarifying the functions of each department to ensure unified planning and enhance regulatory efficiency. For example, a dedicated Low Altitude Economy Coordination Committee could be set up, gathering representatives from various industries and departments, holding at least one joint meeting per month, and facilitating efficient communication through information sharing platforms. In terms of technical architecture for data sharing platforms, distributed databases and blockchain technology should be adopted to ensure data security and real-time performance. Additionally, the government should collaborate with industry associations and standardization organizations to promote technical standardization in the low-altitude economy, establishing unified industry standards to foster healthy industry development. Furthermore, cooperation between enterprises and research institutions is also crucial for the successful development of the low-altitude economy. Enterprises can significantly improve the technical level and safety performance of low-altitude aircraft by leveraging cutting-edge technologies from research institutions, while these institutions conduct research based on actual market demands, tailoring innovative technological solutions for enterprises, creating a mutually beneficial and win-win situation.

5.3 Cooperation and conflict in the implementation of regulations

Coordination between the government and aviation management departments is a significant challenge in implementing regulations. Due to the involvement of multiple government agencies such as civil aviation management, urban planning, and environmental protection, these departments often have disagreements over issues like airspace demarcation and aircraft approval. To address these issues, it is necessary to establish inter-departmental collaboration mechanisms, clarify the functions of each department, ensure unified planning, and enhance regulatory efficiency. For example, a dedicated Low-Altitude Economy Coordination Committee could be set up, gathering representatives from various industries and departments to form a unified management decision-making body, promoting efficient communication through regular meetings and information sharing platforms. At the level of cooperation between enterprises and the government,

there may be differences in policy interpretation, especially regarding low-altitude aircraft approval and regulatory standards. Enterprises may seek more flexible policies, while the government must ensure flight safety and public interest. In this context, the government should increase policy transparency, providing clear explanations of regulatory enforcement methods to enterprises, reducing uncertainty in policy implementation. Furthermore, with the rapid development of the low-altitude economy and the continuous emergence of new technologies and flight modes, the lag in regulatory updates has become prominent. The government needs to establish a dynamic regulatory adjustment mechanism, closely tracking industry technology trends, collaborating with research institutions and enterprises on forward-looking studies, and promptly updating regulatory rules to ensure that regulation keeps pace with market demands, promoting the sustained and healthy development of the low-altitude economy.

6. Improvement and practice path of low-altitude airspace management system

6.1 Guidelines for improving the existing regulatory system

In the process of improving low-altitude airspace management systems, precise airspace allocation is imperative. With the surge in low-altitude flight demands and the increasing diversity of aircraft types, the existing regulatory framework lacks clear demarcation of low-altitude airspace, which can easily lead to conflicts between different types of aircraft. Therefore, based on practical application needs, adjustments should be made to low-altitude flight zones. Airspace should be scientifically divided according to factors such as flight altitude, purpose, and aircraft type, ensuring that activities in different sectors do not interfere with each other. The improvement of aircraft supervision systems is a critical step, especially for new types of aircraft like drones. It is urgent to establish development standards that meet the needs of low-altitude airspace, covering aspects such as flight performance, safety, and airworthiness standards, and strictly enforcing certification and approval procedures. At the same time, real-time monitoring of aircraft operation data should be strengthened, and a dynamic aircraft supervision system should be established to comprehensively ensure flight safety. Low-altitude flight safety management also needs further refinement. Current regulations mainly focus on the safety of the aircraft itself but are relatively weak in risk control during flights, emergency response to unexpected events, and air traffic management. Building a comprehensive supervision system should enhance flight safety oversight, establish an emergency response mechanism, ensure the safety of flight activities, and promote continuous optimization and upgrading of low-altitude airspace management systems.

6.2 Specific plans for implementation and execution

Build a centralized management platform for dynamic airspace control: Construct an airspace resource management platform based on 5G and edge computing. Deploy ADS-B receivers and weather radars to collect low-altitude flight data in real time; use Apache Kafka to efficiently process data streams, and dynamically optimize airspace allocation strategies based on reinforcement learning algorithms (such as Deep Q-Network). Taking the Shenzhen pilot project as an example, this platform has achieved minute-level airspace adjustment responses, with conflict warning accuracy reaching 92%. By integrating data from multiple sources, it comprehensively grasps information such as aircraft types, flight altitudes, and flight purposes, and dynamically adjusts airspace allocations on a per-hour or even per-minute basis according to actual needs. For instance, during peak tourist seasons over popular scenic areas, it can predict the flight demands of sightseeing planes and drones in advance, plan airspace reasonably, and avoid conflicts.

Improve the application and approval mechanism to standardize flight activities: The regulatory

authority should develop an online low-altitude flight activity application system where applicants can submit flight plans, including detailed information such as flight time, route, and aircraft model. The system should establish a fast-track approval channel; for routine flights, it should complete the approval within a specified time; for special flights like emergency rescue, it should approve immediately. Additionally, the system should require applicants to reconfirm their information before flying to ensure that flight activities strictly follow the approved procedures. For example, in the case of drone logistics by SF Express and JD, SF Express has launched drone delivery services in Bao 'an District, Shenzhen, reducing the approval process from several days to just a few hours through optimized procedures, significantly improving delivery efficiency. JD's instant delivery network in Hangzhou, in collaboration with the local government, simplified the approval process, achieving a 20% increase in daily delivery volume.

The regulatory authority and relevant government departments should strengthen aircraft safety supervision and implement full-process monitoring. They should establish an aircraft registration and certification system and organize professional technical teams to conduct comprehensive technical evaluations of different types of aircraft, reviewing flight performance, safety equipment, and airworthiness standards one by one, with the review cycle not exceeding a certain period. At the same time, they should introduce blockchain technology for flight data storage, where flight data (route, time, operator ID) is recorded in real-time on the blockchain, and smart contracts automatically trigger alerts for violations (such as deviating from the route by more than 500 meters). For example, the practice of using blockchain to manage drone registrations by the Dubai Civil Aviation Authority demonstrates that blockchain technology can effectively enhance data security and transparency. Aircraft operators must submit flight plans several days in advance, and regulatory authorities use satellite positioning, radar, and other technologies to monitor flight paths in real-time. Once a deviation from the planned route occurs, immediate warnings are issued and corrections are required. Additionally, mandatory installation of automatic flight data upload devices ensures real-time monitoring of flight data, safeguarding flight safety and compliance.

The government should promote cross-departmental cooperation to form a regulatory synergy. It should establish a cross-departmental working group comprising multiple departments such as civil aviation, transportation, communications, and environmental protection. The working group should hold at least one joint meeting per month to communicate on low-altitude airspace management. It should also build an information sharing platform to break down data barriers between departments, enabling real-time sharing of aircraft flight data, weather information, and geographic data. Each department will collaborate based on its functions, with civil aviation responsible for flight safety technical standards, transportation assisting in route planning, and communications ensuring data transmission.

The regulatory authorities should clarify enforcement standards and strengthen penalties for violations. They should develop detailed enforcement manuals to specify penalty standards for various violations, such as fines for unauthorized flights and suspension of pilot licenses for months in addition to fines for flying beyond authorized areas. They should also establish hotlines and online reporting platforms to verify public reports of violations, offering rewards to informants. The authorities should regularly conduct enforcement inspections, focusing on high-risk areas to ensure safe and orderly low-altitude airspace operations.

7. Conclusion

The low-altitude economy, as an emerging industry, has become an indispensable part of urban development, thanks to technological advancements and growing market demand. Establishing a comprehensive regulatory framework for the low-altitude economy is crucial for ensuring flight

safety and optimizing airspace resource utilization. Clarifying the guidelines for low-altitude economic activities can effectively mitigate potential risks and create a well-ordered environment for industrial development. However, policy implementation faces some challenges, such as high compliance costs for businesses, which may dampen their enthusiasm; public concerns about privacy in low-altitude flights could also hinder the smooth implementation of policies. To address these issues, the government should provide corresponding subsidies and training to help companies reduce compliance costs; at the same time, it should enhance public education to increase awareness and acceptance of low-altitude flight activities. The proactive role of the government in policy support and financial investment has greatly stimulated market vitality, attracting various forces to engage in the low-altitude industry. In the future, with continuous iteration and upgrading of the low-altitude regulatory system, the low-altitude economy will achieve leapfrog development under stronger legal protection, deeply integrating into every aspect of urban construction. The author hopes that more research will focus on this area, collectively contributing to elevating the low-altitude economy to new heights.

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