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Article

Synergistic Development of eVTOL Technology and Low-Altitude Airspace Management: A Pathway to Sustainable Urban Air Mobility

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ABSTRACT

Electric Vertical Take-Off and Landing (eVTOL) aircraft, as the core carrier of urban air mobility (UAM), have become a key driving force for the development of the low-altitude economy. However, the synergistic development of eVTOL technology and low-altitude airspace management remains a major bottleneck restricting the large-scale commercial application of UAM. This study systematically explores the interaction mechanism between eVTOL technological innovation and low-altitude airspace management reform. By analyzing policy frameworks, technical bottlenecks, and application scenarios in major economies such as China, the United States, and the European Union, it identifies key challenges including imperfect airspace classification standards, inadequate infrastructure supporting systems, and backward regulatory models. Based on this, the paper proposes a synergistic development pathway integrating technological innovation, institutional reform, and industrial collaboration. Research findings indicate that the intelligent scheduling system empowered by artificial intelligence, the refined classification of low-altitude airspace, and the cross-regional collaborative management mechanism are critical to promoting the healthy development of the low-altitude economy. This study provides theoretical support and practical references for policymakers and industry practitioners to formulate relevant strategies, and contributes to accelerating the realization of sustainable urban air mobility.

Keywords: Low-Altitude Economy; eVTOL; Airspace Management; Urban Air Mobility; Synergistic Development; Artificial Intelligence

1. Introduction

1.1 Research Background

The low-altitude economy, characterized by flight activities below 3000 meters, has emerged as a new form of productive force and a crucial growth engine for the global economy . Driven by technological advancements in aerospace, artificial intelligence (AI), and new energy, the low-altitude economy integrates multiple fields such as low-altitude aircraft manufacturing, infrastructure construction, operation services, and scenario applications, profoundly reshaping urban transportation patterns and industrial structures . Among various low-altitude transportation tools, electric vertical take-off and landing (eVTOL) aircraft have attracted widespread attention due to their advantages of zero emissions, low noise, and flexible take-off and landing, and are regarded as the core carrier of future urban air mobility (UAM) .

In recent years, major economies around the world have attached great importance to the development of the low-altitude economy and eVTOL technology. China has included the low-altitude economy in the government work report and the national strategic development plan, with the Civil Aviation Administration of China (CAAC) predicting that the scale of China's low-altitude economy will reach 1.5 trillion yuan by 2025 and exceed 3.5 trillion yuan by 2035 . The United States has launched the Advanced Air Mobility (AAM) National Blueprint, clarifying the development goals and implementation paths of UAM . The European Union has promoted the „Digital Sky" program to build a unified low-altitude air traffic management system . Despite the strong policy support and broad market prospects, the large-scale commercial application of eVTOL still faces multiple challenges, among which the mismatch between eVTOL technological development and low-altitude airspace management is the most prominent .

Low-altitude airspace, as a scarce public resource, is the basic premise for the development of the low-altitude economy . The traditional airspace management system, which is mainly designed for large civil aviation aircraft and military aircraft, has the problems of rigid classification, complicated approval procedures, and low utilization efficiency, which cannot adapt to the characteristics of eVTOL such as small size, low speed, high frequency, and scattered operations . At the same time, the immature key technologies of eVTOL, such as battery life, load capacity, and safety performance, also put forward higher requirements for airspace management . Therefore, exploring the synergistic development mechanism of eVTOL technology and low-altitude airspace management is of great significance for breaking through the development bottleneck of the low-altitude economy and realizing sustainable UAM .

1.2 Research Objectives and Significance

The main objectives of this study are: (1) to systematically analyze the interaction mechanism between eVTOL technological innovation and low-altitude airspace management reform; (2) to identify the key challenges and influencing factors in the synergistic development of the two from a global perspective; (3) to propose targeted synergistic development paths and policy suggestions.

The theoretical significance of this study lies in enriching the research system of the low-altitude economy and UAM, and deepening the understanding of the interaction between technological innovation and institutional reform. In practice, this study can provide decision-making references for governments to formulate low-altitude airspace management policies and eVTOL industry development strategies, promote the coordinated development of eVTOL technology research and development, infrastructure construction, and airspace management, and accelerate the commercialization process of UAM, thereby promoting the high-quality development of the low-altitude economy.

1.3 Research Methodology and Structure

This study adopts a combination of literature review, comparative analysis, and case study methods. First, through a systematic review of relevant literature at home and abroad, it sorts out the research progress of eVTOL technology, low-altitude airspace management, and the low-altitude economy. Second, it conducts comparative analysis on the policy frameworks, airspace management models, and industrial development status of the low-altitude economy in China, the United States, the European Union, and other major economies. Finally, it takes typical regions such as Shenzhen, China, and Los Angeles, the United States, as case studies to explore the practical experience and lessons of synergistic development of eVTOL technology and low-altitude airspace management.

The structure of this paper is as follows: the first part is the introduction, which elaborates on the research background, objectives, significance, methodology, and structure. The second part combs the theoretical basis and research progress of eVTOL technology and low-altitude airspace management. The third part analyzes the current situation and challenges of synergistic development of eVTOL technology and low-altitude airspace management in major economies. The fourth part takes typical cases as examples to explore the practical experience of synergistic development. The fifth part proposes the synergistic development path of eVTOL technology and low-altitude airspace management. The sixth part is the conclusion and prospect.

2. Literature Review and Theoretical Basis

2.1 Concept and Connotation of Low-Altitude Economy

The concept of the low-altitude economy was first proposed in China, which refers to an economic form that takes low-altitude flight activities as the core, relies on low-altitude aircraft, communication navigation, and airspace management technologies, and drives the development of related industries through the integration of airspace resources, industrial elements, and application scenarios . Scholars at home and abroad have different understandings of the connotation of the low-altitude economy. Some scholars emphasize that the low-altitude economy is a comprehensive industrial system covering aircraft manufacturing, infrastructure construction, operation services, and scenario applications . Others believe that the low-altitude economy is a new economic growth point formed by the deep integration of aerospace technology and various industries such as transportation, logistics, tourism, and emergency rescue .

The core elements of the low-altitude economy include airspace resources, low-altitude aircraft, infrastructure, and regulatory systems . Airspace resources are the basic carrier of the low-altitude economy, and their development and utilization level directly determines the development potential of the low-altitude economy . Low-altitude aircraft such as eVTOL and drones are the core equipment of the low-altitude economy, and their technological level affects the application scope and efficiency of the low-altitude economy . Infrastructure such as take-off and landing sites, charging facilities, and communication navigation systems are the guarantee for the operation of the low-altitude economy . The regulatory system is an important constraint for the healthy development of the low-altitude economy, which involves airspace management, safety supervision, and industry standards .

2.2 Research Progress on eVTOL Technology

eVTOL technology is a key technology supporting the development of UAM, and its research focuses on battery technology, power system, aerodynamic design, and flight control system . In terms of battery technology, the current mainstream eVTOL uses lithium-ion batteries with energy density of about 250-300 Wh/kg, which can only support a range of 100-200 kilometers, and the fast charging time takes more than 30 minutes, which restricts the long-distance application of eVTOL . Scholars have carried out a lot of research on solid-state batteries and hydrogen fuel cells. It is expected that the energy density of all-solid-state batteries will reach 500 Wh/kg by 2030, which will significantly improve the range of eVTOL .

In the aspect of power system, distributed electric propulsion (DEP) system is widely used in eVTOL. This system can improve the safety and reliability of eVTOL through redundant design . AI algorithms can intelligently distribute the output of each motor according to flight phases, meteorological conditions, and load conditions, so as to achieve optimal energy consumption . For example, compound wing eVTOL can turn off some rotors during cruising, reducing energy consumption by 30% .

In terms of flight control system, with the development of AI and big data technology, intelligent flight control systems based on machine learning and deep learning have become a research hotspot . These systems can realize autonomous flight, obstacle avoidance, and path planning of eVTOL, improving flight safety and efficiency . At the same time, edge AI technology is applied to real-time monitoring of eVTOL energy status, which can predict potential faults in advance and optimize maintenance cycles .

2.3 Research Progress on Low-Altitude Airspace Management

Low-altitude airspace management is a complex system engineering involving multiple subjects such as the government, military, and enterprises. Its core goal is to realize the safe, efficient, and sustainable utilization of airspace resources . Scholars at home and abroad have carried out in-depth research on low-altitude airspace management from the aspects of airspace classification, management system, and regulatory mechanism .

In terms of airspace classification, the International Civil Aviation Organization (ICAO) divides airspace into 7 categories from A to G, and adopts hierarchical and gradient management . Developed economies such as the United States and the European Union have divided low-altitude airspace into different types such as controlled airspace and uncontrolled airspace based on ICAO standards, and formulated corresponding management measures . China has carried out pilot reforms of low-altitude airspace classification, and has opened up airspace below 300 meters except for no-fly zones, but there are still problems such as inconsistent classification standards and fragmented airspace .

In the aspect of management system, the main challenge is to coordinate the relationship between civil aviation and military aviation, local and global . Scholars propose that the „separation of management and use“ model can be adopted to break the departmental interest barriers and realize the overall optimal allocation of airspace resources . At the same time, it is necessary to establish a multi-party collaborative management mechanism involving the government, military, enterprises, and industry associations to improve the efficiency of airspace management .

In terms of regulatory mechanisms, with the development of digital technology, intelligent regulation has become a new trend . Scholars suggest establishing a digital and intelligent low-altitude flight dispatching and supervision platform based on big data and AI, which can realize real-time monitoring, dynamic scheduling, and risk early warning of low-altitude flight activities, and improve the level of airspace management .

2.4 Theoretical Basis of Synergistic Development

The synergistic development of eVTOL technology and low-altitude airspace management is based on the theory of technological innovation and institutional change . According to the theory of technological innovation, technological progress is the core driving force for economic development, and the diffusion and application of technology need the support of institutional environment . The theory of institutional change points out that institutional change can promote technological innovation by reducing transaction costs and providing incentive mechanisms . The two interact and promote each other to form a synergistic effect .

In addition, the theory of industrial ecology also provides a theoretical basis for the synergistic development of eVTOL technology and low-altitude airspace management . The low-altitude economy is a complex industrial ecosystem involving multiple industries and fields . The synergistic development of eVTOL technology research and development, airspace management, infrastructure construction, and operation services can realize the optimal allocation of resources and the efficient operation of the industrial chain, thereby promoting the healthy development of the low-altitude economy .

3. Current Situation and Challenges of Synergistic Development of eVTOL Technology and Low-Altitude Airspace Management

3.1 Current Situation of Synergistic Development in Major Economies

3.1.1 China

China‘s low-altitude economy has developed rapidly in recent years, forming industrial clusters led by the Beijing-Tianjin-Hebei region, the Yangtze River Delta, the Pearl River Delta, and the Chengdu-Chongqing economic circle . In terms of eVTOL technology, Chinese enterprises such as EHang Intelligent have made important breakthroughs. EHang EH216-S obtained the world‘s first manned eVTOL airworthiness certificate in 2023, marking a key step in the maturity of eVTOL technology .

In terms of low-altitude airspace management, China has carried out a series of reform pilots. The „Interim Regulations on the Administration of Unmanned Aircraft Flight“ issued in 2023 for the first time clarified the classification of low-altitude airspace, and opened up airspace below 300 meters except for no-fly zones . Local governments such as Shenzhen, Chongqing, and Hefei have actively promoted the construction of low-altitude infrastructure and application scenarios, and explored the establishment of a „one-stop“ approval service mechanism for flight plans . However, there are still problems such as inconsistent airspace classification standards across regions, imperfect infrastructure supporting systems, and slow approval of flight plans, which restrict the synergistic development of eVTOL technology and low-altitude airspace management .

3.1.2 United States

The United States has a relatively mature airspace management system and a developed aviation industry, which provides a good foundation for the development of the low-altitude economy . The Federal Aviation Administration (FAA) has formulated a phased development plan for AAM, and carried out a series of pilot projects for eVTOL flight tests and airspace integration . In terms of airspace management, the United States has divided low-altitude airspace into controlled airspace, uncontrolled airspace, and special use airspace, and adopted different management measures according to the type and altitude of aircraft .

In terms of eVTOL technology, American enterprises such as Joby Aviation and Archer have made significant progress in battery technology, power system, and flight control system, and have carried out a large number of flight tests . However, the United States also faces challenges such as the high cost of eVTOL infrastructure construction, the difficulty in coordinating civil aviation and military aviation airspace, and the need to improve public acceptance of eVTOL .

3.1.3 European Union

The European Union has always attached great importance to the development of UAM and the low-altitude economy, and has launched a series of programs such as the „Digital Sky“ and „Single European Sky“ to promote the integration of low-altitude airspace and the development of eVTOL technology . The European Union has established a unified airspace classification standard and a cross-border air traffic management system, which provides a good institutional guarantee for the free flow of low-altitude aircraft across regions .

In terms of eVTOL technology, European enterprises and research institutions have carried out in-depth research on hydrogen fuel cells and intelligent flight control systems . The German company H2Fly has verified the potential of AI in the management of hydrogen-electric hybrid systems, which provides a new path for improving the range of eVTOL . However, the European Union also faces challenges such as the high cost of airspace management system construction and the inconsistent development level of low-altitude economy in different member states .

3.2 Key Challenges of Synergistic Development

3.2.1 Imperfect Airspace Classification Standards

At present, the classification standards of low-altitude airspace in various countries are not uniform, and there are problems such as unclear division of airspace types and inconsistent management requirements . For example, China's airspace classification standards vary across regions, resulting in fragmented airspace, which increases the difficulty of cross-regional flight of eVTOL and increases operating costs . Although the United States and the European Union have relatively unified airspace classification standards, they still face the problem of how to adjust the classification standards according to the characteristics of eVTOL to improve the efficiency of airspace utilization .

3.2.2 Inadequate Infrastructure Supporting Systems

The operation of eVTOL requires supporting infrastructure such as vertiports, charging facilities, and communication navigation systems . At present, the construction of low-altitude infrastructure in various countries is relatively backward. The number of vertiports is insufficient, the layout is unreasonable, and the charging facilities are not compatible with eVTOL of different models . For example, the cost of building a medium-sized vertiport in the world is about 20 million US dollars, which is equivalent to the cost of 3 subway stations. The high construction cost restricts the large-scale construction of vertiports . In addition, the communication navigation and monitoring system in low-altitude airspace is not perfect, which affects the flight safety and efficiency of eVTOL .

3.2.3 Backward Regulatory Models and Mechanisms

The traditional air traffic management model is mainly designed for large civil aviation aircraft, which cannot adapt to the characteristics of eVTOL such as high frequency, low speed, and scattered operations . The approval procedures for eVTOL flight plans are complicated and the approval time is long, which affects the efficiency of eVTOL operation . At the same time, the regulatory system for eVTOL is not perfect, and there are gaps in the formulation of airworthiness standards, operation rules, and accident liability identification . For example, eVTOL has a „dual identity" dilemma. It is a vehicle on the ground and needs to comply with the Road Traffic Safety Law, and an aircraft in the air and needs to comply with the Civil Aviation Law. The unclear regulatory responsibility leads to difficulties in the supervision of eVTOL .

3.2.4 Insufficient Technological Innovation Capabilities in Key Fields

Although eVTOL technology has made great progress in recent years, there are still bottlenecks in key technologies such as battery life, load capacity, and safety performance . The energy density of current mainstream lithium-ion batteries is low, which restricts the range and load capacity of eVTOL . The reliability and safety of the distributed electric propulsion system need to be further improved . In addition, the intelligent scheduling technology of eVTOL in high-density flight scenarios is not mature, and there are risks of flight conflicts .

3.2.5 Low Public Acceptance and Trust

Public acceptance and trust are important factors affecting the commercialization of eVTOL . A survey shows that 72% of the public is worried about the risk of air collisions of eVTOL . In addition, the noise, privacy protection, and environmental impact of eVTOL have also aroused public concern . The low public acceptance and trust have restricted the expansion of eVTOL application scenarios and the pace of commercialization .

4. Case Study on Synergistic Development of eVTOL Technology and Low-Altitude Airspace Management

4.1 Case 1: Shenzhen, China

As a pioneer in China's low-altitude economy development, Shenzhen has taken the low-altitude economy as one of the key development directions of future industries, and has introduced a series of supporting policies to promote the synergistic development of eVTOL technology and low-altitude airspace management . In terms of airspace management reform, Shenzhen has taken the lead in formulating local standards for low-altitude airspace classification, dividing low-altitude airspace into free flight airspace, restricted flight airspace, and controlled flight airspace, and implementing differentiated management . At the same time, Shenzhen has built a digital and intelligent low-altitude flight dispatching and supervision platform, which realizes real-time monitoring of low-altitude flight activities, dynamic scheduling of flight paths, and „one-stop" approval of flight plans . The approval time of flight plans has been shortened from several days to a few hours, greatly improving the efficiency of airspace utilization .

In terms of eVTOL technology research and development and application, Shenzhen has gathered a number of eVTOL enterprises and research institutions such as EHang Intelligent. It has built a number of eVTOL test flight bases and vertiports, and carried out pilot applications in scenarios such as medical emergency, airport connection, and tourism . For example, in the medical emergency scenario, eVTOL can transport organs and emergency supplies at a speed four times faster than ambulances, significantly improving the efficiency of emergency rescue .

The experience of Shenzhen shows that the combination of airspace management system reform, intelligent supervision platform construction, and industrial cluster development can effectively promote the synergistic development of eVTOL technology and low-altitude airspace management . However, Shenzhen also faces challenges such as the high cost of infrastructure construction and the need to further improve the cross-regional coordination mechanism of airspace management .

4.2 Case 2: Los Angeles, United States

Los Angeles is one of the important pilot cities for UAM development in the United States. It has a developed aviation industry and a complete airspace management system, which provides a good foundation for the synergistic development of eVTOL technology and low-altitude airspace management . In terms of airspace management, Los Angeles has carried out a pilot project of low-altitude airspace dynamic management, which adjusts the airspace structure in real time according to the actual flight demand and meteorological conditions, improving the efficiency of airspace utilization . At the same time, Los Angeles has established a multi-party collaborative management mechanism involving the government, military, enterprises, and industry associations to coordinate the relationship between civil aviation and military aviation airspace and solve the problem of airspace resource supply and demand contradiction .

In terms of eVTOL technology and application, Los Angeles has carried out in-depth cooperation with enterprises such as Joby Aviation and Archer, built a number of vertiports and charging facilities, and carried out pilot applications in scenarios such as urban air taxi and logistics distribution . The FAA has set up a special working group in Los Angeles to provide technical support and policy guidance for the integration of eVTOL into the airspace management system .

The experience of Los Angeles shows that dynamic airspace management, multi-party collaborative management, and close cooperation between government and enterprises are important guarantees for the synergistic development of eVTOL technology and low-altitude airspace management . However, Los Angeles also faces challenges such as the need to improve public acceptance of eVTOL and the high cost of operation and maintenance of infrastructure .

4.3 Case Summary and Enlightenment

The cases of Shenzhen and Los Angeles show that the synergistic development of eVTOL technology and low-altitude airspace management requires the joint efforts of the government, enterprises, and research institutions . The key experiences include: formulating scientific and reasonable low-altitude airspace classification standards, building a digital and intelligent airspace supervision platform, establishing a multi-party collaborative management mechanism, strengthening the construction of supporting infrastructure, and promoting the pilot application of eVTOL in multiple scenarios .

These experiences provide important enlightenment for other regions to promote the synergistic development of eVTOL technology and low-altitude airspace management: first, it is necessary to carry out airspace management system reform according to local conditions and formulate targeted airspace classification standards and management measures; second, it is necessary to strengthen the application of digital technology and build an intelligent airspace supervision platform to improve the efficiency and safety of airspace management; third, it is necessary to establish a multi-party collaborative mechanism to coordinate the interests of all parties and solve the problems of airspace resource allocation and cross-regional coordination; fourth, it is necessary to increase investment in infrastructure construction and promote the pilot application of eVTOL in multiple scenarios to accumulate practical experience .

5. Synergistic Development Path of eVTOL Technology and Low-Altitude Airspace Management

5.1 Promoting Technological Innovation and Breakthroughs in Key Fields

5.1.1 Strengthening R&D of eVTOL Core Technologies

It is necessary to increase investment in R&D of eVTOL core technologies such as battery technology, power system, and flight control system . Focus on the research and development of solid-state batteries and hydrogen fuel cells to improve the energy density and service life of batteries . Strengthen the research on distributed electric propulsion systems to improve their reliability and energy efficiency . Promote the application of AI and big data technology in eVTOL flight control systems to realize autonomous flight, obstacle avoidance, and intelligent path planning .

At the same time, it is necessary to strengthen the construction of the eVTOL technology innovation system, encourage enterprises, universities, and research institutions to carry out collaborative innovation, and form a joint force for R&D . Support the establishment of eVTOL technology innovation platforms and test bases to accelerate the transformation and application of technological achievements .

5.1.2 Developing Intelligent Airspace Management Technology

Develop intelligent airspace management technology based on AI, big data, and 5G . Build a national unified digital and intelligent low-altitude flight dispatching and supervision platform to realize real-time monitoring, dynamic scheduling, and risk early warning of low-altitude flight activities . Develop intelligent scheduling algorithms to optimize flight paths and improve the efficiency of airspace utilization . Strengthen the research on digital twin technology, simulate high-density eVTOL flight scenarios in virtual cities, and optimize airspace management strategies .

5.2 Promoting the Reform and Improvement of Low-Altitude Airspace Management System

5.2.1 Improving Low-Altitude Airspace Classification Standards

Formulate a unified national low-altitude airspace classification standard, dividing low-altitude airspace into free flight airspace, restricted flight airspace, and controlled flight airspace according to factors such as altitude, flight density, and application scenarios . Implement differentiated management measures for different types of airspace to balance safety and efficiency . Strengthen the connection between local and national airspace classification standards to avoid fragmented airspace .

5.2.2 Establishing a Multi-Party Collaborative Management Mechanism

Promote the „separation of management and use“ of airspace resources, clarify the main body and responsibilities of airspace management, and improve the management system with matching rights, responsibilities, and interests . Establish a multi-party collaborative management mechanism involving the government, military, enterprises, and industry associations to coordinate the relationship between civil aviation and military aviation airspace and solve the problem of airspace resource supply and demand contradiction . Improve the cross-regional airspace coordination mechanism to realize the interconnection of low-altitude airspace and reduce the cost of cross-regional flight of eVTOL .

5.2.3 Optimizing the Flight Plan Approval Process

Simplify the eVTOL flight plan approval process, and establish a „one-stop“ approval service platform to realize online application, approval, and filing of flight plans . For routine flight activities in free flight airspace, adopt the filing system to shorten the approval time . For flight activities in restricted flight airspace and controlled flight airspace, optimize the approval process and improve the approval efficiency . Strengthen the information sharing between approval departments to avoid repeated approval .

5.3 Strengthening the Construction of Low-Altitude Infrastructure Supporting System

5.3.1 Promoting the Planning and Construction of Vertiports

Formulate a national vertiport construction plan, and reasonably layout vertiports according to urban development planning and eVTOL application scenarios . Establish unified vertiport construction and operation standards to ensure the compatibility and interoperability of vertiports . Adopt a government-guided, industry-led, and enterprise-participated construction model to attract social capital to participate in the construction and operation of vertiports . Reduce the construction and operation costs of vertiports through technological innovation and scale effect .

5.3.2 Improving the Communication, Navigation and Monitoring System

Strengthen the construction of low-altitude communication, navigation, and monitoring systems, and improve the coverage and accuracy of signals . Promote the application of 5G, Beidou navigation, and other technologies in low-altitude airspace to realize seamless connection of communication and navigation signals . Establish a unified low-altitude flight data collection and sharing standard to realize the interconnection of flight data between different regions and departments .

5.3.3 Building a Charging and Energy Supply System

Build a charging and energy supply system compatible with eVTOL of different models, and rationally layout charging facilities in vertiports and key areas . Promote the application of renewable energy such as solar energy and wind energy in the charging system to realize low-carbon and environmentally friendly energy supply . Develop fast charging and battery swapping technologies to improve the efficiency of energy supply for eVTOL .

5.4 Improving the Regulatory System and Industrial Ecosystem

5.4.1 Formulating eVTOL Airworthiness Standards and Operation Rules

Give play to the leading role of industry leading enterprises and industry associations, and work with civil aviation authorities to formulate unified eVTOL airworthiness standards and operation rules . Clarify the technical requirements, safety standards, and operation procedures of eVTOL to reduce policy uncertainty and stabilize industry development expectations . Establish a dynamic adjustment mechanism for standards and rules to adapt to the development of eVTOL technology and application scenarios .

5.4.2 Strengthening Safety Supervision and Risk Prevention

Establish a full-chain safety supervision system covering eVTOL R&D, production, operation, and maintenance . Strengthen the supervision of eVTOL flight safety, and establish a fault reporting and handling mechanism . Strengthen the supervision of data security and privacy protection, and formulate relevant laws and regulations to standardize the collection, use, and sharing of eVTOL flight data . Improve the emergency response mechanism for low-altitude flight accidents, and enhance the ability to deal with sudden safety incidents .

5.4.3 Cultivating a Healthy Industrial Ecosystem

Strengthen the coordination and cooperation of the low-altitude economy industrial chain, and promote the deep integration of eVTOL manufacturing, infrastructure construction, operation services, and other links . Support the development of supporting industries such as eVTOL parts manufacturing, maintenance services, and training services . Encourage the exploration of new business models and application scenarios of eVTOL, such as urban air taxi, logistics distribution, medical emergency, and tourism . Strengthen international cooperation and exchanges, introduce advanced foreign technology and experience, and promote the global development of the low-altitude economy .

6. Conclusion and Prospect

6.1 Research Conclusions

This study systematically explores the synergistic development mechanism of eVTOL technology and low-altitude airspace management, and draws the following conclusions: First, eVTOL technology and low-altitude airspace management interact and promote each other. eVTOL technological innovation puts forward new requirements for low-altitude airspace management, and the reform of low-altitude airspace management provides institutional guarantee for the development and application of eVTOL technology. Second, the synergistic development of eVTOL technology and low-altitude airspace management in major economies such as China, the United States, and the European Union has made some progress, but there are still key challenges such as imperfect airspace classification standards, inadequate infrastructure supporting systems, backward regulatory models, insufficient technological innovation capabilities in key fields, and low public acceptance. Third, the cases of Shenzhen and Los Angeles show that formulating scientific airspace classification standards, building an intelligent supervision platform, establishing a multi-party collaborative mechanism, strengthening infrastructure construction, and promoting scenario-based pilot applications are effective ways to promote synergistic development. Fourth, the synergistic development path of eVTOL technology and low-altitude airspace management should include promoting technological innovation in key fields, improving the airspace management system, strengthening infrastructure construction, and improving the regulatory system and industrial ecosystem.

6.2 Policy Suggestions

Based on the research conclusions, this study puts forward the following policy suggestions: First, increase investment in R&D of eVTOL core technologies and intelligent airspace management technologies, and support collaborative innovation among enterprises, universities, and research institutions. Second, formulate a unified national low-altitude airspace classification standard, establish a multi-party collaborative management mechanism, and optimize the flight plan approval process. Third, strengthen the planning and construction of vertiports, communication navigation monitoring systems, and charging energy supply systems, and improve the infrastructure supporting system. Fourth, formulate eVTOL airworthiness standards and operation rules, strengthen safety supervision and risk prevention, and cultivate a healthy industrial ecosystem. Fifth, strengthen public education and publicity, improve public acceptance and trust in eVTOL, and create a good social environment for the development of the low-altitude economy.

6.3 Research Limitations and Future Prospects

This study has certain limitations: first, due to the limited availability of data, this study mainly adopts qualitative analysis methods, and the quantitative research on the synergistic development effect of eVTOL technology and low-altitude airspace management is insufficient; second, this study focuses on the national and regional levels, and the research on the synergistic development mechanism at the enterprise level is not in-depth.

In the future, the following research directions can be carried out: first, strengthen quantitative research, establish an evaluation index system for the synergistic development effect, and conduct empirical analysis using panel data of different regions and enterprises; second, deepen the research on the synergistic development mechanism at the enterprise level, and explore the interaction between enterprise technological innovation and institutional environment; third, pay attention to the development of emerging technologies such as autonomous driving and 6G, and explore their impact on the synergistic development of eVTOL technology and low-altitude airspace management; fourth, strengthen international comparative research, and learn from the advanced experience of different countries in promoting the development of the low-altitude economy.

References

[1] Civil Aviation Administration of China. (2024). Development Report on China's Low-Altitude Economy. Beijing: China Civil Aviation Press.

[2] Li, Y., & Wang, H. (2024). Low-Altitude Economy: A New Engine for High-Quality Economic Development. Journal of Air Transport and Business, 28, 100654.

[3] Zhang, K. (2024). Research on the Functional Issues of Government Agencies in Low-Altitude Management. Journal of Beijing University of Aeronautics and Astronautics (Social Sciences Edition),

37(5), 120-133.

[4] Liao, X., Qu, W., Xu, C., He, H., Wang, J., & Shi, W. (2023). A Review of Urban Air Mobility and Its New Infrastructure: Low-Altitude Public Air Route Research. Acta Aeronautica et Astronautica Sinica, 44(24), 1-29.

[5] Wang, S., & Tan, C. (2025). The Theoretical Mechanism, Core Essence and Action Essentials of Low-Altitude Economy Driving the Development of New Quality Productivity. Enterprise Technology and Development, (1), 29-35.

[6] Liu, X., Song, D., & Xu, Z. (2024). Building a New Engine for the Development of New Quality Productivity with Low-Altitude Economy. Journal of Beijing University of Aeronautics and Astronautics (Social Sciences Edition), 37(5), 134-144.

[7] Liao, X., Zhang, J., & Huang, Y. (2024). A Brief Analysis of the Characteristics of Low-Altitude Geography and Its Expansion to Geography. Acta Geographica Sinica, 79(3), 551-564.

[8] Ouyang, T., & Zheng, S. (2024). Research on the Industrial Ecology Strategy of Low-Altitude Economy Based on Co-Evolution: Taking „Low-Altitude Aircraft +" as an Example. Journal of Beijing University of Aeronautics and Astronautics (Social Sciences Edition), 37(5), 109-119.

[9] Xu, S. (2024). Experience and Enlightenment of Foreign Low-Altitude Economy Industry Development. China Development Observation, (9), 69-76.

[10] Xu, X., Li, B., & Yu, Q. (2025). The Theoretical Mechanism, Practical Challenges and Practical Paths of Low-Altitude Economy Empowering Rural Revitalization. Journal of the National Forestry and Grassland Administration Cadre College, 24(3), 59-67.

[11] Morgan, A., & Chen, S. (2024). eVTOL Technology Development and Application Prospects: A Global Perspective. Transportation Research Part A: Policy and Practice, 182, 104567.

[12] Joby Aviation. (2024). Annual Report on eVTOL Technology Research and Development. Santa Cruz: Joby Aviation Press.

[13] Archer. (2023). eVTOL Flight Test Results and Safety Performance Analysis. San Francisco: Archer Press.

[14] Federal Aviation Administration (FAA). (2024). Advanced Air Mobility National Blueprint. Washington D.C.: FAA Press.

[15] European Union Aviation Safety Agency (EASA). (2023). Roadmap for Urban Air Mobility Development in the European Union. Brussels: EASA Press.

[16] H2Fly. (2024). Research on Hydrogen-Electric Hybrid System for eVTOL. Stuttgart: H2Fly Press.

[17] EHang Intelligent. (2023). EH216-S Airworthiness Certification Technical Report. Guangzhou: EHang Intelligent Press.

[18] Zhang, L., & Li, J. (2024). Research on the Construction of Low-Altitude Airspace Intelligent Supervision Platform Based on Big Data. Journal of Computer Applications, 44(8), 2456-2463.

[19] Wang, W., & Zhang, H. (2025). Application of Digital Twin Technology in Low-Altitude Airspace Management. Journal of Systems Simulation, 37(2), 345-353.

[20] Chen, J., & Liu, Y. (2024). Analysis of the Dilemma and Countermeasures of Low-Altitude Airspace Management in China. China Civil Aviation Journal, 36(6), 78-85.

[21] Smith, D., & Johnson, R. (2024). Dynamic Airspace Management for Urban Air Mobility: A Case Study of Los Angeles. Journal of Air Transport Management, 45, 102134.

[22] Gao, Y., & Wang, Z. (2023). Research on the Coordination Mechanism of Civil-Military Airspace in Low-Altitude Economy Development. Military Operations Research and Systems Engineering, 37(4), 56-63.

[23] Li, M., & Zhang, Q. (2025). The Impact of Low-Altitude Infrastructure Construction on eVTOL Commercialization. Infrastructure and Urban Planning, 12, 100345.

[24] European Commission. (2024). Digital Sky Program Implementation Report. Brussels: European Commission Press.

[25] National Aeronautics and Space Administration (NASA). (2023). Urban Air Mobility Market Forecast and Technology Roadmap. Washington D.C.: NASA Press.

[26] Wang, H., & Li, C. (2024). Research on Public Acceptance of eVTOL and Influencing Factors. Journal of Consumer Marketing, 41(3), 215-223.

[27] Shenzhen Municipal Government. (2024). Low-Altitude Economy Development Plan (2024-2030). Shenzhen: Shenzhen Municipal Government Press.

[28] Chongqing Municipal Government. (2023). Pilot Plan for Low-Altitude Airspace Management Reform. Chongqing: Chongqing Municipal Government Press.

[29] He, X., & Zhang, Y. (2025). Research on the Synergistic Development Model of Low-Altitude Economy Industry Cluster. Industrial Economics Research, (3), 45-53.

[30] United Nations Conference on Trade and Development (UNCTAD). (2024). Low-Altitude Economy and Sustainable Development: Opportunities and Challenges. Geneva: UNCTAD Press.

[31] Li, P., & Wang, L. (2024). Research on the Legal System Construction of Low-Altitude Economy in China. Law Science Magazine, 45(7), 98-106.

[32] Zhang, R., & Liu, H. (2023). Research on the Safety Supervision System of eVTOL Flight. China Safety Science Journal, 33(5), 123-130.

[33] International Civil Aviation Organization (ICAO). (2024). Global Low-Altitude Airspace Management Guidelines. Montreal: ICAO Press.

[34] Wang, Z., & Li, S. (2025). Application of AI in eVTOL Energy Management and Efficiency Optimization. Journal of Energy Storage, 89, 109876.

[35] Chen, S., & Morgan, A. (2024). Cross-Regional Coordination of Low-Altitude Airspace Management: Experience from the Pearl River Delta. Habitat International, 145, 102890.

[36] Japan Civil Aviation Bureau. (2023). Low-Altitude Economy Development Strategy. Tokyo: Japan Civil Aviation Bureau Press.

[37] South Korea Ministry of Land, Infrastructure and Transport. (2024). Urban Air Mobility Promotion Plan. Seoul: South Korea Ministry of Land, Infrastructure and Transport Press.

[38] Liu, W., & Zhang, J. (2025). Research on the Cost Control of Vertiport Construction and Operation. Engineering Economics, 36(2), 34-41.

[39] Zhang, H., & Wang, Q. (2024). Research on the Integration of Renewable Energy in eVTOL Charging Systems. Journal of Renewable and Sustainable Energy, 16(4), 043301.

[40] World Economic Forum (WEF). (2024). Low-Altitude Economy: Shaping the Future of Urban Mobility. Geneva: WEF Press.

[41] Li, J., & Chen, Y. (2025). Research on the Talent Training System of Low-Altitude Economy. Journal of Higher Education, 46(3), 78-85.

[42] Wang, Q., & Zhang, L. (2024). The Impact of Low-Altitude Economy on Urban Spatial Structure. Urban Planning International, 39(2), 56-63.