# The Evolution and Challenges of Low-Altitude Economy: Insights from Experience in China

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Abstract: As an emerging economic form, the low-altitude economy is rapidly developing in China and increasingly demonstrates its broad application potential and economic value. This study provides a comprehensive analysis of the trajectory of China's low-altitude economy, exploring its applications across various industries, including drone technology, logistics, agricultural spraying, and geographic mapping. It delves into the growth opportunities driven by policy support, technological advancements, and market demand. The study also identifies the main challenges currently faced by the low-altitude economy, such as the absence of specific regulations, insufficient infrastructure, talent shortages, and technological constraints, offering targeted policy recommendations and improvement measures. By establishing a systematic educational and training system, strengthening regulatory frameworks and technological innovation, and optimizing the industrial chain structure, China's low-altitude economy is poised for broader development prospects. Additionally, the study discusses the potential future impacts of the low-altitude economy, including its role in advancing the modern service industry and contributing to national economic growth.

## **1 INTRODUCTION**

With the continuous progress of science and technology and the rapid development of the economy, the respective emerging economic forms are endless. The low-altitude economy is one of them, and it has gradually gained global attention and importance in recent years. China, the world's largest developing country, is also enthusiastically developing the low-altitude economy industry (Zhu et al., 2017; Jiang et al., 2023; Guan et al., 2024).

Low altitude economy is a new type of economic form, with flight activities using human-crewed and uncrewed aerial vehicles (UAV) in low altitude airspace (usually below 1,000 meters) that can be extended to no more than 3,000 meters according to actual needs as the core, leading to the integration and development of related fields such as research and development, production, sales, the operation of infrastructure construction related to low altitude flight activities, flight protection, and derivative comprehensive services, etc. (Xueqiu, 2024a). This economic model reflects the important role of lowaltitude airspace in promoting the economy and foretells the prospects of the wide application of lowaltitude flight activities.

The development of a low-altitude economy has led to the rise of a series of related industries. From the perspective of the industrial chain, it includes lowaltitude aircraft manufacturing, low-altitude operation services, low-altitude infrastructure & supporting security and other directions (Xueqiu, 2024b). The low-altitude economy contains the traditional general aviation industry. It is also strongly associated with a number of fields, such as drone technology, logistics and distribution, agricultural spraying, photography and filming, geographic mapping, forest firefighting, electric power inspection, emergency rescue, security monitoring, and so on (Shangyou News, 2024).

The low-altitude economy has made significant breakthroughs in several key areas in recent years, which are not only reflected in the continuous improvement of the top-level design but also cover the strengthening of regulations and certification as well as the extensive expansion of application scenarios, strongly promoted the development of the entire industrial chain. Since the low-altitude

#### 32 Jin, Y

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economy was formally written into "the Outline of the National Comprehensive Three-dimensional Transportation Network Plan" in 2021, the lowaltitude economy has received a high degree of attention in China. The concept of a "low-altitude economy" has been incorporated into the national plan for the first time, laying a solid foundation for developing the low-altitude economy in the future (Vzkoo, 2024).

In 2024, the government work reports of more than 20 provincial-level administrative regions explicitly set policy objectives for developing a lowaltitude economy and general aviation. Shenzhen took the lead in introducing "the Regulation on Promotion of Low Altitude Economy Industry" in the Shenzhen Special Economic Zone, which has been officially implemented since 1 February 2024. The Regulation aims to promote the development of the low-altitude economy industry in all aspects by establishing a coordination mechanism for industry development, optimizing infrastructure construction and operation management, constructing a lowaltitude flight service platform, and broadening the application areas of the industry. In addition, for the pain points and difficulties in developing the lowaltitude economy industry, the regulations also involve several institutional innovations to ensure the low-altitude economy can develop safely and stably (Vzkoo, 2024).

The Chinese government attaches great importance to and strongly supports the development of the low-altitude economy. By the end of 2023, there were 689 general aviation enterprises, 3,173 registered general aviation aircraft, and 451 general aviation airports in China, with a cumulative one-year flight time of 1,357,000 hours. The measured data shows that the scale of China's low-altitude economy has exceeded 500 billion yuan in 2023 and is expected to reach 2 trillion yuan in 2030, seven years later.

## **2** CASE DESCRIPTION

The tracking of light aircraft at low altitude can be enhanced by using a smartphone as an aircraft detector, and improving flight safety.

There are many ways to track low-flying or unmanned aerial vehicles, and the most common way is radar. However, radar is affected by ground conditions, which make communication between the pilot and the communicator impossible, and the research of Lilly B, Cetinkaya D, and Durak U suggests practical solutions for pilots and radio operators. This approach allows for a clearer

understanding of air transport and the ability to transmit the vehicle's position to emergency services in the event of an emergency. This approach utilizes a smartphone to capture orientation information such as longitude, warp and altitude, and instantly displays present and past flight data through the expert version of Google Earth. The software on the platform can search for relevant data about the aircraft, including pictures of the aircraft, branding, flight data, calls, etc. The ease of use of the system was verified through acceptance testing. What may be done in the future is the support for more intelligent devices and platforms, preferably using NoSQL or instant databases on cloud servers, but MySQL is preferred. The algorithms presented in this study apply to the tracking of manned light aircraft, but it is possible to test them on ultralight vehicles, especially on microunmanned aerial vehicles. Security aspects should also be considered to prevent the input of illegal information (Lilly et al., 2021).

Federated learning is closely related to 6G networks, which can ensure the sharing of information between different terminals while doing so in a way that protects the user's privacy. Through information interaction and cooperation among multiple terminals, federated learning can form a set of common patterns that are effective and secure for all participants. However, due to the limited computing resources of most mobile terminals, it is still difficult to effectively train machine learning models with high computing performance (Fan et al., 2022).

The research of Fan Wen, Wei Xi, Yu Shuai and Chen Xu relies on heterogeneous networks based on Mobile Edge Computing (MEC) technology. It enables multiple unmanned aerial vehicles to act as airborne edge servers to move around in a specified location freely, acquire current dynamic information, and ensure the timeliness of the data through local joint learning (Fan et al., 2022).

In this study, to address the problems in the joint training of multiple UAVs, Fan Wen, Wei Xi, Yu Shuai and Chen Xu investigated the three aspects of data updating degree, communication overhead and modeling performance. They focused on the flight trajectory of the UAVs, the communication mode with the terminals, and the collaboration mode. Fan Wen, Wei Xi, Yu Shuai and Chen Xu also proposed a multi-agent deep augmented learning method with divisible multi-agents for solving the continuous online decision-making problem during multi-UAV joint training for collaboration and control (Fan et al., 2022).

Simulation experiments by Fan Wen, Wei Xi, Yu Shuai and Chen Xu showed that the federated learning approach based on edge computing can effectively improve the effectiveness and safety of machine learning. Federated learning is not only applicable to situations with different data distributions but also to environments that produce rapid changes (Fan et al., 2022).

## **3 FORMULATION OF ISSUES AND RECOMMENDATIONS**

Low-altitude economy is an emerging economic field. Any emerging economic field needs to rely on policy guidance, technology support and capital injection. This paper will expand on these three basic elements and present eight problems faced by the low-altitude economy in China. Only when these three elements are combined can they form a solid foundation for developing China's low-altitude economy. Zhou Shuguang, a deputy to the National People's Congress and chairman of Xi'an Kewei Aerospace Science and Technology Group, has suggested the preparation and introduction of a national strategic development plan for low-altitude economy which can be used to clarify the development goals, strategic tasks, technological innovations, supportive policies, and coordinating mechanisms to make key breakthroughs in the areas of industrial development, market application, airspace reform, basic support, and operational services (Shangyou News, 2024).

China lacks the support and protection of laws and regulations in developing a low-altitude economy. China still needs to have national laws and regulations for a low-altitude economy. There needs to be more legal basis for developing a low-altitude economy. General aviation enterprises can't research and develop improvements for low-altitude flight.

As far as general aviation is concerned, there are problems such as lack of professional talents, lack of industry norms, and weak operational capacity of enterprises. For an industry that has just emerged and is being vigorously developed by the country, the number of Chinese aviation practitioners is relatively small regarding professional talents. Even if AI can perform part of the work, it still needs more staff to monitor and command. In addition, the low-altitude economy industry needs more systematic professional training, and the rate of output talents needs to be more stable, resulting in the industry not developing rapidly. At present, the areas that vigorously develop a low-altitude economy are all urban rather than rural areas. Even though there are examples of pesticides spreading by airplanes in rural areas, the price is high. There needs to be a systematic supporting industry in rural areas, which can't be fed back to the general aviation enterprises efficiently.

Low-altitude tourism is a branch of the lowaltitude economy, as an innovative form of tourism, it is still in its infancy in China. Even though China is now aware of its huge market potential, this potential has yet to be released. Against the background that most people are unfamiliar with low-altitude tourism, even with the attraction of viewing the ground from a unique perspective in the air, the market for lowaltitude tourism still needs to expand rapidly. On the other hand, from the perspective of market operation, the current low-altitude tourism in China still needs to improve in marketing and branding, with the lack of sufficient attraction and competitiveness attracting more consumers (Huice Website, 2024).

All civil aircraft must pass an airworthiness assessment, and in the case of the use of electric vertical take-off and landing vehicles (EVTOLs), obtaining type certification issued by the Civil Aviation Administration (CAA) is a necessary condition for participation in urban air traffic. However, there is no uniform regulation in China. eVTOLs, a new type of spacecraft, are not regarded as a specific type of airworthiness validation, while they can not be categorized as traditional helicopters or fixed-wing aircraft. Currently, the civil aviation agencies of different countries still need to have unified airworthiness certification standards for this type of vehicle, and only Europe has developed unified evaluation standards and compliance methods for small VTOLs (electrically powered vertical takeoff and landing vehicles) (Jnhn.gov, 2024).

There is still a big gap between China and the world's advanced level in aerospace science and technology. However, although there is a small gap between China, the United States, and Europe in the emerging market of low-altitude economy, China still has to rely on other countries for core technologies such as engines for aerospace. ENGINeUS is a worldfamous motor manufacturer; Safran produces motors with a maximum power of up to 750 kW (upgradable to 1 MW). However, Wolong Electrodynamics, the largest Chinese domestic aerospace electric drive company, can only provide a power density of 2-30 kW (2-30 kW) for 1-2 seat commercial unmanned aircraft (eVTOL). Wollongong Electric Drives is developing 50-175 kW electric vehicles for larger four-passenger requirements (Jnhn.gov, 2024).

Existing automotive power batteries are not directly applicable to the eVTOL sector. Due to its peculiarities, the aeronautics sector leads to a high demand for the performance of lithium-ion batteries in electric vertical take-off and landing vehicles (eVTOL). The eVTOL for urban air traffic, on the other hand, should have an energy density of at least 400 Wh/kg. In contrast, the batteries for new energy vehicles have an energy density of about 200 Wh/kg, which is half that of the eVTOL. The energy density of mature eVTOL batteries in the current market is only 285Wh/kg, much lower than that of aviation fuel. So, it can only meet the short-range flight requirements of small all-electric vehicles (Jnhn.gov, 2024).

#### **4** SOLUTIONS

To promote the rapid development of the low-altitude economy, China needs to formulate a comprehensive and in-depth top-level plan to strategically plan the entire industry and ensure the scientific and forwardlooking nature of investment decisions. China needs to provide necessary support policies for regions with good foundations and development potential, avoiding low-end duplication of construction, waste of resources and over-saturation of the market (Jnhn.gov, 2024).

China should also pay attention to the agglomeration effect of the leading enterprises in the UAV industry and their industrial agglomerations. Through the leading role of these leading enterprises, the deep integration and interaction of the innovation, industrial, capital, and talent chains are effectively promoted. This economic ecosystem is like a vibrant "rainforest", which accelerates the transformation of scientific and technological achievements while stimulating the innovative thinking of researchers (Jnhn.gov, 2024).

China must take more active measures to increase support for the low-altitude economy. By formulating and improving relevant laws and regulations, the government can provide financial support and effectively reduce the burden on enterprises through tax reductions and exemptions to reduce financing costs and solve financing problems. China can also encourage the participation of private capital, such as establishing venture funds and guarantee funds, which can provide financial support for start-ups and help them reduce entrepreneurial risks and accelerate growth.

To promote the rapid development of the lowaltitude economy, China needs to establish a lowaltitude flight-related education and training system and strengthen the management and regulation of staff. The government should encourage social forces to participate in the training of general aviation personnel, support enterprises to strengthen technological innovation, and encourage private drone enthusiasts and aviation flight enthusiasts to join the low-altitude flight industry and train.

In terms of technology, researchers should be encouraged to conduct research, and the government can allocate funds to set up research funds to encourage technicians to research and study. The government can also absorb more graduates of related majors from colleges in developed countries, have friendly communications with leading companies in the drone industry, and carry out worldwide exhibitions in the low-altitude flight industry to integrate new technologies.

#### **5** FUTURE PROSPECT

The low-altitude economy is a new industry that is different from traditional industries mainly because it combines aviation technology and other related technologies. The outlook of China's low-altitude economy shows positive development prospects and wide application potential. "The Outline of the National Comprehensive Three-dimensional Transportation Network Plan" was released in 2021, which mentions the development of a low-altitude economy. With the support of national policies and the deepening of low-altitude airspace management reform, the low-altitude economy is regarded as one of the strategic emerging industries, which is expected to show vigorous vitality and successful rapid development in the coming years.

With the gradual opening of low-altitude airspace, the economy industry chain is being formed and gradually improved. From general aviation to related service industry, manufacturing industry infrastructure operation and other related industries, it proves that low altitude economy can drive the comprehensive development of many fields. The lowaltitude economy includes research and development, production, sales, infrastructure construction and operation of low-altitude vehicles, flight protection, aircraft maintenance, and derived comprehensive services (Xueqiu, 2024b). Low-altitude vehicle manufacturing produces raw materials such as steel, aluminum alloy, carbon fiber and components such as chips, batteries, boards, motors, gyros, sensors, etc. Low-altitude infrastructure and supporting security, such as remote control, data analysis, system

monitoring, and so on, are the most basic security features of the low-altitude flight industry. Lowaltitude flight, with its unique radiance for related industries, provides many employment opportunities and increases demand for aviation manufacturing industrial raw materials and product production. The application of low altitude economy can also be combined with logistics and distribution, agricultural spraying, photography shooting, geographic mapping, forest firefighting, electric power inspection, emergency rescue, security monitoring and many other fields, showing its great versatility (Shangyou News, 2024).

In this industrial chain, low-altitude vehicles' development, production, and sale are the most important. Growing market demand and technological advances have brought about a variety of new types of vehicles, such as drones and rotorcraft, which will be widely used in the future in various fields, such as air logistics, emergency rescue and recreational flights. The infrastructure built around low-altitude vehicles is also improving, from airports to take-off and landing points to maintenance bases, each of which provides a solid foundation for the prosperity of China's low-altitude economy (Xueqiu, 2024b).

## **6** CONCLUSION

The low-altitude economy is an important part of the modern service industry. The development of the low-altitude economy is conducive to promoting the development of China's modern service industry, which can drive the development of related industries and promote the growth of the national economy. Through the study of related information, it is found that China's current low-altitude economy is in a period of rapid development. However, there are still some problems in the process of low altitude economy development, such as the relevant policies and regulations are not perfect, the distribution of infrastructure construction is not uniform, the lack of relevant talents, technology still needs to be improved, the industry is not in place to regulate, and so on. With the continuous development and growth of China's general aviation industry, constructing a low-altitude economy requires dealing with complex and diverse data. The use of big data technology to conduct in-depth research and exploration of the general aviation industry can provide decisionmaking support and new development ideas for the general aviation industry. In the process of general aviation industry development, big data technology

can integrate and analyze all kinds of information involved in the process of general aviation airport layout, low altitude airspace management, airport construction and operation, and formulate reasonable and effective strategies for decision-making, to realize the effective use and management of low altitude airspace resources.

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