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Study on the Synergistic Development of the Drone Industry and Low-Altitude Economy

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Abstract: In recent years, the rapid development and expanding application scope of UAV technology have made it an important force in promoting the development of the Low-Altitude Economy. A Low-Altitude Economy involves many fields such as Low-Altitude tourism, short-haul transportation, navigation logistics, emergency rescue, flight training, and Low-Altitude advertising, covering a wide range from infrastructure construction to high-end services. With its high flexibility, high efficiency, and wide range of application scenarios, UAVs are gradually showing great potential and value in these fields. The purpose of this paper is to discuss the current situation, application, and strategy of the synergistic development of the drone industry and Low-Altitude Economy, to provide a scientific theoretical basis and practical guidance, and to promote the deep integration and common development of the two.

Keywords: drone industry; low-altitude economy; synergistic development; strategy

Introduction

Relying on Low-Altitude airspace, the Low-Altitude Economy is mainly dominated by drones and supplemented by manned aircraft, covering four major industries: manufacturing, flight, security, and comprehensive services, expanding the spatial dimension of economic activities, giving rise to new scenarios, such as "aerial cabs" and "drone takeout", leading to the collaboration of a large number of enterprises, and facilitating the cooperation of a large number of enterprises, as well as the cooperation between the two. This has led to a large number of collaborations among enterprises and brought about many new careers and opportunities. However, China's Low-Altitude Economy is still in the primary stage of development. From the industrial level, the overall market size is small and unevenly distributed, with the main value concentrated in the upstream manufacturing segment, accounting for nearly 90% of the total, and other sub-industries accounting for less than 10% of the total, which presents a "top-heavy" situation and a lack of an effective industrial linkage mechanism. Secondly, from the application level, the ecological application value of a Low-Altitude Economy has not been fully realized. Enterprise services, government services, and applications are mainly concentrated in emergency communications, energy inspection, urban governance, and other small-scale pilot scenarios, many areas are still to be developed, personal services in the field of application are relatively single, and consumer demand is not strong.

1. Drone Industry

1.1. Classification of Unmanned Aerial Vehicle

Unmanned Aerial Vehicle (UAV) is an aerial vehicle operated by remote control or autonomous flight system without direct driving by the personnel on board. According to the different uses and functions, UAVs can be categorized into consumer-grade UAVs, commercial UAVs, and military UAVs. Consumer-grade UAVs are mainly oriented to ordinary consumers and are designed to be simple and easy to use, usually used for entertainment, aerial photography, personal video production, etc. The price is relatively low, and the operating system is user-friendly, with basic flight stability and filming functions; high-end consumer-grade UAVs are also equipped with advanced functions such as 4K cameras, GPS positioning, automatic obstacle avoidance, and intelligent following, which can meet

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the needs of photography enthusiasts and video creators' needs (Li & Zhou, 2024). Commercial drones, on the other hand, are used in a wider range of specialized fields, such as agriculture, logistics, construction, environmental monitoring, and public safety, with stronger load capacity, longer endurance, and higher flight stability. Military UAVs are high-end applications of UAV technology, mainly used for military reconnaissance, surveillance, battlefield assessment, target striking, and other tasks, equipped with strong concealment, a high degree of autonomous flight capability, and advanced detection and weapon systems.

1.2. Development status of the UAV industry

The UAV industry has been developing rapidly in recent years and has become an important part of the global science technology and economic sectors. According to market research reports, the global UAV market size has continued to grow over the past few years and is expected to remain at a high growth rate in the coming years. In terms of market size, the global drone market has surged with a market of approximately USD 25.9 billion in 2019 and is expected to reach USD 42.8 billion in 2025, growing at a CAGR of 8.73% from 2021 to 2025, a growth trend that is mainly attributed to technological innovation, policy support, and widespread demand for applications. In terms of drone manufacturers, the market is dominated by a few leading players. DJI is the global leader in the consumer and commercial drone market, with a market share of approximately over 70% of the global market. DJI firmly holds the leading position in the market by its strong R&D capabilities, innovative product designs, and extensive market coverage. 3D Robotics of the United States and Parrot of France also occupy a certain market share in the commercial drone segment. The military UAV market, on the other hand, is mainly dominated by several large defense contractors, such as Northrop Grumman, Lockheed Martin, and Boeing of the United States, which have an advantage in high-end UAV technology and applications.

2. Development Status of Low-Altitude Economy

As an emerging economic form, the Low-Altitude Economy has been developing rapidly worldwide in recent years, showing great market potential and broad application prospects. The U.S. Federal Aviation Administration (FAA) has actively promoted the reform of Low-Altitude airspace management and supported the development of general aviation and unmanned aircraft. Low-Altitude tourism, short-haul transportation, and emergency rescue are developing rapidly, especially the drone delivery service has been piloted and successful in several cities, and the market scale of the Low-Altitude Economy in the U.S. has continued to expand, and is expected to maintain stable growth in the next few years (Ouyang, 2024). The European Union has introduced unified regulations for the management of drones and promoted coordination and cooperation among member states, and countries such as the UK, France, and Germany have seen rapid development in the fields of Low-Altitude tourism, aerial logistics, and flight training, which has improved industrial efficiency. China, on the other hand, has shown strong momentum in the Low-Altitude Economy. In recent years, the Chinese government has strongly supported the development of general aviation and the UAV industry, and China's Low-Altitude tourism market has expanded rapidly (Gao & Wang, 2020), and significant progress has been made in UAV logistics and emergency rescue in natural scenic areas and around large cities, and China's flight training market has flourished, providing a large number of professionals for the Low-Altitude Economy.

Third, the application of UAVs in Low-Altitude Economy

2.1. Logistics and distribution

Drones have gradually entered the actual operation stage from the proof-of-concept stage in express delivery and cargo transportation, realizing fast and efficient distribution, pre-planned routes to avoid ground traffic congestion and direct access to destinations, greatly reducing distribution time. The main advantages of drone logistics are reflected in the following aspects: one is the speed of distribution, drones can complete the last kilometer distribution task in a short time, significantly improving the service efficiency; the second is the cost-effectiveness, although the initial investment is high, with the maturity of the technology and large-scale operation, drone distribution in the long term has a significant cost advantage (Li et al., 2014). Thirdly, UAVs have good environmental adaptability and can perform tasks in complex terrain and bad

weather conditions to ensure the stability and reliability of distribution. However, the regulations on flight safety, airspace management, and privacy protection of UAVs in various countries are not yet perfect, which limits the large-scale commercialization of UAVs, and the endurance, load capacity, and anti-jamming ability of UAVs still need to be further improved to meet the demand of practical applications. From the perspective of environmental protection, the safety hazards and noise pollution caused by UAV flights over cities need to be solved through technological improvement and policy guidance. policy guidance.

2.2. Agriculture

In terms of crop monitoring, drones equipped with high-resolution cameras, multi-spectral sensors, and thermal imagers can obtain real-time data on crop growth, soil moisture, and the distribution of pests and diseases in farmland, to grasp information about the farmland and take targeted management measures promptly. Traditional pesticide spraying is often inefficient, has uneven coverage, and is prone to pesticide waste and environmental pollution, while the drone through the pre-set flight path, efficient and uniform pesticide spraying, according to the height of the crop, density, and distribution of pests and diseases, precise control of pesticide spraying volume and range, reducing the use of pesticides and reducing the risk of environmental pollution. In addition, the speed of pesticide spraying by drones is faster, which can cover a large area of farmland in a short time and improve work efficiency. In agriculture, the efficient operation mode of drones can significantly shorten the time of farmland management, reduce production costs, improve the yield and quality of crops, and enhance the market competitiveness of agricultural products (He, 2022). In terms of economic benefits, although the initial investment is high, in the long run, the application of drones in agriculture can improve production efficiency and optimize resource allocation, and also promote the development of related technologies and service markets, creating new employment opportunities and economic growth points.

2.3. Emergency rescue

In natural disasters, drones can quickly arrive at the disaster site, conduct real-time high-altitude reconnaissance and terrain mapping, obtain detailed images and data of the disaster area, help rescuers fully understand the disaster situation, and formulate effective rescue programs. In the process of medical rescue, drones can carry emergency medicines, blood, and medical equipment, and quickly deliver them to locations in urgent need of rescue, significantly shortening the rescue response time. For remote medical treatment, carrying communication equipment provides real-time video transmission, enabling remote medical experts to guide the on-site rescue work in real-time, and enhancing the efficiency and effectiveness of the rescue, for example, after the 2015 Nepal earthquake, drones arrived at the disaster area within hours after the earthquake, providing invaluable assistance to the rescue workers. arrived at the disaster area, providing valuable high-altitude images that helped the rescue team quickly understand the damage and rescue needs of the disaster area. In the 2017 Hurricane Harvey in Texas, U.S.A., drones were used for flood monitoring and rescue material delivery, effectively enhancing the efficiency and coverage of the rescue work. With the continuous progress of technology, UAVs will be able to perform more complex and diversified tasks and enhance the response capacity and effectiveness of emergency rescue.

2.4. Environmental monitoring

The application of UAVs in the field of environmental monitoring has gradually become an important means of modern environmental protection technology. In terms of air quality monitoring, UAVs can carry a variety of sensors, such as particulate matter sensors, gas sensors, and LIDAR, etc., to monitor real-time pollutant concentrations, particulate matter distributions, and meteorological parameters in the atmosphere, collect air quality data at different heights and regions, draw three-dimensional pollution distribution maps, and cover areas that are difficult to be covered by traditional ground monitoring stations. Ground monitoring stations are difficult to cover the area, and in pollution emergencies quickly provide a comprehensive air quality assessment. In terms of water resource management, UAVs can monitor the water quality conditions and hydrological characteristics of rivers, lakes, reservoirs, and other water bodies in real-time, obtain the temperature, dissolved oxygen, pH, nitrogen, and phosphorus content of the water body and other key parameters, and carry out a wide range of water quality

inspections and positioning of pollution sources, assisting the water resource management department in formulating scientific water quality protection and management measures, promoting the intelligent and modernized development of the environmental monitoring system and promoting the innovation and progress of environmental protection technology. innovation and progress of environmental protection technology.

2.5. Infrastructure inspection

In the inspection of key infrastructures such as power lines, bridges, and oil and gas pipelines, UAVs can quickly inspect a wide range of power lines, discover abnormalities on the lines promptly, such as slack wires, broken insulators, and tree barriers, improve inspection efficiency, reduce the time and labor costs of traditional manual inspection, improve safety and avoid the risk of working at high altitude (Huang & Cai, 2024). In bridge inspection, the UAV can fly into the hard-to-reach area, take detailed photos and monitor the structure, connection parts, and surface condition of the bridge, detect the cracks, corrosion, and deformation of the bridge, provide a scientific basis for bridge maintenance and repair, and improve work efficiency and safety. In the field of oil and gas pipeline inspection, drones can inspect long-distance pipeline lines, and utilize infrared imaging and gas detection sensors to monitor temperature changes and leakage of pipelines in real-time, which is more flexible and efficient compared with traditional manual and vehicle patrols, and can ensure the safety and reliability of pipeline operation.

2.6. Commercial

Commercial drone performance refers to the aerial performance using drone formations. Through precise programming and control, complex formation changes, pattern drawing, and lighting effects are accomplished in the air with a high degree of flexibility and creativity, and diversified performance contents are designed according to different themes and scenarios. Whether in large-scale celebrations, music festivals, or opening ceremonies of sports events, drone commercial performances can attract the audience's attention through spectacular visual effects and enhance the influence and participation of the event (Gao & Hui, 2024). For example, at the opening ceremony of the 2018 PyeongChang Winter Olympics, a formation of more than 1,200 drones performed in the night sky, displaying the five Olympic rings and images of skiers, leaving a deep impression on the global audience. Drone advertising, on the other hand, is an innovative way to utilize drones in the air for branding and product promotion. Drones can carry advertising banners, and LED displays, and even form specific brand logos and advertising slogans by flying in formation. In the airspace over the city, business districts, and large-scale event sites, drone advertising can cover a large range of audience groups in a short period, with a strong visual impact and dissemination effect. In addition, through real-time control and data analysis, drone advertising can also flexibly adjust the promotional content and strategy according to the audience's feedback and the on-site situation, improving the accuracy and effect of advertising.

3. Strategies for Synergistic Development of UAV Industry and Low-Altitude Economy

3.1. Technological innovation

Promoting the innovation and application of UAV technology, as well as the R&D and application of Low-Altitude Economy related technologies, is a key strategy for realizing the organic integration and sustainable development of the two, and it is necessary to increase the R&D investment in core technologies, including flight control systems, navigation technologies, sensor technologies, and communication technologies. Breakthroughs in autonomous flight and intelligent control technologies enable UAVs to realize high-precision flight and mission execution in complex environments. Multi-sensor fusion technology, on the other hand, has enhanced the environmental sensing capability of UAVs, enabling them to provide accurate data collection and real-time monitoring in a variety of application scenarios. The R&D and application of technologies related to Low-Altitude Economy are also crucial. the development of advanced airspace management systems and communication networks effectively coordinates and controls UAV flights in Low-Altitude airspace to ensure flight safety and efficient utilization of airspace. the application of 5G communication technologies provides high-speed and low-latency communication security for UAVs, enhancing their real-time control and data transmission capabilities. The combination of new-generation communication

technologies such as 5G and Cloud, Big Data, Internet of Things, Artificial Intelligence, Blockchain, and Security Technology provides innovative means for the regulation of the Low-Altitude Economy and the development of the industrial chain, promotes the integration of the information and communication industry and the Low-Altitude industry, and forms the Low-Altitude intelligent network connection, which, with networking, digitization, and intelligence as the core, covers the whole-dimensional services from terminals to connectivity, application, and regulation, and represents the Low-Altitude intelligent network connection, with networking, digitization and intelligence as the core, covering the whole-dimensional services from terminals to connectivity, application and regulation. With networking and intelligence as the core, it covers all-dimensional services from terminal to connection, application, and supervision, and represents the advanced development form of a Low-Altitude Economy. Low-Altitude intelligent networking has three main features, namely, flight sensing network, data communication network, and arithmetic application network. Among them, the flight sensing network is responsible for providing positioning, navigation, and regulatory services for drones and other aircraft to ensure effective management of Low-Altitude flight activities; the data communication network supports data interaction between aircraft, including remote control data and video, to realize efficient "human-machine-object" and "human-computer-object" services in the three-dimensional space. The data communication network supports data interaction between aircraft, including remote control data and video, etc., to realize efficient interconnection of "people, machines and things" in three-dimensional space (Zhou, 2024); and the arithmetic application network is responsible for processing and storing various types of data, creating a "digital intelligent brain" of Low-Altitude Economy, and improving the intelligence of applications and the scale of data. Therefore, to promote technological innovation, it is necessary to establish an open technological cooperation platform, encourage collaborative innovation among scientific research institutions, enterprises, and the government, share research and development resources and technological achievements, promote the integration and upgrading of drone technology and Low-Altitude Economy related technologies, increase the exploration and demonstration of technological application scenarios, verify the practical effects and commercial value of new technologies through pilot projects and application cases, promote the widespread application of drone technology in Low-Altitude Economy, and promote the use of drone technology in the Low-Altitude Economy, and promote the use of drone technology in the Low-Altitude Economy. Low-Altitude Economy, and promote the synergistic development and overall enhancement of the upstream and downstream of the industrial chain.

3.2. Infrastructure construction

To realize the efficient and safe operation of UAVs and the comprehensive development of a Low-Altitude Economy, it is necessary to accelerate the construction and improvement of infrastructure including UAV airports and charging stations, as well as to improve the management and monitoring capabilities of Low-Altitude airspace. The construction of UAV airports is the core of infrastructure development. UAV airports should include specialized take-off and landing sites, repair and maintenance facilities, control towers, and dispatch centers, and multiple UAV airports should be reasonably distributed in urban and suburban areas to support the efficient development of a variety of Low-Altitude economic activities, such as logistics and distribution, emergency rescue, and Low-Altitude tourism, and should be equipped with advanced navigation systems, automated take-off and landing systems, and quick-response repair stations. Ensure that UAVs can quickly and safely complete takeoffs, landings, and maintenance in a variety of tasks. Efficient energy supply systems are essential to the widespread use of drones. A dense network of charging stations with rapid charging technology should be built at key locations such as drone airports, logistics hubs, city fringes, and rural areas, to minimize downtime for drones between missions, and should be equipped with energy storage devices to provide a stable supply of electricity during peak hours and in emergencies. Around the UAV airports, facilities such as maintenance centers, operation training bases, emergency response centers, and other facilities should be built to form a complete UAV operation guarantee system. At the same time, sites suitable for drone landing and charging should be

reserved in urban planning and architectural design to prepare for the large-scale application of drones in the future.

3.3. Market cultivation and management

In terms of market cultivation, the government and industry organizations should adopt a series of measures to stimulate the enthusiasm of enterprises and individuals to participate in UAV and Low-Altitude economic activities, encourage enterprises to research develop and innovate, introduce more UAV products and services applicable to Low-Altitude Economy, simplify the approval process, lower the threshold of access, and provide a more relaxed development environment for start-up enterprises and individual entrepreneurs. Cultivating and standardizing the market is an important part of ensuring the healthy development of the UAV industry. Formulate and implement unified industry standards and norms, strictly regulate the production, operation, and maintenance of UAVs to prevent inferior products and irregular operations from disrupting the market order, strengthen industry self-discipline and market supervision, enhance the overall industry's technological level and service quality, and create a favorable market atmosphere and social environment. In terms of flight safety education and training, professional flight training institutions should be established, and multi-level training courses should be carried out to provide UAV operators with systematic training in flight knowledge and operation skills, and an examination and certification system should be adopted to ensure that UAV operators have the necessary flight capabilities and safety awareness.

Summary

In the synergistic development of the UAV industry and Low-Altitude Economy, strategies such as technological innovation, infrastructure construction, market cultivation, and safety management can be adopted to promote its healthy and orderly development. The actual effect and wide application of UAVs in various application fields have proved their advantages in enhancing efficiency, reducing cost, and guaranteeing safety, and they will become an important engine to promote modern economic growth and social progress, thus realizing the in-depth integration of UAV technology and Low-Altitude Economy, and creating a smarter, more efficient and safer future.

Conflict of Interest

The author declare that he has no conflicts of interest to this work.

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