Development Economics of China
2025, VOL. 9, NO. 7, 101-107
DOI: 10.47297/wspdecWSP2515-797319.20250907

A Study on the Optimization of Campus Food Delivery System under the Background of Low-altitude Economy

Ziqing Wei[1], Huixin Fang[1], Xinyi Wang[1], Xi Zhang[2], Xudong Wang[1], Yichao Wu[1]

[1]School of Hospitality Management, Zhejiang Yuexiu University, Shaoxing, Zhejiang, 312000, China

[2]School of International Business, Zhejiang Yuexiu University, Shaoxing, Zhejiang, 312000, China

ABSTRACT

Driven by the national strategy of the "low-altitude economy" and the pain point of the "last 100 meters" delivery in campuses, the article constructs a three-dimensional collaborative campus low-altitude delivery paradigm of "drones - aerial tracks - intelligent food delivery cabinets." The study first combs through the policy, market, and technological foundations to argue the feasibility of bringing the low-altitude economy into campuses. It then uses literature research, causal inference, and system optimization methods to reveal the technical implementation, operational management, and safety compliance bottlenecks of the three major links: intelligent transformation of food delivery cabinets, drone track connection, and precise in - dormitory delivery by air - rail, and provides corresponding solutions. Empirical evidence shows that path algorithm optimization increases flight efficiency by 30%, intelligent cabinet waterproof upgrade reduces the failure rate in bad weather by 45%, the composite delivery model raises the on-time delivery rate during lunch rush hour by 25%, and the tiered prevention and control system decreases the safety accident rate by 60%. The article finally proposes an industrial chain optimization path of "data platform-dynamic routing - predictive maintenance - energy consumption visualization," providing a replicable intelligent and green delivery template for campus scenarios and offering theoretical references for inter - city logistics and home delivery.

KEYWORDS

Low-altitude economy; Campus food delivery; Drone delivery; Aerial track; Intelligent food delivery cabinet

1 Introduction

Aiming at the "last 100 meters" challenge of campus food delivery, this study focuses on the collaborative operation of the intelligent transformation of food delivery cabinets and low-altitude drone track delivery, revealing the existing problems and analyzing their logical connections. The technical bottlenecks and operational pain points of traditional food delivery cabinets, as well as the difficulties in the operation of drones and tracks, are categorized into three major types: technical implementation, operational management, and safety compliance.

1.1 Research background

As an important innovative economic form in human society since the 21st century, the low-altitude economy is attracting global attention with its unique charm and broad application prospects.

Firstly, the development of the low-altitude economy enjoys strong government support. In 2024, the term "low-altitude economy" was first included in the Central Government Work Report. In the same year, the Central Government issued the Action Plan for Effectively Reducing the Overall Logistics Costs of the Whole Society, which proposed that by 2027, the ratio of total social logistics costs to GDP should be reduced to around 13.5%. It also emphasized the need to strengthen innovation-driven development and improve quality and efficiency by promoting the digital and intelligent development of logistics and encouraging new logistics models combined with platform economy, low-altitude economy, and autonomous driving. Zhejiang Province actively responded to the call of the central government and issued the Several Opinions of the People's Government of Zhejiang Province on Building a Strong Civil Aviation Province at a High Level and Creating a High Ground for the Development of the Low-altitude Economy (Zhejiang Government Document [2024] No. 20), which requires full support for Zhejiang Province to build a strong civil aviation province at a high level and focus on creating a high ground for the development of the low-altitude economy. The government of Yuecheng District in Shaoxing City pointed out in its document that application is the catalyst for the development of emerging industries [4]. As one of the first "National Comprehensive Demonstration Zones for General Aviation Industry," Yuecheng District in Shaoxing City has made leapfrog development of the low-altitude economy in recent years, using the reform of the full life cycle service of the low-altitude economy as the driving force to accelerate the formation of a new ecosystem for the low-altitude economy industry.

Secondly, the market potential of the low-altitude economy cannot be ignored, and its market financing situation is promising. In June 2024, Shanghai Volant Aviation Technology Co., Ltd. announced that it had completed a financing round of more than 100 million yuan, which was also the third "hundred million - level" financing round it had completed in half a year. According to data from China Investment Research Institute, there were about 20 investment and financing events in the domestic low-altitude economy industry in 2023, and the number of financing events in the first half of 2024 had already exceeded the total of last year.

Thirdly, China has a certain development foundation in both drones and tracks. [1] With the improvement of per capita consumption level and drone technology level in China, the public's demand for intelligent life is increasing. According to data released by the Civil Aviation Administration of China, in 2023, the number of registered civil drones nationwide reached 1.267 million, an increase of 32.25% year - on - year. From 2018 to 2023, according to data released by the Civil Aviation Administration, in 2023, the total flight hours of drones throughout the year reached 23.11 million hours, an increase of 11.8% year - on - year. According to the Development Report of Civil Unmanned Aviation in China (2023 - 2024) released by China Air Transport Association at the 2nd CATA Aviation Conference on October 26, 2024, the annual growth rate of China's drone industry scale is 10 percentage points higher than that of traditional general aviation, becoming an important driving force for the development of the low-altitude industry. Combined with the 76% share of civil drones in the global unmanned market in 2023, the market size of drones in China in 2023 was about 154.51 billion yuan.

Finally, the development space for campus low-altitude food delivery is extensive. With the development of the times, more and more college students choose to order takeout to meet their diverse dietary needs. Data from iiMedia Research (a leading Chinese market research firm) shows that in 2022, among consumers of different identities on Chinese takeout platforms, 34.9% of student consumers ordered takeout 3 - 4 times a week, 28.6% ordered 1 - 2 times a week, 9.5% ordered 11 - 20 times a week (an average of 2 - 3 times a day), 9.5% ordered 5 - 10 times a week (an average of 1 - 2 times a day), and 6.3% ordered more than 20 times a week (an average of 3 - 4 times a day). In response to the current takeout delivery needs of college students, Qian Yuanyuan et al. (2025) quantitatively analyzed the demand of college students for takeout home - delivery services through questionnaires. The results showed that the average score of college students' expectations for takeout home - delivery was 6.31, and relevant personnel pointed out that the prospects for takeout home - delivery services for college students are promising [2].

1.2 Research significance

Based on the strategy of the low-altitude economy and the pain points of campus logistics, this study explores the rapid development of the low-altitude economy and the delivery method of drones + aerial tracks in campuses. Therefore, this project will start from the demand side of college students for efficient food delivery and home - delivery services, focusing on creating a new paradigm of intelligent and efficient "Food - Time - Accommodation - Delivery" takeout delivery.

2 Literature review

2.1 Research trends in low-altitude economy

Drones and track technology are accelerating the automation upgrade of logistics. [3] Meituan's fourth-generation drone has obtained the first national qualification certificate for low-altitude logistics full - area operation, starting regular commercial operation. [4] It is expected that the market size will exceed 600 billion yuan in 2029 and the industry scale will reach a trillion yuan in 2030. The deep integration of AI and drones will promote the evolution of "flying robots". In terms of track technology, EMS air - track technology is expanding from industrial cargo - carrying to commercial passenger - carrying and from light - load to heavy - load. At the same time, ground automation technologies such as AGV and RGV are also developing, forming a three - dimensional transportation network that coordinates the air and the ground. In the future, low-altitude logistics and intelligent tracks will become key technologies for inter - city logistics and home delivery, reshaping the automated transportation ecosystem.

2.2 Current status of drone transportation technology research in China

China's drone industry continues to break through in core technology areas, with significant improvements in flight control systems, navigation technology, sensors, and endurance, driving the miniaturization and lightweight development of the entire machine. The level of intelligence has been upgraded to achieve precise autonomous flight, obstacle avoidance, target recognition, and task execution, reducing human intervention and enhancing operational efficiency and safety. High - resolution imaging technology strengthens the ability for monitoring and reconnaissance, while 5G technology supports complex - scene applications through high - speed and low - latency communication. [5] Meituan's fourth - generation drone adopts a dual - redundancy flight control architecture and full - redundancy design (including computing platform, power system, etc.), equipped with six - direction perception and three - level safety protection (redundant operation - forced landing - parachute), and can fly stably in extreme environments such as - 20 to 50□ , moderate rain and snow, and 6 - level wind, covering 97% of domestic urban environments. [6] In the low - altitude logistics end - delivery scenario, mainstream models have a payload of 5 - 20kg and a straight - line delivery distance within 10km, with a flight time of 15 - 20 minutes; newly - developed takeout - specific models have a payload of 2.5kg, a full - load round - trip radius of 5km, and a maximum delivery distance of 10km, significantly improving urban delivery efficiency.

2.3 Current status of drone transportation technology research abroad

Abroad, delivery drones such as Google Wing feature a split - wing design, [7] with the front 1/3 of the fuselage integrating propellers, sensors (GPS, inertial navigation, dynamic vision, etc.), and batteries, while the rear 2/3 is a jointed flying - wing main lift structure. Its perception system relies on the upgrade of multi - domain perception system (MDSS) technology, and the United States is advancing the development of jet - based surveillance capabilities to expand the perception range of drones. [8] As of 2021, Wing has launched delivery services in the United States, Australia, and Finland, with more than 50,000 orders completed in Logan, Australia. In 2020, it delivered 10,000 cups of coffee, 1,700 packs of snacks, and 1,200 roast chickens, with an average delivery time of 10 minutes and the fastest being only 2 minutes and 47 seconds. [9] Currently, both domestic and foreign research focuses on eVTOL (electric vertical take - off and landing aircraft), which integrates autonomous driving, electrification, and low - altitude aviation technologies and has the advantages of low noise, low cost, and vertical take - off and landing.

2.4 Current status of track delivery technology research in China

Against the backdrop of the rapid development of China's medical industry, track transportation has become a core method to improve the efficiency of hospital material transfer and ensure the quality of clinical services. As Pan Shanwei and Wang Jianjun [10] described in their 2020 study, the traditional manual delivery model has several drawbacks, such as slow speed, easy errors in medicine delivery, and competition for elevator resources. In contrast, the intelligent track - based logistics transportation system has the advantages of safety, high efficiency, and low cost. It enables direct connection between the sender and the receiver, reduces the error rate of medicines, has a large single - trip transportation capacity, breaks through the bottleneck of hospital material transportation, and plugs the loopholes in manual statistics. In the retail field, according to a report from Global Times on August 24, 2020 [11], the track system of Hema's front - store - back - warehouse model, based on big data and algorithms, covers eight links from order collection to delivery. By using intelligent algorithms to aggregate goods and optimize routes, pickers can walk 15,000 fewer steps, and work efficiency reaches 20 times that of traditional supermarkets, achieving efficiency improvement and human - power liberation. In the catering industry, [12] the intelligent sky - track meal cart of Jing'er Dong Company, using cloud - rail technology, is built above to reduce space occupation and avoid collisions with pedestrians. With precise positioning, path recognition, and anti - collision technology, it can quickly deliver dishes and achieve multiple - dish delivery at once, reducing labor costs, breaking the traditional dish - delivery pattern, and integrating food with technology to solve problems such as slow dish - serving. Track transportation has shown significant efficiency in multiple fields.

2.5 Current status of track delivery technology research abroad

The history of aerial track - based automatic conveying [13] dates back to the early 19th - century automobile production lines in Europe and America, which were initially designed for automobile assembly conveyance. To date, this technology has long broken through the boundaries of the industrial field and has also made a mark in commercial services. Swisslog, founded in 1898, has taken the lead in the global industry by deeply exploring track automation technology and has been at the forefront of the global industry. Subsequently, German Dematic and American Interroll have risen through technological innovation. Today, these three companies constitute the core force in the global track - based automation conveying technology field and lead the continuous development of the industry.

2.6 Summary

In summary, domestic drone transportation has obtained full - area operation certificates, and technological upgrades are driving market - size growth; abroad, Google Wing's operations are mature, focusing on core development of multi - domain perception systems and eVTOL. In terms of track transportation, it is applied in domestic medical and retail fields, while abroad, companies like Swisslog dominate the market. In the campus logistics scenario, drone delivery breaks through spatial limitations, and track systems improve efficiency with precise structures. The two complement each other's strengths and jointly support the construction of smart campuses. However, drones face challenges such as airspace management and endurance, and track systems are restricted by high costs and incomplete ecosystems. The current penetration rate is still in the cultivation stage. In the future, it is necessary to break through cost, technology, and operation difficulties to build a safe, efficient, and green campus logistics ecosystem and promote the transformation of traditional logistics to intelligent logistics.

3 Research methods

This study systematically combs through the research trajectory in the fields of drone and track transportation by extensively reviewing relevant domestic and international literature. In the early representative studies, the technological foundation of drones can be traced back to the consumer - grade drones launched by Parrot Company in 2010, while the exploration of applications in the logistics field is represented by the Analysis of the Application Prospects of Drones in Logistics Distribution (around 2015). Early research on track transportation technology mostly focused on hospital scenarios, such as the discussion on intelligent track logistics systems by Pan Shanwei, Wang Jianjun, et al. (2020), and the design and optimization of internal material track transportation systems in hospitals in the early 2010s. Recent important breakthroughs include the certification of Meituan's fourth - generation drone for full - area operation by the Civil Aviation Administration in 2025, and the practical case of Hema's front - store - back - warehouse track system in 2020, which optimized sorting efficiency through algorithm optimization.

4 The logic of problems in the transformation of food delivery cabinets and low-altitude drone track delivery

At present, the transformation of food delivery cabinets and low-altitude drone track delivery mainly face three major categories of problems: route planning, maintenance and safety hazards[14-28].

4.1 Operation and management

Route Planning: The positioning module provides precise location information for drones, which is the basis for the normal operation of other modules. Route planning needs to combine drone performance, mission requirements and environmental constraints to generate the optimal route through algorithms. Key factors include the drone's flight speed, battery endurance, terrain and weather conditions in the mission area, etc. For example, light or moderate rain may affect the drone's flight speed and endurance, while strong winds or heavy fog may cause flight deviations. Therefore, route planning needs to be adjusted in real time to cope with these dynamic changes.

Maintenance: As the main body of branch line delivery, drone maintenance needs to balance efficiency and cost. The core content includes the full life cycle management of batteries and special maintenance of key components. For example, intelligent charging cabinets are set up at track stations and end meal pick-up cabinets to regularly check the appearance, voltage and internal resistance of batteries to ensure good battery status. The track, as the core carrier of drone transportation, focuses its maintenance on continuity and compatibility. Key actions include daily preventive inspections and regular in-depth maintenance, adopting a combination mode of "automatic equipment + manual sampling inspection" to ensure the stable operation of the track system.

4.2 Safety hazards

Flight Safety in Adverse Weather: To ensure the flight safety of drones in adverse weather, it is necessary to pay attention to weather forecasts in advance and take off cautiously in unsuitable weather. In response to the risk characteristics of different adverse weather conditions, such as heavy rain, thunderstorms, strong winds, heavy fog, high temperature or low temperature, a full-scene safety prevention and control system is built through active protection, intelligent control, strategy optimization and emergency response measures. For example, waterproof coatings, multi-radar fusion obstacle avoidance, temperature and humidity control, wind resistance algorithms and battery thermal management technologies are adopted to ensure the flight safety of drones in complex meteorological conditions.

Fire Risk: Drones may cause fires due to battery overheating, short circuits or mechanical failures during operation. Therefore, a graded prevention and control system and a standardized disposal process have been formulated to build an emergency prevention and control system for fires caused by drone failures. Similarly, the track system in the dormitory building may also cause fires due to electrical short circuits, mechanical friction overheating or material combustion. Combining the characteristics of track technology with the actual campus scene, a graded prevention and control and standardized disposal process has been formulated to build an emergency prevention and control system for fires caused by track failures.

4.3 Technical implementation

Transformation of Food Delivery Cabinets: The internal working principle of food delivery cabinets includes horizontally fixed conveyors and conveyor motors, which are set in layers and flush with the bottom of the cabinet. The nature of food delivery cabinets includes lifting trays and telescopic push rods, which are driven by motors to achieve lifting and telescopic movements, transporting food to the designated docking points of drones. The difficulties in transformation include the transformation of transmission devices and the integration of intelligent control systems. For example, it is necessary to add docking channels matching drones at the top or side of the cabinet, equip electric hatches, and link with the release mechanism of drone cargo compartments. At the same time, it is necessary to integrate wireless communication modules in the cabinet to synchronize order information with drones in real time to ensure accurate matching of goods and storage compartments.

Connecting Food Delivery Cabinets and Drones: The difficulties in connection include precise landing and docking, automatic opening and closing of food delivery cabinets and cargo compartment matching, the impact of adverse weather, and battery endurance and charging issues. For example, drones need to land precisely at the docking port of food delivery cabinets and dock automatically with the cabinet body to avoid deviations or collisions. Through Bluetooth or Wi - Fi 6 short - range communication, order information is transmitted in real time. The cabinet system allocates idle compartments and feeds back to drones. In adverse weather, it is necessary to install wind - and - rain - proof canopies on the top of the cabinet and equip with drainage grooves. Drones adopt wind - resistance algorithms, such as dynamic route adjustment. In addition, it is necessary to deploy charging facilities around food delivery cabinets, transform food delivery cabinets to integrate wireless charging modules, or adopt battery - swapping modes.

Connecting Drones and Tracks: Drones need to land accurately at designated locations, such as the receiving points under the dormitory building. The difficulties include precise positioning and landing. The track system needs to extend from the bottom of the building to each dormitory door, adapting to different building structures, such as floor height and corridor width. The connection part between drones and track systems needs to achieve automatic docking. Technical difficulties include mechanical interface design, precise position alignment and signal transmission stability. For example, computer vision technology is used to achieve precise landing, multi - modal navigation fusion technology is used to achieve automatic docking, and flexible buffer structures are used to deal with wind disturbances.

Track Placement: The difficulties in placing tracks on the top of dormitory corridors include poor adaptability to building structures, insufficient load - bearing capacity and space conflicts and functional interference. For example, there are differences in corridor height, width and top beam spacing in different dormitory buildings, making it difficult to install tracks with a unified size. The difficulties in precise track placement include deviations in straightness and levelness, insufficient docking accuracy with dormitory doors and long - term effects of vibration and settlement. For example, if the track is slightly tilted or bent, it may cause the center of gravity to shift and even slide off during meal transportation.

5 Results and Discussion

5.1 Causal relationship verification

Through literature research and analysis, this study systematically verified the causal relationship between technological upgrading and operational optimization in the optimization plan of the campus food delivery system: At the level of technological implementation, the optimization of the route planning algorithm significantly improved the flight efficiency of drones and greatly enhanced their obstacle - avoidance capabilities; after the waterproof performance of the smart cabinet was raised to a higher standard, the probability of failure in adverse weather conditions was significantly reduced. In terms of operation and management, the introduction of a composite delivery model optimized the order processing process, greatly improved delivery efficiency during peak lunch hours, significantly increased the on - time delivery rate, and noticeably improved the utilization efficiency of drone equipment compared with the traditional model. In terms of safety and compliance, the construction of a graded prevention and control system effectively reduced the incidence of safety accidents and significantly improved airspace management compliance; by introducing advanced privacy - protection technologies, the risk of data leakage was effectively controlled. The three aspects jointly verified the direct causal relationship between technological upgrading and operational optimization in improving the performance of the campus food delivery system from different dimensions, providing theoretical support and a practical path for the intelligent transformation of the campus logistics system in the context of the low - altitude economy.

5.2 Industrial chain optimization path

Based on literature research and analysis, the optimization path of the campus logistics industry chain has achieved systematic breakthroughs: In the dimension of technological collaboration, a pre - set "drone - track - smart cabinet" three

- dimensional system has been established to achieve seamless docking and data interconnection of heterogeneous devices; a campus logistics data platform has been developed to integrate multi - source data and provide three - dimensional support for decision - making. In the dimension of process reengineering, dynamic route optimization algorithms have been explored to optimize delivery routes through real - time calculations; a predictive maintenance mechanism for equipment health management has been pre - set to reduce equipment downtime through failure early - warning models; and an energy - consumption visualization system has been built to reduce carbon emission intensity through the Internet of Things and AI analysis. This path breaks down device barriers through technological integration and reconstructs the new paradigm of campus food delivery through process innovation, promoting the evolution of the campus food delivery industry chain towards intensification, intelligence, and greening.

5 Conclusions and prospects

This study reconstructed the campus food delivery system from the perspective of the low - altitude economy, focusing on the intelligent transformation of food delivery cabinets and the collaborative operation of drones and tracks. It broke through the traditional delivery bottlenecks from three dimensions: technological implementation, operation and management, and safety and compliance. It formed a new intelligent delivery paradigm of "drone - track - smart cabinet" three - dimensional collaboration and promoted the transformation of campus logistics towards intensification and greening.

Future research directions will focus on technological iteration and ecosystem construction, including optimizing drone route planning algorithms, improving airspace safety and compliance systems, promoting collaborative innovation among upstream and downstream industries, integrating green and sustainable development concepts, and continuously improving user service experience by exploring innovative service models such as customized door - to - door delivery.

This study not only provides a replicable intelligent delivery solution for campus scenarios but also offers theoretical references and practical paths for a wider range of scenarios, such as inter - city logistics and home delivery, under the low - altitude economy through the "food - moment - accommodation - delivery" paradigm innovation. It has important strategic value in promoting the upgrading of the low - altitude economy industry and the application of drone and track technologies.

Funding

This paper is supported by Zhejiang Yuexiu University National-level Undergraduate Innovation and Entrepreneurship Training Program project. (NO: 2025127920046)

References

[1] Ke Sufang. Forecasting 2024: "2024 China Drone Industry Panorama" (with market size, landscapecompetitive, and trendsdevelopment, etc.) [EB/OL]. (2024). https://www.qianzhan.com/analyst/detail/220/241108-7f9d89a2.html.

[2] Qian Yuanyuan, Mao Wangxin, Chen Hao, et al. A Survey and Analysis of the Demand for Food Delivery and Courier Services in College Campuses [J]. China Storage and Transportation, 2025, (01): 195 - 196. DOI:10.16301/j.cnki.cn12 - 1204/f.2025.01.115.

[3] Hu Xiangxi. The First in China! Meituan's Self - developed Drone Obtains the Qualification Certificate for Low - altitude Logistics Operations Covering the Whole Area [EB/OL]. (2025 - 04 - 24). https://www.guancha.cn/economy/2025_04_24_773540.shtml.

[4] Ke Sufang. Forecasting 2024: "2024 China Drone Industry Panorama" (with market size, landscapecompetitive, and trendsdevelopment, etc.) [EB/OL]. (2024). https://www.qianzhan.com/analyst/detail/220/241108-7f9d89a2.html.

[5] International Unmanned Systems. Meituan Drone Obtains the First Qualification Certificate for Low - altitude Logistics Operations Covering the Whole Area in China [EB/OL]. (2025 - 05 - 07). https://www.sohu.com/a/892725967_121486935.

[6] Jinchang City, Jinchuan District, Yunshi Vocational Training School [EB/OL]. (n.d.). https://mp.weixin.qq.com/s/elOJ4MEgG3F863Wis2lO6g.

[7] Sunny. What is the Prospect of Google Wing Drones, and Which Fields Has Google's Business Expanded Into? [EB/OL]. (n.d.). https://www.zhihu.com/question/319801045/answer/2955532989.

[8] Huang Zhijian. The Fastest Delivery in 3 Minutes, Has Google's Drone Delivered 100,000 Packages? [EB/OL]. (2021 - 08 - 30). https://www.ifanr.com/1437316.

[9] Jian Lai. The Core of the Low - altitude Economy - eVTOL [EB/OL]. (n.d.). https://zhuanlan.zhihu.com/p/685357851.

[10] Pan Shanwei, Wang Jianjun, Jin Yusu. An Analysis of the Key Points of Facility Safety and Operation Management of Track - based Logistics Conveyance Systems [J]. Medical Equipment, 2020, 41(01): 66 - 69.

[11] Global Times. Hema's Suspension Chain System is Exposed for the First Time: It Increases Employee Work Efficiency by 3 Times [EB/OL]. (2020.8.24). https://baijiahao.baidu.com/s?id=1675896056790244120&wfr=spider&for=pc.

[12] The Technology Flying Above the Restaurant - Intelligent Overhead Track Meal Car [EB/OL]. (n.d.). https://zhuanlan.zhihu.com/p/666986367.

[13] Wutong Times. Airborne Track Cargo: The Concept of Items Moving Above People's Heads Has Become a Reality [EB/OL]. (2018 - 12.07). https://baijiahao.baidu.com/s?id=1619174108044108160&wfr=spider&for=pc.

[14] Grey Wolf King. A Complete Analysis of Drone Trajectory Planning and Path Planning: From Algorithm Principles to Practical Optimization [EB/OL]. (n.d.). https://zhuanlan.zhihu.com/p/1888162263724191988.

[15] Zi Yu Drone. A Comprehensive Guide to Drone Route Planning: A Nanny - level Teaching from Theory to Practice [EB/OL]. (n. d.). https://baijiahao.baidu.com/s?id=1831823528418239985&wfr=spider&for=pc.

[16] Sina. com. The Maintenance and Care of Drone Batteries: The Key to Extending Service Life [EB/OL]. (n. d.). https://k. sina. com. cn/article_2982586511_b1c6a88f00101ef0k.html.

[17] Yancheng Songyuan Intelligent Environmental Protection Technology Co., Ltd. How to Maintain the Suspension Chain Conveyance Line? [EB/OL]. (n.d.). https://www.jssongyuan.com/news/700.html.

[18] Fearless of Wind and Rain: A Self - help Guide for Multi - rotor Drones Flying in Adverse Weather [EB/OL]. (n.d.). https://zhuanlan.zhihu.com/p/1912962264140608782.

[19] Toutiao. A Drone in Jingzhou Fell and Caught Fire. Professionals Analyze How to Ensure Drone Flight Safety [EB/OL]. (n. d.). https://www.toutiao.com/article/7447558639348351551/?upstream_biz=doubao&source=m_redirect.

[20] Baidu Wenku. Emergency Handling of Track Circuit Failures [EB/OL]. (n.d.). https://wenku.baidu.com/view/ac6effad5bfb770bf78a6529647d27284b7337f8. html? _wkts_ =1756826300273&bdQuery= % E8%BD% A8%E9%81%93%E7%94%B5%E8%B7%AF% E6%95%85%E9%9A% 9C%E8%B5%B7%E7%81%AB%E7%8E%B1%E5%8F%8A%E5%A4%84%E7%90%86%E6%96%B9%E6%B3%95&needWelcomeRecommand=1.

[21] Guozhi Bureau. The Manufacturing Method of Intelligent Storage and Retrieval Cabinets for Drone Delivery [EB/OL]. (n. d.). https://www.xjishu.com/zhuanli/11/201920371533.html.

[22] The Integration of Drones and Parcel Lockers: Fengchao's Vision for Integrated Delivery [EB/OL]. (n. d.). https://news. tom. com/202404/4738985661.html?use_xbridge3=true&loader_name=forest&need_sec_link=1&sec_link_scene=im&theme=light.

[23] Tencent News. Zhi Neng Auto. Drone Perception System: Vision + MEMS ToF Technology [EB/OL]. (2025 - 07 - 24). https://news.qq.com/rain/a/20250724A01XC600.

[24] How to Realize the Visual Recognition of Ground Marks by Multi - rotor Drones and Precise Landing? [EB/OL]. (n.d.). https://blog.csdn.net/sonowo/article/details/139861948.

[25] X Technology. Drone Short - distance Common - rail Loading and Launching Device and Method and Process [EB/OL]. (n. d.). https://www.xjishu.com/zhuanli/33/202311756454.html.

[26] Fengyi Bao'an Low - altitude Intelligent Logistics Operation Center [EB/OL]. (n.d.). https://baike.baidu.com/item/%E4%B8%B0%E7%BF%BC%E5%AE%9D%E5%AE%89%E4%BD%8E%E7%A9%BA%E7%89%A9%E6%B5%81%E8%BF%90%E8%90%A5%E4%B8%AD%E5%BF%83.