福建省中电海峡智能装备研究院
Fujian Zhongdian Straits Institute of Intelligent Equipment
Asia Pacific Science Press
Advances in Management and Intelligent Technologies
ISSN(O):3079-5869
ISSN(P):3079-5850
Vol. 1 No.4 (2025)

The Development of Low-Altitude Logistics and Smart City Under the Era of Digital Economy

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Abstract: The booming development of digital economy has injected new vitality into the transformation and upgrading of urban economies. In this context, low-altitude logistics and smart city construction have become hot topics in both academic and practical fields. Low-altitude logistics, as an important branch of smart logistics, has been widely researched and applied in practice. The paper aims to explore the collaborative development path between low-altitude logistics and smart city construction in the context of digital economy. By constructing a theoretical framework and discussing the applications of IoT technology in low-altitude logistics and smart city construction, the research results are expected to enrich and improve the theoretical system of smart city and low altitude logistics, providing new perspectives and ideas for research in related fields.

Keywords: Digital Economy; Low-Altitude Logistics; Smart City
Published: Aug 6, 2025
DOI: https://doi.org/10.62177/amit.v1i4.528

1.Introduction

As the digital economy is booming, smart cities are gradually emerging as a new urban development model around the world. With the help of advanced information and communication technologies, smart cities have achieved comprehensive improvements in urban management, public services and quality of life (Silva, Khan, and Han, 2018). Especially in the field of logistics, with the rapid development of intelligent technology, low-altitude logistics is becoming a new force in the construction of smart cities, injecting new vitality into modern urban logistics and distribution with its high efficiency and flexibility (Minaei, 2022).

With its powerful connection and data processing capabilities, the Internet of Things (IoT) technology plays a vital role in the construction of smart cities. Through IoT, various devices and systems can achieve efficient data interaction and information sharing, thereby greatly improving the level of intelligent urban management. In the field of low-altitude logistics, the application of IoT technology has promoted the innovation of logistics distribution (Huang, Fang, Wu, Wang, and Yang, 2024). With the help of advanced technologies such as drones and intelligent dispatching systems, low-altitude logistics not only improves distribution efficiency, but also greatly reduces logistics costs, providing more convenient and faster services for urban residents (Yao, An, He, Li, and Shan, 2022).

In recent years, more and more provinces and cities in China are beginning to regard the low-altitude economy as a new development focus. The Central Economic Work Conference also clearly proposed the need to create strategic emerging industries such as the low-altitude economy (Liu and Liu, 2025). Against this background, low-altitude logistics, as an important part of the low-altitude economy, has broad development prospects. The Central Financial and Economic

Commission also emphasized the need to optimize the logistics system and encourage the development of new logistics models that are combined with low-altitude economy, which provides strong policy support for the development of low-altitude logistics.

In the process of building smart cities, research on low-energy buildings and intelligent thermal energy circulation systems has also made significant progress (Ting, 2024). The studies not only help reduce urban energy consumption and improve energy efficiency, but also provide new ideas for the sustainable development of smart cities. Although these studies seem to have no direct connection with low-altitude logistics , they are actually important components of the grand framework of smart cities, and together they promote the intelligent and green development of cities (Lizana, Chacartegui, Barrios-Padura, and Ortiz, 2018; Ting, 2024).

Low-altitude logistics also faces many challenges in its development. Among them, the issue of low-altitude safety control is particularly prominent. How to ensure the safe flight of low-altitude aircraft such as drones and avoid collisions with buildings, other aircraft or ground obstacles is a key issue that must be solved in the development of low-altitude logistics. In this regard, relevant research have also being carried out in depth in order to provide strong guarantees for the safe and stable development of low-altitude logistics (e.g., Deng, Yang, and Peng, 2023; Zhang, Tian, Feng, Wu, and Zhong, 2023).

In the context of the digital economy, exploring the applications of intelligent technology in low-altitude logistics of smart cities is of great significance on multiple levels. From the perspective of smart city construction, low-altitude logistics can help improve the overall efficiency of urban operations with its efficient and intelligent operation mode. The introduction of intelligent technology enables low-altitude logistics to achieve more refined management in terms of route planning, real-time monitoring, and risk management, thereby promoting the pace of smart city construction (Huang, Fang, Wu, Wang, and Yang, 2024). Specifically, through IoT technology, low-altitude logistics system can perceive the city's traffic conditions in real time, dynamically adjust the delivery route, reduce traffic congestion and energy consumption, and provide more convenient and green logistics services for urban residents (Shee, Miah, and De Vass, 2021).

Accordingly, the paper will explore the applications of intelligent technology, especially the Internet of Things (IoT) technology, in the field of low-altitude logistics. The successful practice of low-altitude logistics will provide useful reference for other industries. Research on the applications of IoT technology in low-altitude logistics has far-reaching significance. It not only helps promote the construction and development of smart cities, but also optimizes the structure of the logistics industry, improves logistics efficiency, and provides new impetus and support for the development of digital economy.

In terms of research methods, the paper uses a combination of concept review and case analysis. Through the concept review, we can fully understand the latest research progress in the field of IoT technology and low-altitude logistics, laying a theoretical foundation for subsequent research. Case analysis enables us to analyze the actual application of IoT technology in low-altitude logistics in a specific and in-depth manner, and understand its operating mechanism and effect more intuitively.

Thus, the contributions of the paper is mainly reflected in the comprehensive and in-depth discussion of the applications of IoT technology in low-altitude logistics of smart cities in the era of digital economy. The paper first analyzes the profound impact of digital economy on the construction of smart cities and the development of the logistics industry, and reveals the internal logic and development laws behind. Second, it systematically explains the key role of intelligent network of IoT technology in low-altitude logistics, and demonstrates its strong application potential and actual effect. In addition, combined with typical cases, it objectively and comprehensively evaluates and summarizes the application effect of IoT technology in low-altitude logistics, providing valuable experience and inspiration for subsequent practice. Finally, innovatively suggestions and methods for optimizing low-altitude logistics operation are provided, aiming to provide useful reference for the development of low-altitude logistics in smart cities.

2.Digital Economy and Smart City Development

2.1 Definition and development of digital economy

Before delving into the impact of digital economy on the development of smart cities, the definition of digital economy and its importance shall be clarifiied. The digital economy is not only an economic form, but also a new social development trend (Williams, 2021). It is based on digital knowledge and information, and promotes profound changes in all areas of the

economy and society through continuous innovation in digital technology.

The rapid development of digital technologies, such as big data, cloud computing, and the Internet of Things, has provided strong technical support for the rise of digital economy. The integrated applications of the technologies has significantly improved the ability to collect, process and analyze data, thereby promoting the digital transformation of various industries (Javaid, Haleem, Singh, and Sinha, 2024). The digital economy is developing rapidly around the world and has become an important engine driving global economic growth. Driven by the digital economy, traditional industries have been deeply transformed and new industries have emerged (Su, Su, and Wang, 2021). This transformation has not only greatly improved production efficiency and reduced costs, but also brought consumers more abundant and diverse products and services.

More importantly, the development of the digital economy has had a profound impact on the construction of smart cities. As a new model of urban development, smart cities aim to improve the level of intelligent urban management, optimize urban resource allocation, and improve the quality of life of urban residents through the extensive application of information technology (Javed, Shahzad, ur Rehman, Zikria, Razzak, Jalil, and Xu, 2022). The digital economy can provide strong data support and technical guarantee for the construction of smart cities. Through the application of big data technology, smart cities can achieve real-time monitoring and prediction of urban operation status, providing a scientific basis for government decision-making. At the same time, the popularization of Internet of Things technology makes it possible to manage urban infrastructure intelligently, greatly improving the efficiency and convenience of urban management (Rejeb, Rejeb, Simske, Treiblmaier, and Zailani, 2022). In addition, the digital economy has also promoted the rapid development of smart transportation, smart medical care, smart education and other fields, providing more convenient and efficient services for urban residents.

2.2 Current status of smart city construction

Smart cities are gradually realizing the intelligence, networking and refinement of various fields of cities with the help of cutting-edge technologies such as the Internet of Things, cloud computing, big data and Artificial Intelligence. At present, the construction of smart cities around the world has achieved a series of remarkable results, which not only improved the efficiency of urban management and the level of public services, but also injected new impetus into the urban economy.

In the process of building smart cities, various modern information technologies have been widely used. Internet of Things technology realizes the intelligent management of urban infrastructure by connecting various smart devices. Cloud computing technology provides cities with powerful data processing and storage capabilities, supporting the efficient operation of various smart applications (Alam, 2021). Big data technology reveals the laws and trends of urban operation through the mining and analysis of massive data, providing a scientific basis for decision-making (Olaniyi, Okunleye, and Olabanji, 2023). Artificial Intelligence technology plays an important role in the fields of smart transportation, smart security, and smart medical care, improving the city's intelligence level and service capabilities (Herath and Mittal, 2022). As a result, with the continuous advancement of technology and the continuous expansion of application scenarios, the construction of smart cities will present a broader development prospect. In the future, smart cities will realize more in-depth intelligent applications in the fields of energy management, environmental protection, and public safety, providing citizens with a more convenient, efficient and comfortable living environment. At the same time, the construction of smart cities will promote the development and innovation of related industries and inject new vitality into the sustained growth of the urban economy.

However, the construction of smart cities is not something that can be achieved overnight, but rather a process that requires long-term investment and continuous optimization. During the construction process, the joint efforts and collaboration of the government, enterprises, and all sectors of society are needed to ensure the smooth progress and sustainable development of smart city construction. In addition, with the continuous evolution of technology and the changing needs of citizens, the construction of smart cities also needs to be constantly adapted and adjusted to meet the actual needs of urban development and the expectations of citizens.

Smart city construction is becoming an important trend in global urban development. By using modern information technology to achieve intelligence, networking and refinement in all areas of the city, it will have a profound impact and change on urban development. In the future, with the continuous advancement of technology and the continuous expansion of

application scenarios, smart cities will bring more convenience and comfort to people's lives and become a new direction and new driving force for urban development. We should also note that in the process of building smart cities, data acquisition, processing and application are crucial links. The use of big data technology enables city managers to grasp the city's operating conditions in real time and predict future development trends, thereby making more scientific and reasonable decisions. This not only improves the efficiency of urban governance and the level of public services, but also brings more convenience and security to citizens' lives (Yan and Jie, 2025). The construction of smart cities has also promoted the development of related industries. For example, the research and development and production of IoT equipment, the provision of cloud computing services, the application of big data analysis, and Artificial Intelligence technology, have formed new industrial chains and injected new vitality into the development of urban economy. The development of the industries has not only created a large number of employment opportunities, but also driven the growth and transformation and upgrading of urban economy.

2.3 Impact of digital economy on the logistics industry

Against the backdrop of the rapid development of digital economy, the logistics industry is undergoing unprecedented changes. The widespread application of digital technologies, especially the Internet of Things, big data, cloud computing and other intelligent Internet technologies, is reshaping the operation model and business processes of the logistics industry (Zhou, Ma, bin Samsurijan, and Xie, 2024).

The digital economy has promoted the digital transformation and upgrading of the logistics industry. The traditional logistics industry relies on manual operations and paper records, which are inefficient and prone to errors. The application of digital technology enables the logistics industry to realize the automation and real-time tracking of goods, improving the visibility and controllability of logistics. For example, through the Internet of Things technology, the location and status of goods can be monitored in real time to ensure that the goods arrive at the destination on time and safely (Ding, Jin, Li, and Feng, 2021). At the same time, big data technology can analyze and mine historical logistics data, helping logistics companies optimize warehousing management, distribution routes and transportation methods (Huang, Yao, Krisp, and Jiang, 2021), thereby improving logistics efficiency and reducing logistics costs.

The rise of the digital economy has also promoted innovation and development in the logistics industry. With the help of digital technology, the logistics industry continues to introduce new service models and product forms. For example, drone delivery, as an emerging delivery method, has the advantages of high efficiency, speed, and flexibility, especially in the "last mile" delivery in cities. Drone delivery can not only improve delivery efficiency, but also effectively alleviate urban traffic pressure and reduce environmental pollution (Manju, Pooja, and Dutt, 2021). In addition, smart warehousing is also one of the logistics innovations driven by digital economy. Through the application of Internet of Things and AI technologies, smart warehousing can realize automated management and optimized storage of goods, improving warehousing efficiency and space utilization (van Geest, Tekinerdogan, and Catal, 2021). The booming development of digital economy has also intensified competition and change in the logistics industry. In the era of digital economy, market competition in the logistics industry has become more intense, and logistics companies need to continuously innovate and improve service quality to adapt to changes in market demand. At the same time, the application of digital technology has also made the supervision of the logistics industry more complex and diversified. The government and relevant departments need to strengthen supervision to ensure the healthy development of the logistics industry.

The impact of digital economy on the logistics industry is multifaceted and far-reaching. It not only promotes the digital transformation and upgrading of the logistics industry, promotes the innovation and development of the logistics industry, but also intensifies the competition and change in the logistics industry. In the era of digital economy, the logistics industry needs to actively embrace digital technology, continuously innovate and improve service quality to adapt to changes in market demand and competitive pressure. At the same time, the government and relevant departments also need to strengthen supervision to ensure the healthy development of the logistics industry.

3.Applications of Internet of Things (IoT) Technology in Low-Altitude Logistics

3.1 Overview of IoT Technology

In the era of digital economy, low-altitude logistics, as an emerging logistics method, has achieved unprecedented efficiency

and accuracy thanks to the deep integration of Internet of Things (IoT) technology. The specific application of IoT technology in low-altitude logistics is mainly reflected in the following aspects.

(1) Real-time cargo tracking and monitoring

Through IoT technology, each piece of cargo can be assigned a unique identification code, and thus every link in the transportation process can be tracked and monitored in real time. This transparency not only enhances customers' trust in the logistics process, but also helps logistics companies to promptly identify and solve problems such as delays, loss or damage. In low-altitude logistics, especially drone delivery, real-time tracking technology ensures flight safety and on-time delivery of goods (Li, Zhang, and Lu, 2024).

(2) Intelligent warehouse management

Through big data analysis, IoT technology can predict the demand and flow patterns of goods, thereby optimizing the use of storage space. In low-altitude logistics, this means that inventory management at drone take-off and landing points, transfer stations, and final delivery points can be more intelligent, reducing the backlog and waste of goods. In addition, through technologies such as RFID (Radio Frequency Identification), the warehousing, storage, and outbound processes of goods can be automated, greatly improving efficiency (Geetha, Arunachalam, Deepikarani, and Shanmugam, 2023).

(3) Delivery route optimization

By leveraging intelligence technologies in IoT, low-altitude logistics can analyze traffic conditions, weather conditions, and customer needs in real time, thereby dynamically adjusting the delivery routes of drones. This optimization not only reduces transportation time and costs, but also improves service reliability and customer satisfaction (Zhang, Tian, Feng, Wu, and Zhong, 2023).

(4) Safety risk warning and prevention

Safety is always the primary concern in low-altitude logistics (Li, Zhang, and Lu, 2024). By integrating various sensors and monitoring systems, IoT technology can monitor the flight status, battery status and changes in the surrounding environment of the drone in real time, and promptly detect and warn of potential safety risks. At the same time, through real-time communication with the ground control system, it can respond quickly to ensure the safe completion of the flight mission.

(5) Customer service and feedback system

With the help of IoT technology, low-altitude logistics can establish a complete customer service and feedback system. Customers can check the transportation status of goods in real time through mobile applications or other digital platforms, and make service requests or complaints. This interactivity not only improves customer experience, but also helps logistics companies continuously improve and optimize service processes.

The applications of IoT technology in low-altitude logistics is comprehensive, which can not only improve logistics efficiency and reduce costs, but also greatly improve service quality and customer satisfaction. With the continuous advancement of technology and the expansion of application scenarios, IoT technology will play a more important role in the field of low-altitude logistics.

3.2 Application scenarios of IoT in low-altitude logistics

Driven by IoT technology, the field of low-altitude logistics is undergoing a profound transformation. IoT technology can provide new application scenarios and solutions for low-altitude logistics, enabling the logistics industry to operate more efficiently and intelligently.

As an outstanding representative of IoT technology in low-altitude logistics, drone delivery is gradually changing our daily lives. Imagine that in a busy city, a drone carries your package, flies lightly over high buildings, and accurately delivers the package to you. This delivery method is not only extremely fast, but also can effectively avoid ground traffic congestion, greatly improving delivery efficiency. At the same time, drone delivery also has the advantage of low cost, bringing tangible economic benefits to both logistics companies and consumers.

In addition to drone delivery, the IoT technology has also demonstrated its strength in warehouse management, cargo tracking, safety supervision and other aspects of low-altitude logistics. Through IoT technology, logistics companies can grasp the location and status of goods in real time to ensure the safety of goods during transportation. At the same time,

the application of big data enables logistics companies to accurately predict transportation needs, thereby optimizing transportation routes and distribution plans and improving logistics efficiency.

In actual applications, some advanced logistics companies have begun to try to apply IoT technology to the field of low-altitude logistics. They have achieved full monitoring and scheduling of drone delivery by building an intelligent logistics management system. The intelligent management method not only improves delivery efficiency, but also greatly reduces logistics costs. At the same time, in order to ensure the safety of drone delivery, the companies have also equipped drones with advanced safety equipment, such as anti-collision systems, and emergency landing systems, etc., to ensure timely response in emergency situations.

In general, the application scenarios of IoT technology in low-altitude logistics are extensive and in-depth. It has not only changed the traditional logistics distribution mode, but also brought unprecedented development opportunities to the logistics industry. With the continuous advancement of technology and the continuous expansion of application scenarios, we have reason to believe that IoT technology will play a more important role in the field of low-altitude logistics in the future.

3.3 Technical challenges and solutions for IoI applications

In the era of digital economy, IoT technology has brought unprecedented opportunities for low-altitude logistics but is also accompanied by a series of technical challenges. The challenges mainly focus on the endurance, flight stability and safety of drones.

The endurance of drones is one of the most pressing issues to be addressed. Due to the limitations of battery technology, the flight time of drones is relatively short, which seriously restricts their application in the field of low-altitude logistics (Neveling, Götz, Zoghlami, Dominik, Babetto, and Stumpf, 2023). In order to overcome this problem, researchers are actively exploring new battery technologies, such as solid-state batteries and fuel cells, in order to improve the endurance of drones (Huang, Li, Ma, Huang, Zheng, and Song, 2024). In addition, by optimizing the aerodynamic design and flight control algorithm of drones, energy consumption can be reduced to a certain extent, thereby extending the flight time (Zhang, Zhao, Mao, Bai, Li, and Pavlova, 2024).

Flight stability is another important technical indicator of drones in low-altitude logistics. In complex urban environments, drones need to fly accurately and hover stably to ensure that the goods can be delivered accurately. To achieve this goal, researchers are using advanced sensors and control systems to improve the flight stability of drones. For example, by introducing technologies such as Inertial Measurement Units (IMUs), GPS, and visual sensors, drones can more accurately perceive their own position and posture, thereby achieving more stable flight (Watts, Perry, Smith, Burgess, Wilkinson, Szantoi, and Percival, 2010; Xu, Liao, Tan, Ye, and Lu, 2020).

Safety is another key factor that must be considered when applying IoT technology in low-altitude logistics. UAVs may encounter various emergencies during flight, such as bad weather and electromagnetic interference, which may pose a threat to the safe flight of UAVs. In order to ensure safety, on the one hand, it is necessary to strengthen the supervision and management of UAVs and formulate strict safety standards and flight specifications (Teng, Wang, Wang, and Yao, 2024). On the other hand, it is also necessary to use technical means to improve the autonomous obstacle avoidance and emergency handling capabilities of UAVs. For example, machine vision and deep learning technologies can be used to identify and avoid obstacles, and the fault tolerance of UAVs can also be improved by designing redundant systems (Mittal, Singh, and Sharma, 2020).

In response to the technical challenges, specific solutions can be adopted. First, strengthening the research and developmen of drone technology is the key. By investing more in the research and development of battery and flight control technologies, the performance of drones can be continuously improved. Second, it is also crucial to establish a sound drone safety supervision system. This includes formulating detailed flight specifications, setting up special regulatory agencies, and establishing emergency response mechanisms. Finally, strengthening the integrated applications of technology and low-altitude logistics is also an important way to promote the development of the industry. By deepening technology applications, optimizing logistics processes, and improving service quality, the market space for low-altitude logistics can be expanded and its competitiveness can be enhanced.

4.Low-altitude logistics operation strategies

4.1 Operation model of low-altitude logistics

As an important part of smart city logistics system, the choice of operation model of low-altitude logistics is directly related to logistics efficiency, cost and customer satisfaction. Drone delivery, with its unique advantages, occupies a pivotal position in the field of low-altitude logistics. This delivery method uses drones to deliver goods quickly and accurately, which not only effectively shortens the delivery time, but also greatly reduces logistics costs. At the same time, drone delivery shows extremely high adaptability and flexibility in dealing with complex terrain and adverse weather conditions, which effectively solves the “last mile” delivery problem. Hoever, drone delivery is not a panacea. When faced with the need to deliver large or urgent goods, helicopter delivery shows its irreplaceable advantages. Helicopters have greater load-carrying capacity and stronger flight stability, and can quickly deliver important materials to their destinations. When responding to emergencies or making long-distance deliveries, the efficiency and reliability of helicopter delivery are fully demonstrated. In addition, the operation of low-altitude logistics is not static. In the actual operation process, factors such as the nature of the goods, delivery requirements, and external environment shall be comprehensively considered. For example, when delivering small and time-sensitive goods, drone delivery is the best choice; when dealing with large or urgent goods, helicopter delivery can play a greater role.

4.2 Strategy formulation for low-altitude logistics

In the era of digital economy, low-altitude logistics is an important part of smart city logistics system, and its strategy formulation is particularly critical. In order to ensure the efficient, safe and sustainable development of low-altitude logistics, it is necessary to start from multiple dimensions and comprehensively consider various factors to formulate a scientific and reasonable strategy.

It is necessary to clarify the positioning of low-altitude logistics in smart cities. Low-altitude logistics should be regarded as an important supplement to the urban logistics system, focusing on solving the “last mile” distribution problem and improving logistics efficiency. By coordinating with traditional ground logistics, low-altitude logistics can give full play to its advantages of high speed and high flexibility to provide more convenient and efficient distribution services for urban residents.

Market demand and competition are important bases for developing low-altitude logistics strategies. We need to have a deep understanding of consumers’ demands for delivery speed, service quality and other aspects, as well as competitors’ service characteristics and pricing strategies. On this basis, we can develop competitive marketing strategies and service models by combining our own resource advantages and technical strengths. For example, we can develop in-depth cooperation with E-commerce platforms to provide customized delivery services to meet the increasingly diverse needs of consumers.

Safety supervision and the construction of laws and regulations are important links in the formulation of low-altitude logistics strategies. In order to ensure the safe operation of low-altitude logistics, a sound safety supervision system must be established to strictly control the quality and flight supervision of drones and other flight equipment. At the same time, the development of relevant national laws and regulations must be payed close attention. In the process of strategy formulation, how to reduce operating costs and improve operating efficiency to achieve sustainable development of low-altitude logistics shall also be fully considered.

In addition, low-altitude logistics strategies needs to focus on environmental protection and green development. In digital economy, green development has become a global consensus. Therefore, when formulating low-altitude logistics strategies, how to reduce energy consumption and emissions and promote low-altitude logistics shall be considered to develop a more environmentally friendly and sustainable industry.

4.3 Optimization of low-altitude logistics operation model

In the era of digital economy, low-altitude logistics is an important part of smart cities, and the optimization of its operation model is particularly important. In order to achieve efficient, safe and sustainable development of low-altitude logistics, the optimization of operation model can be carried out from the following aspects.

First, technological research and development are the core of optimizing low-altitude logistics operation model. By

continuously investing in drone technology, the endurance and flight stability of drones can be significantly improved. This can not only expand the delivery range of drones, but also reduce cargo damage and safety accidents caused by unstable flight, thereby reducing operating costs. At the same time, the use of advanced positioning technology, sensor technology and communication technology can also achieve precision and intelligence in drone delivery, further improving delivery efficiency.

Second, establishing a sound distribution network and logistics system is the key to optimizing low-altitude logistics operation model. By building a widely covered, efficient and convenient distribution network, rapid diversion and timely delivery of goods can be achieved. In addition, strengthening the informatization of logistics system, and using big data, cloud computing and other technical means to process and analyze logistics information in real time can help companies better grasp logistics dynamics, optimize distribution routes, and improve distribution efficiency.By establishing a sound cargo tracking and supervision system, the safety and traceability of goods can also be ensured.

Strengthening cooperation and coordination with other logistics industries is also an important way to optimize low-altitude logistics. As an emerging logistics method, low-altitude logistics has unique advantages compared with traditional logistics methods. However, in the actual operation process, low-altitude logistics still needs to be effectively connected and coordinated with traditional logistics methods. By establishing close cooperative relations with E-commerce platforms and express delivery companies, resource sharing and complementary advantages can be achieved. In addition, actively participating in international exchanges and cooperation, learning from and absorbing international advanced experience of technological achievements, will help enhance the international competitiveness of low-altitude logistics.

Finally, strengthening talent training and team building is a strong guarantee for the optimization of low-altitude logistics operation mode. As a technology-intensive industry, low-altitude logistics has high requirements for talents. Therefore, enterprises need to attach importance to talent training, establish a sound talent training system, and cultivate high-quality talents with professional skills and innovative spirit. Thus, strengthening team building and building a team of unity, cooperation and efficient execution can provide a strong talent guarantee for the development of the enterprise.

5.Case analysis of IoT in Low-altitude Logistics: SingPost

5.1 Background of SingPost

As a world-renowned smart city, Singapore has been committed to promoting the deep integration of technology and urban management. In recent years, Singapore Post (SingPost) has collaborated with the technology startup, FLYTE, to explore the application of drone delivery in the postal field, and achieved remarkable results. Since the introduction of IoT technology, Singapore has achieved remarkable results in low-altitude logistics. First, the efficiency of logistics and distribution can be greatly improved. Compared with traditional delivery methods, drone delivery greatly shortens delivery time and can improve consumer satisfaction. Second, logistics costs can be effectively reduced. The application of IoT technology also reduces labor costs and vehicle usage costs, bringing tangible economic benefits to logistics companies.

Since Singapore introduced IoT technology, the field of low-altitude logistics has undergone tremendous changes. Take drone delivery as an example, through precise GPS positioning and advanced flight control systems, drones can accurately and quickly complete delivery tasks in complex urban environments. FLYTE provides its self-developed drone delivery system, which integrates advanced flight control systems, navigation systems and automatic obstacle avoidance technology to ensure the safe flight of drones in complex urban environments. This not only greatly improves the efficiency of logistics distribution and reduces labor costs, but also brings unprecedented convenience to consumers.

In terms of logistics management, Singapore's IoT technology enables real-time update and management of warehouse cargo information. Through IoT, each cargo is given a unique identification, making the processes of cargo entry, exit, and inventory simple and efficient. This not only reduces human errors, but also improves the operational efficiency of the warehouse. Singapore's SingPost also uses its existing logistics management system to integrate with FLYTE's drone delivery system to achieve intelligent scheduling and route planning for drone delivery.IoT technology also plays a crucial role in optimizing delivery routes. Through big data analysis and AI algorithms, the system can automatically plan the optimal delivery route, avoiding congestion and unnecessary detours, further improving the efficiency of logistics distribution.

In terms of logistics and transportation, the drone delivery in Singapore's "last mile" can effectively avoid ground traffic congestion, quickly deliver packages to the destination, and improve delivery efficiency. In addition, drone delivery can overcome the limitations of inconvenient ground transportation, deliver packages to remote areas, and expand the scope of logistics services. In emergency scenarios, drone delivery can also respond quickly to emergencies and deliver important materials to the destination in a timely manner.

In terms of safety supervision, Singapore has established a complete drone safety supervision system. Through IoT technology, regulatory authorities can monitor the flight status and trajectory of drones in real time to ensure that they comply with flight rules and airspace restrictions.The system can also remotely control and handle emergencies for drones to reduce the risk of flight accidents. In addition, IoT also helps regulatory authorities to conduct qualification review and flight plan approval for drone operating companies to ensure the standardization and safety of the low-altitude logistics market.

5.2 Lessons learned from the case

Through the case of low-altitude logistics in Singapore, we can obtain the following inspirations. First, we must keep pace with the digital era, actively introduce new technologies and new concepts, and promote innovation and development in the industry. Second, we must focus on the combination of technology and practice to ensure technology be truly implemented. Third, we must pay attention to the construction of industry standards and laws and regulations to provide strong guarantees for the standardized applications of technology.

Among them, policy support is the key. The Singapore government has provided a good policy environment for drone delivery, including support in airspace management and safety supervision. Technological innovation is the driving force. FLYTE's drone delivery technology and SingPost's intelligent dispatching platform are the key factors for the success, and Win-win cooperation is the model. The cooperation between SingPost and FLYTE thus provides a reference for other companies to promote the development of low-altitude logistics through complementary advantages.

In the future, with the continuous development and improvement of IoT technology, it is believed that the low-altitude logistics field will usher in broader development space and application prospects. The successful practice of Singapore will also provide useful reference and lessons for other cities.

5.3 Evaluation on the case

After the analysis of IoT applications in Singapore's low-altitude logistics, we then conduct a comprehensive evaluation on its effectiveness. The results show that the introduction of IoT has brought revolutionary changes to the field of low-altitude logistics.

From the perspective of efficiency, the applications of IoT technology has greatly improved the city's logistics and distribution efficiency. Through real-time cargo tracking and intelligent warehouse management, information asymmetry and delay problems in the logistics process have been effectively solved. In addition, the use of big data technology to optimize delivery routes has significantly reduced ineffective transportation and waiting time, thus shortening the cargo delivery time by nearly half. This change not only improves the operational efficiency of logistics companies, but also brings consumers a faster and more convenient service experience.

In terms of improving the intelligence level of warehouse management and cargo safety, IoT technology has also shown great potential. Through the applications of IoT technology, real-time monitoring and early warning of cargo status are achieved, greatly improving the safety of cargo during warehousing and transportation. At the same time, the intelligent warehouse management system effectively reduces the possibility of human operational errors and further ensures the safety of goods.

The successful practice of the case not only provides a useful reference for the development of low-altitude logistics for other smart cities, but also reveals the broad application prospects of IoT technology in the future. This practice fully proves that the deep integration of IoT technology and low-altitude logistics will be an important way to promote the construction of smart cities, optimize the structure of the logistics industry, and improve logistics efficiency.

6.Conclusions

6.1 Research summary

Through systematic analysis, the paper draws the following important conclusions. First, IoT technology has great application

potential in the field of low-altitude logistics. Through the integrated applications of other technology, IoT can realize intelligent management and optimization of the process of low-altitude logistics. This not only helps to improve logistics efficiency and reduce logistics costs, but also brings a more convenient and efficient service experience to the logistics industry. Furthermore, as an important part of smart cities, the development of low-altitude logistics is of great significance to promoting the process of urban intelligence. The applications of IoT technology has enabled the intelligence and automation of low-altitude logistics in terms of cargo distribution and warehouse management, further improving the overall efficiency of the urban logistics system.

The paper also demonstrates the specific application effects of IoT in low-altitude logistics through case study. The case of Singapore shows that the introduction of IoT technology has significantly improved logistics distribution efficiency and cargo safety, injecting new vitality into the development of the urban logistics industry. It also further proves the application value and broad prospects of IoT technology in the field of low-altitude logistics. However, the applications of IoT technology in low-altitude logistics still faces challenges and problems, which requires joint efforts and collaboration from the government, enterprises, scientific research institutions and other parties. It is also necessary to strengthen policy guidance and supervision to ensure the standardized, safe and efficient development of low-altitude logistics.

6.2 Future prospects

The applications of IoT in low-altitude logistics of smart cities in the era of digital economy has broad prospects and important practical significance. Therefore, we should further strengthen technological research and development, promote the applications of technology in the field of low-altitude logistics, and inject new impetus and vitality into the construction and development of smart cities. Among them, IoT technology will further enhance the automation and intelligence level of low-altitude logistics and achieve more efficient cargo distribution and warehousing management. For example, by integrating more advanced IoT and AI technology, real-time monitoring and prediction of goods as well as automated sorting and loading can be achieved, thereby greatly improving logistics efficiency. In addition, the operation model of low-altitude logistics will be more diversified and flexible. In addition to drone delivery, more low-altitude transportation tools, such as flying cars, may appear in the future for logistics delivery. With the improvement of urban air traffic management systems, route planning and flight safety of low-altitude logistics will be better guaranteed. The applications of IoT technology will also promote the deep integration of low-altitude logistics with other areas of smart cities. For example, through collaboration with intelligent transportation systems, smart grids and other fields, more efficient energy utilization and reduced carbon emissions can be achieved, promoting the green development of cities.

As the low-altitude logistics market continues to expand and competition intensifies, major logistics companies will pay more attention to service quality and customer experience. With the help of intelligent technology, logistics companies can accurately grasp and quickly respond to customer needs and provide more personalized and high-quality services.

In summary, the applications of IoT technology in low-altitude logistics has broad development prospects and huge potential. In the future, with the continuous advancement of technology and the continuous expansion of market, low-altitude logistics will become an important part of the development of smart cities, bringing more convenience and efficiency to people's lives. At the same time, governments, enterprises and research institutions should strengthen cooperation, jointly promote the innovation and applications of technology in low-altitude logistics, and contribute to the sustainable development of smart cities.

Funding

This study is supported by the "2025 Quanzhou Social Science Planning Project Cooperation Fund, Grant No. 2025H17", Fujian, China.

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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