



Research on the layout optimization of aviation logistics park in Z city

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Abstract

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<p>With the continuous development of the world economy, air cargo has also increased the number of freight in the continuous expansion of economic exchanges, ushered in a new development opportunity, according to the latest data from the Civil Aviation Administration of China, China's aviation logistics support capacity has been greatly improved compared with the previous, the industry's cargo aircraft fleet has increased to 255, at the same time, China's aviation hub construction is also accelerating, but China's aviation logistics park network layout planning is still in the development stage, the layout ideas are very weak compared with developed countries, and the unreasonable layout planning makes the aviation logistics park in the functional zoning of low transportation efficiency and functional dislocation phenomenon happens from time to time. As the leading city of the economic development in southwest China, Z City has great advantages in its aviation resources and aviation radiation range. After the layout optimization of the aviation logistics park in Z City, the infrastructure utilization rate of the airport in Z City will be greatly improved, and the low transportation efficiency will be improved. The new layout of the aviation logistics park will make the aviation transportation and economic driving capacity of Z City grow and develop, and is expected to become a demonstration of the air cargo industry in southwest China. Firstly, according to the current status of air cargo volume in z city and the development demand of existing park infrastructure, the necessity of optimizing the layout of z city aviation logistics park is discussed from the perspective of social necessity and business necessity. The author mainly uses the MSFLB method of logistics park to analyze the status quo of z city aviation logistics park from five aspects: market research, strategic positioning, functional design, layout planning and business plan, and predicts the change of cargo volume in z city aviation logistics park in the future. Finally, the layout planning method of logistics park is used to reasonably adjust the existing layout to adapt to the future development of the aviation industry, and the logistics park before and after the optimization layout is compared and evaluated, providing some reference suggestions for the future development of z city aviation logistics park.</p>
Key words Aviation Logistics Park; MSFLB Planning Method; Layout Optimization

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Chapter 1 Introduction

1.1 Research Background

With the continuous expansion of economic exchanges in the world, the logistics industry has also experienced rapid development in 2024. As a new logistics sector born out of the development of the logistics industry, air logistics is an important part of modern logistics and can provide safe, fast, convenient, and high-quality services. In his study on the development of air logistics at Yantai Airport (2016), Song Peining mentioned that airports with high efficiency and comprehensive logistics services will play an important role in reducing the production and operating costs of goods, improving product quality, protecting the ecological environment, and accelerating the circulation of goods. Therefore, the development opportunities for air logistics are also very large. As a populous country, China has a very strong demand for daily life, so the country's leaders are very concerned about the development of the logistics industry. Because China is a socialist country, the interests of the people are paramount, and in order to enhance people's sense of happiness in life, a series of policies such as "Guiding Opinions on Strengthening Ecological Environmental Protection and Promoting High-Quality Development in Free Trade Zones" and "Fifth-Year Plan for the Development of Air Logistics" were issued in 2021 to support the high-speed development of the logistics industry. In 2024, China's air cargo industry developed rapidly, with huge potential for growth. From the national air logistics network layout, a cargo air network pattern with North, Shanghai, Guangzhou airports as core hubs, Hangzhou, Zhengzhou, Nanjing, etc. as regional hubs has been formed. Among them, Shanghai Pudong Airport is the world's third largest cargo hub. The cargo throughput is very large, reaching 4.18 million tons. The Civil Aviation Administration of China released the annual main production indicators for 2023, with the entire industry completing 73.54 million tons of cargo and mail transportation, recovering to 97.64% of the pre-epidemic level. Of this, 456.4 million tons were transported on domestic routes, and 279.0 million tons on international routes, up 5.75% year-on-year and setting a new historical high. The favorable development trend has brought more opportunities for airport cargo. As an important role in the airport logistics supply chain, air cargo parks have played an increasingly prominent role in air cargo in recent years. However, with the development of air cargo, there have been problems of insufficient resources and low efficiency in air cargo parks, and the functional areas are not fully utilized. Z City is located in the southwestern region of the Chinese plateau, as the only inland direct-administered municipality in China, it drives the economic development of the southwestern region. Due to the current pursuit of happiness and the booming cross-border e-commerce, the Z City Air Logistics Park has gone from having less than 2 tons of outbound cargo at the beginning to the international cargo station being fully booked with over 800 tons of cargo. Nowadays, Z City serves as an important node in international trade and plays a key role in ensuring the efficient

operation of air logistics in southwestern China. The optimization of the layout of the Z City Air Logistics Park, which is urgent and important, needs to be ensured from the city planning of Z City. We need to connect the logistics park and the surrounding transportation hub stations, industrial zones, and commercial centers effectively to improve logistics efficiency. Secondly, based on the current trend of air logistics in the world, we need to reasonably allocate the functional areas of the logistics park in Z City to enable it to better serve the air logistics industry in southwestern China and radiate the entire Chinese and world air logistics, helping China improve its status in the global air supply chain.

1.2 Research Objectives and Problems

1.2.1 Research Objectives

Due to the expansion of the world logistics industry, the air cargo market in China has also achieved significant growth. Many existing air logistics parks in China have gradually become unable to adapt to the latest air cargo volume, leading to low airport transportation efficiency. The purpose of this article is to solve the current problem of the air logistics park in Z City, which is currently facing the problem of functional area inefficiency and low efficiency as the airport throughput increases. To provide reasonable suggestions for the future upgrading of the air logistics park in Z City. According to the information, due to the continuous increase in the cargo throughput of Z City Airport, the facilities of the current air logistics park in Z City have become unable to adapt to the new cargo volume. The author will analyze the current functional area division of the air logistics park in Z City and divide the existing functional areas based on the latest domestic and foreign research. And propose new functional areas for the air logistics park in Z City to plan for the future as the demand for air cargo continues to increase to adapt to the changing times. To improve the efficiency of the logistics park and minimize operating costs, and achieve the optimal layout and adaptation to the changing times of the air logistics park in Z City.

1.2.2 Research Problem

In this thesis, the author intends to solve the problems existing in Z City's air logistics park and resolve the current problems in Z City's air logistics park through research. Through literature review, the author found that Z City's air logistics park mainly has the following shortcomings.

Here is the translation:

1. Lack of integrated planning in park construction, with redundant functional areas

The Z city aviation logistics park is composed of three main areas: Chongqing Jiangbei Airport, Chongqing Lianglu Cuntan Bonded Port Area Airport Section, and the Muer Logistics Park.

However, these areas are managed by three different governmental enterprises, leading to dispersed management in functional allocation, land use, investment attraction, and project construction. This results in inefficient resource utilization, slow project progress, and redundant functional areas within the park, hindering the synergistic development of the park and limiting the maximization of its potential benefits.

2. Insufficient hub capacity and poor operational capability

The expansion of flight routes at Jiangbei Airport is rapid, but the number of cargo routes is insufficient, with only 77 compared to 116 at Guangzhou Baiyun Airport and 148 at Shanghai Pudong Airport, which shows a significant gap. Although the comprehensive transportation system of the airport has initially scaled up, the integrated air-ground transportation service is not yet smooth, presenting a clear shortcoming. Moreover, the logistics operation service system at Jiangbei Airport is still in its infancy. Airlines such as Air China and Sichuan Airlines, which are near the aviation logistics park, do not cooperate closely enough with Z city's international hub, affecting the construction of Z city aviation logistics park's international transit network.

3. Road conditions in the park need improvement

Currently, the connection between Z city aviation logistics park and Chongqing Science City as well as the Yuxi Logistics Corridor mainly relies on the Ring Expressway, while other routes need to pass through the Airport Expressway or Yuhang Avenue. However, these roads have a high volume of public buses and private cars, which puts a lot of pressure on urban passenger transport and cannot effectively support the function of the airport logistics corridor. These roads also need to accommodate a large amount of traffic from the airport industrial park and transit traffic from Lianglu to surrounding towns. Currently, significant congestion has already occurred at the intersection of Airport East Road and Tonggushan Avenue. As the cargo volume in the north area of the airport cargo and the new express distribution center come into operation, traffic congestion in the area is expected to worsen further.

1.2.3. Research structure:

This thesis takes the optimization of Z City's aviation logistics park layout as the background. Chapter 1 analyzes the background, purpose, and problems of the study, and then identifies relevant literature on logistics park layout from domestic and foreign sources through literature search. Chapter 2 introduces relevant theories and methods. First, the author explains the concept of aviation logistics park and what an aviation logistics park is, what functions it has. Then, the author introduces the research methods that will be used in this article. Chapter 3 begins with an analysis of the current development status of Z City's aviation logistics park, starting from both the

macro and internal environment to analyze how the park should change. Finally, the author references the case of excellent logistics park layout development to provide reference for the optimization of Z City's aviation logistics park layout. Chapter 4 uses the forecasted change data of cargo and mail volume for Z City's aviation logistics park over the next five years as support, and therefore applies the SLP park layout planning method to analyze and reorganize Z City's existing functional zones based on logistics relationships and non-logistics relationships, and plans the new functional zone layout of Z City's aviation logistics park, providing suggestions for the development of Z City's aviation. The last chapter of the article concludes the writing and looks forward to the future.

Table1: Overlay matrix

Research Question	Theoretical framework (chapter)	Results (chapter)
What are the internal and external environmental factors of the aviation logistics Park in z City?	1.2	3.2 3.3
How to determine the new functional area of z City aviation logistics Park?	3.1	4.1
How to carry out the new layout of aviation logistics Park in z City?	3.2 3.3	4.3
What progress has been made after the layout optimization of the aviation logistics park in z City?	1.2.2	4.4
How should the future z City aviation logistics Park adapt to the development of The Times?	3	4.5

1.3 Current Research Status: Domestic and International

1.3.1 International Research Overview:

Facility Layout Direction:

Amine Drira (2007) and colleagues highlighted the significant impact of facility arrangement within a region on costs, delivery times, and efficiency, emphasizing the importance of a rational layout of regional facilities. Sunderesh S. Heragu (1991) advocated that continuous models are more effective than existing facility layout problem models. Using unconstrained optimization algorithms can yield high-quality solutions in less time, making continuous models more suitable for solving facility layout problems. RD Meller and others (1996) proposed a combinatorial optimization algorithm for common facility planning issues, building models to define objective functions and constraints, enabling quantitative problem-solving, and forecasting potential future developments based on emerging technology trends. Russell D Meller (1998) redefined binary variables and strengthened departmental area constraints in his research to reconstruct Montreuil's model. He introduced several effective inequalities to aid in facility layout planning. K.L. Mak (1998) investigated the application of genetic algorithm techniques to optimize facility layout in manufacturing system design, developing a mathematical model to monitor machine layout and material flow patterns. The research demonstrated the effectiveness of this genetic approach through numerical examples, showing that it can resolve facility layout issues.

Logistics Park Planning Direction:

Hirohito Kuse (2010) and others emphasized the foundational role of logistics in supporting continuous and efficient freight transport in cities, crucial for economic development. Logistics is also seen as a means to improve urban environmental conditions. Thus, comprehensive urban logistics planning is needed, and researchers proposed a framework for urban logistics planning, describing three stages: large logistics facilities, road networks, and regional planning. Ravi Kothari and others (2012) noted that the layout of personnel, materials, and equipment in single-row logistics parks is a key issue, with planning solutions proposed using precise and heuristic algorithms. Shah Alam (2013), in a study on Malaysia's logistics infrastructure, observed that Malaysia has not yet established comprehensive logistics villages, with functions provided by freight transportation terminals such as ports, inland ports, and distribution parks (regional parks). Respondents considered the core elements of terminals to be of significant importance.

Air Cargo and Mail Volume Forecasting Direction:

Amit Dasgupta (2009) and others discussed air cargo transport systems, identifying demand forecasting as a key element in major planning processes. The researchers based their new freight capacity plans on forecasted demand and available cargo capacity, employing weighted majority learning algorithms and various predictors to forecast future demand. Gelhausen M.C. (2018) developed a demand forecasting model using cointegration theory, studying the impact of various factors on demand, including the effects of Brexit on German airfreight volumes. Juan Gerardo Muros Anguita (2023) discussed the importance of forecasting air traffic demand (both passenger and cargo) in regional or national air transport systems, using Colombia during the peak of the 2020 pandemic as a case study. The forecasting used machine learning/deep learning (ML/DL) methods capable of identifying the most relevant socio-economic features for predicting air cargo demand (both domestic and international), with international air cargo demand largely dependent on GDP and per capita GDP, while domestic air cargo demand significantly relies on per capita GDP.

1.3.2 Overview of Domestic Research:

Future Park Planning Development Direction:

Lu Fenglu and others (2020) believe that future park planning will develop towards national-level aviation hubs. Traditional aviation logistics park planning has typically relied on constructing air cargo stations near aprons, supplemented by freight agencies of corresponding scales arranged in a hierarchical layout, forming a logistics building cluster combining stations and warehouses. The separation between stations and warehouses is clear, with each having a single, well-defined function, lacking the ability to transform functions between them. With the rapid development of the global economy, park planning is moving towards land intensification and integration of ports, districts, industries, and cities. Li Yuxuan and others (2022), through studying the layout planning of the Changsha Railway Logistics Park, used grey prediction models to forecast logistics demand and flow, effectively predicting future demand changes, providing a quantifiable basis for the park's functional area sizing, and offering a sustainable development example for this thesis. Geng Qingqiao (2023) focused on logistics park layout optimization, especially considering the impact of carbon emissions. The study used STIRPAT and SLP methods, comprehensively considering environmental factors in the planning process, which not only produced efficient economic effects but also had environmental benefits. Guo Feiyu (2019) concluded that logistics park layout planning is often based on infrastructure layout studies, and facility layout methods are frequently referenced in the planning of logistics parks. Wu Qian (2023) suggested that in China's "Fourteenth

Five-Year Modern Logistics Development Plan," the focus on digitalization and green practices has become a driving force for high-quality development in warehousing logistics. Logistics parks should plan future layouts in accordance with government policies and their own circumstances. Pan Dongkun (2021) argued in his study on circular economy in green logistics parks that future construction and operation of logistics parks should integrate circular economy practices, which can reduce ecological damage caused by logistics, but due to current traditional logistics park planning restrictions, the development of auxiliary functions to enhance the park's technological level should be prioritized. Cao Dongmei (2020) emphasized that traffic planning should be a primary consideration in future logistics park layout planning, as scientific road planning can facilitate smooth traffic and efficient internal logistics operations. Ding Yijun and others analyzed global logistics activities, predicting how the aviation logistics industry will develop in the future, suggesting that China's aviation logistics industry development should rely heavily on information system construction. Deng Xinfeng (2010) applied the MSFLB method for logistics park layout, obtained optimal solutions using genetic algorithms, evaluated these using game theory, and adjusted layout plans according to the actual conditions of the logistics park.

Enhancing the Benefits of Aviation Logistics Parks:

Since aviation logistics parks are an indispensable part of aviation economic development, the economic performance of these parks directly affects the development of the regional aerotropolis economy. Hu Yiting (2022, November) in her study, discussed how aviation logistics parks can adapt and promote the diversified integration and intensive development of industries and markets, emphasizing the importance of operational efficiency of aviation logistics parks to economic benefits. Good performance can not only foster new logistics services but also promote employment and regional economic development. Jin Zhen (2019) and others believed that there is a strong correlation between aviation logistics and regional economic development, promoting regional economic growth by developing the "Air Silk Road." Zhang Qiaoyan (2020) highlighted the rapid development of aviation logistics in the process of regional economic integration, noting that aviation logistics are highly modernized and efficient, increasingly influencing the logistics sector. Yu Haoyu (2020) noted that aviation logistics parks are developing towards smart, informative, automated, and systematic directions, emphasizing the core role of information technology in modern logistics to better support the development of aviation logistics industry clusters. Zhao Jianfei (2020) pointed out that in the new era of China's development, logistics parks could apply "Internet+" technology to accelerate integration with the logistics supply chain and cooperation with logistics enterprises, building a shared logistics platform. Li Jing (2022) suggested that aviation logistics parks should consider their business models from the perspective of two-sided markets, using this service to promote interaction and transactions between two groups. Based on the "source innovation" theory, it was proposed that integrating innovative elements from the beginning

stages of business models can form an innovative ecosystem from the source to the service endpoint.

Forecasting Logistics Freight Volume:

You Qingshan (2014) and others used Compressed Sensing (CS) theory combined with Orthogonal Matching Pursuit (OMP) algorithm to model China's air freight volume data from 1991 to 2006, concluding that models based on compressed sensing are suitable for short-term air freight volume forecasting. In terms of freight volume forecasting, the grey GM(1,1) model plays a significant role, with Wen Jun (2010) and others conducting a combined forecast of air freight volume based on the grey GM(1,1) model. This method has been effectively applied in actual freight volume forecasting. Kong Qin (2016), by examining the dispatched and received freight volumes in railway logistics parks, classified the internal and external factors affecting freight volume. This study provided inspiration for subsequent research, showing that research can analyze the impact on freight volume from both regional economic and internal park development dimensions. Wang Huimeng (2018) predicted that the park would need to expand with increasing logistics volume. Xi Weixing, Zheng Yan (2022) used grey relational analysis and multivariate regression models to analyze the correlations between different transportation modes, finding mutual impacts among different logistics methods, demonstrating that grey models can effectively predict regional logistics demands.

Chapter 2: Relevant Theories and Research Methods

This chapter discusses the relevant theories and possible research methods for the layout of aviation logistics parks. The author first explains what an aviation logistics park is, then introduces the concept of an aviation logistics park, the functions of an aviation logistics park, and the characteristics of an aviation logistics park. He then introduces the principles of layout planning for aviation logistics parks, followed by an explanation of optimization theory, the methods that may be used in this study, and a prediction of future development. The research methods are then compared, and the MSFLB planning method is chosen as the main research method for this thesis, laying a foundation for how the layout optimization of Z City's aviation logistics park will be studied.

2.1 Exposition on Air Logistics Parks

The concept of logistics parks was first introduced by Japan in the 1960s. Due to rapid capital economic development, Japan accumulated a vast amount of goods. Given the limited land area, the Japanese government designated specific areas on city maps for the concentrated management and transportation of goods, named "Distribution Parks" (Duan Dongkun, 2018, pp. 4-5). In China, the exploration of logistics parks began in the early 20th century with preliminary definitions of what constitutes a logistics base. It was not until 2006 that the national standard "Logistics Terminology (GB/T 18354)" provided a comprehensive explanation of the concept. However, due to underdeveloped aviation within the country and a reliance on road transportation at that time, no clear definition of air logistics was provided. Nevertheless, air logistics parks have evolved from traditional logistics parks and encompass all the requisite conditions of their predecessors.

2.2 Concept of Air Logistics Parks

Air logistics parks, while derived from traditional logistics parks, fundamentally differ from them. These parks are logistic ports established near airports, primarily comprising cargo, warehousing, aviation, and transportation enterprises. The operation of these parks is dominated by airport companies providing ground services and management at airport aprons, along with port management functions such as customs and quarantine inspections. Government investments in constructing logistics hub facilities and information management platforms serve as essential service guarantees. Furthermore, air logistics parks cater to high-tech industries, courier services, and aviation-oriented industries, providing personalized logistics services and forming a clustered logistics industry region. In addition to storage and transportation capabilities, air logistics parks also include dining and entertainment services to meet diverse needs.

2.3 Functions of Air Logistics Parks

Air logistics parks serve as critical hubs for the transfer of goods between air transport and other modes of transportation. They not only provide efficient and fast logistics services to third parties but also enhance commercial interactions near airport areas. Based on literature review and personal experience, the author identifies the following functions of air logistics parks:

- (1) Consolidation and Distribution: Air logistics parks efficiently handle goods arriving from different regions. They conduct sorting and storage operations and manage the distribution of goods needed at different times, continuing the transport process through packaging transitions. Additionally, these parks can establish commercial trading markets, enhancing their distribution capabilities and thereby continuously improving the overall economic benefits of the region.
- (2) Storage and Custody: In cooperation with businesses, air logistics parks offer temporary and long-term warehousing services. They provide centralized inventory management tailored to business needs, facilitating supply chain adjustments. They can also create dedicated warehouses based on the specific requirements of cooperating businesses, optimizing inventory management.
- (3) Goods Transshipment: As key nodes integrating air transport with other transportation modes, air logistics parks play a crucial role. They not only offer high-efficiency logistics services but also effectively connect different modes of transportation, allowing for a rational match between sea, land, and air transport. By facilitating the connection between different transportation methods, these parks provide transshipment services, efficiently organizing the dispatch of goods from local to other regions and vice versa, ensuring orderly consolidation and distribution of goods.
- (4) Safety Inspection: Air logistics parks are equipped with specialized safety inspection facilities and customs offices, enabling fast customs clearance and rapid inspection of hazardous materials. They detain shipments from businesses lacking proper documentation for dangerous goods, with safety inspections being vital for international trade.
- (5) Environmental Protection and Sustainability: In response to the zero-carbon policy, modern air logistics parks increasingly focus on environmental protection and sustainable development. Newly established parks may utilize green building materials, develop energy-saving technologies, and recycle waste to reduce the aviation industry's environmental impact.
- (6) Commercial and Administrative Services: Air logistics parks can seek governmental financial support to provide integrated logistics service facilities, such as establishing comprehensive service centers, maintenance and repair centers, and offering security, vehicle parking, fueling, and waste disposal services. Moreover, by emulating the operational models of business centers, they can provide value-added services, including conference centers and other business support

services, fostering cooperation and communication among businesses. They can also establish exhibition centers, allowing clients to decide on purchases through browsing.

(7) Emergency Logistics: Humans are vulnerable in the face of natural disasters and emergencies. Air logistics parks can rapidly mobilize emergency resources from across the nation, providing urgent logistics services to ensure that critical supplies are delivered promptly, thereby minimizing casualties and economic losses caused by unexpected events.

2.4. Characteristics of Air Logistics Parks

As people's consumption levels rise, there is an increasing demand for high-quality and efficient logistics products and transportation services, as well as a growing demand for unique products. The establishment of air logistics parks meets this part of the demand.

(1) Geographical advantage: Air logistics parks are usually located near airports because the transportation method adopted by air logistics parks is mainly air transportation. Therefore, from a geographical perspective, it is advisable to choose a location near the airport in an open area to facilitate connection with other transportation routes and improve the speed of goods circulation. It is also convenient to connect with the global air transport network. Having a geographical advantage not only facilitates a quick response to import and export business but also makes it convenient to connect with other transportation networks at home and abroad, such as highway, railway, and seaport.

(2) Highly integrated transport network: In addition to air transportation, air logistics parks also integrate railway, highway, and sea transportation, forming a multi-modal transport hub. Because this highly integrated transport network can provide more flexible and cost-effective transportation solutions. (3) Advanced information technology systems: Modern aviation logistics parks are equipped with advanced information technology and automation systems, including logistics management software, automated warehouses, and intelligent sorting systems, to optimize the speed and accuracy of cargo transportation and reduce human errors.

(4) Handling high-value goods transportation: Due to the high cost of air transportation and the small amount of cargo transported per trip, aviation logistics parks handle the transportation of high-value goods, which have high time-sensitivity requirements and special storage requirements. Such as high-end electronic products, fresh flowers and vegetables, and valuable medical drugs.

(5) Having flexible business models: Under the influence of the overall environment, aviation logistics parks adapt to the needs of different enterprises by providing flexible business models for different enterprises, such as customized services, and developing different service plans for each enterprise. They also share service facilities to help various enterprises (especially small and

medium-sized enterprises) reduce initial investment and operating costs. Achieving mutual benefit and win-win results.

2.5 Principles of Layout Planning for Air Logistics Parks

1. **Efficiency Priority Principle:** In the layout design of air logistics parks, prioritizing efficiency is crucial. This principle emphasizes that at all stages of park design and planning, maximizing operational efficiency and resource utilization should be considered foremost. This involves simplifying logistics processes, eliminating unnecessary steps, streamlining complex processes, and ensuring the directness and unobstructed handling of goods. Thus, efficiency should be the primary consideration in the layout planning of air logistics parks.
2. **Systematic Principle:** When dividing and arranging functional zones in airport logistics parks, it is essential to ensure that each functional area complements and collaborates with others. Each functional zone should not only be capable of performing its logistics operations independently but also work in coordination with other areas to deliver superior services collectively. Therefore, the planning process should fully reflect the systematic and orderly nature of the park.
3. **Integration Principle:** The planning of functional areas within the park needs to effectively integrate existing resources and facilities to enhance the functions of old systems and maximize value. Setting the park's scale appropriately, increasing cargo handling efficiency, optimizing operational processes, and continuously improving customs clearance efficiency are crucial. Such an intensive development strategy helps attract different enterprises to join the park and enhances the industrial scale of the park.

2.6. Research methods and ideas diagram

2.6.1 Research Methods

(1) Literature Research Method:

Through the author's extensive reading of literature, journals, reports, etc. related to the layout planning of air logistics parks, the author gained a certain understanding of the layout planning modes of air logistics parks. At the same time, by reading literature related to other types of logistics parks, the author learned about Z City's logistics development policies, GDP total value, and the development status of Z City's air logistics park, providing sufficient material support for the writing of this thesis.

(2) Case Study Method:

Through the study of the air logistics park layout optimization of cities that have already been completed as case studies. The author conducted in-depth analysis of these cases to obtain specific insights and data support, understand the effects of different strategies, and use the effective conclusions from other cities' air logistics park layout optimization research to help with the writing of this thesis.

(3) MSFLB Planning Method

The MSFLB planning method is a logistics park planning methodology developed by the world-class logistics consulting and research institution, the Fraunhofer Institute for Logistics and Material Flow based on demand-driven, competition-driven, and best practice-driven logistics park planning in many international logistics parks. The MSFLB planning methodology is implemented through five steps, also known as the "five-step process". They are: market analysis, strategic positioning, function design, layout design, and business plan. Because the MSFLB planning method can analyze the advantages from market analysis, strategic positioning, function design, and layout positioning, it is simpler and easier to analyze for researchers. Therefore, the author will use the MSFLB method as the main research method to analyze the Z City aviation logistics park and complete the research on the layout optimization of the Z City aviation logistics park by using other methods for auxiliary analysis.

Regarding the MSFLB planning method, the author will introduce how to use the analysis method to conduct market analysis, strategic positioning, function design, and layout design for Z City.

1. Market Analysis

PEST analysis is a strategic management tool used in daily work to analyze the external environment of an enterprise or organization. PEST refers to Political, Economic, Social, and Technological aspects. By analyzing politics, economy, society, and technology, the PEST analysis can help enterprises understand the changes in the macro environment and their impact on the enterprise, so that they can formulate corresponding strategies. By using the PEST analysis, the author can better understand the current situation and trends of the macro environment of Z City's air logistics park, evaluate the impact of the four aspects on the future development of Z City's air logistics, and help Z City's air logistics park optimize its layout and avoid unnecessary risks. Therefore, the author will use the PEST analysis method to analyze from the four aspects of politics, economy, society, and technology. The analysis results will mainly be presented to readers in the form of tables.

2. Strategic Positioning

SWOT analysis is an internal analysis method that analyzes a company's Strengths, Weaknesses, Opportunities, and Threats. The SWOT analysis method is often used to formulate strategies, plan projects, or evaluate current conditions. By identifying and utilizing strengths, improving weaknesses, seizing opportunities, and taking measures to address threats, the SWOT analysis can help companies achieve better development and performance. The author will use the S-O-W-T analysis method to analyze the advantages, disadvantages, opportunities, and challenges of the Z City aviation logistics park at present, so as to make the author better understand the current situation of the Z City airport and aviation logistics park. For example, what are the outstanding advantages of the Z City aviation logistics park compared with other areas? What policies will affect the development direction of the aviation logistics park in the future? What factors will affect the layout of the aviation logistics park? The conclusions drawn from the SWOT analysis method will be used to help optimize the layout of the Z City aviation logistics park and complete the transformation and upgrading of the park.

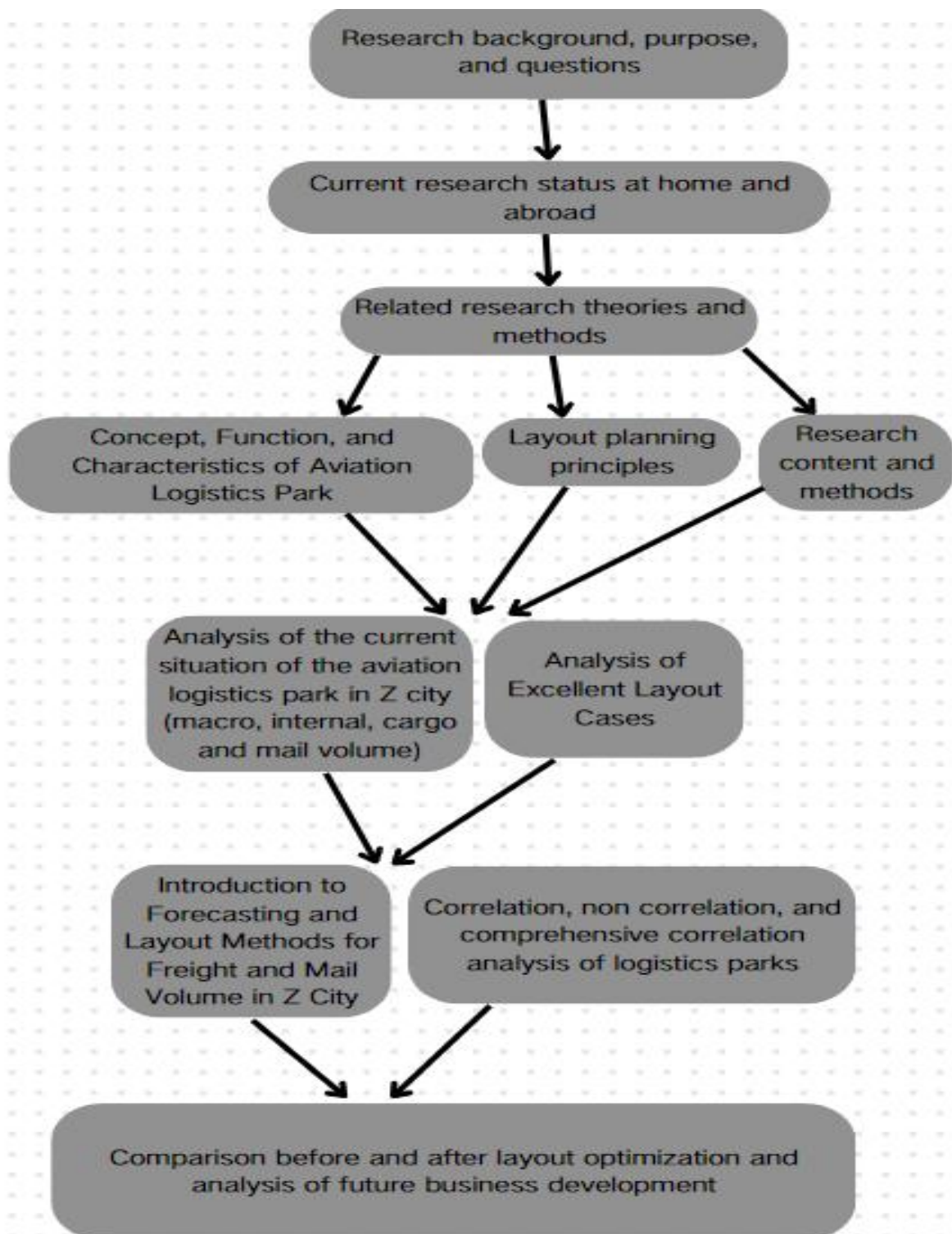
3. Function design

Based on the current layout of the Z City aviation logistics park, the author will combine the structure of the PEST and S-O-W-T analysis methods to rationally increase and adjust the layout of the existing functional areas in the park. By combining China's current logistics development policies and learning from excellent aviation logistics park layout optimization case studies, the author will make reasonable adjustments to the layout of the Z City aviation logistics park to meet the future development needs of the park.

4. Layout design

For the layout design section, the author will use the method comparison to decide to use the grey prediction model (1,1) method and the SLP method to forecast the future cargo volume and optimize the layout of the Z City aviation logistics park. Regarding the gray forecasting model (1,1), this is the most basic and commonly used method. The GM(1,1) model is established on the basis of the theory of gray systems and provides numerical data for the layout optimization of logistics parks through forecasting. Regarding the SLP method, the SLP method optimizes the layout of logistics parks step by step to maximize the efficiency of the park and reduce its costs, thereby improving the park's overall competitiveness and service level. The author will use reference data for the future cargo volume forecast of Z City to optimize the layout of logistics parks.

2.6.2 Roadmap of Thought:



Chapter 3: The Development Status and Experience of Z City Aeronautical Logistics Park

In order to better optimize the layout of logistics parks and adapt to the local logistics development, it is necessary to analyze the background environment of the park. Firstly, Z City is located in the hub of southwest China, with a good geographical location and huge logistics development prospects. These objective factors have laid a foundation for the future development of the park. This chapter first introduces the current air cargo and mail volume of Z City's logistics park, then finds the internal and external environmental factors of Z City logistics park development through PEST analysis and SWOT analysis, and finally takes the layout optimization case of Zhengzhou Xinzheng Bonded Port as a reference.

3.1 The current situation of air cargo and mail volume in Z City

In 2023, China's civilian transport airports completed cargo and mail throughput of 16,833,000 tons, an increase of 15.8% over the previous year, and recovered to 98.4% of 2019. Among the transport airports, there were 63 airports with annual cargo and mail throughput of over 100,000 tons, an increase of 12 from the previous year, accounting for 98.7% of the total cargo and mail throughput of domestic transport airports. There were 196 airports with annual cargo and mail throughput of less than 100,000 tons, a decrease of 7 from the previous year. The top ten airports in terms of cargo and mail throughput in 2023 were: Shanghai/Pudong (No. 1), Guangzhou/Baiyun (No. 2), Shenzhen/Bao'an (No. 3), Beijing/Capital (No. 4), Hangzhou/Xiaoshan (No. 5), Zhengzhou/Xinzheng (No. 6), Chengdu/Shuangliu (No. 7), Chongqing/Jiangbei (No. 8), Nanjing/Lukou (No. 9), and Shanghai/Hongqiao (No. 10).

Table2: Top 10 Chinese cities by air cargo and mail throughput (data source: China Civil AviationStatistics)

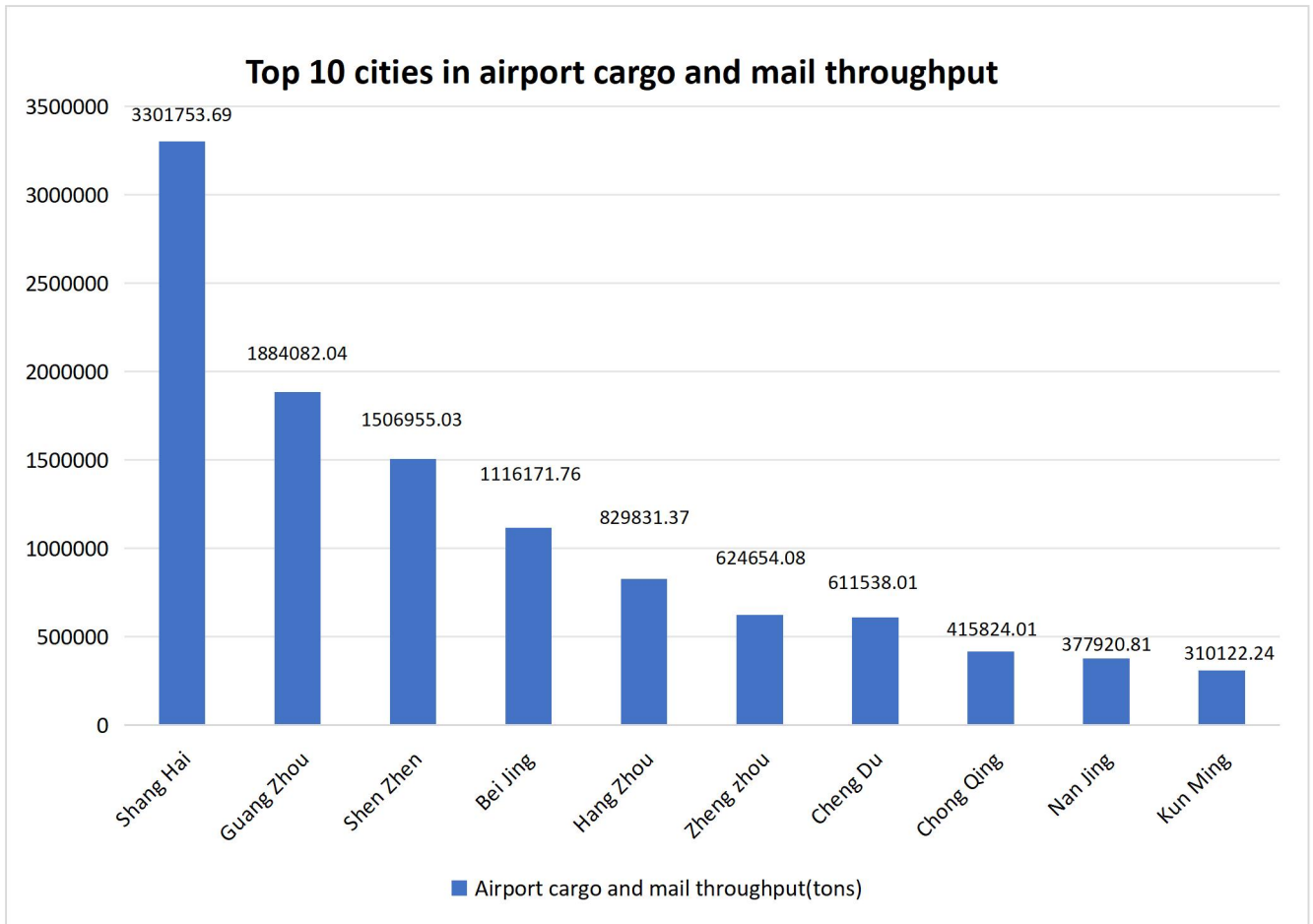


Table 3: Ranking of Passenger and Cargo Throughput at Z City Airport in 2023 (Data Source: China Civil Aviation Statistics)

Ranking	City name	Airport passenger throughput (10000people)	Airport cargo and mail throughput (tons)
1	Shang hai	2889	3301753.69
2	Guang zhou	2610.5	1884082.04
3	Shen zhen	2156.34	1506955.03
4	Bei jing	2298.1	1116171.76

5	Hang zhou	2003.81	829831.37
6	Zheng zhou	922.17	624654.08
7	Cheng du	3109.34	611538.01
8	Chong qing	2246.08	415824.01
9	Nan jing	1214.05	377920.81
10	Kun ming	2123.75	310122.24

From table.2 and table 3, based on the top ten passenger and cargo throughput of domestic airports, Z City Airport has a passenger throughput of 2246.08 (10,000 people) and a cargo throughput of 415,824.01 (tons) in the eighth place nationwide, indicating that Z City has a good development foundation and still has very large development potential and trends in the future.

Table 4. shows the trend of cargo and mail throughput at Z City Airport over the past decade (data source: Research Institute)



z City is located in the southwest plate of China, and the development is relatively slow compared with the coastal areas of China. So the proportion of freight volume in the country is not very large. As can be seen from table 4, the cargo throughput of z City airport in 2023 is 387,900 tons, which is 26,900 tons less than the same period in 2022, a year-on-year decrease of 6.5%. Due to the global COVID-19 epidemic raging in 2019, the development of cargo volume in z dozen times from 19 to 20 years has not changed much. However, due to the fact that there are more than 200 medium-high risk areas in China, the epidemic once affected more than 20 provinces in 2021, which is an extremely severe and complex time for prevention and control in China. As one of the few international airports in Southwest China, the airport of z City has not been blocked. As an international airport, it is the transportation and aviation hub that guarantees international cargo in southwest China in the event of the novel coronavirus epidemic. In 2021, the flight cargo and postal throughput of the airport of z City has been greatly improved. The volume of cargo at the airport of z City has dropped a part compared with previous years. Therefore, in order to further improve the cargo volume of z City airport in the future, it is imperative to optimize the layout of aviation logistics park.

3.2 Z City Macro Environment Analysis

Politics: In terms of politics, Z City is located at the hub of southwest China, and the Central Committee of the Communist Party of China has a very favorable view of Z City's future development. In 2021, the Office of the People's Government of Chongqing Municipality issued the Notice on Printing and Issuing the Chongqing Civil Aviation Development "Fourteenth Five-Year Plan" (2021-2025) to accelerate the construction of a modern airport system. Improve airport

layout, plan to add a new airport in Z City, study the location of additional feeder or general aviation airports, and accelerate the construction project of T3B terminal and the fourth runway at Jiangbei International Airport to form a modern airport system with "widespread coverage, reasonable structure, complete functions, and convenient access." The implementation plan for the construction of the Z City airport economic demonstration zone (2022-2025) and the 2024 Western Development Plan will accelerate the industrial transformation and upgrading of the western region, forming regional advantages. These latest Z City aviation policies can provide excellent policy support for the layout optimization of the Z City air logistics park, endowing the Z City air logistics park with new historical significance to facilitate the future development of air cargo industry.

Economically: the author will conduct research and analysis on the industrial distribution, annual GDP, and growth rate of Z City, as well as the income of Z City residents.

Table 5: Z City's National Economy and Social Development Statistics for 2023 (Data Source: Economic Daily)

Index	2023 (Billion Yuan)	Compared with 2022
Gross Domestic Product	30145.79	6.1%
primary industry	2074.68	4.6%
Secondary industry	11699.14	6.5%
The tertiary industry	16371.97	5.9%

Table 6: Z City's GDP Total and Growth Rate from 2019 to 2023 (Data Source: Economic Daily)

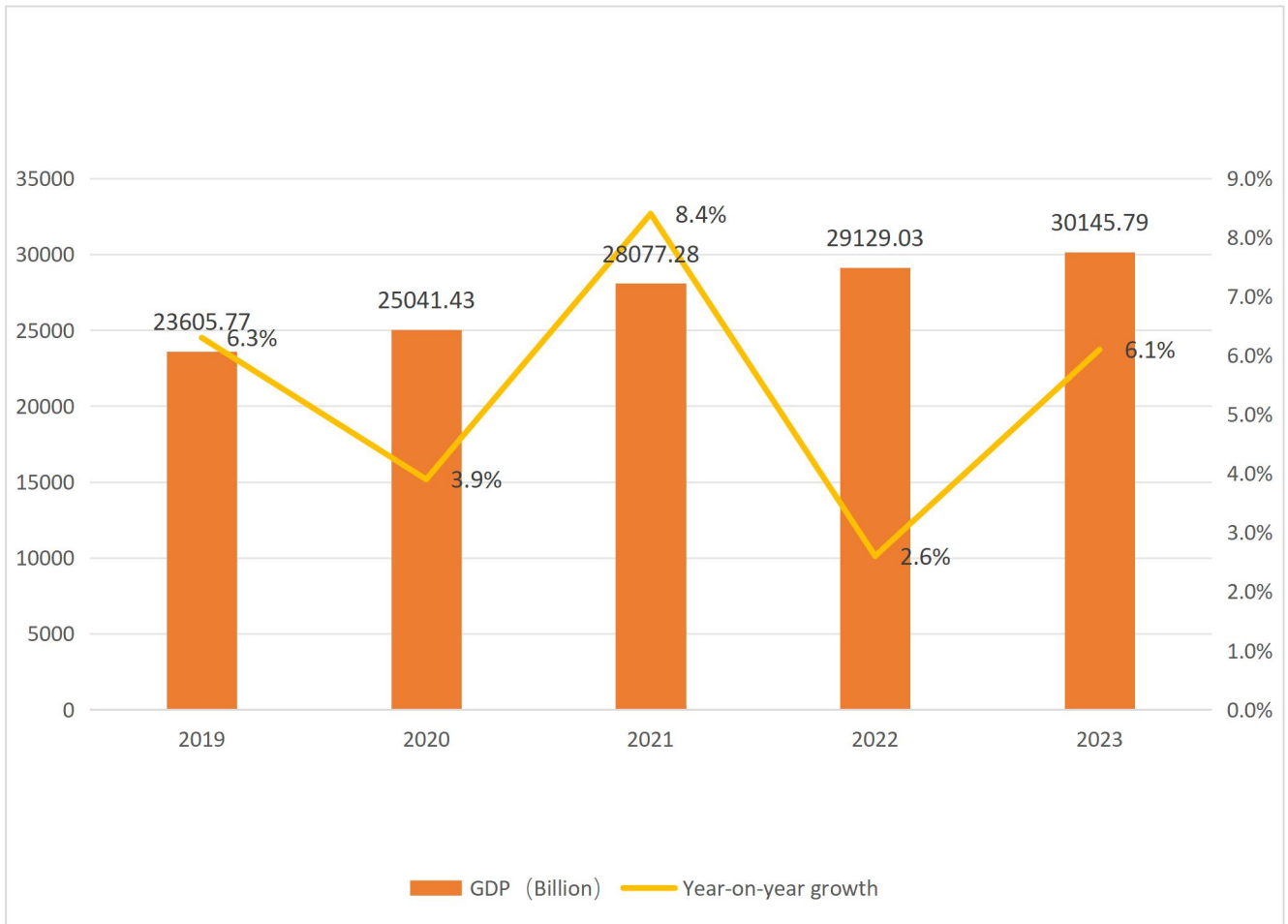


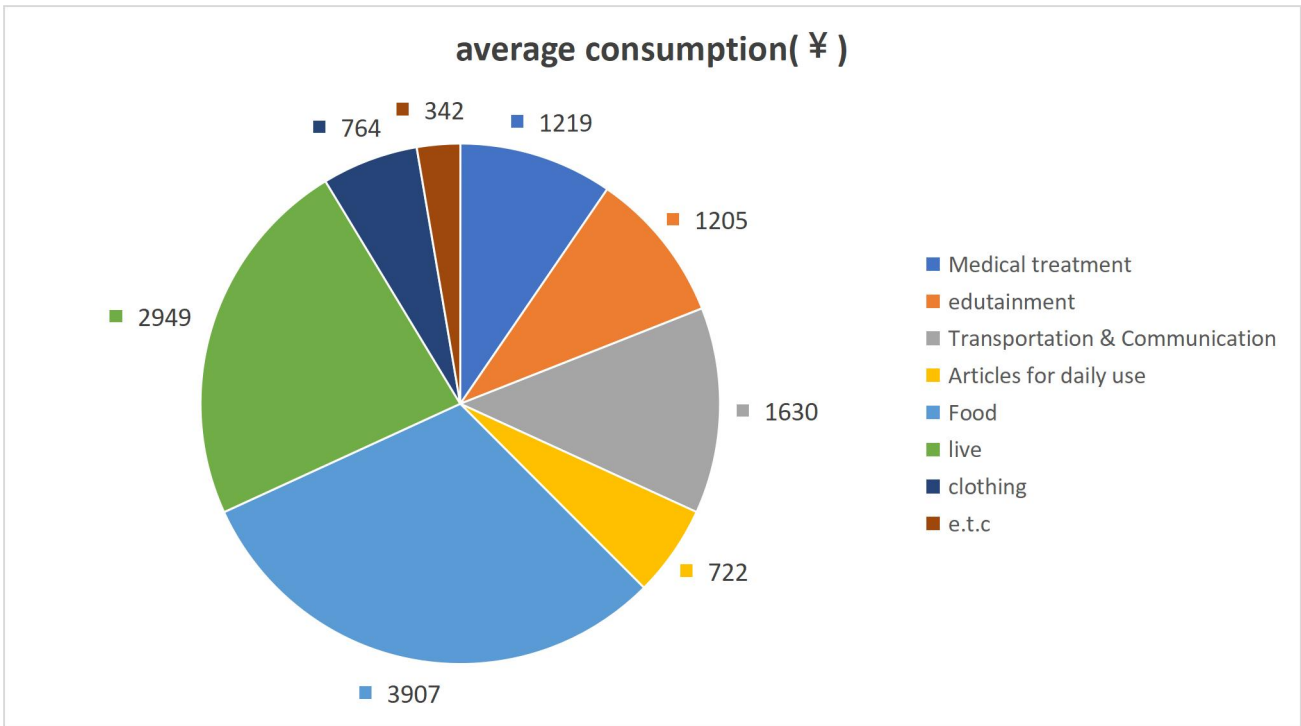
Table 7: Per Capita Disposable Income and Growth Rate of Residents in Z City in 2023 (Data from Economic Daily)

index	Citywide residents		Urban dweller		Rural resident	
	Absolute value (Yuan)	Year-on-year growth (%)	Absolute value (Yuan)	Year-on-year growth (%)	Absolute value (Yuan)	Year-on-year growth (%)
Per capita disposable income	37595	5.4	47435	4.2	20820	7.8

Wage income	20175	5.2	27656	4.1	7421	7.2
Net income from operations	5873	6.3	5350	4.9	6766	8.5
Net property income	2312	4.3	3364	3.0	518	8.7
Transfer of net income	9235	5.6	11065	4.5	6115	7.6

Society: Z City is located in southwestern China's Chongqing, serving as the gateway for East Asian cargo in China and boasting the Silk Road Economic Belt and the Belt and Road open policy. As one of China's four direct-administered municipalities, Z City ranks among the top in terms of population nationwide. Its airport serves as a transit station for domestic and international logistics, with cargo coverage across the entire Asia-Pacific region. Moreover, Z City residents have a strong purchasing power, with food and beverages accounting for a significant portion of household expenditures. Additionally, Chongqing's culinary culture is rich, so there is a higher spending proportion in food consumption. As for other consumption, Z City residents' spending structure shows a relatively small surface proportion, so there is a very large upward potential for their consumption. Z City residents are accustomed to a fast pace, and they enjoy a super-charged pace in their daily lives, so they are keen on consumption and rank among the leading cities in domestic consumption levels. With the growth of e-commerce and people's preference for online shopping, there is an increased demand for express delivery and courier services. Air cargo transportation is a high-end transportation method in daily transportation, and the high added value of products attracts many high-tech industries to join in. The increase in volume leads to scale, facilitating cargo transfers and reducing costs, driving local development, and attracting residents to invest in air cargo consumption.

Table 8: Resident Consumption Structure Chart (Data Source: National Bureau of Statistics 2023)



Technology:

1. Automation and Robotics:

In Z City Logistics Park, automation technologies such as automated warehouse management systems, automatic sorting systems, and automatic loading and unloading equipment can significantly improve logistics efficiency and accuracy, reduce human operation errors and labor costs. Automatic forklifts and mechanical arms can be used for cargo handling and sorting during transportation, accelerating the processing process and reducing damage to goods and processing time. Due to the popularity of intelligent technology, intelligent robot technology has been applied in the logistics industry, especially in the field of drone delivery, providing a new delivery method for remote or inaccessible areas, expanding the service range of Z City's aerial logistics park.

2. Information Application:

Advanced logistics management systems can integrate warehouse management, transportation management, and order processing, enabling real-time information sharing and data-driven decision-making. Such systems can help the aerial logistics park more effectively allocate resources, optimize inventory and transportation routes. Combined with the relatively mature blockchain technology in China, blockchain can provide transparent, unalterable data records,

which is very helpful in improving supply chain transparency, security, and trust. In terms of information application, big data analysis can be leveraged to predict market trends, consumer needs, transport bottlenecks, etc. by analyzing large amounts of data. This enables the aviation logistics park in Z City to prepare in advance and optimize resource allocation. This is also the main direction of development for China's air cargo in the future.

From the PEST analysis, the prospect of the aviation logistics park in Z City is very promising in the future. Currently, the Central Committee of the Communist Party of China attaches great importance to Z City's role in driving economic development in southwest China. The "Notice on Issuing the Civil Aviation Development Plan for Zhangzhou City (2021-2025)" and the "Western Development" policy, both of which are national policies, also help Z City's future good development. Z City's GDP is also steadily increasing, and the consumption structure of Z City residents is gradually improving and their desire to consume is also increasing. The demand for fast transportation is also increasing, which provides strong economic support for the aviation logistics park in Z City. Finally, from the technical aspect, as more and more high-tech technologies emerge and the Internet of Things develops, it provides technical support for the layout optimization of the aviation logistics park in Z City.

3.3 Z City's internal environment analysis

Based on the current development planning of aviation logistics parks in China, combined with the current situation of Z City, an SWOT analysis is conducted for the Z City aviation logistics park to find its positioning, identify the current problems and make up for them in time, and take advantage of the park's strengths to provide a better development plan for the park.

1. Strengths Analysis:

Geographical and Transportation Advantages: Chongqing is located at the transportation hub in the western region of China and is situated in the central area of southwest China, which provides geographical advantages for connecting Southeast Asia, Europe, and North America markets. Such outstanding location provides a natural advantage for the construction and development of the air logistics park.

Industrial Cluster Advantages: Due to the government's strong support for enterprise reform and innovation in recent years, high-tech industries have gradually developed and grown in China. Many domestic microelectronics, new energy, and biotechnology enterprises are eager to cooperate with the logistics park. In addition, the expansion of international trade provides a

guarantee for the development of the park's logistics industry, accelerating the park's economic development.

Government Support: The Chongqing government has sufficient policy support for the development of air logistics, such as financial subsidies and tax exemptions, to help the logistics park reduce operating costs and better develop logistics business.

Infrastructure: The Z City air logistics park is surrounded by complete infrastructure, and many land-based logistics enterprises are located around the air logistics park, generating many downstream enterprises, providing the park with efficient cargo handling and transfer capabilities.

2. Weaknesses: **Cargo volume insufficiency:** In the national cargo volume ranking in 2023, Z City is ranked eighth in the country, but its cargo volume is obviously insufficient compared to coastal cities. It is even further behind the cargo volume of major international airports in Beijing, Shanghai, and Guangzhou.

Higher costs: Compared to the coastal areas of China, the logistics costs in Z City are relatively higher due to its inland location, especially the costs of terminal handling and distribution are higher than those in the developed coastal areas.

Talent shortage: Due to the lower economic development level in southwest China compared to coastal cities, Z City has experienced serious talent loss, resulting in insufficient supply of professional logistics personnel and skilled labor in the local market, which has become a major obstacle to the development of the park.

3. Opportunities:

National policies: The Belt and Road Initiative and the Western Development Policy of the State provide Z City's air logistics with a huge opportunity to expand into the international market in a new international cooperation context. Z City will open more international logistics routes, especially cargo transportation to Central Asia and Europe.

Growth of e-commerce: As e-commerce has rapidly developed, people's demand for efficient logistics systems has increased, bringing benefits to air logistics parks. **Technological innovation:** The innovations in artificial intelligence and the Internet of Things have improved drone delivery, automated warehousing, and smart logistics technologies, providing new opportunities for improving the service efficiency and quality of logistics parks.

Opportunities	SO	WO
<p>1. National policies</p> <p>2. Growth of e-commerce</p> <p>3. Technological innovation</p>	<p>1. Leverage national policies and geographical advantages to promote the development of logistics parks.</p> <p>2. Combine the advantages of e-commerce enterprises and industrial clusters to create a unique transportation advantage for Z City.</p> <p>3. Technological innovation, joint infrastructure to achieve mutually beneficial win-win situation.</p>	<p>1. Utilizing the national policy orientation, determine the future development direction of Z City's aviation logistics park.</p> <p>2. Utilize innovation to achieve talent attraction.</p> <p>3. Rationally optimize the current logistics function area layout.</p>
Threats	ST	WT
<p>1. Highly competitive</p> <p>2. Global economic fluctuations</p> <p>3. Technological innovation</p>	<p>1. Leverage existing advantages to create a competitive advantage for Z City.</p> <p>2. Leverage the advantage of industrial agglomeration to find the right logistics positioning and development.</p>	<p>1. Optimize the layout to gain a competitive advantage.</p> <p>2. Improve the efficiency of the existing logistics operations to gain market competitiveness.</p>

3.4 Excellent Case Studies and Analysis of Air Logistics Park Development

3.4.1 Development Overview of Zhengzhou Xinzheng Comprehensive Bonded Zone

Zhengzhou Xinzheng Comprehensive Bonded Zone is an area that has gradually developed around the Zhengzhou Xinzheng International Airport. Located near Zhengzhou International Airport in Zhengzhou City, Henan Province, it is a crucial aviation logistics hub in Central China. On October 24, 2010, the State Council officially approved the establishment of the Zhengzhou Xinzheng Comprehensive Bonded Zone, marking the first comprehensive bonded zone in Central China authorized by the State Council. The planned area of the zone spans 5 square kilometers, located within mainland China's first aviation port. It extends from Zhenggang Seven Street in the east to the planned third runway boundary of Zhengzhou Xinzheng Airport in the south, Zhenxing North Road in the west, and the Dengfeng-Zhengzhou-Shangqiu Expressway in the north.

The establishment of the Zhengzhou Xinzheng Comprehensive Bonded Zone significantly promotes the economic and social development of Henan, providing a new platform for the Central Plains Economic Zone to soar to new heights, placing it fifth nationally after the Yangtze River Delta, Pearl River Delta, Beijing-Tianjin-Hebei, and the middle reaches of the Yangtze River. This holds tremendous significance for the economic and social development of both Henan and the nation as a whole.

In 2023, Zhengzhou Airport ranked among the top in the country in terms of cargo and mail throughput. The national strategic positioning for the development of the Henan Free Trade Zone is to build a modern three-dimensional transportation system and a modern logistics system, serving as a modern comprehensive transport hub for the "Belt and Road" initiative—essentially "two systems, one hub." Around this positioning, Henan continues to advance the coordination of the "Air Silk Road" and the sea, land, and air "Four Silk Roads." In 2023, Zhengzhou Airport handled 608,000 tons of cargo and mail, ranking seventh nationwide. In terms of air ports, Xinzheng Airport processed 384,600 tons of international regional cargo and mail, consistently ranking fifth nationwide for four consecutive years. The functional port has handled nearly 14,000 tons of import and export goods, worth a total of 1.07 billion yuan, covering trade with over 200 cities in 24 European countries.

The Zhengzhou Xinzheng Comprehensive Bonded Zone consists of seven functional areas:

1. Storage Area: Equipped with various types of automated warehousing systems to ensure rapid and efficient management of goods.
2. Processing and Manufacturing Area: Offers well-equipped manufacturing and processing services to support simple processing and assembly operations within the zone.
3. Business Services Area: Concentrates office buildings, conference centers, and exhibition facilities, facilitating business activities both within and outside the park.

4. Bonded Services Area: Provides clients with tariff benefits and tax optimization services, supporting international trade for import and export companies using bonded advantages.

5. Logistics Services Area: Features modern logistics equipment and information systems, specifically designed to offer efficient loading, sorting, and distribution services to logistics companies.

6. Research and Development and Innovation Center: Houses research institutions and innovation labs aimed at attracting high-tech companies and talent, promoting technology transfer, and fostering innovation.

7. Living Services Area: Provides essential facilities like employee cafeterias, convenience stores, and medical services, ensuring daily needs of the park's employees are met, improving the working environment, and enhancing employee satisfaction and efficiency.

3.4.2 Development Advantages

1. Geographical Location: Zhengzhou is situated at the geographic center of China, providing a significant locational advantage. The city is served by two major railways (the Beijing-Guangzhou and Longhai railways), two highways (the Lianhuo and Jingzhu expressways), and two national roads (310 and 107). It also hosts China's largest railway freight transit station. This strategic location enables convenient connections to major domestic and international cities and markets, greatly facilitating international trade and logistics transportation.

2. Policy Support: As an important economic and logistics hub in Central China, the Zhengzhou Xinzheng Comprehensive Bonded Zone benefits from numerous national policy supports, including tax incentives and trade facilitation measures. These policies significantly reduce operational costs for businesses and attract many domestic and international investments.

3. Advanced Facilities and Technology: The zone's storage and processing facilities employ internationally advanced technologies, such as automated warehouses and intelligent sorting systems. These advanced technological applications enhance the logistics efficiency and accuracy of the park, ensuring the high-speed and safe handling of goods.

4. Rich Industrial Aggregation: The Xinzheng Comprehensive Bonded Zone is not only a logistics hub but also a convergence point for multiple industrial chains, including electronic information, high-end equipment manufacturing, and biopharmaceutical industries. This industrial agglomeration effect allows enterprises within the park to share resources and complement each other's strengths.

5. International Cooperation and Open Environment: The Zhengzhou Xinzheng Comprehensive Bonded Zone actively participates in international cooperation projects. China's Belt and Road Initiative connects the zone with multiple countries' logistics and trade networks, establishing strong international partnerships. This provides businesses within the zone with access to a broad international market, enhancing their global reach and opportunities.

3.5 Lessons and Experiences in Layout Development

1. Integration of Multifunctional Zones:

In the design of logistics parks, it is crucial to have a scientific and rational layout of various functional zones to achieve the effective integration of logistics, processing, business, and research and development functions. Therefore, when planning new logistics parks, developers should consider from the outset how to effectively combine different functions to enhance the overall operational efficiency and attractiveness of the park.

2. Efficient Transportation Connections and Infrastructure Development:

The Zhengzhou Xinzheng Comprehensive Bonded Zone leverages an optimized transportation network, including proximity to an international airport and connections to major highways, ensuring efficient logistics transportation. The success of a logistics park largely depends on its accessibility. During planning, significant attention should be given to the development of transportation networks to ensure smooth connections between the park and domestic and international markets.

3. Policy Drive and Government Support:

A favorable policy environment can reduce the operating costs of logistics parks and promote rapid industrial capital development. Improvements in the policy environment are mainly reflected in the development policies for enterprises and the enhancement of government efficiency. These factors help attract high-quality logistics enterprises to the park and promote its development and transformation. The Zhengzhou Xinzheng Comprehensive Bonded Zone has received strong support from both national and local governments, including tax incentives and land optimization policies, which are crucial drivers of its development.

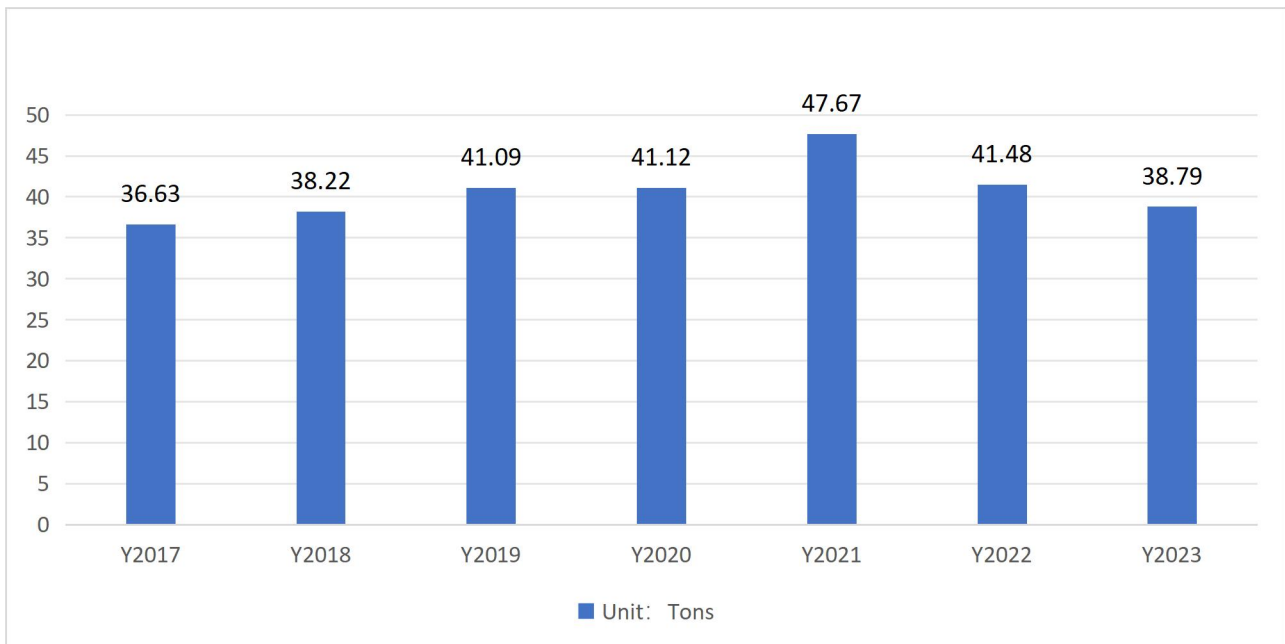
Following the research analysis and the summary of exemplary logistics park layouts presented in the first three chapters, the next section will first forecast the cargo and mail volume of the Z city air logistics park. Based on the results of this forecast, a re-layout of the functional areas in the Z city air logistics park will be proposed. This will provide reference suggestions for the layout optimization of the Z city logistics park.

Chapter 4: Air cargo and mail volume forecast and functional area optimization for Z City Aeronautics Logistics Park

4.1 Forecast of cargo and mail volume in Z City Aeronautical Logistics Park

The most important basis for the expansion and development of the aviation logistics park is the size of cargo and mail volume. Successfully predicting the future trend of cargo and mail volume has a significant impact on the later functional area layout, land use, and transportation efficiency of the entire logistics park. The grey model (1,1) can predict the future cargo and mail volume of the aviation logistics park in Z City relatively simply and accurately. The author will list the chart of the number of airmail handled in Z City in recent years to help the model calculate the numerical value of the future air cargo and mail volume.

Table 10: Z City's Air Cargo and Mail Volume Over the Years



Through the above data charts, a GM(1,1) model was established, and the data was accumulated once to generate a new sequence. A differential equation and a linear trend were established. Since the author used relevant gray prediction software to make data predictions, the calculation process was ignored, and only part of the code process is presented here.

The cargo and mail volume in 2017 was 3.663 million tons, the volume in 2018 was 3.822 million tons, the volume in 2019 was 4.109 million tons, the volume in 2020 was 4.112 million tons, the volume in 2021 was 47.67 million tons, the volume in 2022 was 4.148 million tons, and the volume in 2023 was 3.879 million tons.

Original data (X0): the cargo and mail volume data of Zhi City Airport from 2017 to 2023

Accumulated data (X1): the original data was accumulated to generate the operation (1-AGO), in order to reduce the randomness of the data and reveal the inherent laws of the data.

Background value (Z1): the average of the adjacent two items of the accumulated data was calculated as the background value, used to construct the gray differential equation.

$$Z1 = 0.5 * (X1[:-1] + X1[1:])$$

Parameter estimation (a and b): the parameters a (development coefficient) and b (gray effect coefficient) of the gray prediction model were estimated using the least squares method.

```
def time_response(t, a, b, X0): return (X0[0] - b / a) * np.exp(-a * (t - 1)) + b / a
```

```
return X0, X1, Z1, B[:, 0], Y, X_pred, X_pred_reduced
```

```
X0, X1, Z1, B_col, Y, X_pred, X_pred_reduced = detailed_gm11_calculation(cargo_volumes)
```

Based on the above code, the following chart is generated to show the future air cargo volume in Z City, as shown below.

Table 11: Predicted Air Cargo Volume in Z City for the Next Five Years

Year	2024	2025	2026	2027	2028
Forecasted Cargo and mail throughput (Unit: ten thousand tons)	42.41	42.71	43.01	43.31	43.61

According to the results of grey prediction, it can be seen that the cargo and mail volume at Z City Airport will maintain relatively stable growth in the next five years, with little change in the scale of variation. The reason for this result may be that other regions' air logistics parks and transportation modes (high-speed rail, sea transport) provide more competitive services, diverting part of the cargo flow that would otherwise pass through Z City, or that the lifting of COVID-19 restrictions in China in 2022 has had an impact on Z City's cargo supply chain, leading to a slow recovery.

In the following chapters, the author first introduces the layout optimization method, then draws relevant charts based on the air cargo volume data of Z City in the next five years as data support,

to display the logistics flow chart, logistics intensity grade chart, non-logistics mutual relationship chart, and optimized layout diagram.

4.2 Optimization Methods for the Layout of Z City Aviation Logistics Park

4.2.1 Introduction to Layout Methods

In the 1960s, Richard Muther, from the United States, proposed a representative research method called Systematic Layout Planning, or SLP. This method has been widely applied in various facility layout and logistics planning fields. As a basic procedural model, systematic layout design is not only suitable for optimizing factory buildings, arranging work units, placing equipment and adjusting them in the process of constructing, renovating or expanding factories, but also for designing hospitals, airports, libraries, campuses, catering services, stores and various service industries. It is also applicable to office and laboratory layout design.

SLP method is a systematic layout design method that has five basic elements: P, Q, R, S, and T. P represents the object, Q represents the workload, R represents the work route, S represents auxiliary production, and T represents the work technique. Based on these processes, the required work units are determined. Finally, the relationships of relevance and integration between the various work units are analyzed to determine their relative positions, and a layout plan is drawn up accordingly.

4.2.2 Basic Element Analysis

P represents the logistics object, i.e. various goods entering and leaving the park. For example, electronic products, daily necessities, and chilled and preserved goods.

Q represents the flow of goods, referring to the quantity of goods. In the previous chapter, the grey model (1,1) was used to predict that the air cargo and mail volume in Z City will reach 436.1 thousand tons in 2028, which provides data support for the subsequent functional area layout design.

R represents the logistics operation process, i.e. the transportation route of goods. This is a key factor in the SLP method for functional area layout design. After the goods arrive at the park, some of them need to be split and assembled before being transferred to other functional areas based on their demand.

S represents the production service auxiliary departments. In the Z City air logistics park, although these departments do not directly participate in the handling of goods flow, they provide necessary services for logistics activities in the park, thereby indirectly affecting the flow rate of goods.

T represents logistics technology, i.e. the total sum of theories, facilities, equipment, and technologies used in the entire logistics flow process within the park. The purpose of logistics technology is to achieve the efficient transportation of goods in the park.

4.3 Logistics Relationship Analysis of Functional Zones in Z City Aeronautics Logistics Park

In this section, the author will draw relevant charts and graphs based on the forecast data obtained from the previous chapter's grey prediction model, including logistics flow charts for each functional zone, logistics intensity maps, non-logistics mutual relationships, and finally, an optimized layout diagram.

Using the forecasted air cargo and mail volume for Z City Aeronautics Logistics Park in the future based on the grey prediction model in the previous chapter, the author will select the forecasted 43.61 million tons of cargo and mail for the year 2028 as the reference data for optimizing the layout of Z City Aeronautics Logistics Park. The daily cargo and mail volume is then calculated by dividing the total by 365 days, which is approximately 1,195 tons per day.

4.3.1 Logistics Related Analysis

It is divided into 5 grades of A, E, I, O, and U based on the intensity, with A representing the highest intensity and the intensity decreasing in sequence. (The corresponding functions of each code are listed in the appendix.)

Table12: Logistics Intensity Table

Functional area	The volume of material flow (tons)	Share of material	Strength level
1—————2	——	More than 20%	A
1—————3	——	19%——10%	E
1—————4	——	9%——5%	I
.....	——	Less than 5%	O
.....	——	Negligible	U

In the Z City Aviation Logistics Park, the logistics relationships mainly exist in the reception area, storage area, processing area, loading and unloading area, distribution area, trade show area, and security supervision area.

Through investigation and analysis, the author concluded that the logistics flow of goods in the park is approximately as follows:

1. All goods first arrive in the reception area, of which 20% enter the storage area, 40% enter the processing area, 15% enter the loading and unloading and distribution area, 9% enter the trade show area, and 13% enter the security supervision area.
2. Goods entering the processing area, of which 40% enter the loading and unloading and distribution area, 20% enter the security supervision area, 10% enter the trade show area, and 25% enter the international cargo center.
3. Goods entering the storage area, of which 10% enter the processing area, 36% enter the international cargo center, and 42% enter the domestic cargo center.

Table 13: Logistics from to table (Data source: Chongqing Aviation Logistics Park)

To \ From	1	2	3	4	5	6	7	8
1	---	239	478	179.25	107.55	155.35	0	0
2	239	---	23.9	0	0	0	86.04	100.38
3	478	23.9	---	191.2	47.8	95.6	119.5	0
4	179.25	0	191.2	---	0	0	0	0
5	107.55	0	47.8			0	0	0

6	155.35	0	95.6	0	0		0	0
7	0	86.04	119.5	0	0	0		0
8	0	100.38	0	0	0	0	0	---

Table 14: Logistics Intensity Grade Table Between Functional Zones

Functional area flow direction	The volume material flow	Ratio%	Strength level
1-2	239	20%	A
1-3	478	40%	A
1-4	179.25	15%	E
1-5	107.55	9%	I
1-6	155.35	13%	E
2-3	23.9	2%	U
2-7	86.04	7.2%	I
2-8	100.38	8.4%	I
3-4	191.2	16%	E
3-5	47.8	4%	O
3-6	95.6	8%	I
3-7	119.5	10%	E

According to table 14, the intensity relationship diagram of the functional zones in the logistics park is drawn as shown in table 15.

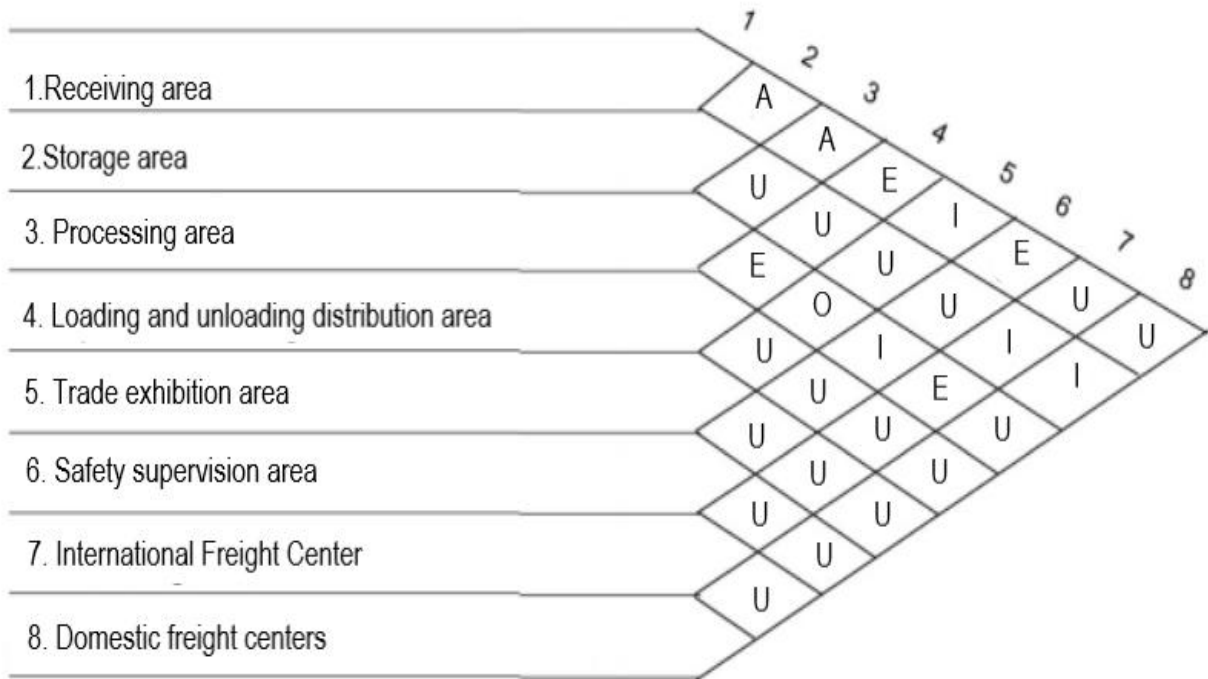


Table 15: Relationship diagram of functional area intensity in logistics park

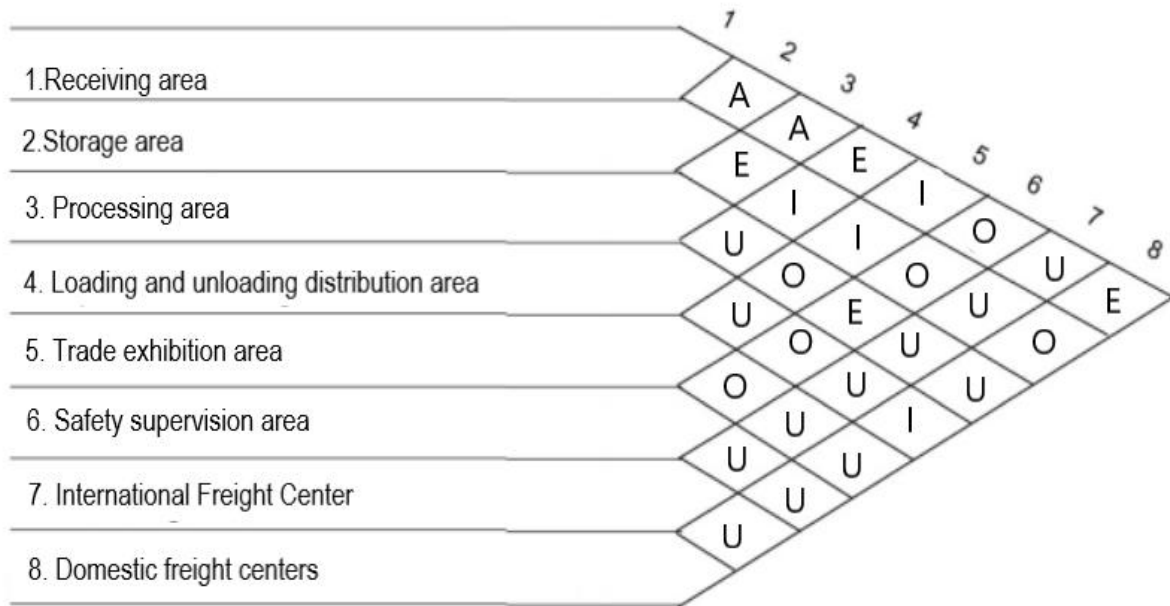
4.3.2 Non-logistics Relatedness Analysis

Analyzing non-logistics relatedness is an important part of ensuring the rationality of functional area layout and improving efficiency. The author has summarized the following five factors as evaluation indicators through reviewing relevant materials, combining factors related to processes, management, and environment. As shown in table 15, a non-logistics relatedness relationship diagram is drawn as shown in table 16.

Table 16: Hierarchy of Non-Logistics Relationships Among Functional Areas

NO	Non-logistics relationship reasons	Degree of association	Association level	Score
1	Continuity of Operational Processes	Absolutely essential.	A	4
2	Logistics Operations Similarity	Of particular importance.	E	3
3	Staff Contact Level	Important	I	2
4	Convenience of management oversight	It's not very important.	O	1
5	Noise and pollution problems	It doesn't matter.	U	0

Table 17: Function Area Non-Logistics Relatedness Diagram



4.3.3 Synthesized Correlation Analysis

The final comprehensive correlation is evaluated by both logistics and non-logistics correlation relationships. The comprehensive correlation value of the functional area of the Z City Aviation Logistics Park is obtained by combining the grade table obtained from the correlation analysis and the non-correlation analysis. The author found that the result obtained by taking the ratio of logistics correlation relationship and non-logistics correlation relationship to be 3:1 was more accurate through literature review. Therefore, this thesis selects a ratio of 3:1 for mapping, as shown in table 18 below.

Table 18: Integrated Relationship Diagram of Functional Zones in Z City Aeronautical Logistics Park

Function area flow direction	Logistics Relationship p	Non-logistics Relationship p	Combined Value	Function area flow direction	Logistics Relationship p	Non-logistics Relationship p	Combined Value
1-2	4	4	16	4-5	0	0	0
1-3	4	4	16	4-6	0	1	1
1-4	3	3	12	4-7	0	0	0
1-5	2	2	8	4-8	0	2	2
1-6	3	1	10	5-6	0	1	1
1-7	0	0	0	5-7	0	0	0
1-8	0	3	3	5-8	0	0	0
2-3	0	3	3	6-7	0	0	0
2-4	0	2	2	6-8	0	0	0
2-5							

	0	2	2	7-8	0	0	0
2-6							
	0	1	1	-	-	-	-
2-7							
	2	0	6	-	-	-	-
2-8							
	2	1	7	-	-	-	-
3-4							
	3	0	9	-	-	-	-
3-5							
	1	1	4	-	-	-	-
3-6							
	2	3	9	-	-	-	-
3-7							
	3	0	9	-	-	-	-
3-8							
	0	0	0	-	-	-	-

Table 19 Classification Chart by Level

Total Score	level
15-16	A
11-14	E
6-10	I
1-5	O
0	U

4.3.4 Function Area Layout Positioning Determined

Based on the principles of park layout planning, the logistics relationships, non-logistics relationships, and comprehensive logistics relationships among function areas, an order diagram of function areas is obtained as shown in table 20.

Table 20: Sequence of Function Area Mapping

---	1	2	3	4	5	6	7	8
1	---	A/4	A/4	E/3	I/2	I/2	U/0	O/1
2	A/4	---	O/1	O/1	O/1	O/1	I/2	I/2
3	A/4	O/1	---	I/2	O/1	I/2	I/2	U/0
4	E/3	O/1	I/2	---	U/0	O/1	U/0	O/1
5	I/2	O/1	O/1	U/0	---	O/1	U/0	U/0
6	I/2	O/1	I/2	O/1	O/1	---	U/0	U/0
7	U/0	I/2	I/2	O/0	U/0	U/0	---	U/0
8	O/1	I/2	U/0	U/0	U/0	U/0	U/0	---
Accumulated Points	16	12	12	7	5	7	4	4
Planning Sequence	1	2	2	3	4	3	5	5

According to the integrated relationships and drawing sequence, the diagram of the relevant positions of the functional areas is drawn as follows:

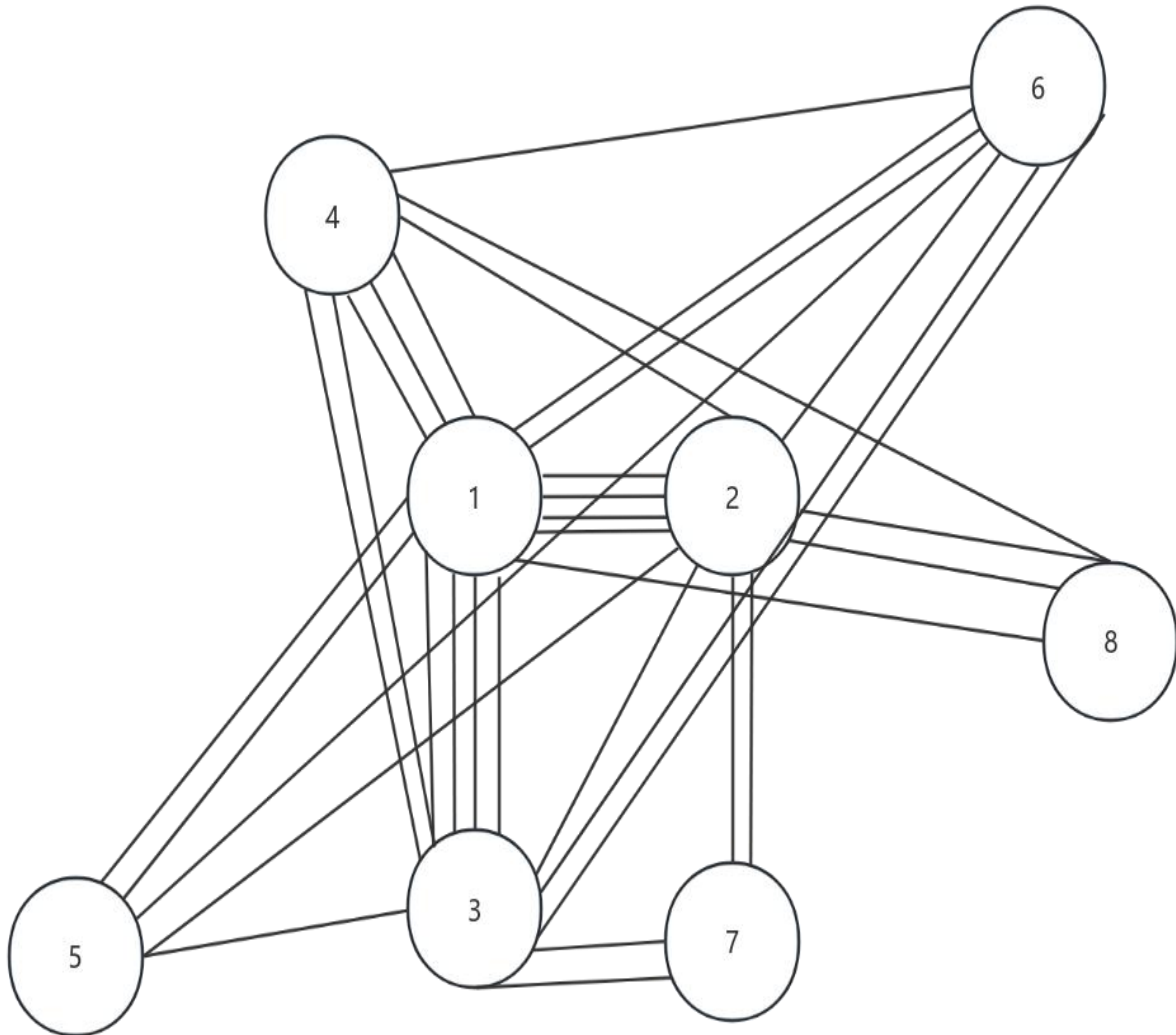


Table 21 Location of the preliminary layout diagram of z City air logistics Park

4.4 Comparison of layout before and after optimization

As shown in table 21, the initial layout, the following table will display a comparison of the layout before and after optimization.

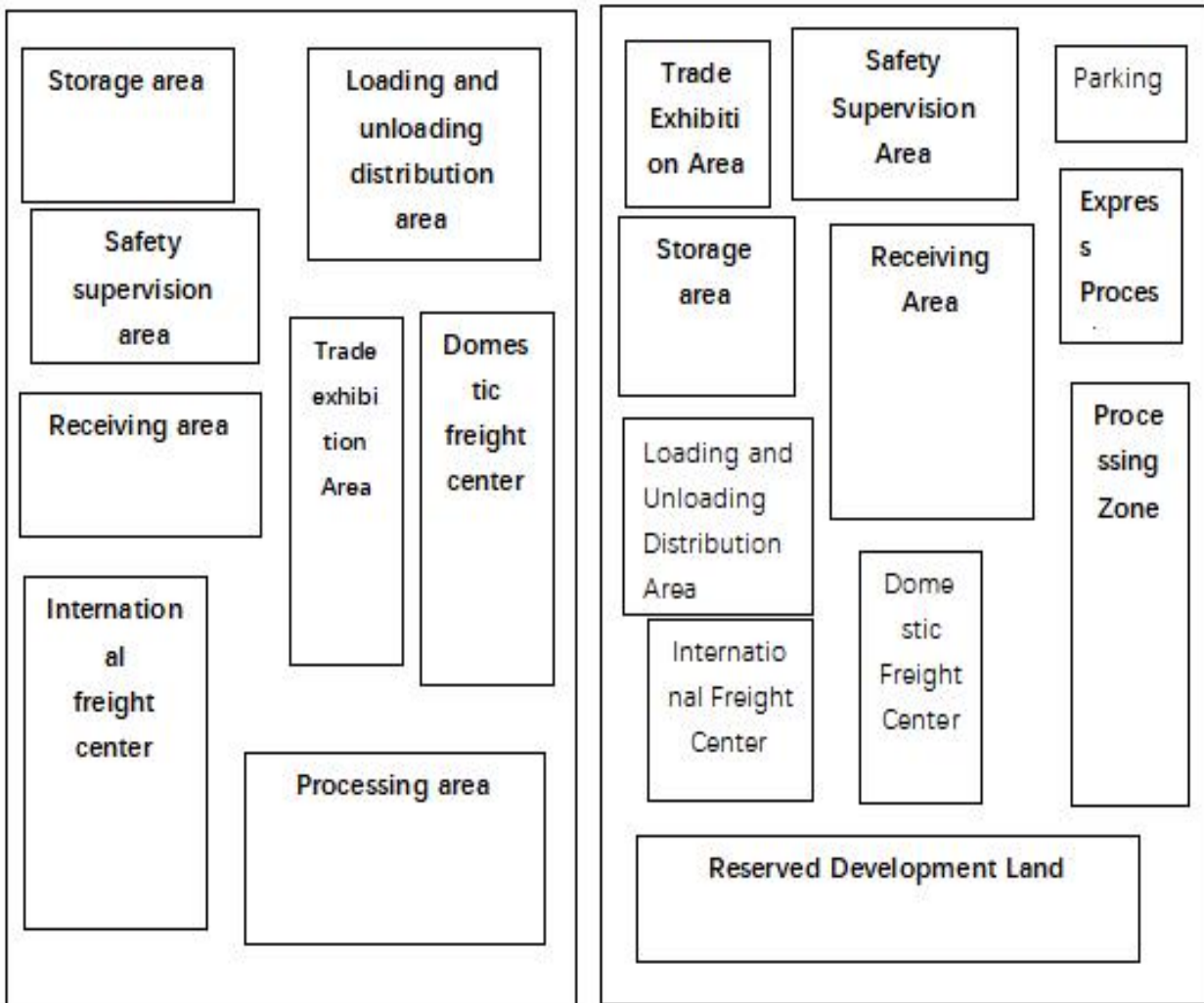


Table 22 Comparison of layout before and after (the layout reference before optimization was from Baidu Maps, details can be found in the appendix)

Through the optimization of the layout of the air logistics park in Z City, the changes after the layout are as follows:

1. By closely connecting the three key functional areas of receiving, storage, and loading and unloading distribution, the distance that goods need to be moved between different areas can be greatly reduced. The physical proximity reduces the moving time, accelerates the goods handling

process, and makes the entire process of receiving, storage, and loading and unloading more smooth and efficient. It can also reduce the loss rate of goods because in a more compact layout, there are fewer opportunities for damage to goods during handling, and the risk of long-distance handling is reduced.

2. The safety supervision area is located at the top to better conduct safety inspections when goods are received and enter the trade exhibition area, and to protect the logistics security of the park.

3. To facilitate the exchange and coordination of the freight center, the domestic freight center and the international freight center are located together. With the Z City Belt and Road policy driving an increase in the volume of domestic and international goods received, the physical proximity of the two freight centers makes management more centralized and unified. This layout facilitates the sharing of management resources and information systems, simplifies management processes, reduces redundant work, and improves decision-making efficiency. It can also promote exchanges between the two freight centers, thereby improving overall operational standards and efficiency. In order to help Z City Aviation Logistics Park complete its transformation and upgrade, a new express processing area was added, which can improve customer stickiness because high-tech enterprises tend to prefer convenient logistics processing. The newly added express processing area can solve the problem of slow delivery of technical goods for high-tech enterprises, thereby improving the park's efficiency.

The parking area in the trade exhibition area before was separated out and relocated, not only solving the problem of functional area duplication, but also effectively solving the environmental pollution caused by vehicle parking and starting in the park. It is more conducive to the independent development of functional areas in the park. A reserved development area was also set aside to prevent the park's development from being slowed down by the problem of cargo volume in the future. If there are insufficient layouts in the park's development in the future, the reserved development area can be put into use to help the park better deal with the problem.

4.5 The Possibility of Future Business Development in Z City Air Logistics Park

Since the focus of this study is on the layout optimization of Z City Air Logistics Park, the development direction of Z City Air Logistics Park in the future is proposed based on the PEST analysis and SWOT analysis in Chapter 3.

The construction of Z City's free trade zone is being carried out in an orderly manner. With the expansion of the free trade zone in the future, there will be more international goods in Z City. Z City should focus on developing international freight business because with the increasing number

of multilateral international trade in the future, international freight business will definitely flourish. Z City should actively promote international business in the future and increase the park's international visibility to increase the number of international freight business.

Chapter 5 Conclusion and Prospects

Based on the analysis of the development status, development problems and necessity of the aviation logistics park in Z City, this thesis studies and analyzes the excellent domestic aviation logistics park layout planning experience. And according to z city aviation logistics Park cargo volume data in recent years, forecast the cargo volume in the next five years. And according to SLP park layout planning method, through the analysis of mutual logistics relationship and non-logistics relationship between functional areas, the latest layout diagram of z city aviation logistics park is obtained. Although this method may not be the optimal layout scheme compared with other scholars' research conclusions, the layout planning in this thesis is also a conclusion based on theory and data analysis, and has certain practicability. It has certain reference significance for the layout optimization of the aviation logistics park in z city.

In this study, the author mainly did the following work:

1. Reviewed relevant logistics park layout cases and scholarly analyses, and queried per capita GDP, total GDP changes, and resident consumption structure from the official website of the Chongqing municipal government and the China Economic Yearbook. At the same time, the air cargo volume, plane take-off and landing times in recent years were queried from the annual report of Chongqing Jiangbei Airport as the data support for the article.
2. In the chapter on cargo volume forecasting, the article uses code tools to use the GM(1,1) model to forecast the air cargo volume for the next five years, laying a foundation for the application of SLP layout planning.
3. In the final SLP layout planning analysis, by carefully analyzing the functional area logistics relationship relevance, non-logistics relevance, and the comprehensive relationship of functional areas, considering the strength of inter-functional area links, a new layout plan was obtained.

After the re-layout planning of Z City's air logistics park, it has a clearer functional area positioning, and the links, coordination, and cooperation between the functional areas are more efficient than before. It is hoped that Z City's aviation industry will strengthen its own industrial chain, embrace the track of development of the times, and become one of China's top air transport hubs.

Through this thesis project, the author learned many different survey thinking methods, including how to correctly browse official data and read different survey methods adopted by scholars in the direction of park layout planning on academic websites, summarizing the author's own insights into the optimization of air logistics park layout. And under the guidance of the tutor, the author learned how to academically modify the inappropriate expression methods in the study, and express gratitude to the tutor for his guidance, which allowed the author to make further progress in the

study. Finally, the author will continue to maintain a learning mindset and continuously improve himself. He will strive to shine in the aviation field in the future.

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Appendices:

Appendices 1. Map before optimizing the layout of the aviation logistics park in Z city (from Baidu Maps)



Appendices 2 .Explanation diagram of functional area serial numbers for the thesis

Number	Functional area
1	Receiving area
2	Storage area
3	Processing area
4	Loading and unloading distribution area
5	Trade exhibition area
6	Safety supervision area
7	International freight center
8	Domestic freight center