Study on the layout planning of CDTF airport air logistics park based on SLP

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Abstract

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Aiming at the layout planning of CDTF Airport airport Logistics Park, this paper uses SLP method, combined with the data of CDSL Airport and other domestic multi-airport cities, to predict the logistics flow of CDTF Airport in the future and plans six functional areas. Proposed on the final layout plan based on logistics correlation, non-logistics correlation and comprehensive analysis, this study gives a schematic diagram of the relative location of the layout planning of the CDTF airport aviation logistics park, and puts forward suggestions for the layout planning of the aviation logistics park of the new airport in the multi-airport city, which provides a reference for solving the layout planning problem of the airport logistics park of the new airport in the multi-airport city.	
Key words Air Logistics Industry, SLP, Logistics Park Layout Planning, Multi-airport	

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1 Introduction

This section will introduce the significance of this study , the selection of the research subjects and the objectives of this study.

1.1 The significance of this study

The significance of this study will be developed in terms of macro trends in the industry, current trends within the industry and gaps in relevant research.

On a macro level , in recent years, with the development of global economic integration, the e-commerce industry has entered a new stage of development, which has brought about the vigorous development of express logistics. With the development and upgrading of the express delivery industry, air freight is rapidly occupying the market of traditional express delivery industry, which is driving the large-scale development of aviation logistics park construction. And with the rapid development of the air cargo industry, the construction of its supporting facilities has also entered a period of large-scale, rapid development. In this case, as the most important central hub of the air cargo industry, the construction of air logistics parks has undoubtedly become the focus of research within the industry. There is no doubt that the study of the layout and planning of an air logistics park is a precondition for its construction and strategic layout. So the research on the layout and planning of aviation logistics parks has become a highly promising research topic

In the air cargo industry, with the development, the trend of "multi-airport", which means building multiple large airports and supporting aviation logistics parks in important port cities, is gradually emerging.(Qiao Yingli & Ge Chunjing 2020, 13-16+27 , Cai Wenting 2020, 9-11.)

In the past two decades, scholars from all over the world have studied the layout planning of different aviation logistics parks using methods such as SLP, mathematical modeling, and computer intelligent optimization algorithms. (Wang Zhu 2006,79-81; Cagan 2005,33-38; Chi Yue 2016,19.)

However, due to the late development of related research, there is still a certain gap in the research field, and the research is mostly limited to isolated and unique aviation logistics parks. In other words, there is still a lack of targeted research on the layout of new airport air logistics parks in "multi-airport" cities.

1.2 The selection of the research subjects

The CDTF airport was selected for this study, which is located on the Airport Avenue in Lujia Town, Janyang City, Chengdu, Sichuan Province, China, and is a 4F international airport, an international aviation hub and the main hub of the Chengdu International Aviation Hub. It is located in Sichuan Province, which is an important economic, population and resource province in the western region. In 2022, the passenger throughput of CDSL airport, which is located in the same city as CDTF airport, has reached 17.81 million passengers, ranking sixth in China, and the cargo and mail throughput has reached 529,000 tons, ranking seventh in China. In the future, a dual hub civil airport network system with CDTF airport and CDSL airports will be formed, driving the development of branch airports and connecting major cities around the world and radiating the national airline network (CAAC 2022, 25-28+63).

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1.3 The objectives of this study

The purpose of this paper is to do research of the layout planning of air logistics parks in CDTF airports, in line with the trend of "multi-airport", and to conduct a targeted study on the air logistics parks in one of the new airports in China's newest "multi-airport" cities, in order to provide a reference for future related research (table 1).

Table 1. Overlay matrix

Emphasis	Theoretical framework(chapter)	Results(chapter)
1. What can be the result of the layout planning of logistics park?	2.2	5.1
2. What are the results of the study with SLP?	3.1	5.1
3. What kind of strategy does the trend of multi-airport require?	2.1	5.2

2 Theoretical framework

This chapter establishes the validity of this study by analyzing the necessary trends in the development of multi-airports purposefully. This chapter selects the SLP approach by comparing different approaches to the layout planning of air logistics parks. They support each other and build a scientific theoretical framework.

2.1 Multi-airport

This section includes a definition of multi-airport, case studies and a description of the necessary trends in its development. However, there are relatively few relevant studies and a certain research gap still exists.

2.1.1 Definition of Multi-airport

There are two interpretations of multi-airport. One interpretation is that a region has more than one airport. This interpretation is based both on the IATA airport code management system and on research by international research institutions on the planning, management and operation of mult-airport, such as the five airports in the Greater London area of the UK, namely Heathrow (LHR), Gatwick (LGW), Stansted (STN), Luton (LTN) and London City Airport (LCY). Another is that a city has two or more airports, such as San Francisco International Airport (SFO), Oakland Airport (OAK) and San Jose Airport (SJC)(Richard de Neufville. 1995, 99-110.) .

2.1.2 Multi-airport case study

The existing literature combined with the international multi-airport cases from the aspects of construction, operation, coordination and so on.

From the perspective of construction, Zhu Fanghai, Ling Jianming, Hao Voyage, and Chen Li (2007, 57-61+64) put forward that local economic indicators, capacity indicators, capacity allocation indicators and selection indicators should be considered simultaneously when building multi-airport. From the perspective of operation, Cai Wenting (2020, 9-11) divided multi-airport into two situations of "one main and one auxiliary" and "two hubs" based on the functional orientation and operation market types of airports. From the perspective of internal relations of multi-airport system, Qiao Yingli and Ge Chunjing (2020, 13-16 +27) pointed out the imbalance within multi-airport system and puts forward suggestions for coordination in various aspects..

2.1.3 The inevitable trend in multi-airport development

With the rapid development of airports worldwide and the strong demand for airport construction and expansion, the multi-airport model is becoming more and more common in the vast majority of mega or large cities around the world. All major cities (regions) with an annual passenger traffic of 10 million have several airports serving their air traffic. Although there are still a significant number of cities that, for reasons of urban development, are only expanding their existing airports in the short term and have no plans to build them, it is foreseeable that most of them will build more airport in the near future to meet the demand for air transport.

2.2 Overview and selection of methods for the study of air logistics parks and their planning

This section defines the air logistics industry and air logistics parks at first, then introduces different approaches to the layout planning of air logistics parks in the light of historical development and methodological evolution, and finally selects the research method applicable to the case of this paper by comparison.

2.2.1 Definition of air logistics and air logistics parks

Air logistics refers to the use of air transportation, which means providing enterprises with product transportation services and the formation of the industrial chain of storage, classification, sub-assembly and distribution of products on the ground. Air logistics in the process of operation to provide users with a high level of transport services, expand the scope of circulation of enterprise products, and promote the rapid development of enterprises (Shan Lianhong 2016,184-185.)

The aviation logistics park refers to a specific area, with the aviation logistics service provider as the main body, the airport company to provide airport ramp ground services and management as the leading, with customs, quarantine and inspection and other port management functions as the characteristics, with government investment in the construction of logistics hub facilities, information management platform and management departments, etc. as the necessary service guarantee platform, with its services to high-tech industries, express delivery industry, aviation-oriented industries It is a logistics industry cluster area with multiple subjects and related organizations. It provides specific logistics services with industries such as express delivery industry and aviation-oriented industries as service targets (Li Tianyu 2014,56-58+71.)

2.2.2 Approach to logistics park layout planning

In the early days of logistics park planning, qualitative design methods were commonly used, but this empirical method inevitably resulted in the waste of various resources. Later, some scholars gradually tried scientific, qualitative and quantitative methods to solve the layout planning problems and achieved remarkable results.

When conducting targeted studies on layout planning, the System Layout Planning method proposed by scholars represented by Richard Muther (1973) is more relevant.

The method has been optimised and improved in the course of its development and completeness, and its scope of use has been expanded while maintaining the relevance of the research problem: Over time, the layout has expanded from a workshop planning layout when it was proposed to include logistics companies, traditional logistics parks and air logistics parks.

Ju Ke and Wang Zhuan (2006,79-81) proposed the SLP method for the layout of logistics facilities for process-oriented enterprises and used cases to verify the feasibility of the method. Song Zhuo-Ning (2010,50-52) used an improved SLP method with control structure to analyse and did a study in the Nanning International Logistics Park to make its layout more reasonable. Zhang Chen (2014,18) used the SLP layout method and estimation method to analyse the basic structure under different modes of transport and made corresponding suggestions for the layout planning and development of the aerodrome logistics park at Shenzhen Airport.

At the same time, as research time progresses, there are also many scholars who use modelling methods and apply some mathematics-related theories such as models and algorithms to the layout planning of logistics parks.

Cagan (1998, 33-38) first utilized a simulated annealing algorithm based on a hierarchical model for the layout planning of a logistics park.C.Papahristodoulou (2004, 55) focused on a binary linear model and proposed an optimization scheme based on it. Meller, Chen, W & Sherali, H.D. (2007, 651-659) elaborated on the process of facility layout using sequences for logistics park models. Leek Y, Francisco Mota Filho et al. proposed the application of genetic algorithms to the related field of aviation logistics park layout planning. (Leek Y, Rohm I & Jeong H.S2005, 116-119; Francisco Mota Filho2008, 161-180.) Schol, D, Petrick, A & Domschke, W (2009, 166-178) proposed using split trees to plan functional areas and used table search to find the optimal solution a new idea. Wong Kuan Yew & Komarudin (2010, 5523-5527) solved a related problem using an ant colony system by analyzing the relationship between the locations of different sized functional areas in a flexible spatial layout park.

In recent years, with the popularity of computer simulation technology, scholars have added this technology to the study of logistics park layout planning, and it has helped to make the planning and layout of aviation logistics parks more standardized and effective.

Zhou Hong, Ou Jianxin, and Li Zhengdao (2008,3314-3319) applied simulation PlatianFuorm e M-Plant to carry out simulation modelling to identify the main factors that constrain the flow of logistics activities and make suggestions for the layout planning of cargo centres. Ji Yue (2016,19) used Petri to model Tianjin Airport and used the TINA simulation tool to assign simulation experiments to demonstrate the optimisation of layout planning on cargo business processes at Tianjin Airport.

2.2.3 Method selection

At the same time, through different studies, it can be seen that it is different from other studies that only regard layout planning as a part or part of the study, SLP focuses most on specific layout planning, which is highly logical and practical and is widely used in the layout of facilities, so this research will choose SLP.

In the following chapters, SLP is described in more detail and complete.

3 Method

This chapter analyses the SLP method based on the selection of methods in the previous chapter and describes the data sources involved in this study.

3.1 SLP methodology

After choosing SLP, this chapter explains the proposal and improvement of SLP, and also introduces the application scenarios and expansion of SLP with the passage of time and its practical application.

3.1.1 Presentation and addition of the SLP method

The method of System Layout Planning (SLP) was first proposed by Richard Muther (1973), a famous American planner, who used a structured and organized planning model based on logistical and non-logistical factors of the operating unit, and used diagrams, symbols and tables as the main means of presentation for facility planning. This was the first time for SLP method to be developed, and it has been refined and supplemented by scholars since then, taking into account specific problems.

Zhang Chengqian (1995,45-50) made a discussion on the application of SLP method in the technical transformation and production layout adjustment of enterprises. Liu Wansheng and Lan Peizhen (2006,82-85) analyzed the shortcomings of the SLP method and, on the basis of the basic theory, proposed a dynamic SLP method suitable for modern enterprises. Zhu Canghui (2013,25) added external traffic control points to the analysis by improving the SLP.

In addition to improvements to the SLP method itself, scholars have combined it with other methods and models.

Wang Xiping (2008,18-20) combined it with the graphical and Corelap methods; Zhang Dongyu (2021,27-30) used both the SWOT method, the hierarchical analysis method and the integrated grey judgement method. Wu Tingting (2014,11) used the framework of MSFLB to jointly analyse it with FlexSim dynamic simulation software; Zhao Yue (2017,18-27) combined Petri net model and EXSPECT software simulation while using the SLP method; Lei Chunlong (2021,11-17) used the modified SLP method to construct a raster model and combined the grey prediction model, genetic algorithm and weighted grey correlation method for related research.

With the continuous improvement and development of the SLP method, it has developed into one of the classical paths for facility planning and has gradually expanded its use.

3.1.2 The scope of application of the SLP method in its early days

In the early days, although the scope of SLP research was expanded, it was still limited to the traditional logistics park layout planning.

Song Zhuo-Ning (2010,50-52) conducted an analytical study of the Nanning International Logistics Park to make its layout more rational. Tang (2010,21) planned the layout of the Jingbei Logistics Park. Dalalclayton B (2013,1553-1557) analyzed a chemical logistics park by considering the functional areas of the park as a dynamic linkage and designed the layout planning for it..

3.1.3 Application of the SLP method in the layout planning of traditional logistics parks

In terms of temporal development, the the SLP method was mostly improved in the early stages of its development by the expansion of its research scope. At a later stage, its improvements were mostly motivated by linkage and integration with other methods or techniques.

Studies on the layout planning of air logistics parks using the SLP method alone are more common in the early stages of their scope expansion.

Luan Feng, Li Bin and Yang Xiaochun (2005,67-71) used the SLP method to determine the functional positioning and functional area layout of the Qingdao Chengyang District Airport Logistics Park, taking into account the actual situation of Chengyang District. Zhou Zhuodan, Xu Yuefang and Chen Weiwei (2006,82-83) analyzed Hong Kong's airport logistics and used the SLP method to provide feasible suggestions for the construction of an aviation logistics park in China's inland areas. Li Suyan and Zhang Yue et al. (2006, 94-96) designed a layout planning scheme for the Pudong Airport Logistics Park. Hu Xiao and Qian Yuan (2013,28-30) explored the interrelationship between the functional areas and planned the spatial layout of Zhengzhou Airport Logistics Park.

When the research developed to a more recent period, scholars more often combined it with new methods and techniques for analysis.

Bai Yuhui (2016,27) used the grey prediction GM(1,1) model to make quantitative forecasts of air cargo demand, introduced external regional conditions, optimized the SLP and proposed a general layout plan for the northern cargo area. Zhao Yue (2017,18-27) chose Petri modelling, EXSPECT software simulation, and applied the SLP method and its optimization method to plan the layout of the internal functional area of the domestic air express centre of the new Beijing airport. Lei Chunlong (2021,11-17) used an improved SLP method to construct a raster model and used a grey prediction model, genetic algorithm and Flexsim software to plan the space of the Tianjin Air Logistics Park. Zhang Dongyu (2021,27-30) combined the SWOT method, GM(1,1) model and GM(0,N) model, and improved the correlation weights of SLP by hierarchical analysis and grey comprehensive evaluation method to arrive at the optimal solution.

3.1.4 Application of SLP method in the layout planning of aviation logistics parks

In application, the process of the SLP method is as followed.

Firstly, the functional division of the object of study is confirmed by a general analysis of the object. This is followed by the determination of the layout planning principles in the study and the analysis of the logistics object P, the material flow Q, the logistics process R, the auxiliary service sector S and the logistics technology T of the study object. The analysis is then carried out using excel tools in terms of the logistical, non-logistical and integrated relationships between the functional areas. Finally, based on the above analysis, the importance of the interlinkages between the functional areas is confirmed and the relative location of the layout plan is drawn.

The SLP method was not applied to the layout planning of logistics parks when it was first proposed, but with its development and evolution, it gradually became an important method for the layout planning of logistics parks and was applied to the functional area layout planning of aviation port logistics parks with the development of traditional logistics parks. During the development of SLP, researchers have organically combined it with different methods and improved it to varying degrees according to demand, supplementing and innovating it. This has broadened the scope of use of the SLP method, kept it up to date and better adapted to production needs.

However, the research object of the SLP method in the layout planning of aviation logistics parks is usually a single, independent airport aerodrome, so there is still the problem of a single research object.

The aim of this paper is to broaden the scope of its application and to provide a reference for the layout planning of the second airport aerodrome logistics park in a dual-airport city.

3.2 Data

The parts of the study that require the use of data are the analysis of the material flows Q and the analysis of the logistical relationships between the functional areas.

In the section on material flows, the forecasted material flows for the next few years are used, and in the analysis of inter-functional logistics relationships, the inter-functional logistics flows are used.

However, in this study, as a new airport, CDTF has not yet been able to obtain relatively constant and informative data on the volume of material flows and inter-functional logistics.

The predicted value of logistics flow Q will be based on recent data from CDSL Airport (CAAC 2022, 12-14), combined with data from other dual-airport cities in China, and obtained using a linear and non-linear relationship scatter plot method.The logistics traffic between functional areas will be roughly calculated by referring to the proportion of express traffic in the logistics park of CDSL airport and combining it with the daily inbound cargo traffic of CDTF airport (table 2).

Table 2. Table for data source and destination

Required data	Forecast data	Source for Forecast data	Predicted data usage (chapter)
Predicted Value of CDTF Airport Logistics Flow Q	Logistics volume of CDSL airport and China's dual airport cities	Statistical Bulletin on the Development of the Civil Aviation Industry in 2021	4.2.2
Predicted logistics flow between functional areas in the CDTF Airport Logistics Park	The proportion of express delivery traffic in the CDSL airport logistics park & the predicted value of CDTF airport logistics traffic Q	Statistical Bulletin on the Development of the Civil Aviation Industry in 2021	4.3.1

As this part of the forecasting process is more cumbersome and complex, and the related process is not very relevant to the main body of this study, the specific forecasting steps will be omitted in the course of the subsequent text, and the specific data will be given directly.

4 Empirical part

This chapter is the main part of the text and contains sections on background analysis, functional area division, SLP analysis and deriving a schematic layout plan.

4.1 Functional orientation and functional division

This section includes an analysis of CDTF Airport and a delineation of the functional areas, which is a prerequisite for completing the analysis of this study.

4.1.1 Overall background analysis

CDTF airport Logistics Park Location Analysis

(1) Obvious location advantages

Opening up to the west has become an important strategy for the country's opening up to the outside world, and the Chengdu Airport Economic Zone is located at the strategic intersection of the "One Belt and One Road" and the Yangtze River Economic Belt, as well as an important node of the Eurasian shipping route. The city has the advantage of being the most convenient window for opening up to the west, leading Sichuan Province and even the western region to accelerate its integration into the global economic map.

(Dong Qiming 2019,11-27.)

(2) Strong support for the development of air-side economy

Sichuan Province is an important economic, population and resource province in the western region. In 2015, the passenger throughput of CDSL Airport reached 42.24 million, ranking fourth in China, and the cargo and mail throughput reached 557,000 tons, ranking fifth in China. In the future, a combined dry and branch civil airport network system will be formed with CDTF Airport and CDSL International Airport as the twin hubs, driving the development of regional airports, as well as a route network connecting major cities around the world and radiating across the country.

(Wu Weili 2019,34-39.)

2. CDTF Airport Aviation Port Logistics Park Policy Analysis

In order to better promote the development of the express industry and air logistics, the National Postal Administration promulgated the "Thirteenth Five-Year Plan" for the development of the express industry, proposing nine major projects such as the air express hub project and the construction project of the express professional logistics park to promote the prosperous development of the express industry. In the 13th Five-Year Plan report of the Civil Aviation Administration of China, it is also clearly stated that the development of air logistics industry should be promoted and the professional level of air express should be enhanced.

(Liu Danli 2018,23-24.)

The "Support Policy for Accelerating the Construction of Chengdu's Air Cargo Hub" issued in 2020 explicitly promotes the development of air cargo transshipment business in Chengdu. Prior to this, Chengdu held a high-profile conference on the development of advanced productive services, proposing a new positioning of the city as a "strategic hub for the allocation of global service resources", of which air transport is a key part. In September 2020, the Development and Reform Commission and the Civil Aviation Administration issued the "Opinions on Promoting the Development of Air Cargo Facilities", which explicitly promotes the international competitiveness of air cargo enterprises and the sustainable and healthy development of the civil aviation and logistics industries.

(National Development and Reform Commission 2020,3-4.)

4.1.2 Functional area division

Based on the planning of the park, combined with the infrastructure required by the park, and with reference to the division of the functional areas of the relevant parks in China and the current development status of CDTF Airport, this paper divides the CDTF Airport Air Express Industrial Park into the following six functional areas: bonded warehousing area, domestic express processing area, international express transit area, special cargo processing area, comprehensive supporting area, and information service area.

(Guo Feiyu 2019,24-35)

(1) Bonded Warehouse Zone. It mainly provides bonded warehousing services for imported and exported goods, and also provides a complete set of logistics services such as transportation, processing and trade for the logistics activities of domestic and foreign enterprises.

(2) Domestic Express Processing Zone. It is mainly a processing place for domestic express delivery, providing air express delivery services for domestic customers, including sorting, distribution and forwarding services.

(3) International express transit area. It is mainly a processing place for international express, providing customs supervision function for international express, as well as sorting, distribution and transshipment services for international express, etc.

(4) Special cargo handling area. In the process of express security inspection, the area for temporary handling of non-standard and non-identifiable expresses as well as valuable goods and fresh products that appear need to be temporarily stored in this area and wait for staff to handle them before entering the relevant area.

(5) Comprehensive support area. A living area that provides basic livelihood protection for the visitors and staff in the port area, including accommodation, shops, hospitals, car parks, etc.

(6) Information service area. Provide strong information services as a guarantee place. Including each warehouse logistics information, freight flight information, customs clearance enquire, inspection enquire, customs clearance operations and centralized analysis of weather conditions and surrounding traffic conditions information notification.

4.2 Analysis of layout planning principles and basic elements

This section identifies the guiding basis and principles for the layout planning of CDTF Airport in the context of this case, and provides a qualitative elemental analysis.

4.2.1 Layout planning principle

The layout planning of the CDTF airport Logistics Park is different from the traditional logistics park layout planning. To ensure the normal operation of the functional areas, the normal operation of the park and the reduction of operating costs, the layout planning needs certain principles and requirements as a guiding basis.

(Li Xin, Jin Kemei & Li Sirui 2020,190-192)

Therefore, based on the above, this paper summarizes the previous research results and concludes that the layout planning and construction of CDTF airport Logistics Park follows the following five major layout planning principles:

1. The principle of proximity and priority

It is the most important and the main principle that must be followed in the SLP method and is it needs to be observed in any case of the SLP method. It means that: in the planning process of the park, the interrelationships between the functional areas and the size of the logistics flows between them need to be determined. Also, it means that functional areas with a high degree of relevance and a high volume of logistics traffic should be placed close to each other, and vice versa, at a distance .

2. The principle of sustainable development

The principle of sustainable development, as the mainstream guiding direction for the layout planning of an aerodrome logistics park, is likewise a principle needs to be observed in all circumstances. Since the logistics park will be used for a long period of time after planning and construction, a reserved area should be set up in the park at the beginning of planning and construction to provide a certain amount of flexible operation space so that it can continuously adapt to and serve the needs of local development.

3. Principle of meeting environmental requirements

Against a background of high environmental requirements in all sectors, the principle of meeting environmental requirements meets the requirements of green and environmental protection and guides the logistics park to reduce pollution of the environment. In the process of planning the layout of the functional areas of the aviation express industrial park, priority should be given to environmental factors, and functional areas that may produce environmental pollution during use should be kept away from living and water areas, in response to the call for green development.

4. Safety and standardization principle

It is an important principle in the layout planning of logistics parks to ensure that they can be implemented effectively. A safe and standardized logistics operation process is the top priority in the layout planning of the air express industrial park. In the layout planning, a set of strict logistics operation process needs to be formulated to ensure that the logistics operation is safe, efficient and reasonable.

5. The principle of flexibility

The principle of flexibility is also essential as a means of identifying gaps and making adjustments during the layout planning process. In the process of planning the layout of the functional area of the air express industrial park, there may be many uncertainties, so in the specific layout should be adjusted according to the actual situation.

4.2.2 Basic element analysis

1. Logistics object (P)

In CDTF airport Logistics Park, the logistics objects are goods imported and exported from the logistics park, including domestic and international express, such as business documents, information, textiles and raw materials, equipment and instruments, daily necessities, electronic spare parts, fresh food, etc.

2. Cargo flow (Q)

Based on the data of CDSL Airport in recent years(CAAC 2022,12-14), combined with the analysis of the data of the remaining domestic dual airport cities, the method of scatter diagram of linear and non-linear relationship is used to obtain the predicted volume of CDTF Airport Aerodrome Logistics Park in the next 8 years, the express volume of CDTF Airport Aerodrome Logistics Park in 2030 is about 17 million tons. This paper applies the system layout design method to CDTF Airport The express volume of the aerodrome is analyzed in terms of the daily express volume of the park, i.e. the daily express volume of the park is 46,573.40 tonnes.

3. Logistics process (R)

This article combines the layout of the aviation logistics park of CDSL Airport, the first airport in Chengdu, and designs the main logistics operation functional areas of CDTF Airport Logistics Park as bonded storage area, domestic express processing area, international express transfer area, comprehensive supporting area, information service area, and special cargo handling area in the functional area design, Thus, on the basis of ensuring the improvement of the functional area of CDTF Airport's own aviation logistics park, we can better cooperate with the business of First Airport. For the express delivery in and out of the park, the management department in the park is required to make unified arrangements for them. For express shipments entering the park, some enter the domestic express handling area for direct distribution, some enter other areas for storage, and international express shipments enter the international express transit area for sorting. For express shipments leaving the park, after security checks are required, part of them will enter the special cargo handling area for the next operation, and the other part will enter the domestic express handling area for distribution or enter the international express transit area for transfer .

4. Ancillary Services Sector (S)

The auxiliary departments of CDTF airport Logistics Park are mainly contained in the comprehensive supporting area and the information service area of the Airport Logistics Park, which provide the necessary support and guarantee for the smooth completion of logistics activities and are indispensable functional departments for the development of air express cargo in the park, and are also important factors that should be considered in the layout planning process.

5. Logistics technology (T)

he logistics technology is difficult to show in the planning of the air express industrial park. Logistics technology-related facilities exist in all aspects of the air terminal and contribute to its proper functioning. Therefore, non-logistics relationships are also primarily considered in the layout.

4.3 Functional area correlation analysis

This section analyses the degree of association between the functional areas of CDTF Airport in terms of their logistical, non-logistical and integrated relationships, and uses the SLP method to polarize the degree of association.

4.3.1 Correlation analysis of logistics in functional areas

Determining the logistics interrelationships between the functional areas of the CDTF airport Logistics Park is a key step in the application of the Systematic Layout Design method to layout planning and determines whether the final layout plan is reasonable.

1. Flow of goods between functional areas

The analysis of the logistics interrelationship between functional areas begins with the determination of the flow of goods between the various functional areas in the future CDTF airport Logistics Park. The flow from to table is the simplest and most direct way to reflect the direction of the flow of goods and the flow of goods between functional areas. Based on the average daily courier volume of 46,573.40 tonnes at CDTF Airport in 2030 as predicted , combined with its daily inbound cargo flow, and with reference to the percentage of courier flow between functional areas in CDSL Airport Logistics Par, the flow of cargo between functional areas in the park can be roughly calculated. The "row" is the "from", which indicates the source of cargo flow, and the "column" is the "to", which indicates the aggregation. Therefore, the logistics flow between the functional areas of Tianfu International Air Express Industrial Park can be derived from to table (table 3).In the table, function Area 1 represents the domestic express handling area, Function Area 2 represents the international express transit area, Function Area 3 represents the special cargo handling area, Function Area 4 represents the bonded storage area, Function Area 5 represents the comprehensive supporting area and Function Area 6 represents the information service area.

Table 3.From to table for CDTF Airport Aerodrome Logistics Park functional area between express traffic (tonnes)

to / from	1	2	3	4	5	6	total
1	-	16919.89	8459.95	0.00	0.00	0.00	25379.84
2	6768.53	-	990.94	2368.55	0.00	0.00	10128.02
3	3383.78	1127.93	-	0.00	0.00	0.00	4511.71
4	3158.39	3395.44	0.00	-	0.00	0.00	6553.83
5	0.00	0.00	0.00	0.00	-	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	-	0.00
total	13310.70	21443.26	9450.89	2368.55	0.00	0.00	46573.40

2. Levels of logistics intensity between functional areas

The next step is to determine the logistics intensity level between each functional area. Logistics intensity refers to the proportion of the total volume of the park occupied by the logistics operation area in the average cycle, the greater the proportion value, the greater its logistics intensity, and the closer the logistics intensity grade is to A grade; conversely, the logistics intensity grade is farther away from A grade. For functional areas without express flows between them, the grade between them is U level (table 4).

Table 4.Table for logistics intensity classification

Level	Description of the degree of relevance	Proportion of total logistics (%)
A	Ultra-high strength	＞20
E	Extra High Strength	10-20
I	Higher strength	5-10
O	Normal strength	5＜
U	Negligible strength	0

According to Table 3 and Table 4, by calculating the proportion of material flow between functional areas to the total amount of the park, we can obtain a table of the classification of logistics intensity levels between logistics functional areas (table 5).

Table 5.Table for CDTF Airport Aerodrome Logistics Park Functional Area Logistics Intensity Level Classification

Flow Direction	Material flow (tonnes)	Percentage (%)	Level
Domestic Courier Handling Area - International Courier Transit Area	23688.42	50.86	A
Domestic Express Handling Area - Special Cargo Handling Area	11843.73	25.43	A
Domestic Express Processing Area - Bonded Storage Area	3158.39	6.78	I
International Express Transshipment Area - Special Cargo Handling Area	2118.87	4.55	O
International express transit area - bonded warehousing area	5763.99	12.38	E

3. Logistics intensity relationship diagram between functional areas

Finally, according to Table 5, we can obtain the logistics relationship intensity correlation diagram between functional areas of CDTF Airport Aviation Port Logistics Park (Figure 1).

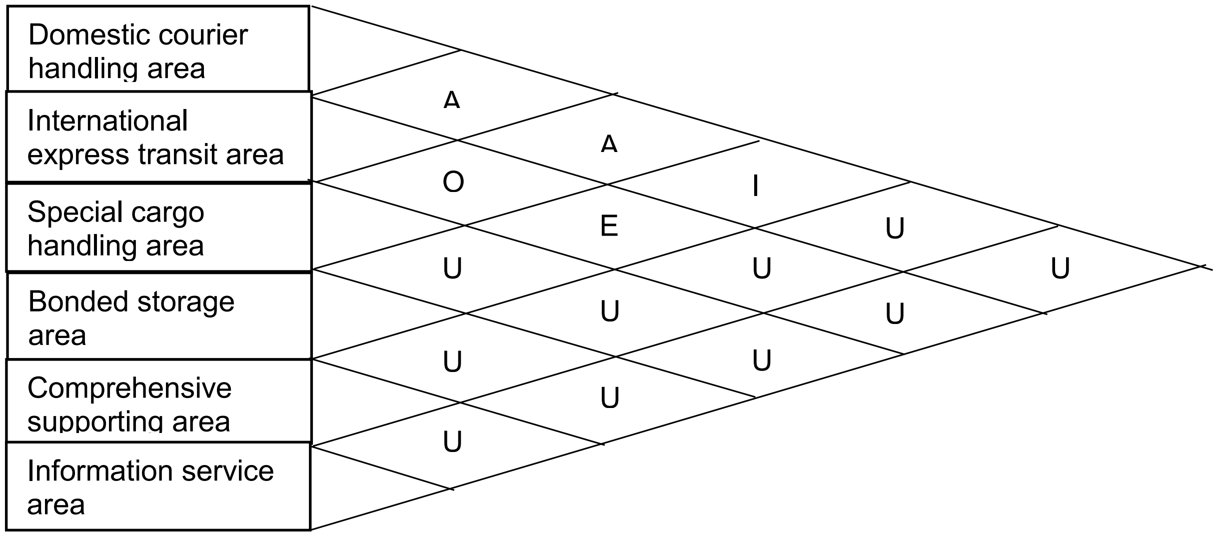

Figure 1. CDTF airport Logistics Park functional area logistics relationship intensity related map

4.3.2 Correlation analysis of non-logistics in functional areas

When applying the system layout design method to the functional area layout planning of the CDTF airport Logistics Park, the logistics relationship between the functional areas cannot only be considered, but also the non-logistics relationship of the park needs to be analyzed, such as the environmental factors within the park and the flow of staff, etc. The reasonableness of the layout of the CDTF Airport Air Express Industrial Park depends on the logistics relationship and non-logistics relationship. Therefore, the analysis of the non-logistics interrelationships between the functional areas is crucial. According to the actual situation of CDTF airport Logistics Park, this paper mainly analyses and studies the non-logistics relationship of functional areas from the following six influencing factors (table 6).

Table 6.Table for factors influencing non-logistic relations

No.	Non-logistics related factors
1	Logistics related, continuity
2	Similarity of logistics operations
3	Frequency of logistics operations
4	Logistics handling
5	Ease of supervision, management
6	Environmental issues

According to Table 6, a hierarchy of non-logistic relations in functional areas is classified (table 7).

Table 7.Functional Area Non-Logistics Relationship Scale

Level	Meaning
A	Absolutely important
E	Particularly important
I	Important
O	Generally close
U	Unimportant
X	Unapproachable

To some extent, the above non-logistics factors are similar to logistics factors, and will also affect the efficiency of logistics operations within the park in some ways.

Between the international express transit area and the bonded storage area, logistics operations are more frequent and of high continuity, so they are closer, hence the choice of grade A. Between the international express transit area and the domestic express handling area and the special cargo handling area, more handling operations are involved, the logistics intensity is high and the layout location is close, hence the choice of grade E. Between the domestic express handling area and the special cargo handling area and the bonded storage area and Between the information service area and the domestic express handling area and the international express transit area, it mainly involves the handling, dismantling, security inspection and reprocessing of goods, and there are not many goods, so I grade is chosen; between the special goods handling area and the bonded storage area, there are similarities in logistics operations, so O/2 grade is chosen. Between the information service area and the comprehensive supporting area, bonded warehousing area and special cargo handling area, the flow of people is large, the flow of goods is small, the location can be appropriately remote, so choose O/5 grade; comprehensive supporting area and bonded warehousing area and express domestic processing area, comprehensive supporting area and bonded warehousing area, special cargo handling area, international express transit area, domestic express processing area, does not involve handling activities, therefore U class is chosen.

The relationship analysis diagram of the non-logistics relationship between the functional areas of the CDTF airport Logistics Park was obtained through the appeal analysis (Figure 2). The numbers in the diagram represent the corresponding influencing factors in Table 4 that play a major role in this functional area pair, and the letters represent the corresponding classes in Table 7.

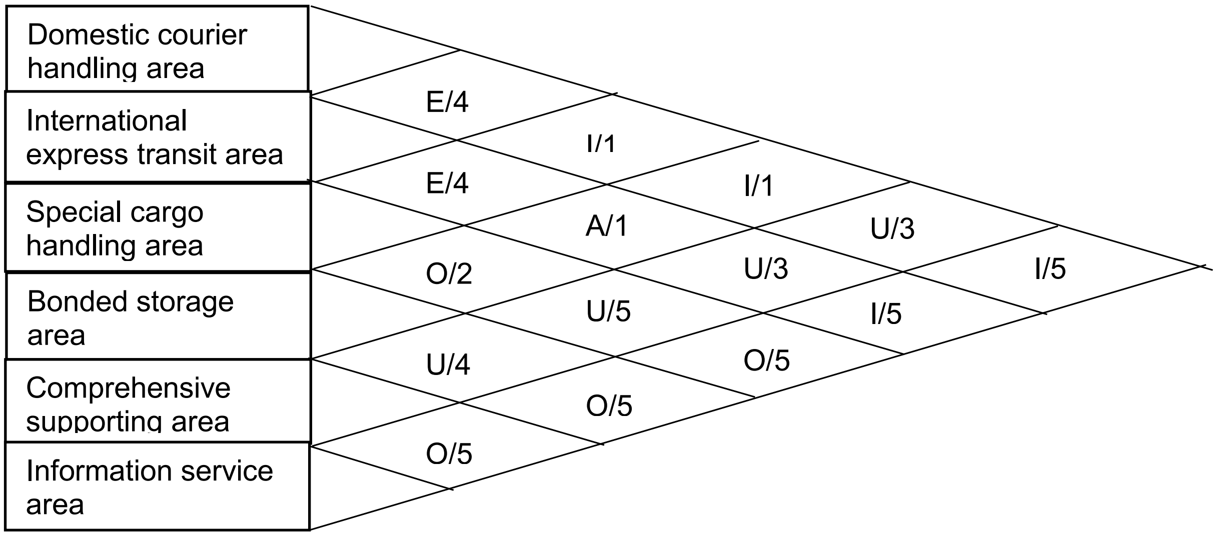

Figure 2. CDTF airport Logistics Park functional area non-logistics relationship intensity related map

4.3.3 Comprehensive relationship analysis of functional areas

In the actual layout planning process, the logistical and non-logistical relationships between functional areas cannot be split and analysed; the integrated relationships between functional areas should be focused on and the two should be considered together. The specific steps for determining the level of integrated relationships are as follows:

Firstly, quantify the logistics relationship level and non-logistics relationship level based on each functional area (Table 8).

Table 8.Scale and quantification of the integrated relationship level of functional areas

Level	Meaning	Percentage (%)	Quantification values
A	Absolutely important	2-5	4
E	Particularly important	3-10	3
I	Important	5-15	2
O	Generally close	10-25	1
U	Unimportant	45-80	0
X	Unapproachable		-1

Secondly, in the layout planning of the system layout design method, the weighting ratio of logistics relations and non-logistics relations needs to be determined. As to CDTF airport Logistics Park is a professional logistics park with logistics occupying a dominant position, 3:1 is chosen as the ratio of logistics and non-logistics relationship weights in the park, i.e. logistics relationship takes m=3 and non-logistics relationship takes n=1. According to the formula, $CR_{ij} = mMR_{ij} + nNR_{ij}$, and the logistics relationship scores and non-logistics relationship scores between each functional area, and quantify them according to the above weights analysis, we can obtain the quantitative analysis table of the comprehensive relationship between the functional areas of Dalian Air Express Industrial Park (Table 9).Among them, Function Area 1 represents the domestic express handling area, Function Area 2 represents the international express transit area, Function Area 3 represents the special cargo handling area, Function Area 4 represents the bonded storage area, Function Area 5 represents the comprehensive supporting area and Function Area 6 represents the information service area.

Table 9. Quantitative analysis table of integrated functional area relationships

PorTianfuolio of functional areas	Logistics relationship levels	Logistics relationship score	Non-logistics relationship levels	Non-logistics relationship score	Integrated relationship score
1-2	A	4	E	3	15
1-3	A	4	I	2	14
1-4	I	2	I	2	8
1-5	U	0	U	0	0
1-6	U	0	I	2	2
2-3	O	1	E	3	6
2-4	E	3	A	4	13
2-5	U	0	U	0	0
2-6	U	0	I	2	2
3-4	U	0	O	1	1
3-5	U	0	U	0	0
3-6	U	0	O	1	1
4-5	U	0	U	0	0
4-6	U	0	O	1	1
5-6	U	0	O	1	1

Finally, according to the comprehensive relationship scores in Table 9, and according to the proportional division in Table 6, we can obtain the comprehensive relationship level determination table of CDTF Airport Air Express Industrial Park functional area (Table 10).Among them, Function Area 1 represents the domestic express handling area, Function Area 2 represents the international express transit area, Function Area 3 represents the special cargo handling area, Function Area 4 represents the bonded storage area, Function Area 5 represents the comprehensive supporting area and Function Area 6 represents the information service area.

Table 10. Table for determining the integrated relationship level of functional areas

Score	Number	Percentage of total(%)	Percentage cumulative (%)	Level	PorTianfuolio of functional areas
15	1	6.67	6.67	A	1-2
14	1	6.67	13.33	E	1-3
13	1	6.67	20.00	I	2-4
8	1	6.67	26.67	O	1-4
6	1	6.67	33.33	O	2-3
2	2	13.33	46.67	U	1-6，2-6
1	4	26.67	86.67	U	3-4，3-6，4-6，5-6
0	4	26.67	100.00	X	1-5，2-5，3-5，4-5
Total	15				

From this it is possible to draw a diagram of the intensity of the integrated relationship between the functional areas (Figure 3)

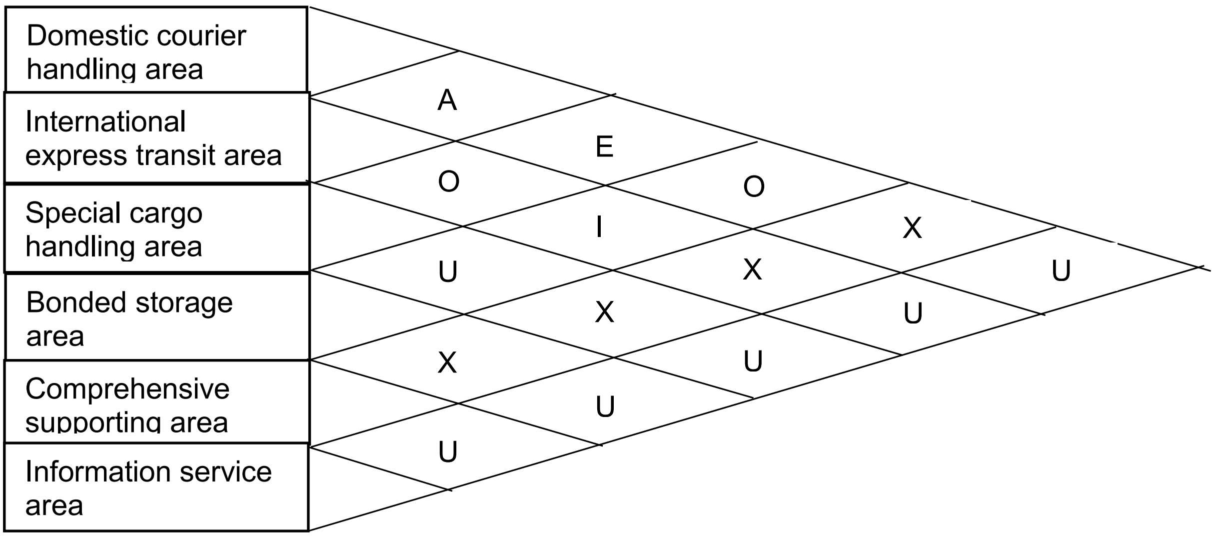

Figure 3. CDTF Airport Aerodrome Logistics Park Functional Area Comprehensive Intensity Related Map

4.4 Determination of relative position of functional area

Through the analysis of the logistics relationship and non-logistics relationship between the functional areas of CDTF Airport Logistics Park, the strength level of the comprehensive relationship between the functional areas in the park was determined, and then the relative position relationship of each functional area was determined according to the relevant principles of layout planning. According to the relevant map of the strength of the comprehensive logistics relationship of the functional area of CDTF airport Logistics Park, combined with the corresponding score of each level, the score value is calculated, and the layout planning order table of each functional area can be obtained after sorting (Table 11).Among them, Function Area 1 represents the domestic express handling area, Function Area 2 represents the international express transit area, Function Area 3 represents the special cargo handling area, Function Area 4 represents the bonded storage area, Function Area 5 represents the comprehensive supporting area and Function Area 6 represents the information service area.

Table 11. Table for ribbon sort order

-	1	2	3	4	5	6
1	-	A/4	E/3	O/1	X/-1	U/0
2	A/4	-	O/1	I/2	X/-1	U/0
3	E/3	O/1	-	U/0	X/-1	U/0
4	O/1	I/2	U/0	-	X/-1	U/0
5	X/-1	X/-1	X/-1	X/-1	-	U/0
6	U/0	U/0	U/0	U/0	U/0	-
Accumulate points	7	6	3	2	-4	0
Plan the order	1	2	3	4	6	5

Next, according to the functional area planning order in Table 9, the relative position of the functional area of CDTF airport Logistics Park is plotted. When drawing, it is necessary to connect the various functional areas with different icon lines, referring to the relationship hierarchy identification icon table (Table 10).

Table 12. Table for relationship hierarchy identification icon

Level	A	E	I	O	U
icon lines					

4.4.1 The comprehensive relationship is the layout planning of the functional area of grade A

Referring to Figure 3, in the layout planning of the functional area of CDTF airport Logistics Park, priority is given to the functional area with comprehensive relationship strength of grade A, according to the planning order, it is necessary to determine the layout location of the domestic express processing area first, and the relative position map of the domestic express processing area and the international express transit area can be obtained (Figure 4).

Figure 4. A-level functional area location relationship map

4.4.2 The comprehensive relationship is the layout planning of the functional area of grade E

Similarly, referring to Figure 3, in the layout planning of the functional area of CDTF airport Logistics Park, find the functional area with comprehensive relationship strength of E grade for planning, according to the planning order, it is necessary to first determine the layout location of the domestic express processing area, and the relative position of the domestic express processing area and the special cargo processing area can be obtained. On the basis of the above figure, after adding the E-level functional area, a relative position map can be obtained (Figure 5).

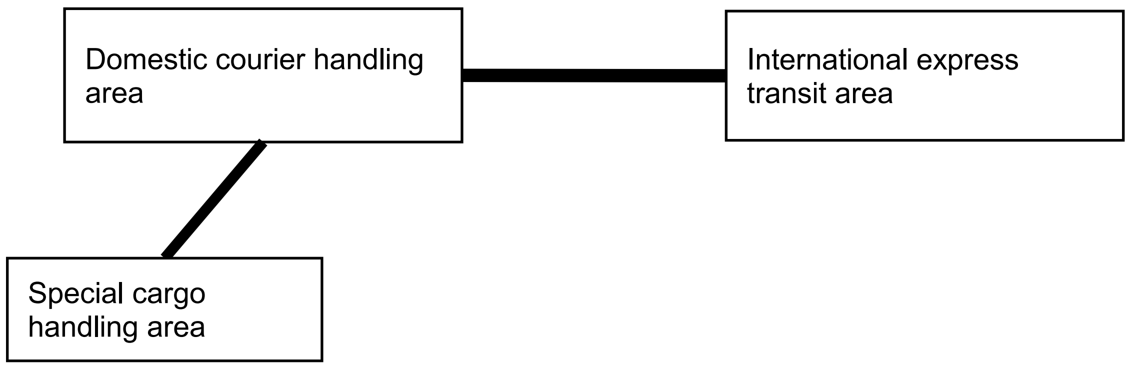

Figure 5. E-level functional area location relationship map

4.4.3 The comprehensive relationship is the layout planning of the functional area of grade I

Similarly, referring to Figure 3, in the layout planning of the functional area of CDTF airport Logistics Park, find the functional area with comprehensive relationship strength of grade I for planning, according to the planning order, it is necessary to first determine the layout location of the international express transit area, and the relative position of the international express transit area and the bonded storage area can be obtained. On the basis of the above figure, after adding the I-level functional area, a relative position map can be obtained (Figure 6).

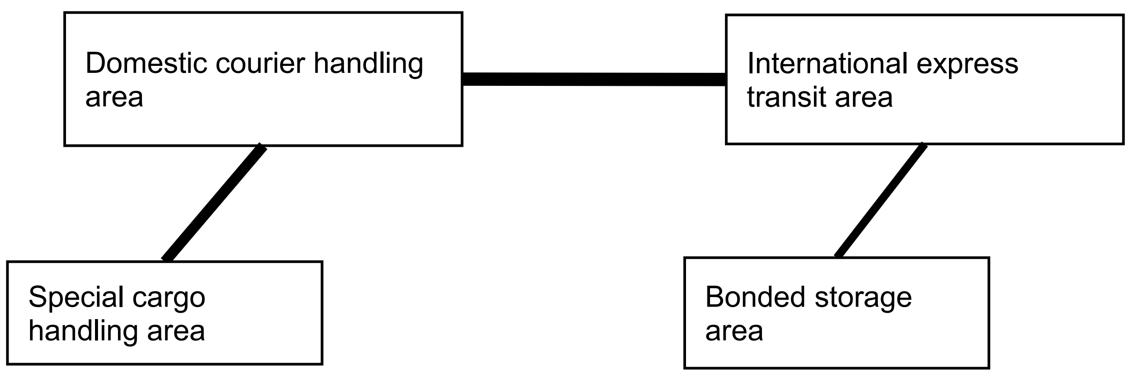

Figure 6. I-level functional area location relationship map

4.4.4 The comprehensive relationship is the layout planning of the functional area of grade O

Similarly, referring to Figure 3, in the layout planning of the functional area of CDTF airport Logistics Park, the functional area with the comprehensive relationship strength of O grade is found for planning. There are two pairs of functional areas with comprehensive relationship level O level, namely domestic express processing area - bonded warehousing area, and international express transit area - special cargo processing area. It is necessary to comprehensively analyze the relative position relationship between the O-level functional area pair and the A-grade, E-grade and I-level functional area pairs. On the basis of the above figure, and after adding the O-level functional area, a relative position map can be obtained (Figure 7).

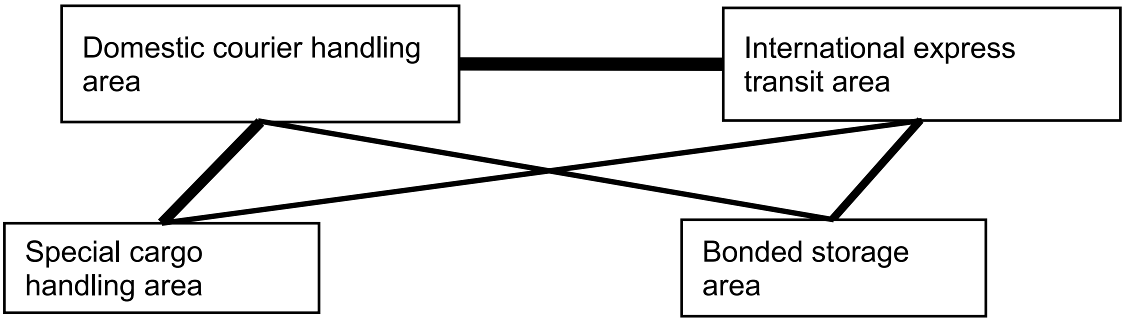

Figure 7. O-level functional area location relationship map

4.4.5 The comprehensive relationship is the layout planning of the functional area of grade U

Similarly, referring to Figure 3, in the layout planning of the functional area of CDTF airport Logistics Park, the functional area with a comprehensive relationship strength of U-level is found for planning. There are six pairs of functional area pairs with a comprehensive relationship level of U-level, and the relative position of the layout of the functional area with the strength of the U-level needs to be ranked after the first four levels, so the functional area location map after adding the U-level functional area pair can be obtained (Figure 8).

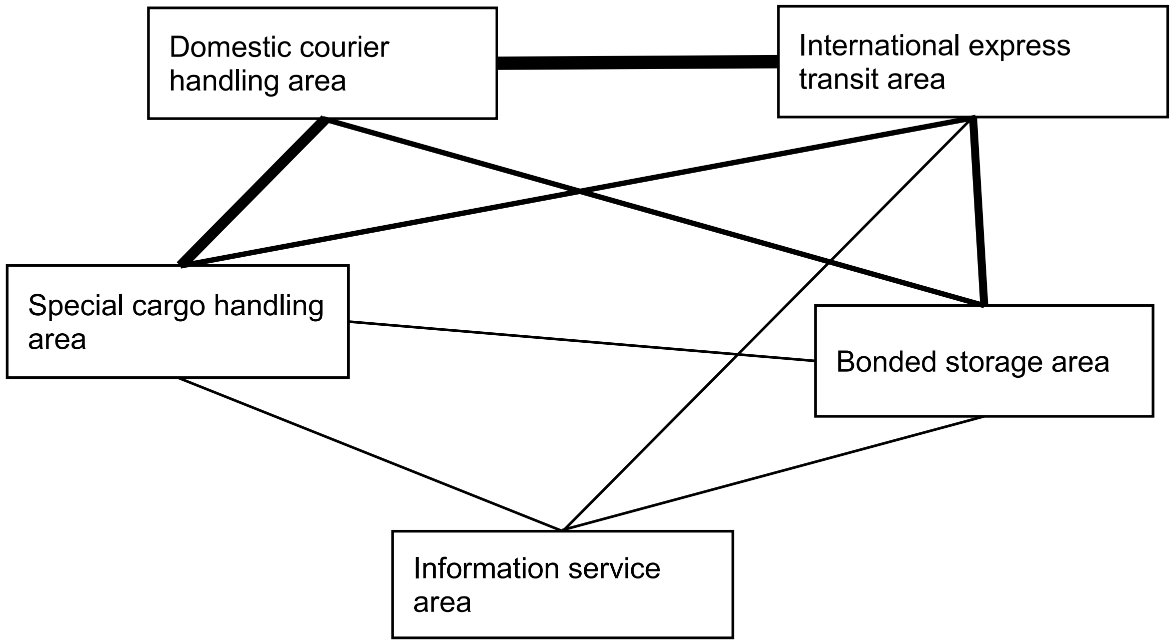

Figure 8. U-level functional area location relationship map

4.4.6 The comprehensive relationship is the layout planning of the functional area of grade X

The comprehensive relationship is that there are 4 pairs of X-level functional areas, and the X-level functional areas do not need to be considered in layout planning. Therefore, after adding the X-level functional area pair, the final position map can be obtained (Figure 9).

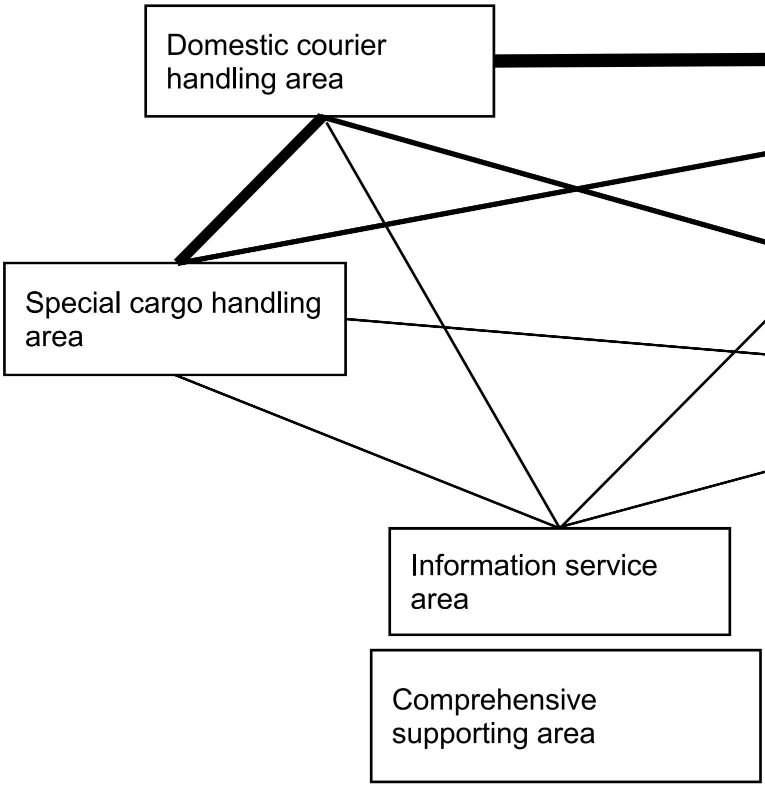

Figure 9. Final functional area location relationship map

The above only layout according to the layout principle of the system layout design method to layout the relative position of the functional area, in the specific layout process, it is also necessary to consider the specific situation of CDTF airport Logistics Park and the actual area of each functional area. However, because the relevant data of CDTF Airport is not clear, it will be ignored here.

4.5 CDTF Airport Aviation Logistics Park Layout Plan

According to the above content, the layout plan of CDTF Airport Logistics Park can be drawn up by the layout and design method of CDTF airport Logistics Park relative location map obtained by the comprehensive system layout design method (Figure 10).

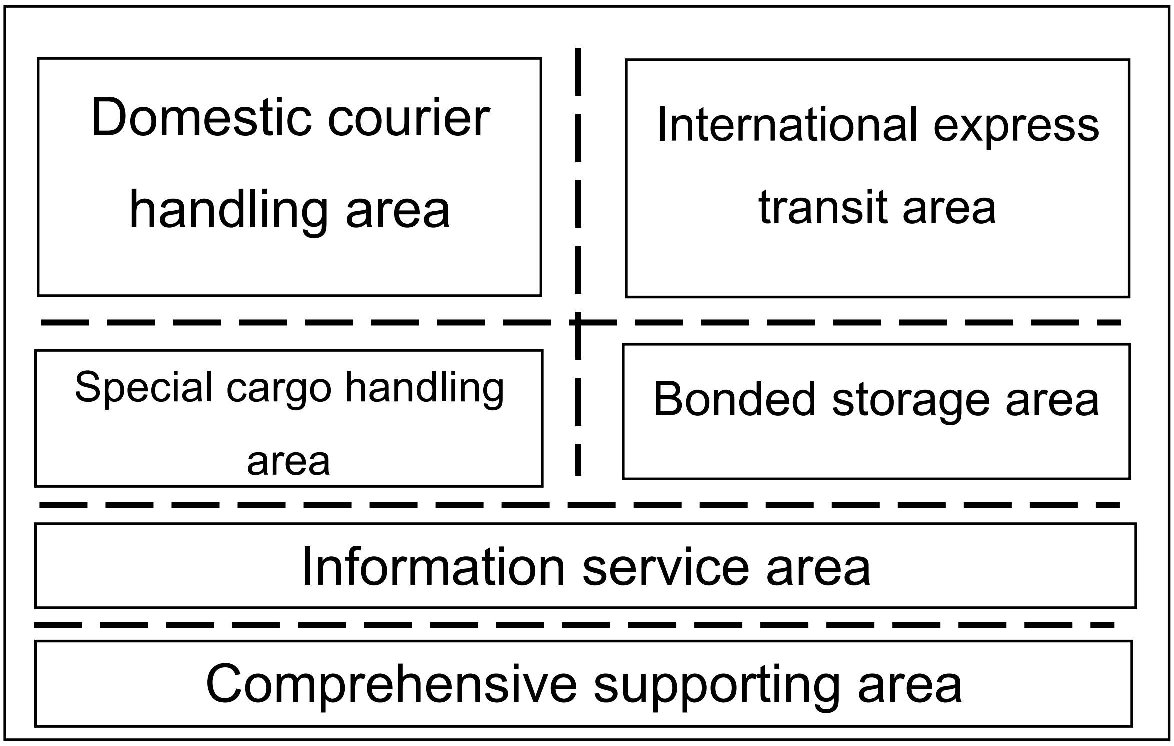

Figure 10. CDTF airport Logistics Park layout plan

5 Discussion

This chapter is divided into two sections, Conclusions & Reflections and Recommendations. The conclusion and reflection sections are closely aligned and this research described what is completed and what is still missing from this study.

5.1 Conclusion and reflection

This paper combines qualitative and quantitative research and adopts the SLP approach to study the layout planning of the aviation logistics park at CDTF airport. In this paper, the aviation logistics park at CDTF airport is divided into six parts: domestic express handling area, international express transit area, special cargo handling area, bonded storage area, information service area and comprehensive supporting area, with the domestic express handling area and international express transit area as the core functional areas for layout, and the comprehensive supporting area with intensive personnel activities is set at a location far away from the logistics traffic and separate from the logistics operation area to ensure A good working environment to meet the relevant requirements.

This study combines the actual situation of the multi-airport system in which CDTF airport is located, with the five principles of layout planning, and by analysing the interrelationship of the functional areas of the logistics park at CDTF field, a relatively reasonable layout plan is derived, which provides guidance and reference for the planning and construction of the aviation logistics park at CDTF airport.

However, from another aspect, there are some shortcomings in the research of this paper that are worth reflecting on.

Firstly, due to the lack of research and information related to the CDTF Airport Aviation Logistics Park, the study in this paper does not consider the issue of roads and reserved land in the park in the overall layout planning, nor does it design the area of functional areas in conjunction with the pre-determined area of the logistics park. In terms of landing, this study is still somewhat detached from the actual situation and has certain limitations.

Secondly, at the level of method selection and use, the SLP method chosen in this paper takes the logistics transport volume between functional areas as the main factor. Although the SLP method also takes into account the influence of non-logistical and combined factors, these two are not as important in the SLP method. This makes this paper somewhat limited in its approach.

Overall, despite its shortcomings, the layout plan of the CDTF air logistics park designed in this paper is still relatively scientific and reasonable, providing some experience and reference value for its specific construction and for the study of the new airport air logistics park in the multi-airport at home and abroad.

5.2 Suggestion

In today's highly developed multi-airport trend, it is foreseeable that large cities are or will be establishing multi-airport linked to an air logistics system. This paper makes the following suggestions through the study of the layout planning of the aviation logistics park of the second airport in Chengdu.

1. When building a non-first airport in a large city, full reference should be made to the air logistics-related data of the first airport and the relevant data of multi-airport cities of the same level and volume. This will enable a clearer and more definite planning of the future development strategy of the new airport. At the same time, this is the only way to better guide the layout planning of the new airport's air logistics park.

2. In order to make better use of the advantages of multiple airports, the functional areas of multiple airports in the city should be planned in an integrated manner so that they can both echo and complement each other, and develop their own unique functional areas according to their location advantages while ensuring the basic functional areas.

3. While ensuring the interconnection between the new airport and the existing airport, strengthen the construction of its own transport network as far as possible, increase air-to-ground transfers, and cover the entire air-side economic zone, so that both the new and old airports can have unique transport networks covering the area and avoid a situation of strong substitutability.

4. Increase the importance attached to the hardware and software environment of the new airport's field industry park, strengthen the construction and maintenance of infrastructure and public facilities, and create a good atmosphere to attract quality enterprises to move in.

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