Best practices for the airport digitalization

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Abstract

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With the development of science and technology, people's demand for intelligence is getting higher and higher. At present, digitalization is widely used in various fields. At the airport, digitalization can not only improve the operational efficiency of the airport, but also enhance the travel experience of passengers and enhance the competitiveness of the airport. Moreover, in today's digital age, the airport is no longer just a simple transportation hub, but has become a comprehensive transportation hub integrating aviation, railways, highways and other modes of transportation. By exploring the best practice of airport digitalization, we can better understand the value of digital airport re-entry and provide better reference for passengers and airport personnel. Therefore, it is necessary to explore the best practice of airport digitalization.

This paper will study and analyze the best practice of airport digitalization according to the feedback of questionnaire survey, case analysis and related literature review, and discuss how airport digitalization can provide people with more convenient travel from the feedback. Taking Chongqing Jiangbei International Airport as the research object, this paper analyzes the digital application of Chongqing Jiangbei International Airport by means of questionnaire survey, and then through the analysis of some cases at home and abroad and the analysis of related literature, it is concluded that the integrated service module is the best practice of airport digitalization.

Key words
Airport digitalization, Digitalization,Digital service, Best practice, Chongqing Jiangbei International Airport

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1 Introduction

All walks of life are describing digital innovation, such as travel, shipping, tourism, medical care, insurance, consumption, high technology, energy, public sector and education (Kovynyov, Ivan and Ralf Mikut. 2019.). However, few people describe the practice of airport digitalization.

Moreover, with the development of the global economy and the increasing demand for convenient travel, the airport, as an important transportation hub, has become increasingly important. In China, airport construction and development are facing unprecedented opportunities and challenges. In this context, airport digitalization has become a key way to improve airport operation efficiency, improve passenger experience and meet future challenges. Taking Chongqing Jiangbei International Airport as an example, this paper discusses the application of airport digitalization in order to provide reference for the digital transformation of other airports in China.

As an important aviation hub in southwest China, Chongqing Jiangbei International Airport has many remarkable advantages. First, Chongqing Jiangbei International Airport is located in Jiangbei District of Chongqing, in the upper reaches of the Yangtze River, with a unique geographical position. Second, Chongqing Jiangbei International Airport has modern terminal buildings, runways and other facilities to meet the needs of various flights and passengers. Thirdly, Chongqing Jiangbei International Airport has established cooperative relations with many airlines at home and abroad and opened flights covering major cities around the world. Fourthly, in recent years, the passenger throughput of Chongqing Jiangbei International Airport has been increasing year by year, and the operational efficiency of the airport has been continuously improved. Fifth, in the process of airport construction and development, Chongqing Jiangbei International Airport always adheres to the concept of green environmental protection and pays attention to energy conservation and emission reduction. Therefore, Chongqing Jiangbei International Airport has a unique geographical position, market potential, route network, facilities and service level and green environmental protection concept in other airports in China or around the world. Therefore, Chongqing Jiangbei International Airport is chosen as the research object.

1.1 Research reasons and problems

Chongqing Jiangbei International Airport is an important transportation hub in Chongqing, which promotes the economic development of Chongqing and provides an important guarantee for the growth of Chongqing's GDP. Therefore, this paper aims to analyze the present situation and achievements of the digital transformation of Chongqing Jiangbei International Airport, discuss the problems and challenges in the process of digital transformation, and put forward corresponding countermeasures and suggestions, so as to provide reference for other airports in China.

In this paper, the coverage matrix is used to investigate and study from four aspects: convenience, reliability, comprehensiveness and environmental protection, so as to calculate the best practice plate of airport digitalization. The following is the set coverage matrix:

Table 1: Overlay Matrix

Overlay matrix			
The main problem of research: How to find out the success of airport digitalization practice by analyzing the digitalization application of Chongqing Jiangbei International Airport, and provide some reference for future airport innovation? The object of the study: passengers Beneficiaries of the study: passengers and airport personnel			
The problem of investigation	Frame theory	The results of the investigation	Questionnaire survey
Q 1: Is it convenient to use the airport digitally?	2、3	4.4	A
Q 2: Is the digital application of the airport reliable?	2、3	4.4	B
Q 3: Is the digital application of the airport comprehensive?	2、3	4.4	C
Q 4: Is the digital application of the airport environmentally friendly?	2、3	4.4	D

Q 5: Does the digital application of the airport need to be improved?	2、3	4.4	E

1.2 Research scope

This paper focuses on finding out the success of airport digitalization practice by analyzing the digitalization application of Chongqing Jiangbei International Airport, mainly from the following aspects: First, it studies and analyzes the process of airport digitalization transformation; On the basis of relevant theoretical literature, this paper analyzes the current application level of airport digitalization. The second is to study the improvement of operational efficiency and passenger experience brought about by digital transformation; The reason to realize the digital transformation of the airport is to better serve passengers and achieve efficient operation, so studying this issue can be better improved and understood. Third, the problems and challenges in the process of digital transformation; Through the discovery of the problems, we can better summarize the quality of the current airport digital operation. The fourth is the countermeasures and suggestions to solve the problem; Although the research direction of this paper is the best practice of airport digitalization, we should also give our own suggestions if we find bad problems, so as to improve them better. Therefore, through the development of these four aspects, we can get the best practice of airport digitalization, and also provide reference for the improvement of airport digitalization, so as to increase passengers' understanding of airport digitalization.

1.3 The structure of the paper

The research object of this paper is Chongqing Jiangbei International Airport. First of all, by reading relevant literature, we have a detailed understanding of the digital transformation of the airport. Then, from the convenience, reliability, comprehensiveness and environmental protection, this paper designs a questionnaire survey on the digital application of Chongqing Jiangbei International Airport, and analyzes the practice of airport digitalization. Finally, the relevant conclusions are analyzed, the best practice direction of airport digitalization is discussed, and relevant strategic suggestions are put forward for travel problems. The following is the structural roadmap of the full text:

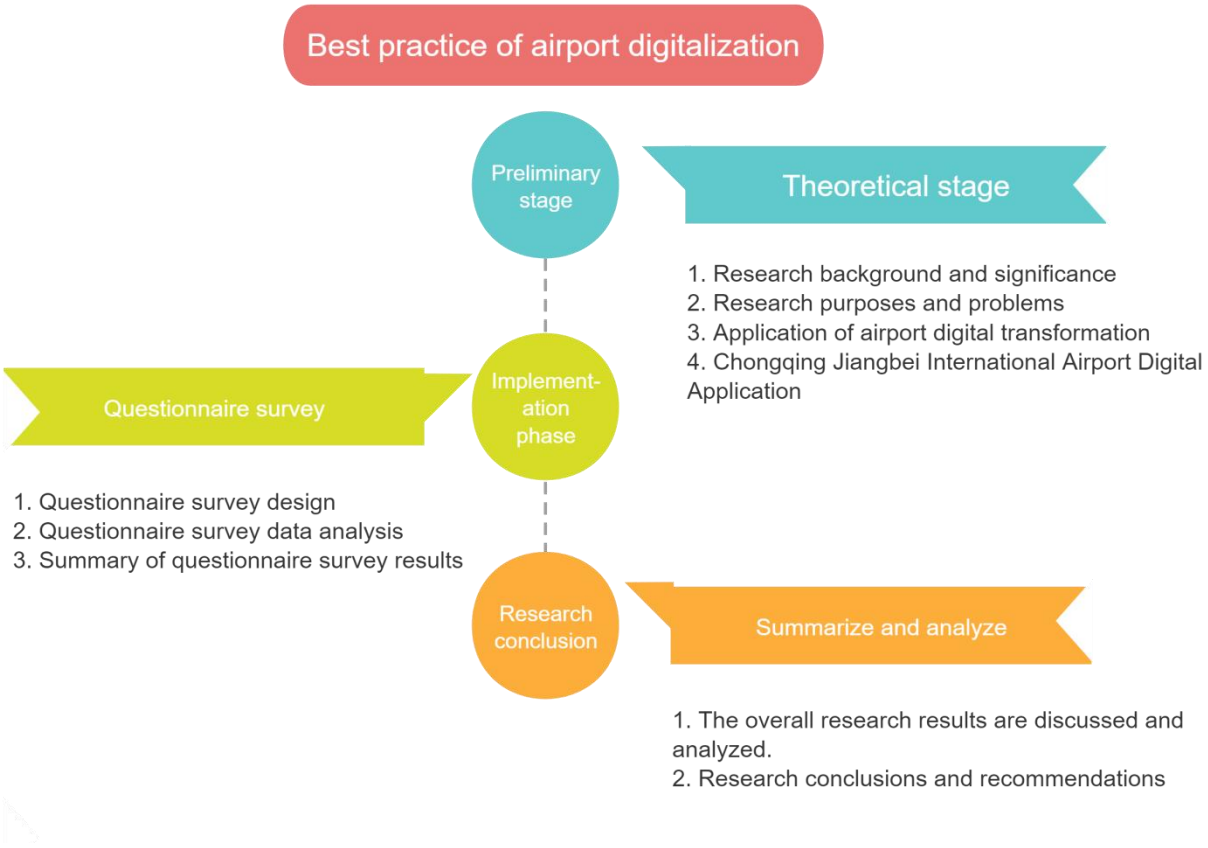

Figure 1: Structure diagram of the paper

2 Research theoretical basis

This paper will take Chongqing Jiangbei International Airport as an example to study the best practice of airport digitalization and analyze it from multiple dimensions. Moreover, the best practice of airport digitalization has been the focus of China's domestic aviation industry in recent years. Especially under the background that the COVID-19 epidemic has had a great impact on the global aviation industry, digital transformation and upgrading has become an important means for airports to improve operational efficiency, optimize passenger experience, reduce costs and cope with uncertainties.

2.1 Research background and significance

Airport is an important infrastructure for social development, an engine for national and regional economic growth, and a gateway for global business, tourism and economy (Tian Lijun & Zhang Xiu, 2023). In recent years, China airport construction has made remarkable achievements, but at the same time it faces many challenges, such as flight delay and passenger congestion. In order to solve these problems, airport digitalization has become an inevitable trend. As an important aviation hub in the southwest of China, Chongqing Jiangbei International Airport's digital transformation is representative. Studying the digitalization practice of Chongqing Jiangbei International Airport is of great significance for improving the overall operation level and passenger experience of China Airport.

The concept of airport digitalization originates from the development and application of information technology. It covers the digital transformation of airport operation, safety management, passenger service and logistics. Airport digitalization realizes intelligent management and optimization of airport business by introducing advanced technologies such as Internet of Things, big data and artificial intelligence.

As an important hub of modern transportation, the airport needs to handle a large number of passengers and goods every day. With the continuous progress of science and technology and the acceleration of digitalization trend, airport digitalization has become an important means to improve airport operation efficiency, improve passenger experience and ensure aviation safety. Therefore, it is of great significance to study the best practice of airport digitalization.

First of all, studying the best practice of airport digitalization is helpful to improve the efficiency of airport operation. Digital technology can be applied to all aspects of the airport, such as flight management, security inspection, baggage consignment, etc. Through automatic and intelligent means, manual intervention can be reduced and processing speed and accuracy can be improved. At the same time, digital technology can also help the airport achieve data sharing and collaborative work, and further improve the operational efficiency of the entire airport.

Secondly, studying the best practice of airport digitalization is helpful to improve the passenger experience. Digital technology can provide passengers with more convenient and personalized services, such as online check-in, self-service consignment and intelligent navigation. These services can not only reduce the waiting time of passengers in line and improve their travel efficiency, but also enhance their travel experience and enhance their trust and satisfaction with the airport.

Finally, studying the best practice of airport digitalization is helpful to ensure aviation safety. Digital technology can improve the airport's ability to identify and warn security risks through intelligent monitoring and data analysis, and find and deal with security problems in time. At the same time, digital technology can also help the airport to realize the comprehensive monitoring and management of information such as flights, passengers and goods, and ensure the safety and stability of air transportation.

To sum up, it is of great significance to study the best practices of airport digitalization for improving airport operation efficiency, enhancing passenger experience and ensuring aviation safety. In the future, with the continuous development and popularization of digital technology, airport digitalization will become one of the important directions of airport development and inject new impetus into the sustainable development of air transport industry.

2.2 Background of airport digitalization

As far as airport digitalization itself is concerned, the background of airport digitalization mainly includes the intensification of global airport competition, the continuous innovation of information technology and the strong support of China government. In this context, the digitalization of the airport will continue to improve, bringing passengers a more convenient and comfortable travel experience. At the same time, airport digitalization will also bring new development opportunities and challenges to airlines, airport operators and other participants.

First of all, the global airport competition is becoming increasingly fierce, and improving operational efficiency and passenger experience has become the goal pursued by airports all over the world. In such a competitive environment, airport digitalization has become an inevitable trend. Through digital technology, airports can better optimize resource allocation, improve operating efficiency and reduce operating costs, thus occupying a favorable position in the competition.

Secondly, the continuous innovation of information technology provides strong technical support for airport digitalization. With the continuous development of advanced technologies such as big data, Internet of Things and artificial intelligence, airport digitalization has been realized. These technologies can help the airport realize real-time data analysis and intelligent decision-making, and further improve the operational efficiency and passenger experience of the airport. For example, through big data analysis, airports can predict passenger flow and provide reference for flight scheduling; Using Internet of Things technology, remote monitoring and maintenance of equipment can be realized, and the failure rate of equipment can be reduced. Use artificial intelligence to improve the intelligence level of security inspection, tour guide and other services.

Finally, China government's strong support for airport digitalization is also a key factor to promote the development of airport digitalization. China government attaches great importance to the development of civil aviation industry, and regards airport digitalization as an important strategic direction for the development of civil aviation industry. Through policy guidance, financial support and other means, encourage the airport to carry out digital reform and accelerate the process of airport digitalization.

In terms of the necessity of airport digitalization for China, China Civil Aviation Airport is currently in a period of rapid development, with many new construction, reconstruction and expansion projects and the scale of major transport airports expanding. At the same time, with the expansion of the airport scale, the difficult problems encountered in the field of production and operation are becoming more and more obvious. In order to solve the main contradictions in the field of production and operation, all major civil aviation airports in China have put forward digital development plans and continuously increased investment in digital construction. However, from the actual effect, the basic contradictions in the organization, process, data and decision-making of production and operation have not been effectively solved, so the effect of digital construction is not obvious. (Deng Songwu, 2024)

First of all, the production organization. At present, most airports generally adopt pyramid-shaped hierarchical organizational structure, emphasizing vertical administrative authority, which leads to insufficient horizontal cooperation among production factors and can not effectively match the production organization needs of digital enterprises. Second, the production process. At present, most airports still adopt section-to-section management mode, which leads to unclear interface, inconsistent operating standards and lack of consistency between local and overall, and cannot effectively meet the process management requirements of digital enterprises. Thirdly, in terms of situational awareness, at present, most airports in China are not agile enough in operational situational awareness, and problems are often discovered only after things happen. Fourthly, airport management relies too much on people's experience in operational decision-making and lacks scientific decision-making technology platform. (Deng Songwu, 2024)

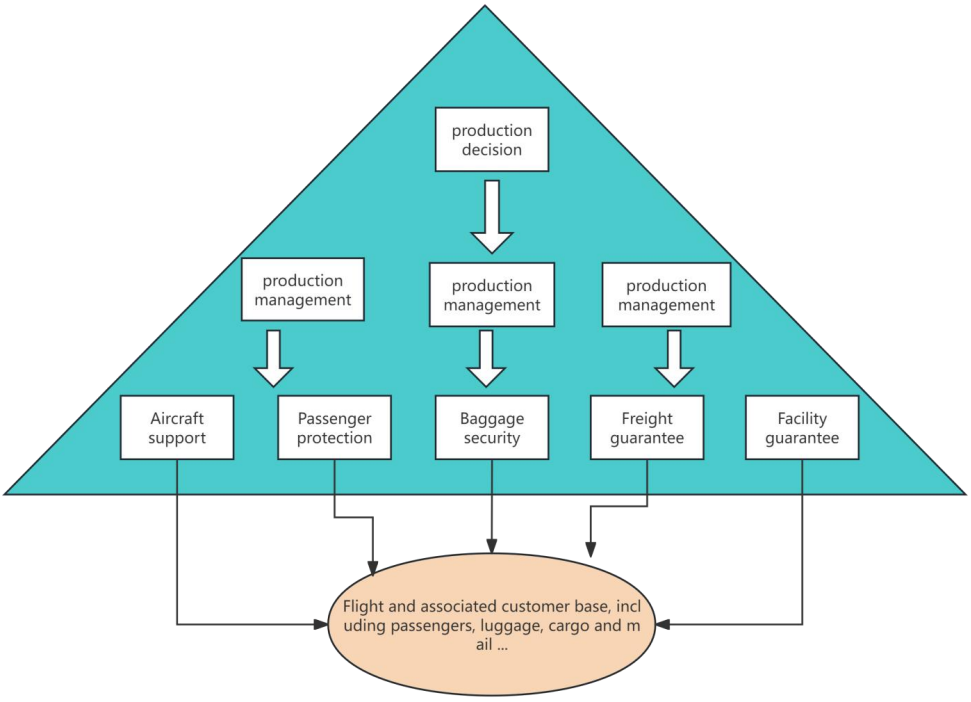

Figure 2: Production organization chart of most airports in China (Deng Songwu, 2024).

2.3 Research on the Application of Airport Digitization

With the rapid development of science and technology, the aviation industry is constantly seeking innovation and breakthrough. As an important carrier of aviation industry, the digital application of airport has become an important trend of industry development. This paper will make an in-depth study on the application of airport digitalization, analyze the application status of digital technology in all aspects of the airport, and explore the future direction of airport digitalization, with a view to providing useful reference for the modernization and digital transformation of China airport. Moreover, the research on the application of airport digitalization reveals the trend and direction of airport development today.

First, the status quo of digital application of domestic airports in China.

At present, China Airport mainly adopts digitalization in security inspection, check-in and indoor positioning. The main contents are as follows: First, intelligent security inspection. Some domestic airports in China have adopted technologies such as face recognition and baggage tracking, which have improved the security efficiency and passenger experience. Second, self-service check-in.

Self-service check-in equipment is widely used in domestic airports in China, and passengers can check in by themselves, saving queuing time. Third, indoor navigation. Some airports use indoor navigation systems to provide real-time location information and navigation services for passengers.

Second, the current situation of digital application in international airports.

At present, the international airport mainly adopts digitalization in security inspection, check-in and indoor positioning, but it is still different from China airport. First, smart security. International advanced airports have realized self-service security inspection in the whole process, greatly improving the efficiency of security inspection. Second, self-service check-in. International airports have a high proportion of self-service check-in, and some airports have achieved 100% self-service check-in. Third, indoor navigation. Indoor navigation systems are widely used in international advanced airports to provide accurate location information and navigation services.

3 Research methods

This paper uses case analysis, literature analysis and questionnaire survey to study. Firstly, taking Shanghai Hongqiao Airport and dubai international airport as cases, the paper analyzes their digital applications. Secondly, by consulting relevant literature, we can understand the theoretical system and practical achievements of airport digital transformation. Finally, taking Chongqing Jiangbei International Airport as a case, the specific measures and effects of its digital transformation are analyzed, and the problems and challenges in the process of digital transformation of the airport are deeply understood in combination with the questionnaire survey.

3.1 Digital Airport Case Analysis

Case 1: Smart Security System of Shanghai Hongqiao Airport (Hu Xiyuan & Haan Lee, 2022)

Shanghai Hongqiao Airport adopts technologies such as face recognition and baggage tracking to realize self-help in the whole process of security inspection. Passengers can complete the security check through self-service equipment, shorten the queuing time and improve the travel experience. After the implementation of the project, the efficiency of security inspection has increased by more than 30%.

First, efficient and secure ticket consignment. First of all, in the aspect of check-in island, the man-machine interaction "one-button" switching function of the integrated intelligent counter is realized. According to the specific needs of passengers, the staff can flexibly adjust the service mode to assist in the relevant procedures such as ticket purchase, seat selection, consignment and payment for excess baggage. The optimized baggage weighing identification system shortens the weighing time by nearly 50%, thus reducing the delay rate of baggage transmission. In the new check-in island, every place is equipped with a smart baggage self-check desk to help passengers check in compliance and reduce unnecessary expenses. Passengers only need to put their luggage on the equipment and select the airline, and the equipment will immediately judge whether the luggage is overweight. In addition, the shell of the new counter is made of medical-grade antibacterial materials, and RFID baggage tracking service is provided, so that passengers can keep track of the status of checked baggage at any time.

The RFID system automatically classifies the luggage in the process of processing, that is, an RFID electronic tag is attached to the luggage randomly checked by each air passenger, which records the arrival point, personal information, starting point, parking space, departure time, flight data number and other information of the passenger. Install electronic tag reading and writing equipment at baggage flow control nodes such as baggage extraction, sorting and loading. When the tagged baggage enters each entry node, its reader will read the information and transmit it to the database. Moreover, the reading and writing distance is as high as 30.48 meters, and the label can be read quickly (Booth-Thomas 2003). The information sharing and monitoring of luggage can be realized in the whole transportation process.

Barcodes	RFID tags
Barcodes require line of sight to be read	RFID tags can be read or updated without line of sight
Barcodes can only be read individually	Multiple RFID tags can be read simultaneously
Barcodes cannot be read if they become dirty or damaged	RFID tags are able to cope with harsh and dirty environments
Barcodes must be visible to be logged	RFID tags are ultra thin, and they can be read even when concealed within an item
Barcodes can only identify the type of item	RFID tags can identify a specific item
Barcode information cannot be updated	Electronic information can be over-written repeatedly on RFID tags
Barcodes must be manually tracked for item identification, making human error an issue	RFID tags can be automatically tracked, eliminating human error

Table 2: RFID vs barcode technology（Wyld, Jone & Totten 2005）

RFID Components	Description
Tag (Transponders)	Ultra high frequency (UHF)-band (862–900 MHz), wireless, passive, and unique identification number
Readers	Stand-alone, hand-held, and shelf readers
Antenna	UHF, and able to identify tag and receive transmitted signal
Printers	Baggage Printer
Information Systems	Enterprise Resource Planning systems and database management system (DMS)
Mobile devices	Smartphone with Android operating system
Point-of-Sale (POS) with RFID readers	POS system integrated with the DMS and RFID tag readers

Table 3: Radio Frequency Identifification (RFID) components（Wong & Wong 2017,4）

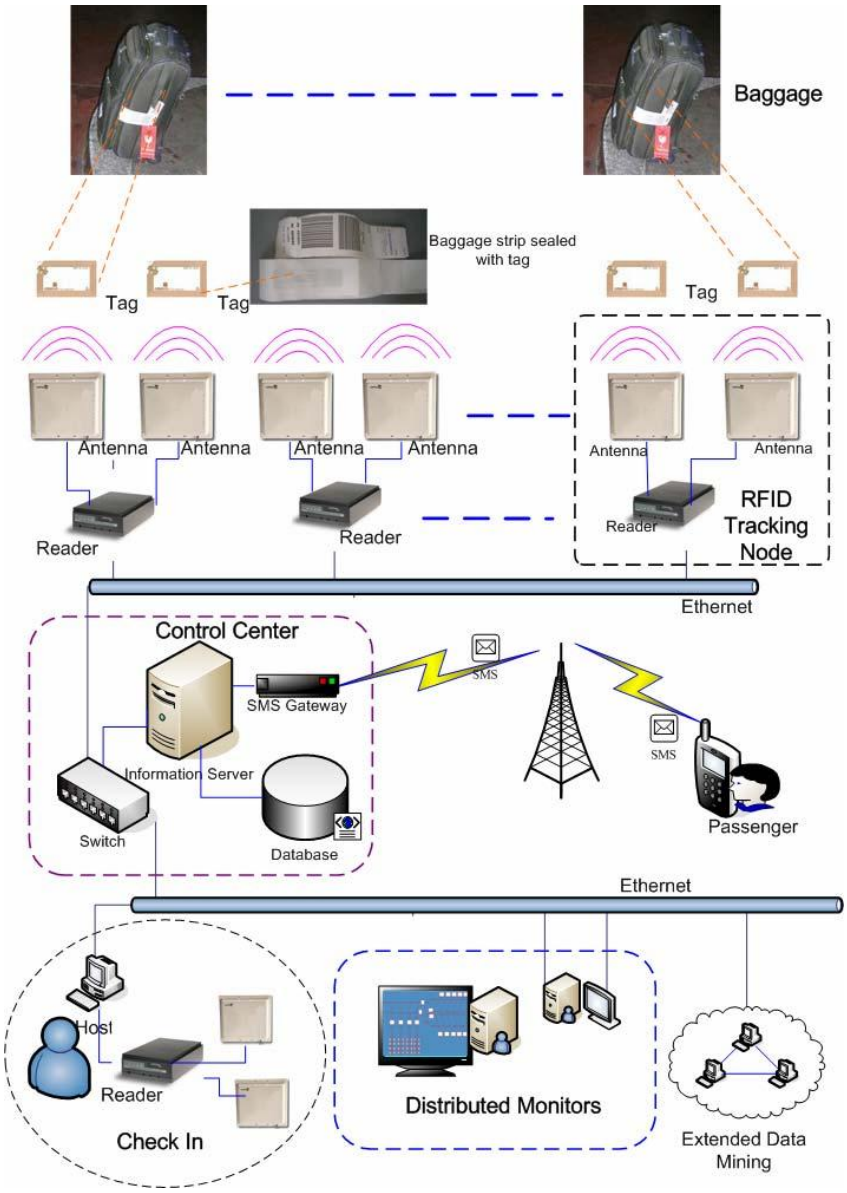

Figure 3: Structure of RFID Tracking Air Baggage Handling System（Zhang, Ouyang & He 2008,109）

Secondly, some security channels have been upgraded to realize the innovative application of "smart channels". The channel adopts automatic transmission, face recognition and RFID technology. When passengers put their carry-on luggage in the security basket, the intelligent equipment on the basket can realize "person-bag binding", so that the security basket can automatically follow the passengers, thus avoiding the trouble of manual handling by passengers. Different from the traditional security inspection channel, the conveyor belt behind the security inspection instrument of the "intelligent channel" is divided into two parts, one for the luggage that

does not need to be unpacked, and the other for the luggage that needs to be unpacked, thus realizing automatic "parting ways", as shown in Figure 4. In addition, the "smart channel" also has the functions of automatic return of the security basket and ultraviolet disinfection, which not only improves the security efficiency, but also meets the requirements of non-contact epidemic prevention in the whole process.

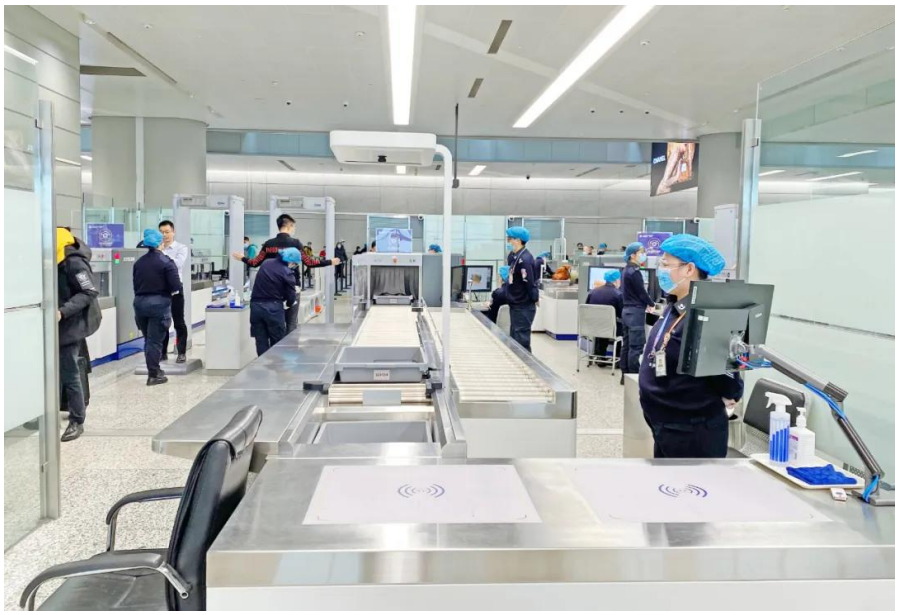

Figure 4: Intelligent Security Channel (Hu Xiyuan & Haan Lee, 2022)

Second, efficient boarding and returning. In the past, if passengers need to return and change their visas after passing the security check, they often have to return to the check-in counter and go through complicated procedures such as the second security check again. In order to solve the pain point of this passenger experience, Hongqiao Airport actively cooperated with China Airlines and China Eastern Airlines, and took the lead in launching the refund and change service in the control area among domestic airports. Nowadays, passengers can easily return and change their visas through the airline's App, and there is no need to travel back and forth, thus greatly improving the service efficiency and shortening the time that might have taken tens of minutes to a few minutes, as shown in Figure 5. This innovative measure undoubtedly provides passengers with a more convenient and efficient travel experience.

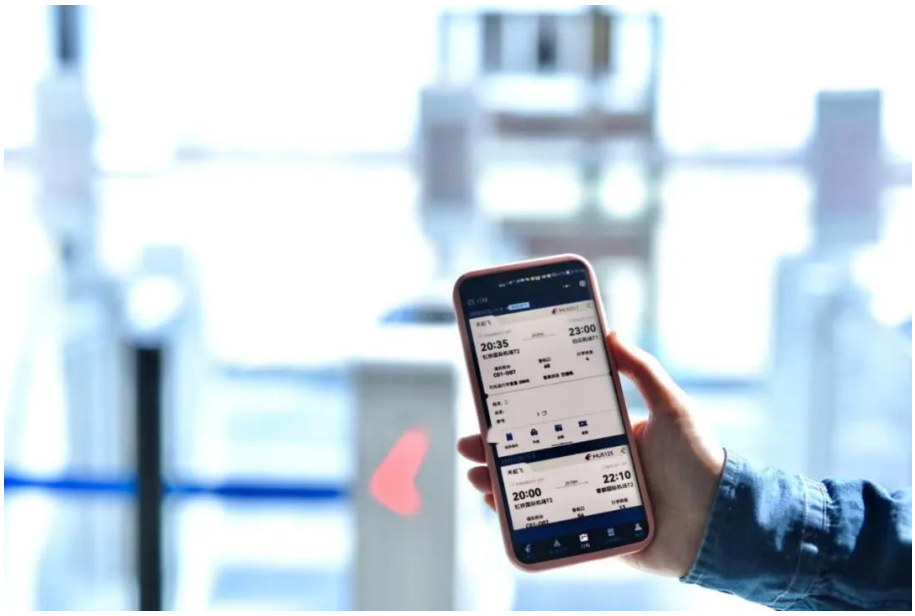

Figure 5: Refund and change in the controlled area (Hu Xiyuan & Haan Lee, 2022)

At the same time, Hongqiao Airport has brought passengers a brand-new "non-inductive boarding" experience by optimizing the face recognition algorithm. In this process, passengers do not need to show any certificates or vouchers, just stroll through the gate passage, and the boarding verification process can be successfully completed. The fully self-service boarding gate adopts streamlined design and elegant theme color, which is beautiful and generous in appearance. Multiple display screens are integrated around the door to display airport service information such as flights, cabins, free wireless Internet access, etc. to provide all-round guidance for passengers, as shown in Figure 6.

Figure 6: Intelligent boarding gate (Hu Xiyuan & Haan Lee, 2022)

Hongqiao Airport became the first airport in China to implement OneID "one-face customs clearance" service together with the "Travel and Travel" App. After registering for the "Travel and Travel" App and submitting face information, passengers can enjoy the whole process of contactless flight, including self-service check-in, self-service baggage consignment, self-service security check-in and self-service boarding. OneID service has mask recognition function, and even if passengers wear masks, they can successfully complete various self-service processes, as shown in Figure 7. One ID is a service platform of one-pass customs clearance+face boarding launched by Daxing Airport. Passengers can check-in, check-in and "brush their faces" to board the plane with valid booking documents, and their products have been certified by the International Air Transport Association (IATA) as "Platinum Logo" (Baidu, 2020).

Figure 7: OneID's "Going through Customs with One Face" (Hu Xiyuan & Haan Lee, 2022)

Case 2: dubai international airport (Zhihu, 2020)

Dubai international airport is under the pressure of 7%-8% passenger growth every year. However, due to the geographical environment around the airport, the airport cannot expand its space to build a new terminal. Therefore, dubai international airport is committed to using advanced technology to improve airport operation efficiency and passenger service level. First, provide location services based on Beacon for passengers, that is, build a wireless WiFi network covering

the whole airport, and provide positioning, navigation, quick consultation, movie viewing and other services for passengers in combination with ICFLIX platform, as shown in Figure 8. Secondly, biometric technology is introduced in the check-in and security check-in of passengers to reduce the waiting time of passengers in line. Finally, face recognition technology and UAE wallet are used to provide smooth check-in and customs clearance services for outbound passengers.

Figure 8: dubai international airport beacon-based electronic consultation platform (Zhihu, 2020).

As one of the busiest airports in the world, dubai international airport, United Arab Emirates is also in the forefront of the industry in the field of artificial intelligence. Dubai International Airport widely uses artificial intelligence technology and services, covering passenger security, baggage handling, airport passenger transportation and other aspects, in order to achieve a high-quality travel experience for passengers without waiting in line.

First, AI security inspection is expected to completely replace security inspectors in the future. It is estimated that by 2020, the UAE will completely replace the artificial intelligence of entry-exit security inspectors. At that time, passengers can complete the security scanning only through the security system driven by artificial intelligence without taking off their shoes, unbuttoning their belts and taking out their pockets. The airport has begun to pilot the intelligent channel of the virtual aquarium, and tourists can pass through the tunnel surrounded by fish. In this process, the camera captures all angles of tourists' faces to realize rapid recognition. As shown in Figure 9, there are

about 80 cameras in the pilot channel, and hidden cameras are used to scan the face or iris when passengers are moving.

Figure 9: dubai international airport's security tunnel exhibited in Gitex (Zhihu, 2020).

Second, AI baggage handling and automatic driving simplify the boarding process. Tim Clark, CEO of Emirates Airlines, argues that artificial intelligence technology should play an important role in baggage handling. He envisioned that automated equipment and robots similar to those used in Amazon warehouses could be applied to baggage identification, packing and baggage extraction without human intervention. In addition, he predicted that self-driving cars would be quickly applied to improve the daily operation efficiency of dubai international airport. These cars are controlled by artificial intelligence, and 100% are driven by solar energy or electricity to optimize ground transportation and flights. In this process, artificial intelligence will run through the whole travel process, from the airport where passengers leave to the destination airport. In the future, self-driving cars may be able to load passengers' luggage in advance and pick them up on the roadside. Self-driving cars can even transport luggage directly to hotels or homes, eliminating the cumbersome baggage conveyor belt and handling luggage.

Third, AI personnel filter and use facial recognition to ensure flight safety. With the increasing concern about aviation safety, especially in passenger security screening, artificial intelligence (AI) technology has begun to play an important role in personnel filtering. Airport management

generally believes that many major security threats are often closely related to internal staff. However, dubai international airport, as an international aviation hub, is making efforts to strengthen the management of employees' entry and exit points by using AI technology, as shown in Figure 10. This task involves a variety of artificial intelligence technologies, including biometric technology and facial recognition technology. The AI system can even analyze and evaluate employees' daily behaviors, violence records and criminal records by searching their areas of concern before they are hired, so as to assess their potential risks. After employees are hired, AI algorithm can continuously monitor their behaviors in order to find suspicious behaviors that may threaten flight safety in time, thus ensuring aviation safety.

Figure 10: The latest biometric equipment is installed in Emirates Terminal 3 of Dubai International Airport (Zhihu, 2020).

Fourth, promote AI air traffic management projects and explore more AI aviation uses. The United Arab Emirates Civil Aviation Authority (GCAA) is working on the application of artificial intelligence technology in the field of air traffic management in the country. In 2018, GCAA established a cooperative relationship with Canadian technology company Searidge Technologies to jointly explore artificial intelligence and other cutting-edge technologies to promote the continuous innovation and development of the aviation industry. Its core purpose is to improve the safety and efficiency of air traffic management, and this innovative project is expected to have a far-reaching impact on a global scale.

In addition, the UAE Airport Laboratory is actively promoting the "Dubai Future Accelerator Facility Project", which aims to provide passengers with more convenient services by using artificial intelligence technology. Specifically, through AI technology, passengers will be able to choose meals more easily, book taxi pick-up service, and enjoy personalized itinerary customization. At the same time, Dubai Airlines is also studying how to use artificial intelligence technology to assist the crew training of UAE flights to improve service quality and passenger satisfaction.

In a word, the application of artificial intelligence technology in the UAE aviation field is expanding, and its unique perspective and efficient processing capacity provide new possibilities for solving various boarding problems.

3.2 Literature review

On the whole, Du Zefu (2022) thinks that the smart airport industry in China has gradually formed a market segment with smart operation, smart security, smart service and smart business as the main parts. In each market segment, products have been implemented, which involve flight service, security monitoring, airport information, etc., including self-service check-in, self-service baggage consignment, face recognition, fingerprint recognition, millimeter wave security inspection, regional traffic analysis, face payment, RFID baggage flow tracking, digital cluster scheduling, etc.

Wang Yi Renhe Yang Guang (2023) pointed out in the article that the application of airport digitalization is mainly in business operation, data operation, system operation and security operation. These four aspects cover the overall operation of the airport, allowing the airport to compress the original unreasonable and repetitive processes, leaving the original repetitive and operational work to the machine for automatic execution, releasing business productivity; Moreover, with the goal of data commercialization, data value is extracted through data resources mining and effective analysis, forming a unique data consumption pattern of enterprises, providing strong data support for enterprise strategy, decision-making and development; Improve the quality and efficiency of operation and maintenance, effectively split the system by emphasizing the component and service of business systems, realize agile development and deployment, and improve the accuracy, flexibility and application efficiency of system services; Finally, the network security monitoring and early warning, emergency response and disaster recovery capabilities have been improved.

From all aspects of management, Shen Lancheng, Yan Wang and Shi Yunfei (2023) analyzed the use of digitalization in airport aviation service settlement, and concluded that digitalization made the airport's main revenue field realize the integration of industry and finance in four aspects: target, data, management and system; The quality of financial data has been greatly improved, the integrity and accuracy of data have been significantly improved, and the timeliness of data has been improved from monthly measurement to hourly measurement, achieving a qualitative leap and providing accurate and high-value data for management decision support; Moreover, the efficiency of financial services has been significantly improved, and the main income has been automated from data collection to financial accounting to newspaper management, which can provide accurate and comparable analysis and forecast data for management in time; Finally, the function of financial services has been expanded, and finance has been freed from basic accounting work and put into business analysis and decision support, which has taken a solid step towards the transformation of management accounting.

Moreover, the data center is the foundation of the digital transformation of the airport, and it is the means by which data can empower the construction of smart airports and promote the application of data elements in airports. Li Xiaojiang (2023) thinks that at present, most airport data management has generally realized the awareness of the basic management of data and the initial importance of data assets, that is, at the stage of management level or initial definition level, there is still a big gap between the ability level of achieving the foundation of airport survival and development and the ability level of real-time optimization of related management processes based on data. The architecture and implementation of data center is a fundamental technical means to realize the optimization level of airport data management. Moreover, Tong Zongyi (2023) pointed out in the article that different layers are used for digital management in civil airport tracks to realize cross-linking query of various attributes. Through comprehensive analysis of the research status of digital management system, managers at different levels can manage it conveniently, which is more conducive to monitoring the airport status quo.

Zhao Yaqing, Tian Zhigang and Luo Cong (2022) survey pointed out that at present, airport groups all over the country have promoted the digital transformation of production mode, operation mode and management mode, and gradually extended from infrastructure digitalization to supply chain digitalization, and realized the refined management of supply chain operating costs such as

inventory and circulation through digital and intelligent means. Warehousing is the main functional link and cost link of the supply chain, and the refined cost management is an important part of the refined supply chain management. Therefore, the refined cost management of airport spare parts inventory under the digital transformation has important practical guiding significance for the airport to achieve the goal of reducing costs and increasing efficiency and the need for refined cost management.

Ren Jie, Zhuo Haihui and Zhang Xuanyi (2020) believe that the construction of smart airport is closely related to information technology. The comprehensive collection and analysis of airport data through big data technology, data transmission based on Internet of Things technology, artificial intelligence to assist manual decision-making, and digital twin technology to realize management visualization can provide passengers with more convenient airport services.

In terms of airport pavement management, Liu Bin (2022) thinks that it is an inevitable trend for the development of civil aviation industry to adopt digital technology to assist airport pavement management, and it is also the only way to integrate infrastructure and smart airport construction. The development and application of pavement digital management system involves many departments such as field affairs, operation, maintenance and inspection, including patrol inspection, maintenance, maintenance, evaluation and construction implementation.

Liu Hongye, Li Yafei, Zhang Kaiyue and others (2021) think that the digital management of airport pavement is the trend of the times, but the construction of the digital management system of airport pavement is a complex project that needs multi-department cooperation, multi-link cooperation and multi-technology application. Its construction and application broke the information barrier of traditional pavement management, improved the use value of pavement information, produced obvious economic and social benefits, and promoted the development of the airport.

Kovynyov and Mikut(2018) pointed out that ground handling agents are deploying new technologies, mainly to improve process efficiency and reduce costs. Their research shows that ground agents are adapting to the current trend, creating new business models and developing new sources of income. By studying the value chain of ground handling agents, they identified the

areas strongly affected by digital transformation and the areas not affected by digital transformation. By discussing different business scenarios of digital technology, and connecting them with related research, such as automatic service data capture, new digital services for passengers, big data, indoor navigation and wearable devices in airport ground operations.

Ma Qianliang, Shi Rong, Liu Yingbo and others (2022) pointed out that the use of digital construction technology in the airport is helpful to improve the management level of airport projects, change the organizational structure and management methods, accumulate experience in digital construction project management of airport projects, and promote the improvement of project management level in the industry.

From the aspect of transformation, Chen Yan (2022) thinks that in the process of airport digital transformation, top-level design should be strengthened, with business process digitalization and data governance as the starting point, scenarios as the support, applications as the guidance, advanced scientific and technological support, application benefit value enhancement, airport area system architecture remodeling, operation and maintenance technical personnel reserve, and risk control in the transition stage of new and old systems, etc., which will become the main direction of related research in the future.

Chen Gen Tu and Zhong Juanjuan (2022) also believe that the construction of smart airport has become the development trend of civil aviation industry in the future, which is of great strategic significance to better promote the technological progress in the construction, operation, management and decision-making of China airport, improve the informatization level of China civil aviation and realize the sustainable development of civil aviation industry.

Moreover, Bu Yan (2021) believes that digital transformation is a digital survival for large airport businesses; For passengers, it is a better digital travel. Therefore, it is necessary to speed up the digital transformation and promote the construction of four types of airports. Therefore, large airports should actively adapt, innovate and change, and drive the high-quality development of civil aviation with technology.

Zaharia and Pietreanu(2018) pointed out that digitalization affects airports, their business partners and customers at different levels, and its benefits are reflected in operational efficiency, activity automation, real-time monitoring of processes, and providing passengers with self-service, guidance and real-time travel information. Moreover, the application of the digital measures analyzed before will help to reduce waiting time, minimize queues, thus ensuring continuous traffic, improving passengers' perception, and at the same time allowing them to spend more time in restaurants, shops and other places, which will bring higher non-aviation income to the airport. However, it is important to point out that the obstacles to the successful airport digital transformation mean that there is not enough investment to seize the opportunities brought by the digital plan.

Kila(2020) also pointed out in the article that the digital transformation of airports involves not only the implementation of new technologies, but also the integration of existing technologies, processes and services, thus providing a better experience for all stakeholders. DT integrates systems and services, including services provided by airlines, security, customs, franchising, ground handling and other partners, to realize the seamless flow of the airport. The main technologies used are cloud, mobile, blockchain technology, big data, robotics, social media and IT.

From the perspective of environmental protection, Tian Lijun and Zhang Xiu (2023) pointed out that airport digitalization can significantly curb carbon emissions. For every 1% increase in digitalization level, the carbon intensity will decrease by 0.108%, and the carbon reduction effect of digitalization has obvious differences in administrative divisions, but it has not formed a scale effect. Digitalization mainly realizes carbon emission reduction by improving the efficiency of resource allocation, improving management level and improving passenger service satisfaction.

From the security perspective, Wu Shengbing, Lin Qing and Zhu Xiao Yun (2022) pointed out that the use of digital emergency plan management system at the airport is an important part of improving the airport's emergency capacity. By taking emergency responsibility inventory, resource visualization, command systematization, disposal process, deduction automation and evaluation intelligence as the goals, the overall design and function analysis of the airport digital emergency plan management system are carried out, and it is believed that a set of digital technology can assist decision makers to make decisions.

Huegli and Merks(2020) point out that digital technology is implemented in the security field by screening carry-on baggage with the help of automatic explosive detection system, which analyzes the content and supports security personnel to make decisions. Moreover, Thums, Künzel and Klumpp(2023) pointed out that the digital system in airports has changed the job profile and qualifications, especially for security personnel and pilots; Future research may analyze how the crew can improve their safety awareness with the support of digital tools. For professional pilots, the application of digital technology can help to monitor the important flight parameters in the flight process, provide them with effective reference and reduce the probability of accidents. Rudi, Kiefer and Giannopoulos(2020) also pointed out that it can be assumed that pilots will accept technologies such as eye tracking and augmented reality for gaze-based interaction in the future cockpit, and these technologies will also improve the pilot's situational awareness. Khan, Ansell and Kuru(2018) also believe that flight guardians on airplanes also show convincing results in tests and statistical studies, which improve flight safety and serve as additional support for pilots.

From the efficiency point of view, Liu Wanling (2023) analyzed the application of digital technology in the airport, and concluded that the smart airport needs to enhance the relationship with information technology during its operation. Big data technology, Internet of Things technology, digital twinning technology and artificial intelligence technology are used to assist the implementation of data retrieval, analysis and transmission in the smart airport, so that managers can complete the decision-making work in the first time, ensure the efficient operation of the smart airport, and at the same time, improve the convenience for passengers to take the flight.

In addition, from the perspective of passenger experience, digital transformation is also very important for the airport. Passengers' expectations for the airport are far more than simple travel functions. They expect a more convenient, personalized and comfortable experience. Therefore, the airport needs to provide passengers with more efficient and comfortable services through digital transformation.

For example, by applying artificial intelligence and big data technology, airports can accurately predict passengers' needs and provide them with personalized services. Before the passengers arrive at the airport, the airport can push the flight dynamics, airport maps, traffic information and

other related information to the passengers through mobile APP or WeChat WeChat official account, so as to help the passengers prepare for their trip in advance. After passengers enter the airport, the airport can provide accurate navigation and guidance for passengers through the intelligent guidance system to help them quickly complete the check-in and security check-in processes. During the waiting period, the airport can provide intelligent entertainment system to provide passengers with diversified entertainment options, so that they will no longer feel bored and anxious during the waiting process.

At the same time, digital transformation also helps the airport to improve service quality. By applying digital technology, the airport can realize real-time monitoring and optimization of service flow, find and solve problems in time, and improve service quality and efficiency. In addition, digital transformation can also help the airport to improve the level of safety management, and timely discover and deal with security risks through intelligent monitoring and intelligent early warning to ensure the safe travel of passengers.

To sum up, digital transformation is of great significance to the airport. Through digital transformation, the airport can improve operational efficiency, passenger experience, service quality and safety management. Therefore, large airports should actively embrace digital transformation, strengthen cooperation with partners and jointly promote the high-quality development of civil aviation.

3.3 Chongqing Jiangbei International Airport Digital Application Research

Chongqing Jiangbei International Airport is an important aviation hub in southwest China, and its digital application research has significant practical significance. The purpose of this study is to conduct a comprehensive and in-depth discussion on the digital application of Chongqing Jiangbei International Airport, with a view to providing useful reference for the best practice of airport digitalization.

3.3.1 Airport background information

Chongqing Jiangbei International Airport is located in Jiangbei District, Chongqing, China, about 19 kilometers away from the city center. The airport was built in 1990 and covers an area of about 40 square kilometers. Since its establishment, the business volume of Chongqing Jiangbei International Airport has increased year by year. At present, more than 200 domestic and international routes have been opened, covering major cities on five continents. The annual passenger throughput of the airport exceeds 40 million passengers and the cargo and mail throughput exceeds 500,000 tons, making it one of the most important aviation hubs in southwest China.

3.3.2 Research content scope

This study focuses on the digital application of Chongqing Jiangbei International Airport, mainly from six aspects: digital infrastructure, digital services, digital management, big data and applications, artificial intelligence technology and security and privacy.

First, digital infrastructure. By analyzing the current situation of airport information infrastructure, including communication network, server equipment, cloud computing platform, etc., the supporting ability of airport operation is evaluated. Second, digital services. This paper studies the digital services provided by the airport, such as online services, self-service and mobile applications, and discusses their effects on improving the passenger experience and airport operation efficiency. Third, digital management. By analyzing the intelligent management systems adopted by the airport, such as flight information management system, security inspection system, baggage tracking system, etc., the improvement effect of the airport operation management is evaluated. Fourth, big data and applications. This paper discusses the application of big data technology and methods in airport flight scheduling, passenger service and marketing, and analyzes its role in airport decision support and business optimization. Fifth, artificial intelligence technology. This paper studies the present situation and prospect of the application of artificial intelligence technology in security inspection, passenger service and flight support, and evaluates its improvement potential for airport operation. Sixth, security and privacy. By analyzing the security risks and privacy protection problems in the process of airport digital application, the corresponding solutions and suggestions are put forward.

4 Questionnaire survey on digital application of Chongqing Jiangbei International Airport

This survey comprehensively analyzes the actual situation of digital application of Chongqing Jiangbei International Airport from five dimensions by means of coverage matrix. After analyzing the related cases, documents and the digitalization of Chongqing Jiangbei International Airport, the table of digitalization application of Chongqing Jiangbei International Airport is designed.

4.1 Questionnaire survey content design basis

When designing the questionnaire on the digital application of Chongqing Jiangbei International Airport, we need to consider the existing digital application of the airport. Therefore, when designing the questionnaire, we should follow the following six principles: conciseness, objectivity, logicality, representativeness, feasibility and comprehensiveness. The reasons are as follows: First, simplicity. The questions are short and direct, and complex and vague words and sentences are not used, so the respondents can quickly understand the contents of the questionnaire. Second, objectivity. The way of asking questions remains objective and neutral, with no leading questions and no emotional preference. Third, logic. The content of the questionnaire has a clear logical structure, the questions are in a reasonable order, and the upper and lower questions can be coherent. Fourth, representativeness. The questions are representative and can reflect the key aspects of the survey theme. Fifth, feasibility. Considering the actual situation, ensure that the questionnaire can be completed within the specified time. Sixth, comprehensiveness. The content of the questionnaire covers all aspects involved in the purpose of the survey, ensuring the comprehensiveness of the survey. Therefore, these principles will ensure the credibility and practicability of the questionnaire survey and provide support for drawing the best practice of airport digitalization.

4.2 Questionnaire Design

According to the above principles, combined with the way of coverage matrix, the survey scale of Chongqing Jiangbei International Airport is designed, and the specific contents are shown in Table 4. The Questionnaire Survey of Chongqing Jiangbei International Airport's Digitalization Application includes the frequency of the respondents' trips, the way of understanding information, and the understanding of the digital service of the airport. Respondents expressed their opinions according to their actual situation.

Table 4: Chongqing Jiangbei International Airport Digital Application Questionnaire

Dimensions	No.	Questionnaire Content
Convenience	A1	There are many channels for understanding airport information.
	A2	The digital intelligent service provided by the airport is easy to use.
	A3	Passengers often use the digital services provided by the airport.
	A4	The digital service of the airport improves the efficiency of passenger travel.
Reliability	B1	Airports provide reliable digital security measures.
	B2	The electronic boarding pass and baggage tracking at the airport have greatly helped passengers.
	B3	The digitalization of the airport can quickly deal with emergencies.
	B4	The digital application of the airport played a great role during the epidemic.
	B5	The digital service of the airport has improved the satisfaction and loyalty of passengers.
	B6	The airport provides reliable information guarantee.
	B7	Passengers are willing to recommend the digital services provided by the airport to others.
Comprehensiveness	C1	The digital services provided by the airport are comprehensive.
	C2	The airport provides intelligent customer service.
	C3	The airport provides free Wi-Fi service.
Environmental protection	D1	The airport has adopted relevant environmental protection measures by using digitalization.

	D2	The digitalization of the airport is helpful to improve the level of environmental protection and sustainable development of the airport.
Improve	E1	Users want to see more intelligent robot services.
	E2	Users want to have a simplified boarding process.
	E3	Users want more personalized services.

This questionnaire is completely produced, distributed and collected by asking questions. Respondents can receive my survey through the questionnaire link and QR code. The distribution group of this questionnaire is mainly people who fly frequently, because only by flying frequently can we know more about the digital service of the airport. See Appendix 1 for the original questionnaire.

4.3 Reliability and validity analysis of questionnaire survey

In this study, different types of passengers were selected to fill in the questionnaire, and 295 valid questionnaires were collected.

4.3.1 Reliability analysis

In this study, SPSS software was used to analyze the reliability of the questionnaire, and 295 subjects were used to test 25 items, and the Cronbachα coefficient was calculated to be 0.894. When Cronbachα coefficient is between 0.70 and 0.90, it can be regarded as having high internal consistency. Therefore, the results of this study show that there is a high internal consistency among the 25 projects tested. This means that these items can measure the potential variables studied as a whole, and the scores of these items can be substituted for each other. In a word, the results of this study prove the reliability and effectiveness of the measurement tools used, which provides a solid foundation for the follow-up research. At the same time, it also shows that the questionnaire on the digital application of Chongqing Jiangbei International Airport is credible and the survey results are effective. The results of reliability analysis table are shown in Table 5:

Table 5: Reliability Analysis of Questionnaire Survey on Digital Application of Chongqing Jiangbei International Airport

Sample size	Number of entry	Cronbach α coefficient
295	25	0.894

4.3.2 Validity analysis

In this study, SPSS factor analysis was used to test the validity of the questionnaire. The questionnaire is designed to explore the impact of airport digital services on passengers' travel experience, including several items, involving passengers' perception, willingness to use and satisfaction with airport digital services.

1. Factor extraction and rotation

Six factors were extracted from the original data by principal component analysis and maximum variance rotation. These factors are reflected in the characteristic root value, variance interpretation rate and cumulative variance interpretation rate before and after rotation.

2. Factor explanation

Factor 1: This factor is mainly related to passengers' overall perception and satisfaction with airport digital services, such as "Do you think airport digital services have played an important role in improving passengers' satisfaction and loyalty?" Wait for the project. These projects reflect passengers' overall evaluation of digital services, including their views on the improvement of travel efficiency and the ease of service.

Factor 2: This factor mainly involves passengers' views on the security and privacy protection of airport digital services, such as "Do you want airports to pay more attention to passengers' personal privacy protection in digital services?" Wait for the project. These projects reflect the degree of attention paid by passengers to security and privacy protection when enjoying digital services.

Factor 3: This factor is related to passengers' willingness and satisfaction with the specific digital services provided by the airport, such as "Have you used the free Wi-Fi service provided by the airport?" Wait for the project. These projects reflect the actual use and satisfaction of passengers with the specific digital services provided by the airport.

Factor 4: This factor mainly involves passengers' perception of the airport's improvement and new services in terms of digital services, such as "Have you noticed the airport's improvement or new services in terms of digitalization in your past trips to the airport?" Wait for the project. These projects reflect passengers' attention to the improvement of airport digital services and new services.

Factor 5: This factor is related to the passengers' performance in dealing with emergencies and epidemics, such as "Do you think the digital service of the airport is excellent in dealing with emergencies (such as flight delays and security incidents)?" Wait for the project. These projects reflect the passengers' evaluation of the digital service performance of the airport under special circumstances.

Factor 6: This factor mainly involves passengers' satisfaction and usage of the virtual assistant or intelligent customer service provided by the airport, such as "How satisfied are you with the virtual assistant or intelligent customer service provided by the airport?" Wait for the project. These projects reflect passengers' actual use and satisfaction with the virtual assistants or intelligent customer service provided by the airport.

3. Validity test

The validity of the questionnaire was tested by KMO value and bartlett spherical test. KMO value is 0.883, which indicates that the data is suitable for factor analysis. The P value of bartlett spherical test is less than 0.001, which further confirms that the data is suitable for factor analysis.

To sum up, the questionnaire designed in this study has good validity and can effectively measure passengers' perception, willingness to use and satisfaction with airport digital services. The six factors extracted by factor analysis can better explain the items in the questionnaire, which provides strong support for the subsequent data analysis and interpretation. The results of validity analysis are shown in Table 6.

Table 6: Validity analysis of questionnaire survey on digital application of Chongqing Jiangbei International Airport

Project	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Common degree
Do you often travel in Chongqing Jiangbei International Airport?	-0.02	-0.09	0.03	0.04	0.71	-0.00	0.512
Do you think the digital services of the airport (such as self-service check-in machines and electronic boarding passes) are convenient and easy to use?	0.22	0.18	0.75	0.20	-0.09	0.05	0.692
Will you take the initiative to use the digital services provided by the airport?	0.33	0.19	0.66	-0.01	-0.04	-0.03	0.578
Do you think the digital service at the airport has improved your travel efficiency?	0.14	0.22	0.71	0.13	-0.27	-0.07	0.668
Which service are you most satisfied with in the digital service of the airport?	0.06	0.00	-0.01	0.03	-0.07	0.95	0.913
Do you know the security measures of digital services	0.16	0.01	0.79	0.09	0.21	-0.05	0.702

provided by the airport?							
Would you like to recommend the digital service of Chongqing Jiangbei International Airport to your relatives and friends?	0.12	0.15	0.79	0.17	-0.04	0.09	0.704
In your past trips to the airport, have you noticed any improvements or new services in digitalization at the airport?	0.14	0.31	0.22	0.72	0.06	0.01	0.691
Have you ever used the free Wi-Fi service provided by the airport? (If "No, I've never used it" or "No, I don't know about this service" is selected, please skip to question 17.)	0.06	0.03	-0.08	-0.01	0.64	-0.20	0.461
Do you have any suggestions or opinions about the free Wi-Fi service at the airport?	0.21	0.15	0.12	0.82	0.07	-0.07	0.766
Do you want the airport to provide more digital related free services in the future?	0.24	0.28	0.13	0.71	-0.12	0.21	0.714
Do you think the digital service of the airport has played an important role in improving passenger satisfaction and loyalty?	0.15	0.31	0.12	0.75	-0.08	-0.04	0.710

Have you ever encountered any privacy or security concerns during your use of digital airport services? (If you choose "Yes, I have concerns about privacy or security", please continue to answer question 20; If you choose "No, I have no privacy or security concerns", please skip to question 21.)	-0.09	0.02	-0.06	-0.05	0.59	0.09	0.373
Do you think the digital service of the airport will help to improve the environmental protection and sustainable development level of the airport?	0.09	0.65	0.08	0.31	-0.13	-0.01	0.554
Do you think the digital service of the airport is excellent in dealing with emergencies (such as flight delays, security incidents, etc.)?	0.10	0.81	0.10	0.13	-0.07	-0.05	0.700
Do you think the digital service of the airport played an important role in prevention, control and protection during the epidemic?	0.17	0.79	0.19	0.24	-0.10	-0.07	0.751
During the epidemic, did you use the digital health	0.08	0.76	0.16	0.18	0.12	0.07	0.665

declaration or contact tracking service provided by the airport?							
What do you think of the digital health declaration or contact tracking service provided by the airport during the epidemic?	0.12	0.78	0.14	0.14	0.09	0.07	0.679
Do you think airports should pay more attention to the protection of passengers' personal privacy in digital services?	0.74	0.18	0.11	0.10	-0.24	0.14	0.677
Do you want the airport to provide more education and training on digital services to help you use these services better?	0.74	0.29	0.07	0.11	-0.06	-0.03	0.659
Have you ever known and used the virtual assistant or intelligent customer service provided by the airport?	0.79	0.08	0.21	0.04	0.15	0.07	0.706
How satisfied are you with the virtual assistant or intelligent customer service provided by the airport?	0.72	0.05	0.18	0.19	0.10	-0.10	0.611
Do you want the airport to introduce more artificial intelligence technologies into digital services, such as intelligent navigation and face recognition?	0.70	0.08	0.04	0.28	-0.20	0.01	0.619

In the process of using the digital airport service, have you ever encountered any service interruption or failure?	0.75	0.07	0.19	0.10	0.19	-0.03	0.655
How do you usually deal with the interruption or failure of airport digital service?	0.73	-0.00	0.24	0.08	-0.15	0.07	0.622
Characteristic root value (before rotation)	7.79	2.66	1.90	1.68	1.33	1.02	-
Variance interpretation rate% (before rotation)	31.15%	10.65%	7.60%	6.73%	5.33%	4.07%	-
Cumulative variance interpretation rate% (before rotation)	31.15%	41.80%	49.40%	56.13%	61.45%	65.53%	-
Feature root value (after rotation)	4.28	3.47	3.14	2.74	1.67	1.08	-
Variance interpretation rate% (after rotation)	17.12%	13.89%	12.55%	10.95%	6.69%	4.32%	-
Cumulative variance interpretation rate% (after rotation)	17.12%	31.02%	43.57%	54.52%	61.21%	65.53%	-
KMO value	0.883						-
Barth spherical value	2478.547						-
df	300.000						-
P value	-						-

4.4 Analysis of questionnaire survey data results

This paper analyzes the results of questionnaire survey data by means of chart statistics.

4.4.1 Basic information of users

According to the travel frequency, 71.19% of the respondents often travel in Chongqing Jiangbei International Airport. Travel frequency can reflect passengers' understanding of the digital application of the airport, and can better draw the actual situation of the digital application of the airport.

According to the way of obtaining information, social media (83.73%) is the main way for users to obtain airport information, followed by SMS notification (60.68%) and official website (52.2%). It shows that there are not single ways for passengers to know airport information. Most passengers get airport information through three channels, and it is successful for airports to use big data to push airport information, which can provide customers with more, better and more convenient information.

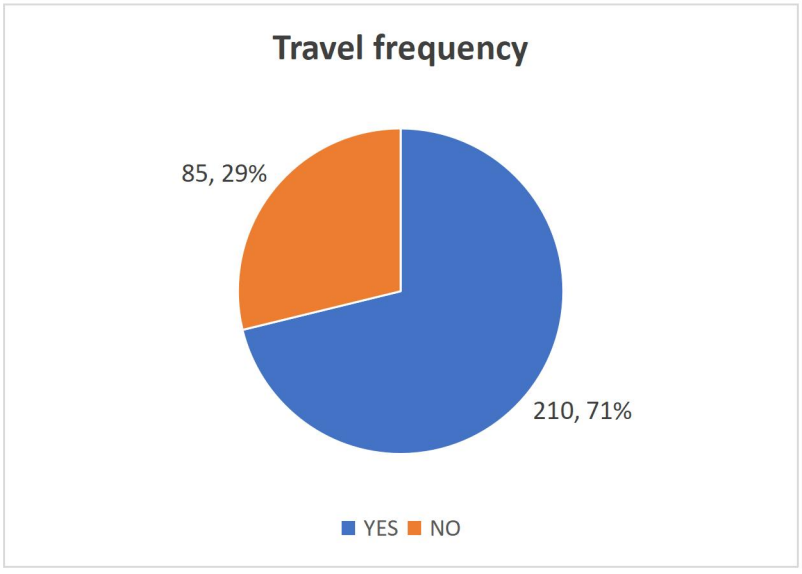

Figure 11: Travel Frequency Analysis

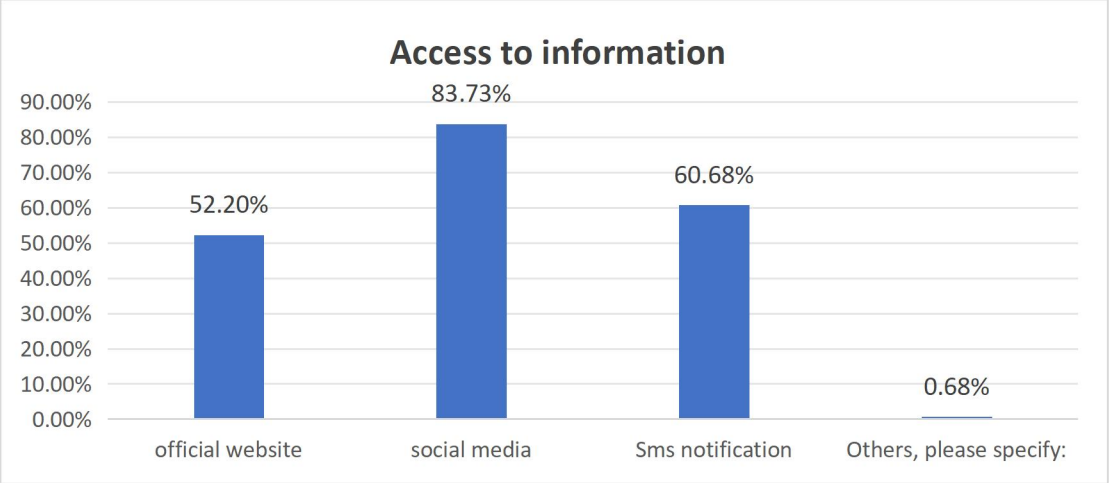

Figure 12: Analysis of Information Access Ways

4.4.2 Use and evaluation of digital services

From the perspective of various services, 75.25% of users think that the digital service at the airport is convenient or very convenient. Among them, self-service check-in machine (88.14%) and electronic voice broadcast display screen (63.05%) are the most familiar services for users. Moreover, 70.51% users always or often take the initiative to use the digital service of the airport. In addition, 76.95% of users feel that digital services have improved travel efficiency. Moreover, mobile applications have become the most satisfactory service for users with a proportion of 24.75%. And 62.03% of users fully understand or have a better understanding of the security measures of digital services at the airport. Therefore, it can be concluded that the digitalization of the airport has been well practiced in terms of service, and it has provided passengers with more convenient travel services and increased their satisfaction.

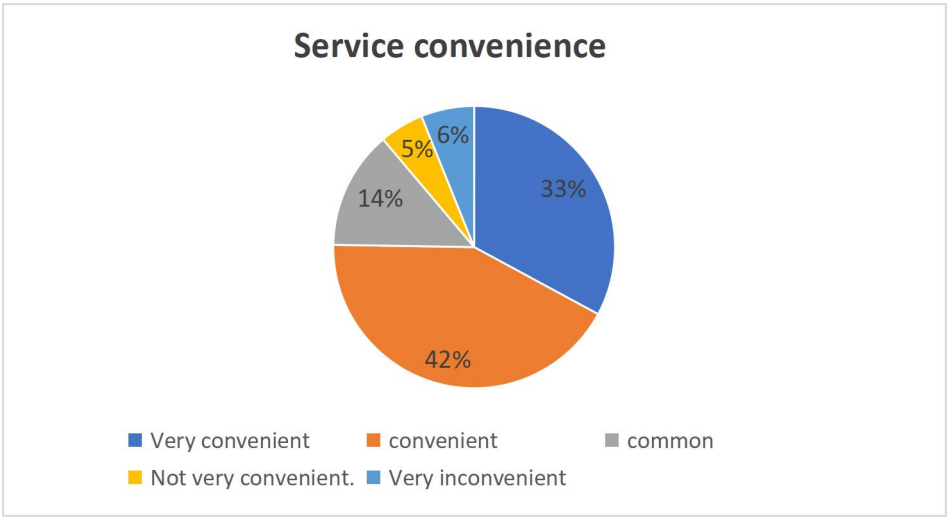

Figure 13: Service Convenience Analysis

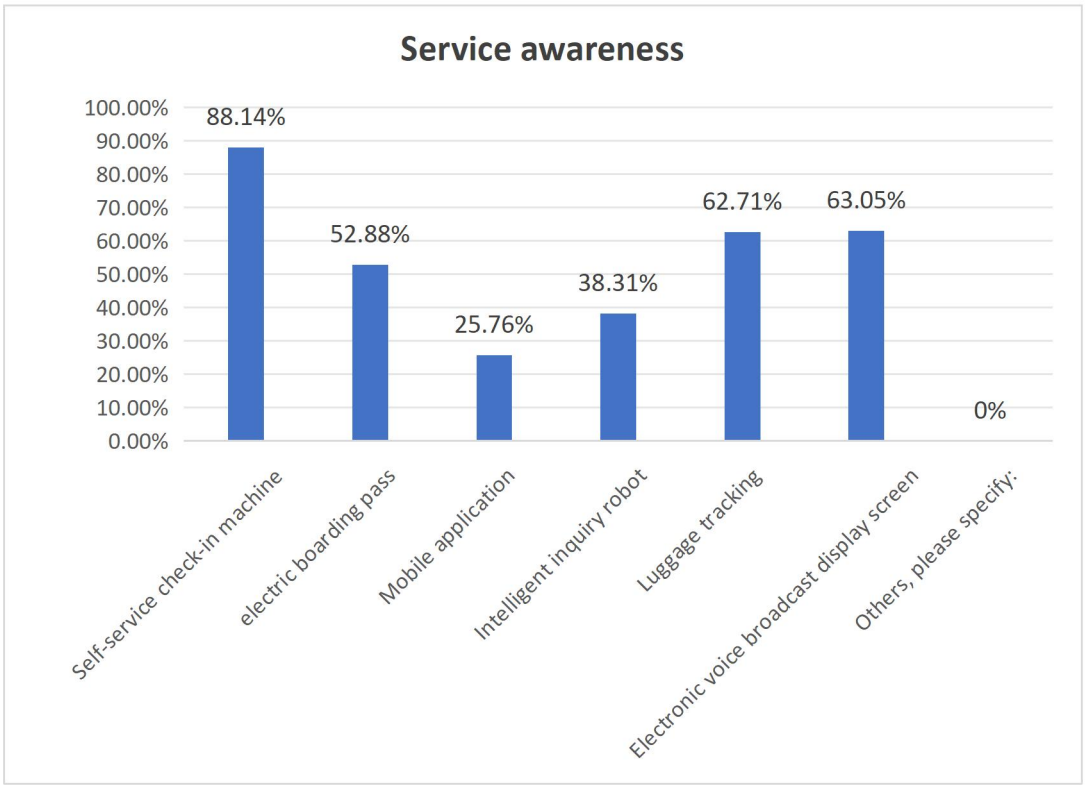

Figure 14: Service Awareness Analysis

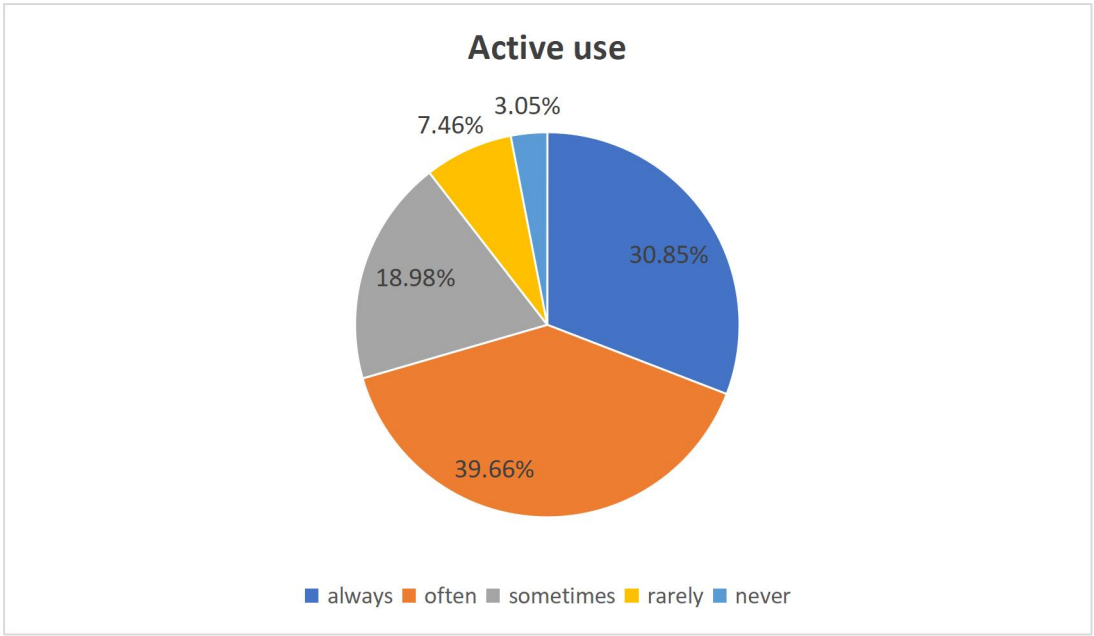

Figure 15: Active usage analysis

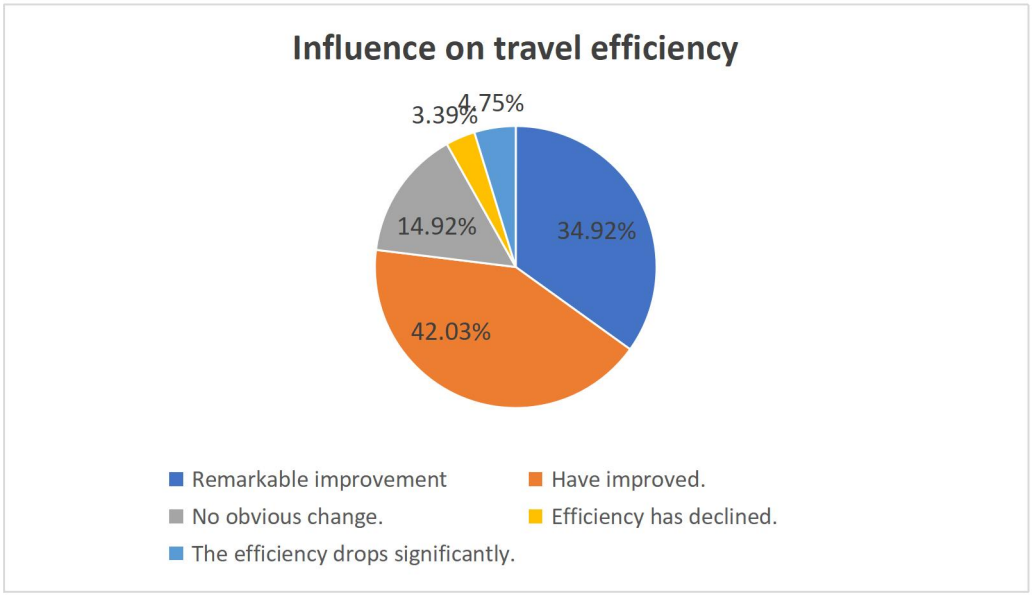

Figure 16: Impact Analysis on Travel Efficiency

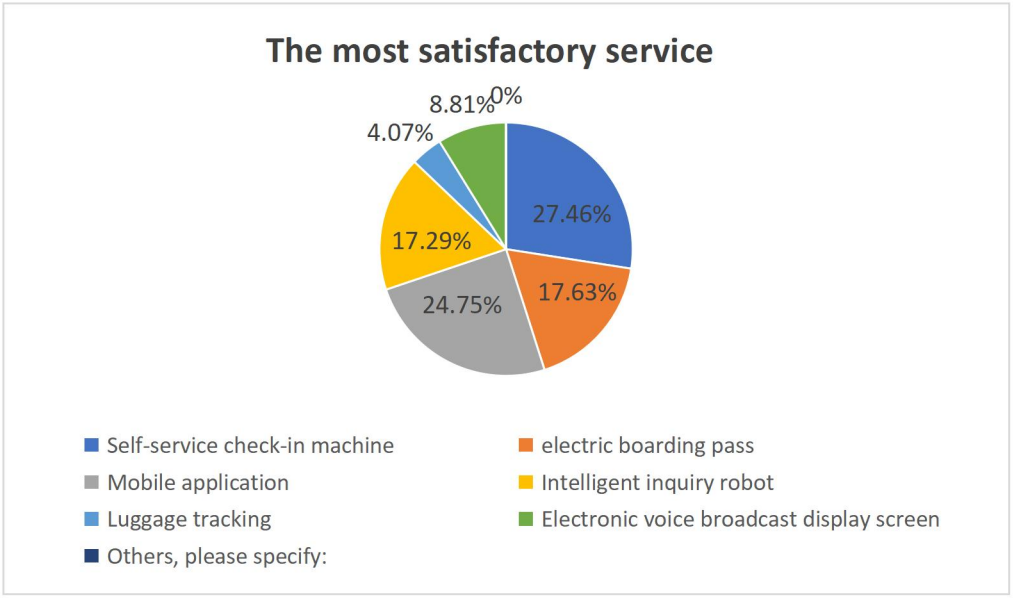

Figure 17: Analysis of the most satisfied service

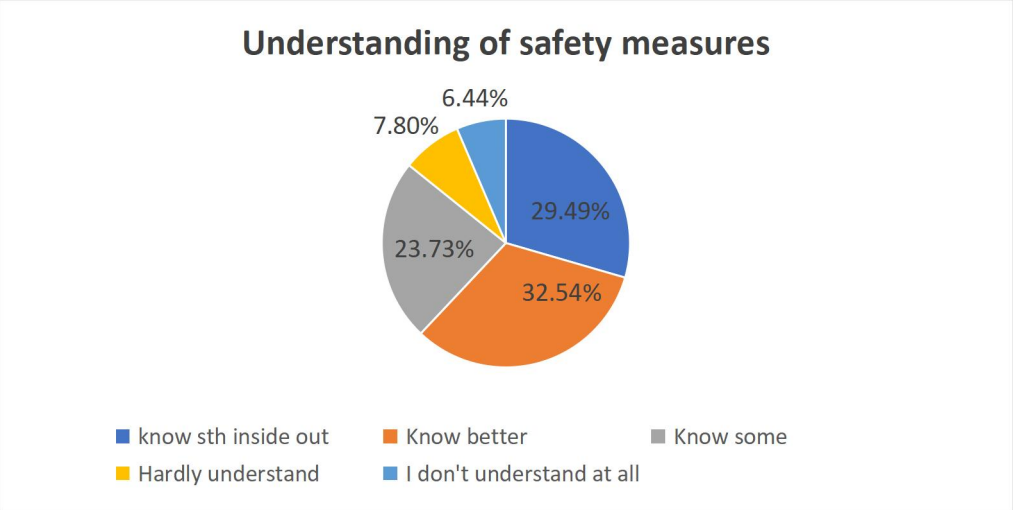

Figure 18: Analysis of Understanding of Safety Measures

4.4.3 User's worries and expectations

Users still have some worries and expectations about the application of airport digitalization. For example, users' concerns about security include privacy protection, information security and personal information protection. Moreover, according to the survey results, 76.27% users are willing or very willing to recommend the digital service of the airport to their relatives and friends. It shows that the digital service customers of the airport are satisfied. In addition, 63.73% of users have noticed the improvement or new service of the airport in digitalization. This shows that the improvement of airport digitalization is obvious and effective. Finally, users suggest to further promote digital services in publicity, service flow and real-time information update. This shows that users hope that the airport can continuously update its digital services and provide more perfect digital services, so as to improve their travel efficiency.

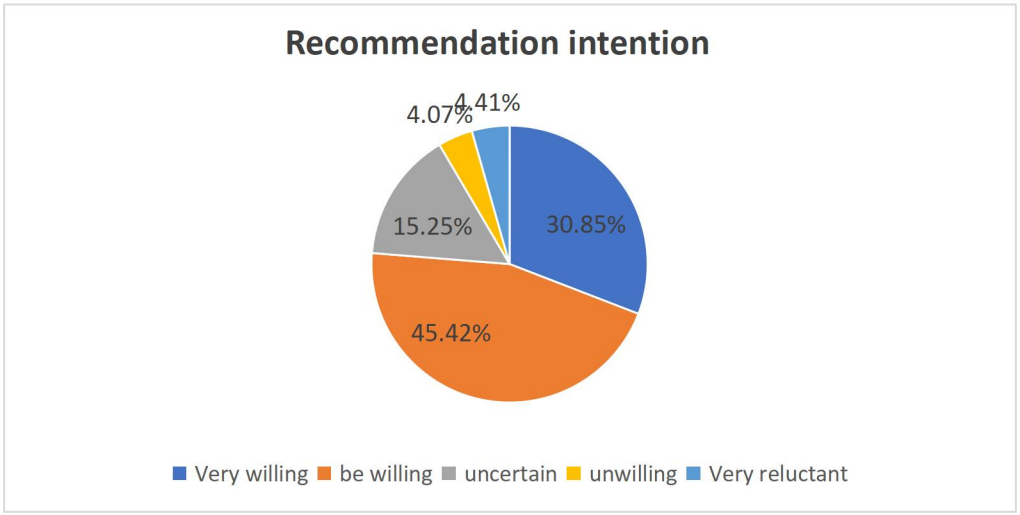

Figure 19: Analysis of Recommendation Intention

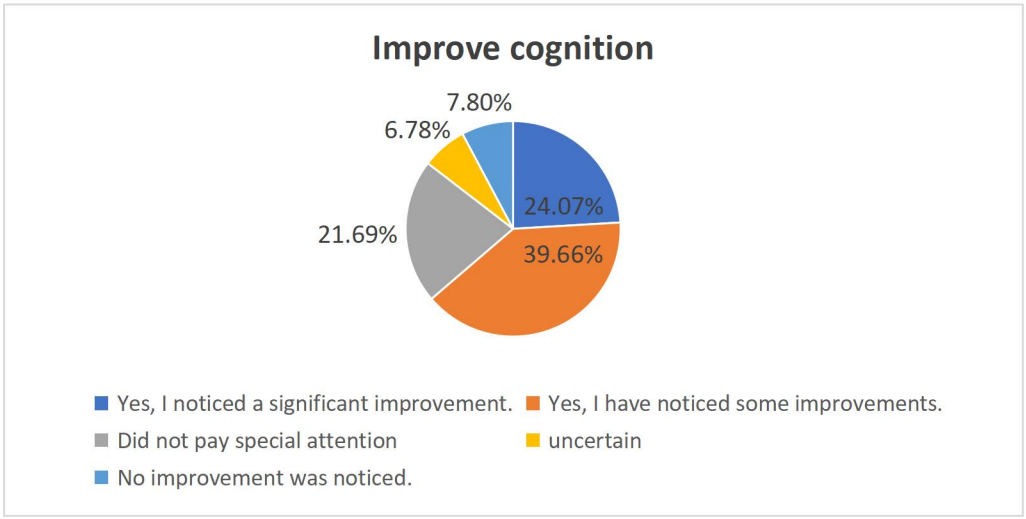

Figure 20: Improved cognitive analysis

4.4.4 Service performance under special circumstances

When dealing with emergencies, 67.8% of users think that the digital service of the airport has performed well or well in dealing with emergencies. It shows that the digital application of the airport can feed back the problems of customers' travel in time and respond quickly. In addition, in terms of epidemic prevention and control, 70.51% of users believe that digital services have played an important or certain role during the epidemic. This shows that the application of airport digitalization can provide certain security.

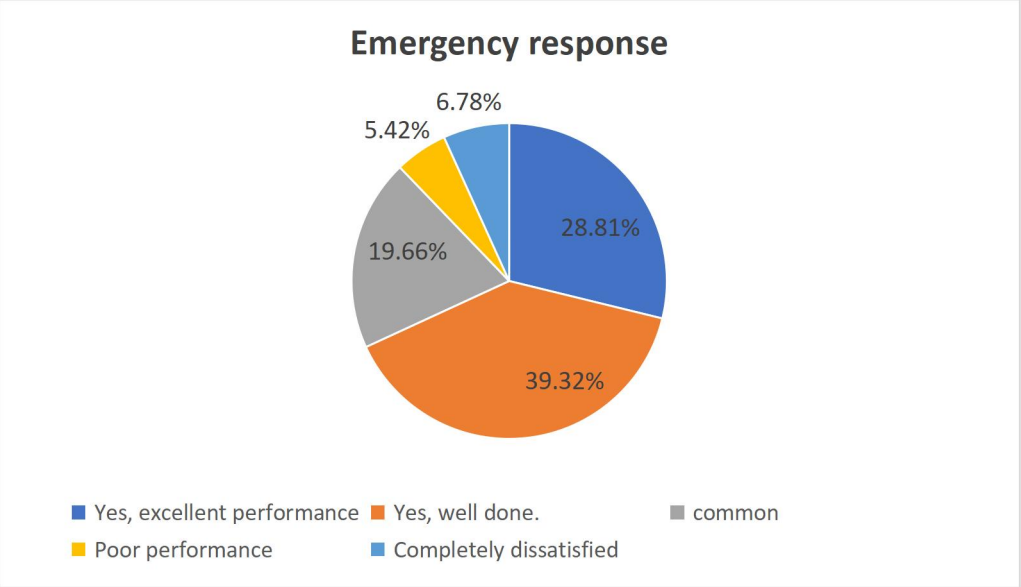

Figure 21: Analysis of Emergency Response

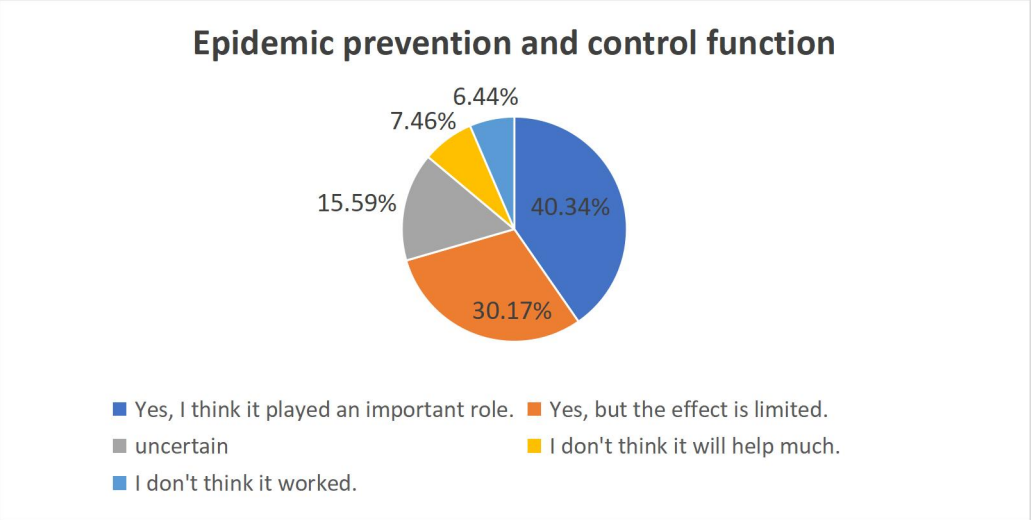

Figure 22: Analysis of epidemic prevention and control

4.4.5 Suggestions for improving user experience

For the current application of airport digitalization, users also put forward some suggestions. Users expect more convenient boarding process (88.14%), more personalized service recommendation (78.98%) and more accurate flight information update (65.42%). Moreover, users tend to try to reconnect or contact customer service for help when they encounter service interruption or failure. This shows that although the current digital service is very good, it still needs to be optimized.

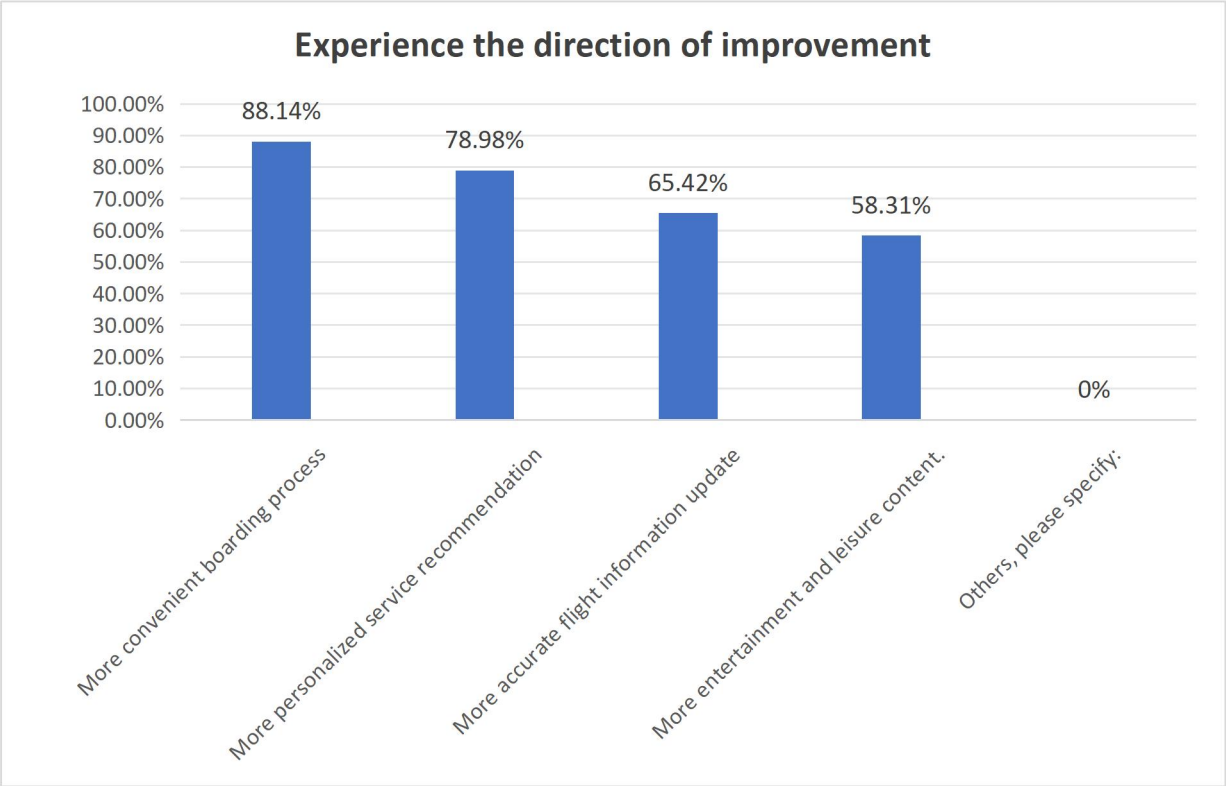

Figure 23: Analysis of Experience Promotion Direction

4.4.6 Future expectations and suggestions for improvement

Users also have their own suggestions for future expectations and improvements. The improvements or new functions users want to see include smarter robot service, simplified boarding process and personalized service. And 43.39% users think that privacy protection is very important, and more attention should be paid to the personal privacy protection of passengers. This shows that users are worried about the digital application and their data will be leaked.

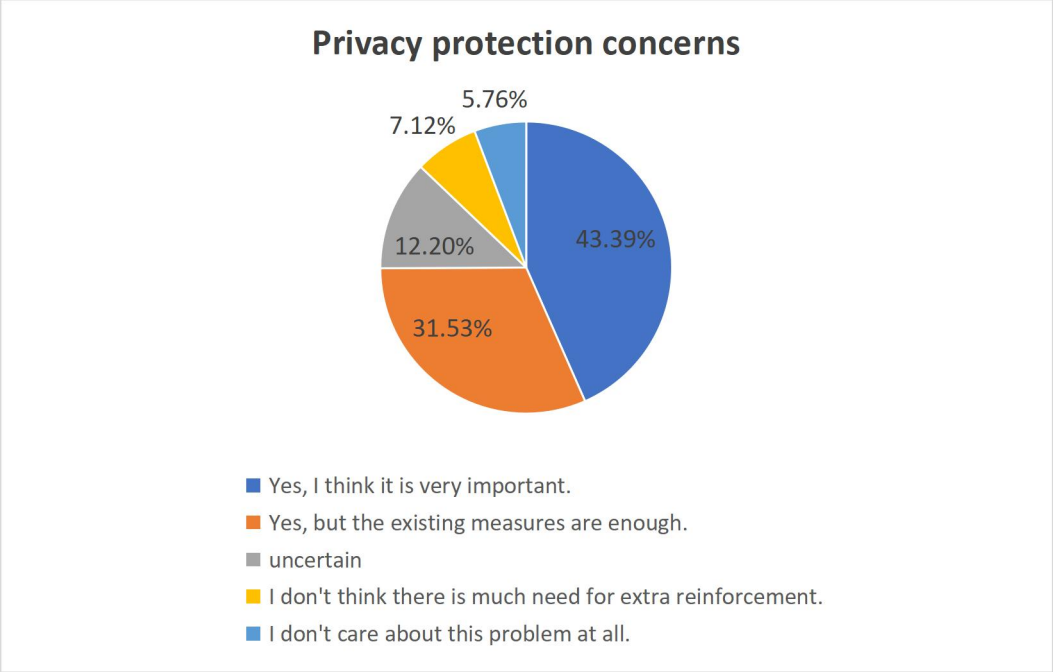

Figure 24: Privacy Protection Analysis

4.5 Survey and summary of digital application

The survey results show that the digital service of Chongqing Jiangbei International Airport has been accepted by most users and has played a positive role in improving travel efficiency and passenger satisfaction. Users have high expectations for privacy protection, convenience and personalization of services. Airports should continue to optimize existing services, focus on users' safety concerns, and promote new technologies to enhance the passenger experience.

5 research results and discussion

Through the above research, from the four aspects of practicality, convenience, security and service situation, integrated service situation is the best practice module of airport digitalization. First of all, the integrated service module can realize centralized management and monitoring of airport services through digital technology. By integrating the data of various service systems, the airport can know the needs and behaviors of passengers in real time, so as to better allocate resources and provide services, which has certain practicability. Secondly, the integrated service situation module can provide a one-stop service platform, and passengers can complete all service requirements through an application or website, such as online check-in, self-service consignment, baggage tracking and so on. This can reduce the waiting time of passengers, improve travel efficiency and make travel more convenient. More importantly, the integrated service status module can monitor the airport security status in real time through intelligent monitoring and data analysis. By integrating video surveillance, face recognition and other technologies, abnormal behaviors and potential safety hazards can be found in time, and the airport's security capability can be improved, which is very safe. Finally, the integrated service situation module can provide personalized services. By analyzing passengers' preferences and historical data, airports can provide personalized recommendations and customized services to passengers. For example, recommend restaurants, shops or tourist attractions according to passengers' preferences, and provide customized itinerary planning.

No matter from the point of view of management or service, the application of airport digitalization is undoubtedly successful. For example, the application of big data technology can not only help airport staff to carry out management work, but also provide customers with better and more accurate services. Secondly, the application of intelligent security inspection can not only reduce the burden of airport staff, but also improve the efficiency of passenger security inspection. Finally, the application of airport intelligent service equipment can not only help airport staff to provide airport information in time, but also help passengers to understand information and other related digital applications in time.

To sum up, by integrating various services, the airport can provide more efficient, convenient, safe and personalized services, and enhance the passenger experience and satisfaction. At the same time, the integrated service module can also help the airport management to better understand and

master the airport operation, make timely decisions and adjustments, and improve the airport operation efficiency and competitiveness.

6 Research conclusion, discussion and reflection

6.1 Conclusion

Integrating service situation module is the best practice of airport digitalization. However, in order to achieve the best practice of integrating the service situation module, the airport needs to make full use of digital technology and big data analysis capabilities to establish a sound information system and data platform. In addition, the airport also needs to work closely with various service providers and partners to share data and resources, so as to realize seamless connection and cooperative operation of services. Finally, the airport needs to strengthen the security and privacy protection of digital technology to ensure the safety of passengers' personal information and data.

To sum up, integrating service situation module is the best practice of airport digitalization, which can bring many benefits, but it also needs to overcome some challenges and problems. Through continuous innovation and improvement, the airport can realize digital transformation and improve service quality and competitiveness.

6.2 Discussion

With the rapid development of science and technology, as the hub of modern transportation, the digital transformation of airport has become an important trend of industry development. Among them, the integrated service situation module, as the best practice of airport digitalization, has far-reaching significance for improving airport operation efficiency, improving passenger experience and promoting industry development.

First of all, the integration of service situation module plays a significant role in improving airport operation efficiency. Traditional airport management methods often have information islands, and it is difficult to effectively share data between departments, resulting in low resource utilization and high operating costs. By integrating the service situation module, the airport can manage and analyze the data of each business link in a unified way, and realize the optimal allocation and efficient utilization of resources. For example, by real-time monitoring flight take-off and landing, passenger flow and equipment operation, the airport can more accurately schedule human resources, adjust flight plans and optimize equipment configuration, thus improving the overall operational efficiency of the airport.

Secondly, integrating the service situation module has a positive impact on improving the passenger experience. In the digital age, passengers' demand for airport services is increasingly diversified and personalized. By integrating the service situation module, the airport can know the needs and feedback of passengers in real time, thus providing more accurate and convenient services. For example, by analyzing passengers' travel habits, preferences and other information, the airport can provide passengers with more personalized flight recommendation, check-in service, luggage consignment, etc., so that passengers can travel more easily and happily.

In addition, integrating the service situation module also plays an important role in promoting the development of the industry. With the rapid development of aviation industry, airports are facing increasing competitive pressure. By integrating the service situation module, the airport can keep abreast of the latest trends of the industry, market demand and other information, so as to formulate a more scientific and reasonable development strategy. At the same time, through data sharing and cooperation with other airports, resources sharing and complementary advantages in the industry can be realized, and the healthy development of the whole industry can be promoted.

To sum up, integrated service situation module, as the best practice of airport digitalization, is of great significance for improving airport operation efficiency, improving passenger experience and promoting industry development. In the future, with the continuous development and application of digital technology, it is believed that the integrated service situation module will play a more important role in the digital transformation of the airport and inject new vitality into the prosperity and development of the aviation industry.

6.3 Reflection

In the process of thesis writing, I can fully understand the development status, application fields, best practices and future trends of airport digitalization, which will help me improve my professional quality. Although the paper strives for perfection in all aspects, there are still some shortcomings. First of all, the research scope is limited, which fails to comprehensively cover related fields. Secondly, some data and cases may be insufficient, and future research should strengthen data

collection and case analysis. Finally, the paper is still insufficient in some theoretical elaboration, and it is necessary to strengthen the research and understanding of related theories.

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Appendices

Appendix 1. Questionnaire

Questionnaire survey on digital application of

Chongqing Jiangbei International Airport

Digital transformation has become an important trend in the development of modern airports. As an important aviation hub in Southwest China, Chongqing Jiangbei International Airport has been actively exploring digital transformation, aiming to provide more efficient and convenient services. Your answers will help us understand the coverage and effectiveness of information dissemination. The results of this questionnaire are only used for paper writing, not for commercial use.

1.How often do you travel through Chongqing Jiangbei International Airport? [Single choice] *

○ Yes

○ No

2.How do you usually keep up with the latest news and information at the airport? [Multiple choice] *

○ Official Website

○ Social media

○ SMS Notification

○ Others, please specify: _____*

3.Do you find the airport's digital services (such as self-service check-in, electronic boarding passes, etc.) convenient and easy to use? [Single choice] *

○ Very convenient

○ Convenience

○ Normal

○ Inconvenient

○ It is very inconvenient

4.Do you know what digital services are available at Chongqing Jiangbei International Airport? [Multiple choice] *

○ Self-service check-in

○ Electronic boarding pass

○ Mobile applications (such as APP)

○ Intelligent inquiry robot

○ Luggage Tracking

○ Electronic voice broadcast display

○ Others, please specify: _____*

5.Will you actively use the digital services offered by the airport? [Single choice] *

○ All the time

○ Often

○ Sometimes

○ Very few

○ Never

6.Do you feel that digital services at airports have improved your travel efficiency? [Single choice] *

○ Significant improvement

○ Improvement

○ No significant change

○ Reduced efficiency

○ Significant decrease in efficiency

7.Which of the airport's digital services are you most satisfied with? [Single choice] *

○ Self-service check-in

○ Electronic boarding pass

○ Mobile applications (such as apps)

○ Intelligent inquiry robot

○ Luggage Tracking

○ Electronic voice broadcast screen

○ Others, please specify: _____ *

8. Are you aware of the security measures for digital services provided by the airport? [Single

choice]*

○ Complete understanding

○ Better understanding

○ Know Something

○ I hardly know

○ I have no idea

9. How do you think airports should enhance security measures in digital services? (Open Q&A) [Fill in the blanks] *

_____

10. Would you like to recommend the digital services of Chongqing Jiangbei International Airport to your friends and relatives? [Single choice] *

○ Very willing

○ Yes

○ Uncertainty

○ Reluctant

○ Very reluctant

11. In your past trips to the airport, have you noticed any improvements or additions to the airport's digital offerings? [Single choice] *

○ Yes, I have noticed a marked improvement

○ Yes, I have noticed some improvement

○ Not particularly noticed

○ Uncertainty

○ No improvement was noted

12. Where do you think airports can further promote digital services to improve passenger experience? (Open Q&A) [Fill in the blanks] *

_____

13. In your opinion, what functions need to be improved or added most in airport digital services? (Open Q&A) [Fill in the blanks] *

_____

14. Which digital services at airports do you think have helped improve your travel experience the most? [Multiple choice] *

○ Fast security check channel

○ Flight dynamic real-time update

○ Electronic boarding pass and baggage tracking

○ Airport map navigation and route planning

○ Airport dining, shopping recommendations

○ Others, please specify: _____*

15. Have you ever used the free Wi-Fi service at the airport? (If you selected "No, I have never used this service" or "No, I was not aware of this service", please go to question 17.) [Single choice] *

○ Yes, I use it often

○ Yes, I use it occasionally

○ No, I have never used it before (Please skip to question 17)

○ No, I am not aware of this service (please skip to question 17)

16. Do you have any suggestions or comments about the free Wi-Fi service at the airport? [Single choice] *

○ Very fast, very satisfied

○ The speed is normal and needs to be improved

○ Coverage is not wide enough

○ The connection process is tedious

○ Other suggestions: _____

17. Do you expect airports to offer more digital-related free services in the future? [Single choice] *

○ Yes, very much

○ Yes, hope

○ Uncertainty

○ Not really

○ Not at all

18. Do you think digital services at airports play an important role in increasing passenger satisfaction and loyalty? [Single choice] *

○ Yes, I think it played a key role

○ Yes, I think it plays a role

○ Uncertainty

○ I don't think it will work

○ I don't think it worked

19. Have you encountered any privacy or security concerns during the use of airport digital services? (If you select "Yes, I have had privacy or security concerns," proceed to question 20; If you select "No, I have no privacy or security concerns," go to question 21.) [Single choice] *

○ Yes, I have had privacy or security concerns

○ No, I have no privacy or security concerns (please skip to question 21)

20. Please specify any privacy or security concerns you have encountered when using airport digital services. [Fill in the blank] *

_____

21. Do you think that digital services at airports can help improve the environmental protection and sustainable development of airports? [Multiple choice] *

○ Yes, I think it played a key role

○ Yes, I think it plays a role

○ Uncertainty

○ I don't think it will work

○ I don't think it worked

22. Have you noticed any environmental measures or technologies that the airport has adopted in its digital services? [Multiple choice] *

○ Electronic boarding passes reduce paper waste

○ Energy-saving and efficient self-service equipment

○ Intelligent lighting system

○ Recycle and reuse old equipment

○ Others, please specify: _____*

23. In your process of using airport digital services, what aspects do you think need to be strengthened to improve the user experience? [Multiple choice] *

○ Service response speed

○ Simplified service process

○ User interface friendliness

○ Timely update of information

○ Others, please specify: _____*

24. Do you feel that the airport's digital services are excellent in responding to emergencies (such as flight delays, security incidents, etc.)? [Single choice] *

○ Yes, excellent performance

○ Yes, good performance

○ Normal

○ Poor performance

○ Completely dissatisfied

25. Do you think digital services at airports have played an important role in prevention and control during the pandemic? [Single choice] *

○ Yes, I think it played an important role

○ Yes, but the effect is limited

○ Uncertainty

○ I don't think it will work

○ I don't think it worked

26. Have you used the digital health declaration or contact tracing services offered at the airport during the pandemic? [Single choice] *

○ Yes, I use it often

○ Yes, I use it occasionally

○ No, I have never used it

○ No, I am not aware of this service

27. What is your comment on the digital health declaration or contact tracing services provided by airports during the pandemic? [Single choice] *

○ Very satisfied, convenient and fast

○ Satisfactory, but with some room for improvement

○ In general, there are no obvious advantages or disadvantages

○ Not satisfied, the use process is a little cumbersome

○ Very dissatisfied, reluctant to use

28. Do you think airports should pay more attention to the protection of passengers' personal privacy when it comes to digital services? [Single choice] *

○ Yes, I think it is very important

○ Yes, but existing measures are sufficient

○ Uncertainty

○ I don't think there is much need for additional strengthening

○ I don't care about this at all

29. Would you like airports to provide more education and training on digital services to help you make better use of them? [Single choice] *

○ Yes, I very much hope

○ Yes, I hope

○ Uncertainty

○ I hope not

○ I hope not at all

30. Do you know and use the virtual assistant or intelligent customer service provided by the airport? [Single choice] *

○ Yes, I use it often

○ Yes, I use it occasionally

○ No, I have never used it

○ No, I am not aware of this service

31. How satisfied are you with the virtual assistant or intelligent customer service provided by the airport? [Single choice] *

○ Very satisfied, quick and accurate answers

○ Satisfactory, but sometimes the answers are not accurate

○ In general, there are no obvious advantages or disadvantages

○ Not satisfied, the answer is slow or often wrong

○ Very dissatisfied, reluctant to use

32. In what ways do you think airport digital services can further enhance the passenger travel experience? [Multiple choice] *

○ More convenient boarding process

○ More personalized service recommendation

○ More accurate flight information updates

○ Richer entertainment and leisure content

○ Others, please specify: _____*

33. Do you expect the airport to introduce more artificial intelligence technologies in digital services, such as intelligent navigation, face recognition, etc.? [Single choice] *

○ Yes, I am looking forward to it

○ Yes, I expect some improvements

○ Uncertainty

○ I have reservations about this

○ I hope not at all

34. In the process of using the airport digital service, have you ever encountered service interruption or failure? [Single choice] *

○ Yes, often

○ Yes, occasionally

○ No, never encountered

○ No, not sure

35. How do you usually deal with interruptions or failures in airport digital services? [Single choice] *

○ Reconnect or use another service

○ Contact airport customer service for help

○ Express grievances or seek solutions on social media

○ Forgo digital services in favor of traditional methods

○ Others, please specify: _____ *

36. How do you think airports should improve their digital services to reduce service interruptions or breakdowns? [Fill in the blank] *

_____

37. What improvements or additions would you like to see in the future for digital services at airports? (Open Q&A) [Fill in the blanks] *

_____

Thank you for participating and completing this questionnaire！