A method to Evaluate the Rationality of Check-in Island Usage during Flight Departure Peak Period

Yunyan Gu¹, Jianhua Yang ¹*, Guo Xie ²

¹Department of Automation Control, Northwestern Polytechnical University, Xi An, Shan Xi, 710129, China
²Shenzhen Airport CO. ILD., Shen Zhen, Guang Dong, 518128, China

*Corresponding author’s e-mail: 24990696@qq.com

Abstract: With the rapid development of civil aviation in China, airlines and passenger throughput are increasing. Evaluating the rationality of check-in islands usage can effectively avoid overload of baggage system in some check-in islands and low utilization rate of other check-in islands during flight departure peak period, which is conducive to improving the utilization rate of resources and the efficiency of passenger ticket handling in terminal. According to Statistics of daily flight data of Shenzhen Airport in 2017, the average number of passengers in each check-in island is calculated based on the factors such as the number of flights, type of aircraft and passenger occupancy rate. According to the time rule of passengers arriving at the terminal, the arrival distribution of passengers in different time periods is obtained by weight which is the probability of passenger arrival in different periods. The number of passengers in the same period is divided by unit time, and the distribution of the number of passengers arriving at different times is obtained. The number of passengers arriving at the same unit time for each check-in island is accumulated. According to the hourly theoretical design capacity of check-in island baggage system, the rationality of single check-in island is evaluated. It provides scientific and intuitive decision-making basis for optimizing airport check-in resources during flight peak period.

1. Introduction

The check-in counter in terminal buildings is generally divided according to airlines in China. Airlines' flight plans are not evenly divided according to time. For airports, there will be flight departure peak period. The flight peak period lead to the passenger check-in peak period, and some of check-in island luggage systems are overload but other counters are underutilized due to different flight times. The overload check-in island luggage system greatly reduces the check-in efficiency, and might causes flight delays, which affects other flight passengers. The utilization rate of check-in Island baggage system is low, which can not make full use of airport resources. As airport throughput increases, this phenomenon becomes more frequent. According to internal statistics, during the morning rush hours of Shenzhen Airport in 2017, 7 flight delays are caused by overload of baggage system in check-in island C. Therefore, the rationality of check-in counters usage during flight peak period is beneficial to improve work efficiency.

At present, many scholars have studied the optimization of check-in counter resources. Nico M. and van Dijk et al. used 0-1 planning to obtain the minimum amount of the opening check-in counters and total opening time of check-in counter in each period [1]. Wang Zhiqing et al. used queuing theory to focus on the airport check-in system and proposed two optimization methods which is queuing
mode and dynamic control of check-in counters[2]. Wang Ruiming and Zhu Jinfu focused on the perspective of reducing airline costs, also used the queuing theory to measure the most effective quality of check-in counters[3]. These studies mainly focus on the number of check-in counters, utilization rate, and economic cost under normal check-in status, but are rare to combine the number of passengers with the overload of baggage system. According to flight Statistics of the Shenzhen Airport's check-in island C and F in 2017, taking the time rule of passengers arriving at the terminal as the weight, the utilization rate of check-in Island baggage system is analyzed according to the number of check-in passengers at different time periods. It provides a method for civil aviation staff to judge the rationality of check-in island.

2. Related concepts
Check-in Island: The check-in island in the terminal is generally composed of several check-in counters and a baggage sorting systems. Each check-in counter's ticketing system is operated independently. The baggage sorting systems at each counter are both interconnected and independent.

Baggage system overloaded: Each check-in island baggage system has its own saturation threshold, that is the maximum capacity of the baggage system. The baggage system overload means the real volume exceeding this design capacity, which probably causes the baggage system to not work properly. The baggage system needs to be manually cleaned up, which seriously affects passenger check-in effectiveness.

Flight rush hour: The flight rush hour is the period of high departure flight density, and there are a large number of passengers checking in at that time.

Passengers peak period: Passengers arrive at the terminal are usually arranged according to their flight schedules. During peak hours, number of passengers is large, and there is also a peak time period when arriving at the terminal earlier, which is called the passengers peak period.

Passenger check-in process: Passengers arrive at the terminal and select the check-in counter for boarding card refer to flight information. If passengers who have luggage need to check in, they will be checked by staff.

3. Related data sources
According to Shenzhen Airport terminal passenger travel survey report[4], the arrival time distribution of Shenzhen Airport Terminal passengers is as follows: 26.1% of passengers arrive in 2 hours before the flight departure, 25.3% in 90-120 minutes, 29% in 60-90 minutes, 17.1% in 30-60 minutes, and 2.9% in 30 minutes.

According to survey statistics [5], 83.3% of passengers at Shenzhen Airport chose to check in luggage, and 16.7% of passengers did not check in luggage. Among the check-in baggage passengers, 49.5% of them checked in at the check-in counter, and 33.8% of the passengers completed check-in process by some other methods.

According to Shenzhen Airport's research report on preparation of the baggage system in 2017 [6], the maximum theoretical design capacity of a single check-in island is 1,100 pieces per hour.

According to the statistics of Civil Aviation Administration of China, the average passenger occupancy rate of one flight is 81% in 2014 [7].

4. Research methods

4.1. Average number of passengers on a single flight in each check-in island
Count the number of everyday flights, the volume of different aircraft, and number of flights for each check-in island to obtain the average number of available seats. Combined with the flight load factors from the civil aviation statistics, get the average number of passenger of a single flight on each check-in island, The specific formula is as follows:
\[
D = \frac{\sum_{j=1}^{i} (M_j \times Z_j)}{\sum_{j=1}^{i} Z_j} \times C \quad j=1,2,\ldots,i
\]  

Here, \(i\) represents the number of aircraft types on each check-in island, \(j\) represents the type on each check-in island, \(M_j\) represents the number of seats of a single flight in each check-in island, \(Z_j\) represents the number of aircrafts in each check-in island, \(C\) represents passenger occupancy rate, \(D\) represents the average number of passengers on a single flight for each check-in island.

4.2. The distribution of passenger numbers at different times

Taking the rules of passenger arrival time as the reference, and using the amount of passengers arriving in different time periods as the weight, the weights are evenly distributed in each time period (unit time is generally based on 1 minute or a small interval), to get the passenger arrival probability at different times periods of each flight. According to the number of passenger arrivals in section 4.1, the number of passengers arriving at all flights at the same time is accumulated, and get the number of passengers arriving at the terminal at different times. The formula is as follows:

\[
n = \sum_{s=1}^{S} P_s \times D, \quad s=1,2,\ldots,N
\]

\[
P_s = \frac{P_q}{V_q} \times t
\]

\[
N = \sum_{j=1}^{i} Z_j, \quad j=1,2,\ldots,i
\]

Here, \(n\) represents the number of passengers arriving of all flights on each check-in island at the same time, \(s\) represents the flight of each check-in island, \(V_q\) represents the time interval form the passenger travel rules, \(q\) represents the time period of the passenger travel surveys, \(P_s\) represents the arrival probability of passengers in different time periods before flight departure, \(t\) represents unit time, \(N\) represents the total number of full-day flights on each check-in island.

4.3. Reasonable Analysis of Check-in Counter Using

The total number of passengers arriving at each unit time is superimposed to obtain the distribution of the number of passengers arriving per hour. Combined with the design capacity of the terminal check-in island baggage system and passenger baggage consign statistics, comparing with the actual baggage system of each check-in island each hour to judge the rationality of the check-in counter allocation. The key formula is as follows:

\[
T = \sum_{s=1}^{S} n_{s1}, \quad s=1,2,\ldots,r
\]

\[
\eta = \frac{(T \times U \times H)}{Y} \times 100\%
\]

Here, \(T\) represents the total number of arrivals on each check-in island per hour, \(\eta\) represents the utilization ratio of baggage system on each check-in island, \(U\) represents the proportion ratio of passengers carried on in the terminal, \(H\) represents the number of luggage carried by each check-in passenger, \(Y\) represents the design capacity of each check-in island baggage system, \(r\) represents the number of unit time in the whole hour, \(n_{s1}\) represents the number of passengers arriving at each check-in island per unit time per hour.
5. Case analysis
Taking Shenzhen Airport as an example, the numbers and flight schedule of check-in islands C and F during the rush hours (06:00-07:00) in Shenzhen airport terminal are shown in Table 1.

| Check-in island | Time       | Number of flights |
|-----------------|------------|-------------------|
| C               | 06:00-07:00| 14                |
| F               | 06:00-07:00| 2                 |

(1) Count the number of the flights, aircraft types and seats of all the aircraft types in Shenzhen Airport check-in islands C and F. According to the section 4.1, gain the average number of passengers for each type of the aircraft on C and F check-in island flights, as shown in Table 2:

| Aircraft type | A   | B   | C   | D   | E   | F   | G   | Number of passengers per flight of check-in Island C | Number of passengers per flight of check-in Island F |
|---------------|-----|-----|-----|-----|-----|-----|-----|------------------------------------------------------|------------------------------------------------------|
| Number of seats| 124 | 150 | 185 | 293 | 335 | 162 | 242 | 175                                                  | 175                                                  |
| Number of flights in island C | 6   | 6   | 4   | 1   | 5   | 58  | 58  | 175                                                  | 175                                                  |
| Number of flights in island F  | 2   | 16  | 16  | 1   | 3   | 21  | 0   | 175                                                  | 175                                                  |

(2) According to the Section 4.2, we can obtain the passenger arrival distribution on the check-in island C and F every 5 minutes during the peak hours (04:00-07:00), as shown in figure 1 and figure 2.

Figure 1. Number of passengers arriving at Island C at 4:00-7:00

Figure 2. Number of passengers arriving at Island F at 4:00-7:00

(3) According to formula (6), the data in Fig 1 and Fig 2 is accumulated by hour respectively to obtain the number of passengers arriving at islands C and F per hour during the peak hours (04:00-07:00). During the rush hours of the flight, the number of passengers at the check-in island C in 04:05-05:00 was 1,415, during 05:00-06:00 was 989, and during 06:00-07:00 was 497; The number of
check-in islands F during 04:05-05:00 is 156, during 05:00-06:00 is 359, and during 06:00-07:00 is 174. The details are shown in Table 3.

| Number of passengers | 4:00-5:00 | 5:00-6:00 | 6:00-7:00 |
|----------------------|-----------|-----------|-----------|
| Number of passengers in island C | 1415 | 989 | 497 |
| Number of passengers in island F | 156 | 359 | 174 |

(4) According to Section 4.3, the design capacity of the check-in island baggage system at Shenzhen Airport is 1,100 pieces/hour. For the convenience of research, assume that passengers who need baggage check-in only consign one baggage. According to formula (7), the number of check-in island C service people at 04:05-05:00 is 1415. Around 83.3% of passengers at Shenzhen Airport choose to check-in luggage. 1179 pieces of baggage need to be handled in check-in Island C, and the utilization rate is 107.2%. The utilization rate of the luggage system is 74.9% and 37.6% respectively during two time periods (05:00-06:00 and 06:00-07:00). However, Check-in Island F serves 156 people at 04:00-05:00, and consign 130 pieces of luggage, the utilization rate is 11.8%, which is far below the design capacity. The utilization rate of the luggage system was 27.2% and 13.2% respectively during two time periods (05:00-06:00 and 06:00-07:00). The utilization rate as shown in Table 4.

| Utilization rate hourly | 4:00-5:00 | 5:00-6:00 | 6:00-7:00 |
|-------------------------|-----------|-----------|-----------|
| Island C utilization rate | 107.2% | 74.9% | 37.6% |
| Island F utilization rate | 11.8% | 27.2% | 13.2% |

It can be seen that the luggage system of Island C is overloaded during 04:00-05:00, and the utilization of the luggage system of Island F is low during the entire peak period (04:00-07:00). It is suggested that some flights in island C are relocated to island F in case to avoid overloading in Islands C and waste of Island F resources.

6. Conclusion

Combining factors such as rules of passenger arrival time, flight baggage, and check-in island design capacity, the number of different flights passengers is distributed in each unit time with weights. The number of passengers arriving in different time periods is calculated. Compared to the number of checked baggage of passengers arriving and the designed capacity of check-in Island baggage system, the rationality of terminal check-in island is evaluated. This method is conducive to improving the utilization rate of check-in resources in the terminal. It shows that the assessment method meets the needs of on-site management in terms of ensuring flight normality, on-site support staff pressure, and passenger satisfaction.

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