Simulation Research on Optimization of Airport Ground Operation

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Abstract: To determine the reasonable and effective ground operation capacity of the airport is of great significance for the overall planning of the airport construction. Selected Beijing Capital International Airport (BCIA) with 3 parallel runways as the research object, the airfield operating models were simulated by using Simmod in current operating condition and optimizing operation condition respectively. The operation capacity of BCIA is close to its maximal value. By reducing the air traffic control separation and optimizing the flight schedule, the flight movements of peak day can reach 1760, and the annual passenger throughput is around 95~98 million-person-times.

1 INTRODUCTION

The continuous growth of social economy drives China air transport on the fast-growing track, during which China civil aviation has become the second largest air transport system in the world. The increase of air demand leads to huge pressure of large hub airports and trunk airports in China. How to determine the ground capacity of existing airports and improve the capacity by optimizing operating rules and flight schedules is of great significance for the scientific decision-making of airport development and the rational co-ordination of new, modified and expanded airport projects.

In general, there are three approaches to evaluate airport capacity and operation efficiency: data statistics, mathematical theory and computer simulation. (1) Method of data statistics is used to estimate airport capacity through drawing a capacity envelope graph based on existing statistical information of airport flow. As a frequently-used approach for capacity analysis in early stage, it accompanies disadvantages that it only evaluates established operation pattern of existing runway system in busy airport, which lacks prospectiveness (Gilbo, 1993). (2) Approach of mathematical theory could be harnessed to calculate runway capacity through proposing proper assumption, establishing mathematical equations of airport ground operation parameters. It is mainly used for macroscopic capacity evaluation, lacking consideration on operation details and commonality (Neufville and Odoni, 2002). (3) Approach of computer simulation is at present the most popular solution to evaluate airport capacity and efficiency. Via establishing operating environment and control rule models through simulation software, it reflects airport operation status with reality, and reaches to airport capacity based on analysis on simulated operation data (Gao and Jiang, 2010). Simmod and TAAM are the mainstream simulation modeling software for airport capacity evaluation (Li and Wei, 2015).

In this paper, Beijing Capital International Airport (BCIA) is selected as the research object. The airport operation efficiency is improved by analyzing the operation status of the airport, optimizing the operating rules and improving the flight schedule. The effect of the application is verified and evaluated through the simulation of the airport.

2 AIRPORT STATUS OPERATION

BCIA has three north-south parallel runways, the west runway, the middle runway and the east runway. The distance between the west Runway / middle Runway / East runway is 1960m and 1525m, respectively. The west runway and the east runway are mixed operation; the middle runway is mainly

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used for take-off, as shown in Figure 1. The main landing direction of the airport is restricted by the noise, and the east runway 23:30-5:30 (the next day) is forbidden to land.

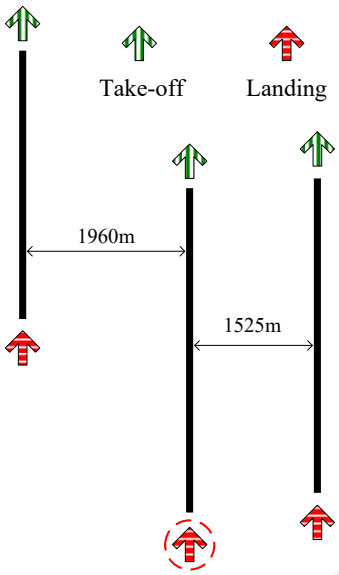

Figure 1: Runway use mode of BCIA.

The apron of BCIA is bounded by the middle runway, which is divided into west and east apron. , The gate aprons, departure points and runways use basic principles: West to the west side of the apron aircraft using the west runway; East to the east side of the apron aircraft using the east runway; West to east side of the apron aircraft, east to the west side of the apron aircraft, mainly using the middle runway. The basic principles of using the gate apron, approach point and landing runway are as follows: on the premise of giving priority to the smooth flight path of inbound flight, the flight entering the west on the inbound point will mainly land on the west runway; the east side will enter the port Point-to-point flights mainly use the east runway to land; landing flights in more cases, the middle runway can assist the east and west into the flight into the flight landing.

Analysis of the peak monthly flight schedule of BCIA for the last two years (2015~2016) shows that the average daily take-off and landing waveforms are shown in Figure 2. The peak monthly average flight movements are about 1725, including 865 arrival flights and 860 departure flights. The flight schedule has obvious characteristics, namely more take-off flights at 7:00~9:00, more landing flights at 23:00~ 1:00(the next day).

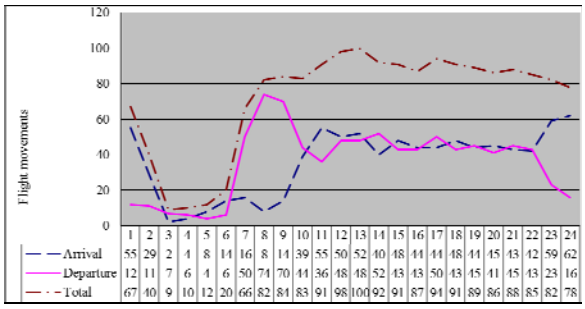

Figure 2: Flights take-off and landing waveform of the current peak month.

3 SIMULATION MODELING

This paper operates Simmod Plus 7.6(simulation software) to make a simulation analysis of the operational efficiency in different operational patterns of BCIA. Simmod, one dynamic and comprehensive airport simulation micro-software firstly proposed by FAA in 1978, through the continuous upgrading and perfection, has become one of the most applied airport and airspace simulation software (Gao and Huang, 2010).

In the simulation model, the use of BCIA taxiway and apron is set up by reference to the manual of the ground operation of BCIA. The arrival and departure routes are set up to refer to the standard RNAV instrument flight procedures. The simulation model takes into account the analysis of four typical daily flights, and the related parameters are shown in Table 1, in which the types of flights include passenger, business and cargo. The parameters such as take-off and landing waveform, aircraft combination and airline share of typical daily flights are set up, referring to the current operation statistics of BCIA and its prediction data.

Table 1: Typical daily take-off and landing flights.

Flight movements in peak day	Movements in peak hour	Annual passenger throughput (in 10,000 person-time)
1680	95	8400
1720	100	8900
1760	105	9400
1820	110	9900

Considering the operating conditions feasible in the future, this paper presents optimization operation scheme for BCIA: (1) the airport runway all-weather

operation; (2) based on the promotion of the total daily flights, optimization flights waveform, appropriate to reduce the peak hour flight; (3) in the premise of ensuring security, moderately reduce the air traffic control operation interval, as shown in table 2.

Table 2: Aircraft wake turbulence separation.

Aircraft Wake Turbulence Separation			
Front / Follow	A380	Heavy	Middle
A380	8 km	5.5 km	5.5 km
Heavy	12 km	7.4 km	5.5 km
Middle	13 km	9.3 km	5.5 km

The demonstration of the simulation of BCIA under optimal operating conditions is shown in Figure 3.

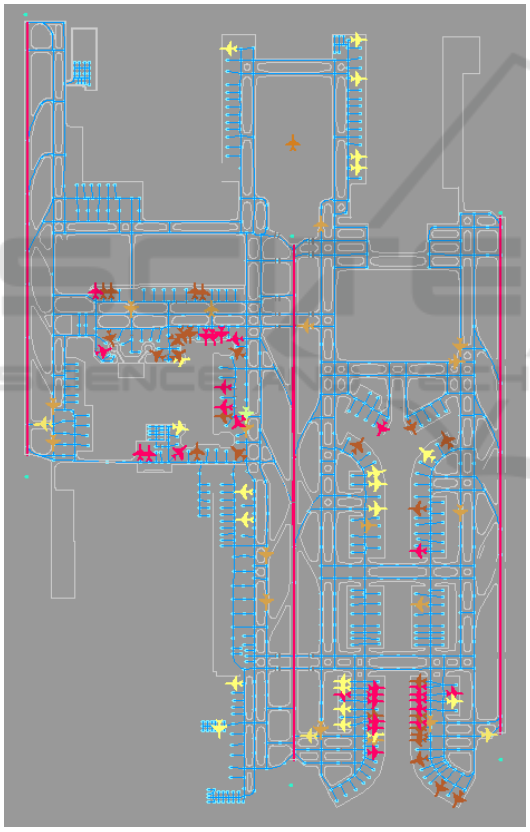

Figure 3: Demonstration in optimal operation conditions.

4 RESULT ANALYSIS

According to the status and optimized air traffic control operation conditions of BCIA, the airport flight area simulation model is established. After each model runs several times, the average value of the simulation results is taken for data analysis.

The capacity of airport system is directly related to the level of flight delay (FAA, 2015). In general, on the premise of landing priority, the average ground delay time of departing flights can be used to measure the airport's busy degree and utilization capacity. The ground delay time and trend of departure flights are shown in Figure 4 under different daily flights.

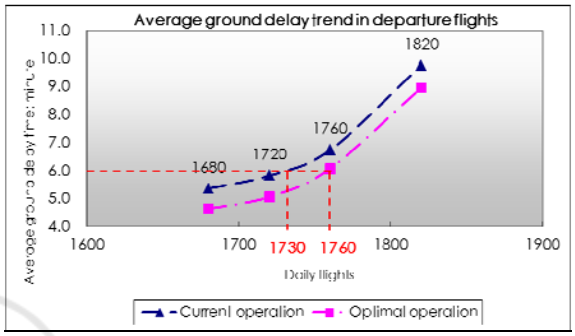

Figure 4: Ground delay trend of departure flights.

Taking the 6 minute delay level as a standard to measure airport operation capacity, it is concluded that under the improved operation condition, the airport can meet the peak daily movements capacity of 1760, and the corresponding annual passenger throughput is about 95~98 million-person-times, as shown in Figure 5. The optimized operation capacity increases about 5%, compared with the current operating conditions.

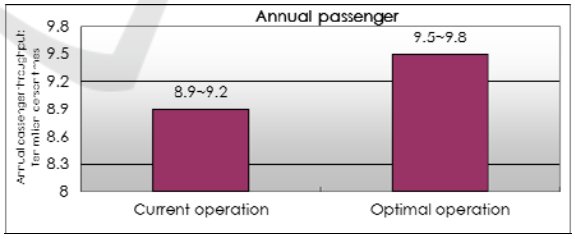

Figure 5: Comparison of annual passenger throughput.

It is mainly used for the capacity and delay evaluation of the airport under normal condition. The simulation results are not including the flow control, bad weather, continued flight delay, passengers and military aviation activities, and so on. As a result, the simulation result shows that the delay is usually lower than the actual operational delay.

5 CONCLUSIONS

This paper operates Simmod simulation software to establish the computerized simulation model for different utilization conditions of BCIA, and make systematic analysis and quantitative evaluation of airport capacity and operational efficiency.

The operation capacity of BCIA is close to saturation. Before the Beijing new airport put into operation, the current stage is undoubtedly the busiest stage of BCIA. Through reasonable optimization of control operation, the operation capacity of BCIA can be improved properly. The flight movements of peak day can reach 1760, and the annual passenger throughput is around 95~98 million-person-times.

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