

**ICAO***International Civil Aviation Organization***Third Meeting of the Asia/Pacific Air Traffic  
Management Automation System Task Force (APAC  
ATMAS TF/3)**

Video Tele-Conference, 8– 10 June 2022

Agenda Item 4: ATM Automation System Implementation by States

4.3 Development of New Technology

**OPTIMIZATION OF ARRIVAL FLIGHT RUNWAY ALLOCATION IN THE  
GUANGDONG-HONGKONG-MACAO GREATER BAY AREA**

(Presented by China)

**SUMMARY**

This paper introduces the arrival flight runway allocation optimization method in the AMAN aided decision-making function in the Guangdong-Hong Kong-Macao Greater Bay Area. This method is a runway allocation optimization method based on the minimum intersection and ground taxiing time. The application of this method can reduce air cross conflicts, controller workload and ground taxiing time. Through the analysis of operational data, compared with 2018, the Guangdong-Hong Kong-Macao Greater Bay Area in 2019 reduced the time of inbound flight and airport ground taxiing time after the application of the AMAN aided decision-making system, and improved the operation efficiency.

**1. INTRODUCTION**

1.1 As the southern gate of China, the Guangdong-Hong Kong-Macao Greater Bay Area has airports including Guangzhou, Shenzhen, Zhuhai, Hong Kong, Macau and other airports. The airspace of the Guangdong-Hong Kong-Macao Greater Bay Area mainly involves two Flight Information Regions (FIRs), namely Guangzhou FIR, Hong Kong FIR. The control area is mainly divided into the Guangzhou control area, Guangzhou approach control area, Zhuhai terminal control area and Hong Kong terminal control area.

**Agenda Item 4.3**

8-10/06/22

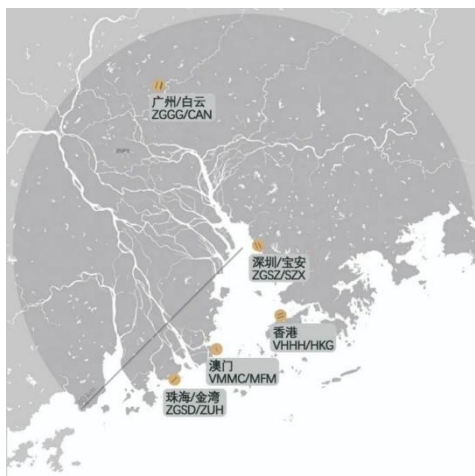


Figure 1 the Guangdong-Hong Kong-Macao Greater Bay Area airport clusters

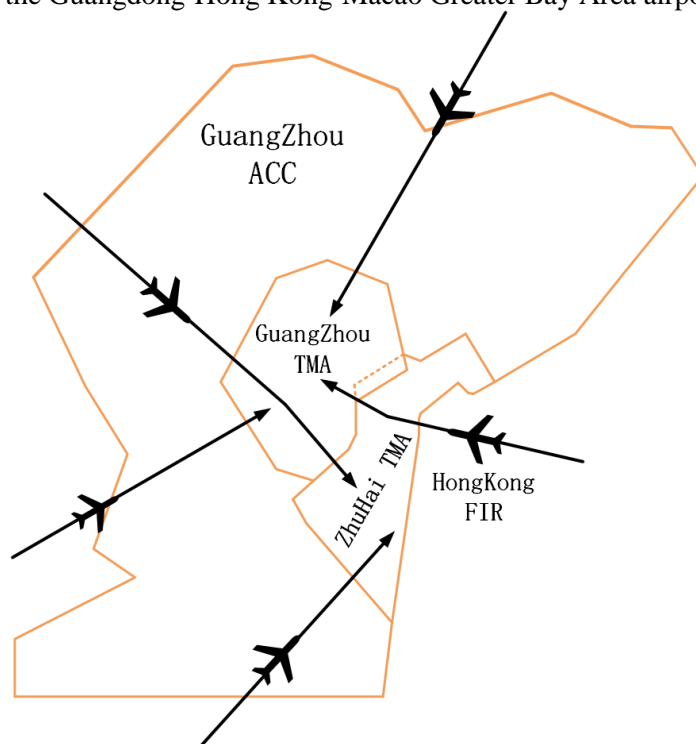


Figure 1 Schematic diagram of the Guangdong-Hong Kong-Macao Greater Bay Area and inbound flight flow

1.2 With the rapid growth of flights, the traditional approach route selection, runway allocation, and approach sequencing in the terminal area are done manually by the controller. During the peak arrival time, the workload of the controller is increased obviously, and it is difficult to guarantee the overall operational efficiency of the approach. Therefore, in the Guangdong-Hong Kong-Macao Greater Bay Area, the Arrival MANager (AMAN) is also deployed to assist the controller to allocate inbound flights.

1.3 Guangzhou Baiyun International Airport has three runways. The west runway (01/19) and the east outer runway (02R/20L) can land at the same time, and the east inner runway (02L/20R) can only take off. Traditionally, the inbound runway is allocated and sorted according to the direction of the inbound traffic flow, that is, the allocation mode of the east runway in the east inbound direction and the west runway in the west inbound direction. This leads to longer taxiing time, and the

passenger's sense of the experience is terrible. However, only relying on the nearest stand to allocate the runway also increases the probability of flight crossing in the air and increases the workload of the controller.

1.4 This paper describes the landing runway optimization method for inbound flights applied by the AMAN aided decision-making function in Guangzhou and Shenzhen airports, so as to improve the operating efficiency of the terminal area and reduce the ground taxiing time without increasing the controller's workload.

## 2. DISCUSSION

### *Concept of the Nearest Landing Runway*

2.1 The runway on the side of the flight stand is defined as the nearest landing runway, with the shortest taxiing time on the ground; the runway on the side near the inbound direction is set as the default runway, with the shortest flight time in the air and the least crossover. By deploying the flight from the default runway to the nearest runway, the taxiing time on the ground will be shortened, which will improve the travel experience of passengers.

### *Runway Allocation Optimization Method*

2.2 The runway allocation method is based on minimum air crossing and ground taxiing time. The allocation priorities are in the following order: minimum crossing > minimum ground taxiing time > minimum air flight time.

- In order to reduce air crossings, inbound flights are given priority to allocate default runways and non-crossing paths according to the direction of arrival.
- In addition, optimize the ground taxiing time of the flight. When the nearest runway is inconsistent with the default runway, adjust from the default runway to the nearest runway, and perform cylindrical detection in the air to reduce the air path crossing after adjusting the runway.
- Finally, based on the runway and approach direction, the minimum air flight time is optimized, and cylindrical detection is performed during the optimization process.

### *Minimum Cross Detection and Runway Allocation Method*

2.3 The four-dimensional trajectory of each flight is predicted, a cylindrical intersection detection space (Figure 3) is constructed on the flight prediction path, and all flights in the airspace are cylindrically detected.

When two or two flights overlap in the three-dimensional space at the same time, it is regarded as a crossing.

When the flight is adjusted from the default runway to the nearest runway, if there is a crossing, the delay time of the crossing flight will be increased at the crossing point. If the delay time reaches the set value and the crossing has not been resolved, the runway will not be adjusted. Otherwise, adjust the default landing runway of the flight to the nearest landing runway.

Adjust the flight path with the minimum flight time as the target after the minimum crossing and the ground taxiing time are satisfied.

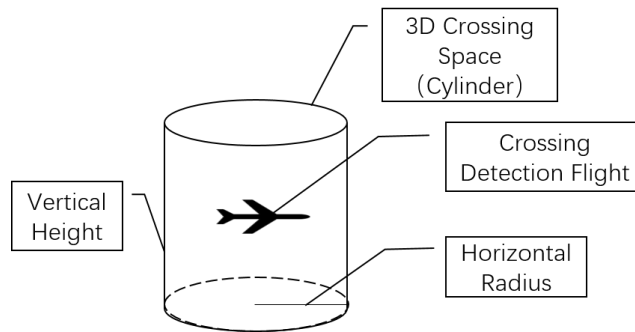


Figure 2 Schematic diagram of 3D crossing detection

**Example of Runway Allocation Optimization Scenario**

2.4 As shown in Figure 4, flight CSN3204 enters from the left, and the runway is allocated to R1 by default. R1 is the non-nearest runway, and "!" is displayed on the system HMI (Figure 5).

Since the stand is closer to the R2 runway, try to adjust the flight from R1 to R2, and adjust the preferred selected arrival path (STAR) corresponding to the R2 runway synchronously.

Detect the intersection with the flight on the right at the same position and time, if the intersection occurs, the flight that arrives at the intersection later will be delayed. Delay until the set value does not resolve the intersection, then do not adjust the runway; otherwise, after adjusting the runway and the preferred route, try to adjust the route from preferred to the alternate to reduce the flight time.

After the CSN3204 is allocated from R1 to R2, the allocated logo is displayed, and the path is also adjusted from "GYA-1D" to "GYA-1B", as shown in Figure 6.

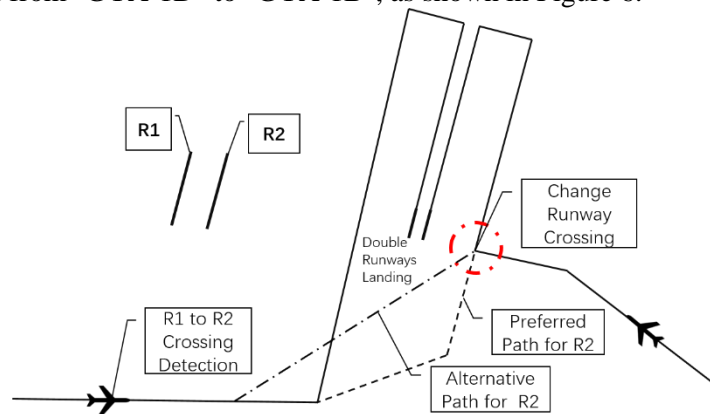


Figure 3 Schematic diagram of the optimally adjusted runway (STAR)



Figure 4 The non-near runway displays "!" on the system HMI



Figure 5 Logo of the nearest runway on the system HMI

### 3. APPLICATION EFFECT

3.1 Both Guangzhou Baiyun International Airport and Shenzhen Bao'an International Airport have deployed and used the AMAN aided decision-making function, and achieved obvious effects.

3.2 Taking Guangzhou Baiyun International Airport as an example, the performance analysis of operational data is analyzed from several aspects, such as flight time probability density, arrival delay time, ground taxiing time, and arrival trajectory heat map.

#### Flight Time Probability Density

3.3 In 2019, Guangzhou Baiyun International Airport guaranteed 491,249 takeoffs and landings throughout the whole year. And the trial operation of the AMAN aided decision-making function in March of that year.

3.4 Compared with the flight data of Guangzhou approach area in 2018, the arrival flight time decreased, and the cumulative probability density of the same flight time increased. As shown in Figure 7.

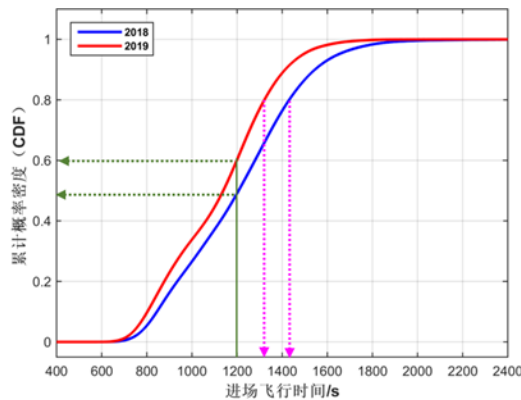


Figure 6 Comparison chart of the cumulative probability distribution of arrival flight time

#### Arrival Delay and Carbon Emissions

3.5 The average arrival delay in each month was reduced by 171.81 hours, a decrease of 26.94%, and the average delay per flight was reduced by 45.18s, a decrease of 30.61%. It is estimated that the annual fuel consumption will be reduced by 4,236 tons, and CO2 emissions by 13,368 tons.

#### Ground Taxiing Time

3.6 According to the taxiing time data provided by Guangzhou Baiyun International Airport, the ground taxiing time of inbound flights was reduced by 2.86 minutes on average compared to 2018, an increase of 29.79%, and the average monthly taxi-in time was shortened by 642 hours, and the annual taxi-out time can be shortened by 7,704 hours. As shown in Figure 8.

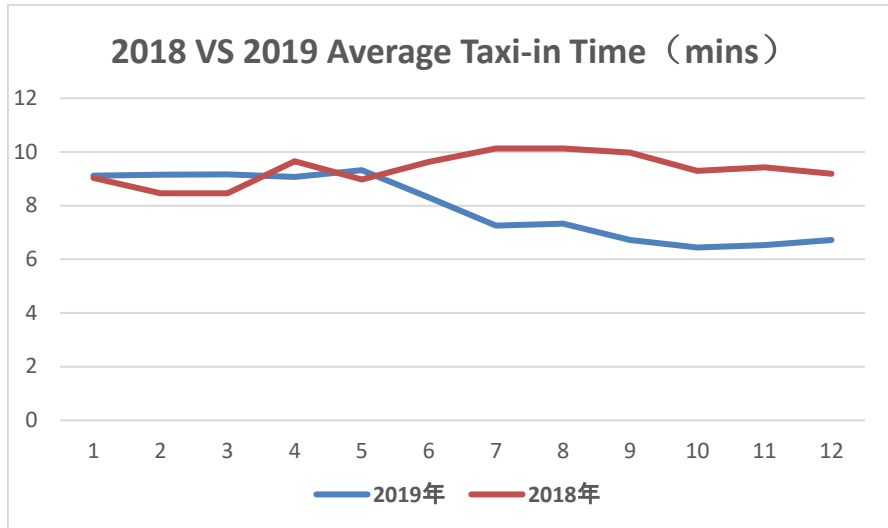


Figure 7 2018 VS 2019 average taxi-in time of Guangzhou Baiyun International Airport

**Arrival Trajectory Heat Map**

3.7 Through the historical trajectories heat map of the Guangzhou Baiyun International Airport (Figure 9/figure 10), compared with 2018, the predictability in the A/B/C has been improved, and the flight trajectory has been more solidified, reducing radar guidance and reducing controller workload.

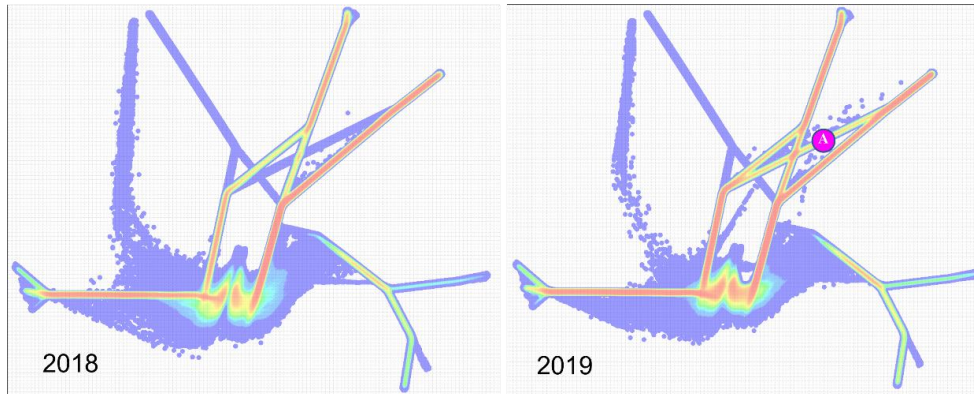


Figure 8 2018vs2019 Guangzhou Baiyun International Airport north direction historical trajectory heat map

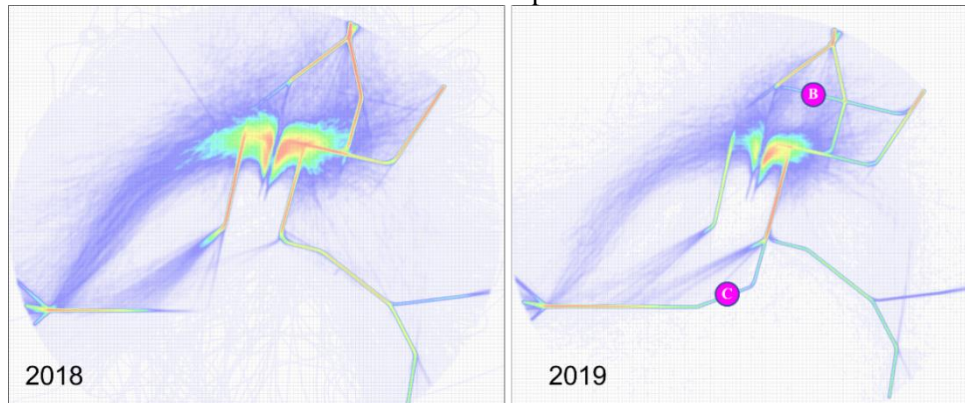


Figure 9 2018vs2019 Guangzhou Baiyun International Airport south direction historical trajectory heat map

3.8 In summary, Guangzhou Baiyun International Airport has been deployed the AMAN aided decision-making function that includes this runway allocation method, which can effectively reduce air conflicts, improve safety, reduce the workload of controllers, and reduce the inbound flight taxiing time.

**4. ACTION BY THE MEETING**

4.1 The meeting is invited to:

- a) note the information contained in this paper; and
- b) discuss any relevant matter as appropriate

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