International Civil Aviation Organization

Fourteenth Meeting of the Asia/Pacific Air Traffic Flow Management Steering Group (ATFM/SG/14)

Bangkok, Thailand, 22 – 26 April 2024

Agenda Item 6: Regional ATFM Framework, A-CDM Plan and related Guidance Material

CAPACITY ASSESSMENT METHOD BASED ON SIMILAR CHARACTERISTICS

(Presented by China)

SUMMARY

This paper presents the background, process and application of the capacity assessment method based on similar characteristics in China. Taking the opportunity of building the National Traffic Flow Management System (NTFM), China has proposed and implemented a capacity assessment method based on similar historical characteristics. This method not only takes into account the objectivity of capacity assessment through historical data, but also makes up for the technical shortcomings of the current method that cannot accurately predict capacity. The application in the NTFM system has laid a solid foundation for unifying assessment standards, analyzing airspace bottlenecks, and formulating ATFM measures. Based on this objective, this paper introduces in detail the capacity assessment method based on similar characteristics.

1. INTRODUCTION

1.1 With the continuous and rapid development of the social economy, the total turnover of civil aviation transportation, the total volume of flights, and the number of transport aircrafts continue to grow. At the same time, the growth rate of air transportation demand is significantly higher than the growth rate of capacity supply. The contradiction between limited airspace resources and rapidly growing demand for air transport has become increasingly prominent, which has become one of the main bottlenecks restricting the sustainable development of civil aviation transport. The implementation of capacity assessment is an important measure to grasp the available capacity and efficiently and rationally utilize limited airspace resources. Through the implementation of capacity assessment, on the one hand, it can support the optimization of airspace structure, and on the other hand, it can provide prerequisites for the efficient implementation of ATFM. China has consistently supported the relevant principles and policies of ICAO on capacity assessment, and actively participated in the related work of capacity assessment in the Asia-Pacific region, however, with the challenges of new changes in the operating environment of multi-user and high-density air traffic flows, the current capacity assessment methods should be further improved and optimized to be beneficial to the development of ATFM in Asia-Pacific region.

1.2 In recent years, all States/Administrations have attached great importance to capacity assessment, for example, China has initiated and implemented a number of related plans and methods for air traffic capacity assessment with the purpose of effectively managing and pre-allocating resources for high-density airports and airspace, which ensures the congestion relief capability and air traffic control support capability during peak hours in areas with rapid flight traffic growth such as Beijing, Shanghai, and Guangzhou. In this process, it is easy to find that the core of capacity assessment work

is to propose reliable capacity assessment methods. There are usually two problems in this process. One is that various capacity assessment methods and capacity value standards adopted by various States/Administrations are not uniform, which results in poor adaptability of capacity between States/Administrations. The other is that in the face of events such as ATFM and weather effects, it is difficult to guarantee the real-time response capability and the accuracy of the results of the operational capacity assessment method.

1.3 Since China officially implemented the National Traffic Flow Management System, one of the core goals is to use digital means to unify the data, processes and methods related to ATFM, of which the capacity assessment method is an important component. Based on various types of data integrated in the system, and taking the universality and accuracy of the current mainstream capacity assessment methods into consideration, a new capacity assessment method - the capacity assessment method based on similar characteristics is proposed and implemented, which has been applied in NTFM. The method provides a common capacity assessment service for all system users, and lays a solid foundation for analyzing airspace bottlenecks and formulating ATFM measures.

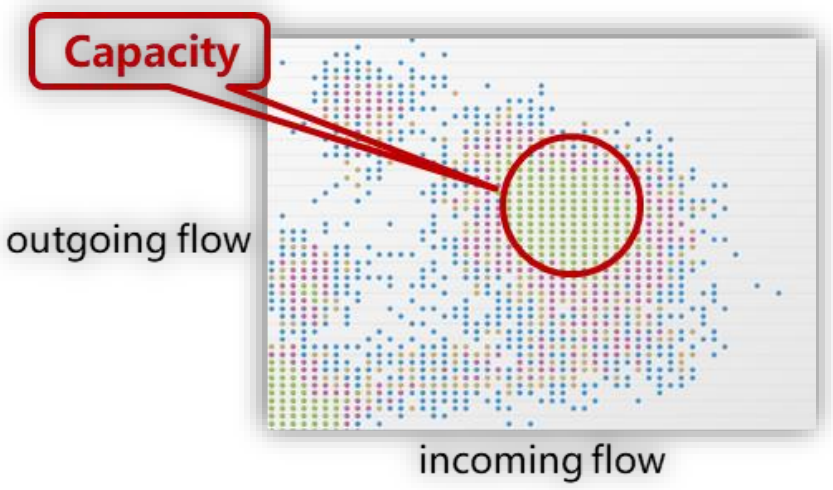
2. DISCUSSION

Concepts of capacity assessment methods

2.1 *Analysis of current capacity* assessment *methods*

- The current mainstream capacity assessment methods can be divided into four categories: assessment methods based on air traffic controller workload, assessment methods based on historical statistical data analysis, assessment methods based on mathematical calculation models, and assessment methods based on computer simulation. How to obtain the capacity reference value of the object to be assessed through historical data analysis is a current hot issue.

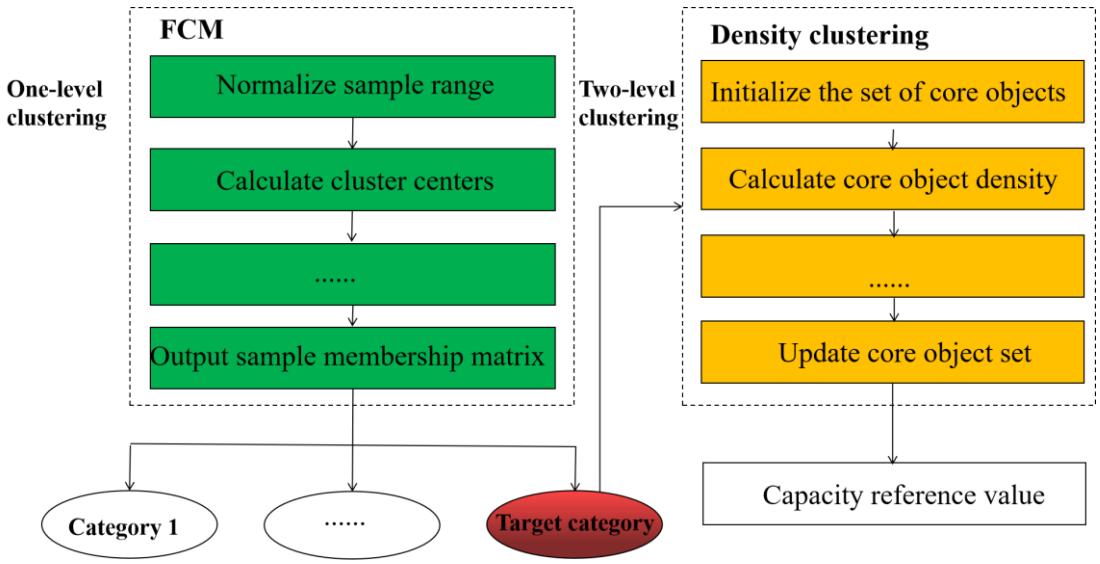
- As so far, the assessment method based on historical statistical data analysis is a method with less difficulty in implementation and higher accuracy. The core idea is to assess capacity through envelope analysis. The idea can be briefly described as follows. First, select the operating data for a period of time, and slice the operating data according to the time granularity of the assessment. The time granularity is usually 15 minutes, 30 minutes, and 60 minutes. Second, count the incoming flow and outgoing flow of each slice, and draw scattered points in the two-dimensional coordinate system. Finally, according to the principle of statistics, draw the envelope of the convex polygon in the two-dimensional coordinate system, usually with an envelope of 80 % or 90% of the scattered points in the target set, then the sum of the abscissa and ordinate of the points on the envelope is the capacity value.



- It is not difficult to observe from the above description that the current capacity value obtained through historical data analysis reflects the macroscopic set characteristics, the selection of sample sets has a greater impact on the capacity results, and the using process is more data-driven than purpose-driven. Moreover, this method is mainly used for post-event capacity analysis, which lacks capacity prediction capabilities for specific evaluation scenarios, resulting in a relatively narrow field of application for this method.

2.2 *Concept of capacity assessment method based on similar characteristics*

- The capacity value of historical data analysis is highly objective, and the capacity prediction value for specific assessment scenarios requires strong real-time performance. In order to take into account the above characteristics, a capacity assessment method based on historical similar characteristics is proposed. The idea of this method can be briefly described as follows. The first step is to define the operation indicators, describe the operation data by slices through the operation indicators, and record the capacity value of each slice to form a sample set. The second step is to describe the operation data of the scenario to be assessed in slices. The third step is to compare the operation data slice of the assessed scenario with the slices in the sample set. One or several slices with the highest matching degree are found, and the capacity value of the scenario to be assessed is estimated

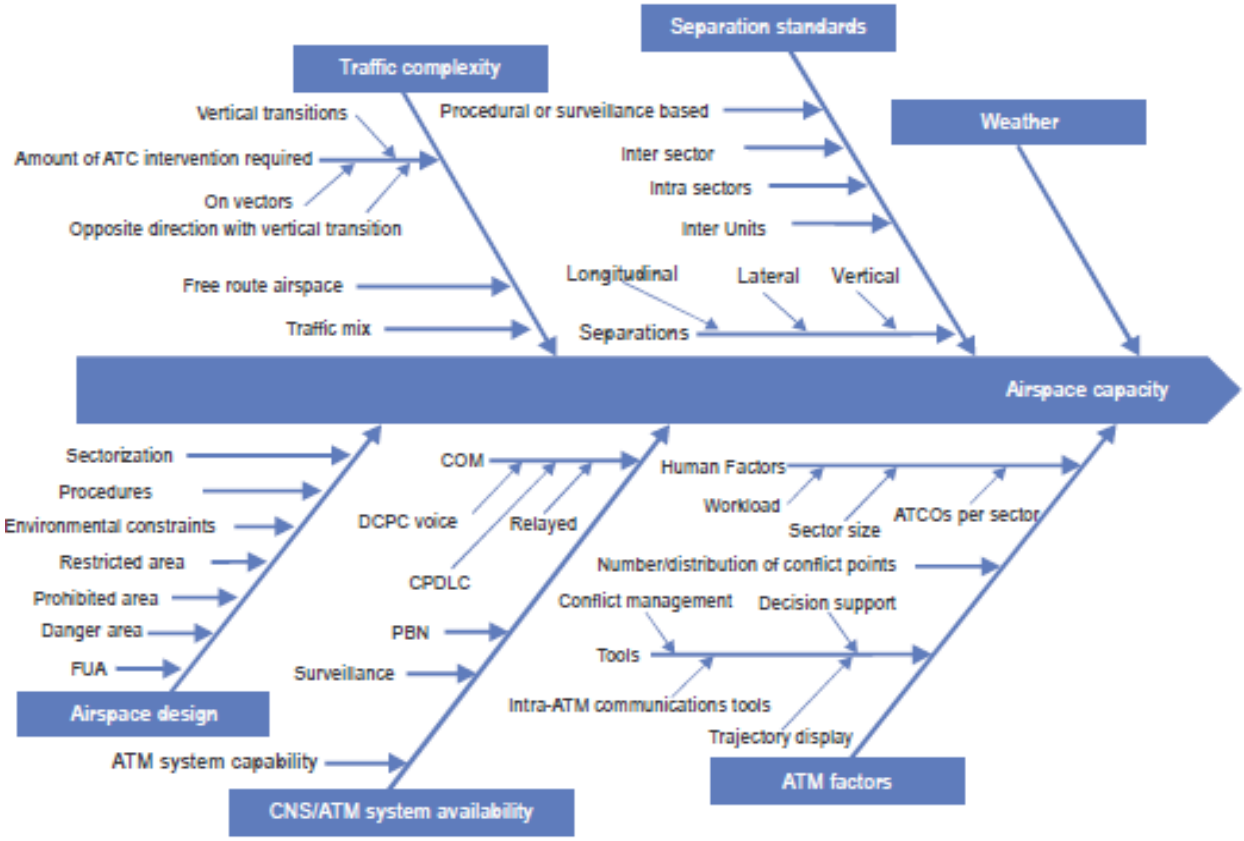


Process of capacity assessment method based on similar characteristics

2.3 Definition of similar characteristics and selection of operating indicators

- Similar characteristics are defined from the perspective of capacity, which means that the operating indicators of two or more selected slice samples are "homogeneous", that is, elements or indicators that can determine the capacity value.

- The factors that determine the capacity value are diverse, mainly including airspace static factors and airspace dynamic factors. Static airspace influencing factors mainly include airspace structure, airspace scope, flight procedures in airspace, etc.; airspace dynamic influencing factors mainly include weather influencing factors, airspace operating rules, and traffic flow distribution in airspace, etc. In ICAO Doc9971, the factors affecting airspace capacity are described as shown in the figure.



By classifying and analyzing the factors that affect capacity, the following three types of indicators that mainly affect capacity are selected.

- *Structural factor concept.* It is used to characterize the relationship between the static characteristics and capacity of the object to be assessed. It refers to the statistical analysis of the object to be assessed from the perspective of a complex network after the object to be assessed is abstracted into a weighted network; the main indicators include non-linear coefficients, node pressure, the average value of the node degree. The non-linear coefficient is the average value of the ratio of the actual flight length to the space distance between the start and end points of the flight route within the statistical period; the node pressure is the average value of the flow passing through the key points within the

statistical period; the mean of the node degree is the complexity of the spatial structure, etc.

- *Operational factors concept.* It is used to characterize the relationship between the dynamic characteristics and capacity of the object to be assessed, which refers to the macroscopic operation of the object to be assessed within the period to be assessed under the premise of a specific flight plan. The main indicators include period flow, average delay time, etc.

- *Dynamic factors concept.* It is used to characterize the relationship between the random characteristics and capacity of the object to be assessed, which refers to the quantitative measurement of the impact of the events on the operation of the object to be assessed. The main indicators include meteorological congestion degree, capacity decline rate, etc.

2.4 Analysis of homogeneous samples

- *A set of indicators with similar capacity characteristics.* The historical operation data of the object to be assessed and the data of the period to be assessed are indexed and counted by time period to form a set matrix of capacity similar feature indicators, in which the number of columns is the number of capacity similar feature indicators, and the indicators mainly include non-linear coefficients, nodes pressure, average node degree, period flow, average delay time, meteorological congestion degree, capacity decline rate. The number of rows is the number of time period samples, and the length of the time period is the time granularity of the capacity assessment (usually 15 minutes, 30 minutes, or 60 minutes).

- *Clustering Algorithm.* In the face of new actual operation scenarios, it is impossible to know the capacity assessment value of the new scenario. Based on the set of capacity similar feature indicators, the clustering algorithm is used to classify the historical data samples in different periods, and generate the similar capacity period of the evaluation period of the current evaluation object. The sample collection realizes the homogeneity and normalization of the sample data in the new operational scenario.

2.5 *Calculate capacity reference value*

- *Capacity set.* After classification based on capacity similarity features, the clusters of capacity similar features of the objects to be evaluated in the period are obtained, and the historical operating capacity of each sample period in the clusters is obtained to form a capacity set.

- *Density clustering.* According to the tightness of the sample distribution, the data set is classified on the basis of the density of the spatial distribution, and the historical capacity values of the sample sets in similar capacity periods are classified to determine the aggregation characteristics of the capacity values of the sample sets.

- *Capacity reference value.* After determining the aggregation characteristics of the capacity value of the sample set to which it belongs, calculate the reference value of the capacity of the object for the period to be evaluated by the method of calculating the mean.

Application in National Traffic Flow Management System

2.6 *Concept of application mode*

- In NTFM, the capacity assessment method based on similar characteristics has two trigger modes, which are manual trigger and event trigger. Manual trigger refers to the triggering of capacity assessment when ATFM personnel need capacity values for auxiliary decision-making; event trigger refers to the automatic triggering of capacity assessment after monitoring the weather impact information provided by the weather processing module. Under the two trigger modes, the capacity assessment method based on similar characteristics will search for a certain period of data from the historical data sample database as the sample set, and the data of the same period last year will be selected as the sample first. If there is no corresponding data, it will select the data of recent period as a sample.

2.7 *Application Scenario*

- In NTFM, the capacity assessment method based on similar characteristics is mainly used in two types of scenarios currently: normal operation and meteorological impact. Normal operation refers to the operation without special external interference, and the assessment results are usually used as declared capacity; meteorological impact refers to the operation under weather conditions. If the preliminary analysis of the system shows a drop in capacity, it will automatically trigger the capacity assessment. The assessment results are mainly used as a means to assist decision makers.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information contained in this paper;

b) collaboratively improve the capacity assessment method based on similar characteristics

c) jointly enhance the methods and capabilities in the field of capacity assessment in the Asia-Pacific region

d) discuss any relevant matters as appropriate.

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