Research on Airport Support Capability Assessment Method Based on Operation Data

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***Abstract*—Airport is a key component of air transport system and important node of civil aviation transport production. In order to quantitatively assess the airport support capability, the latest research progress of support capability from academic and industry is reviewed. An airport support capability assessment procedure is presented and discussed. The airport support capability can be assessed by evaluating aircraft support capability and passenger service support capability. An airport support capability assessment method is proposed based on identified important influencing factors of aircraft support capability and passenger service support capability. A case study of an airport is given to verify the validity and feasibility of the proposed method. The support capability assessment results can be used to find shortcomings of support capability, allocate resources reasonably and improve the operation efficiency of the airport.**

Keywords—airport, support capability, operation data, support capability assessment

I. INTRODUCTION

Airport is the key component of air transport system and the important node of civil aviation transport production. It is not only the jointing point of civil aviation transport system, but also the connection point of ground traffic and civil aviation traffic. In addition, it's the place where the interaction between airports, airlines, passengers, cargo owners or their agents takes place. Under the condition of modern economic structure, airport is not only a convenient facility for transportation, but also plays an irreplaceable role in regional employment, tax revenue, service and regional competitiveness. As an important infrastructure in civil aviation industry chain, airport is an important part to ensure the safety of the whole operation of the industry.

With the continuous development of China's economy, especially after the 18th national congress of the CPC, the pace of economic transformation and industrial structure adjustment is accelerating day by day, and the civil aviation industry is transforming from a major transportation country to a powerful country with high quality civil aviation. As an important part of civil aviation transport service, airport has made great progress in recent years. According to the national airport production statistics bulletin, there were 235 civil airports in China in 2018 (excluding Hong Kong, Macao and Taiwan), and the annual passenger throughput exceeded 1.2 billion, an increase of 10.2% over the previous year. Numbers of civil transport airports and new airports from 2010-2018 is presented in Fig. 1 [1-10]. The number of completed transport flights was 9.373 million, an increase of 7.4% over the previous year. From 2009 to 2018, the average annual growth rate of transport flights was 9.5%, and the average annual growth rate of passenger throughput was 12.38%. The number of airports with more than 10 million levels increased from 10 in 2008 to 37.

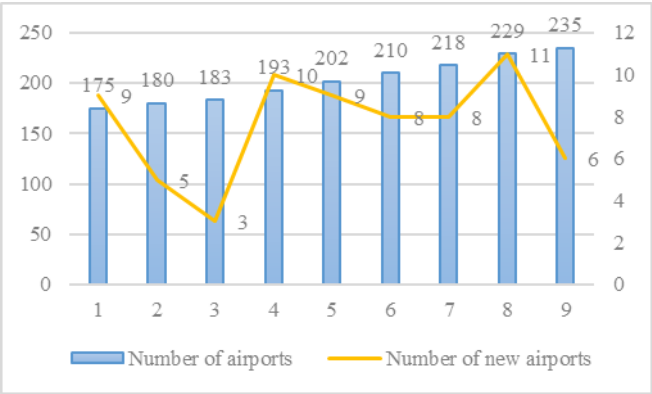

Fig.1 Numbers of civil airports and new airports from 2010-2018

Airport is a complex operating system, which has the characteristics of complex operating environment, numerous supporting units, multiple influencing factors of supporting work and strong randomness. In addition, the organizational structure of different airports is very different, leading to

their different management modes. By the end of 2018, China had 235 civil aviation certified airports (excluding Hong Kong, Macao and Taiwan). The passenger turnover of civil aviation has reached 31% in the comprehensive transportation system. In 2018, China's airports handled more than 1.2 billion passengers, 16.74 million tons of cargo and mail, and completed 11,088 million flights. There are 37 airports with an annual passenger throughput of 10 million or more, 29 airports with an annual passenger throughput of 2-10 million, and 169 airports with an annual passenger throughput of less than 2 million. With the sustained and rapid development of civil aviation, although many airport resources continuously added in recent years, but many civil transport airports are still faced with difficulties and challenges, such as: airport capacity reaching saturation, shortage of airspace resources, airport facilities construction relative lag, airport operation efficiency to be insufficient, operation ability, etc.

In recent years, the evaluation of airport operation safety support capability has become a hot and difficult issue in the civil aviation industry. Yin [11] built an evaluation model of the technical support capacity for the aviation equipment based on the grey relational analysis. Chen et al. [12] built an ATC safety support capability model containing static and dynamic capabilities to make ATC safety support capability matches with increasing needs from air traffic transportation. Wang et al. [13] built a civil aviation line maintenance personnel's safety support capability model by identifying assessment indicators of line personnel's ability and quality, factors that influence capability based on Reason model and SHELL model. Zhang et al. [14] provided a technique system of equipment maintenance support assessment and presented a new assessment method based on ExtendSim and neural networks ensemble. Zhao et al. [15] established a renovated system evaluation model by using the Fuzzy-ANP to resolve the uncertainty of the evaluation process and interdependence among the influential factors of the index of airport passenger security checking support capability. Wang et al. [16] established a flowchart of the airport safety operation and support capability via a software named Vensim PLE by analyzing the interactional relationship between the airport safety operation and the support capability (the supporting resources, the safety investment, and regional transportation demand). Hu et al. [17] established the evaluation index system of aircraft equipment support capability to evaluate aircraft support equipment support ability by using analytic hierarchy process and gray clustering method. Zhang et al. [18] established the evaluation index system of commercial aircraft maintenance support system. Then, the optimization decision model was built by using principal component analysis. Wang et al. [19] established the airport alternate support capability assessment model based on rough set theory, genetic algorithm, Johnson reduction algorithm, and the entropy method. Cui et al. [20] built a multi-object optimization allocation model of aircraft deicing to study the influences of non-scheduled factors on aircraft deicing support capability of busy airports during winter operation. Based on ANP, gray system theory and fuzzy mathematics, Li et al. [21] proposed a networking weighting method to resolve the uncertain and correlative of the index of aeronautic equipment maintenance support capability. Du et al. [22] identified eighteen influencing factors influencing firefighters' rescue capability according to expert interviews and literature review.

The remaining of this paper is organized as follows. The support capability assessment procedure is presented in Section 2. Then, Section 3 introduces the airport support capability assessment method. In Section 4, a case study of an airport is provided to verify the proposed method. Finally, some conclusions are given in the last section.

II. Airport Operation Safety Support Capability Assessment Procedure

Generally speaking, the procedures for assessing the operation safety support capability of civil transport airports are illustrated in Fig. 2.

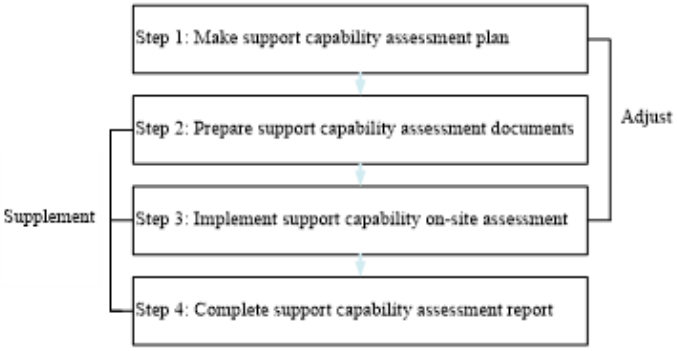

Fig.2 Airport support capability assessment procedure

Step 1. Make support capability assessment plan: confirm assessment purpose, assessment object and scope, assessment date and assessment team, etc.

Step 2. Prepare support capability assessment materials: the civil transport airport shall provide relevant assessment materials as required.

Step 3. Implement support capability on-site assessment: assess relevant departments and personnel of civil transport airport by means of discussion and questionnaire, on-site inspection of documents and records, assess the operation safety status on- site, etc. In this step, some unreasonable parts of support capability assessment plan can be adjusted according to the actual situation, such as assessment date, assessment team members, etc.

Step 4. Complete support capability assessment report: summarize the weaknesses found in operation safety support capability of airports, and propose effective suggestions to improve the operational safety support capability of civil transport airports. In this step, some documents and other evidences should be supplemented for the final assessment report.

III. Airport Operation Safety Support Capability Assessment Method

In order to assess the operation safety support capability of an airport, some influencing factors are identified as follows: relevant departments of equipment configuration, staff number and qualification, suitability and effectiveness of the tool, relevant departments of the coordination level of communication, the existing mechanism in normal and flight delays, etc.

The operation safety support capability of an airport can

be divided into two categories: aircraft support capability and passenger service support capability. In the support capacity assessment process, operation data is indispensable. In this paper, operation data mainly refer to data from aircraft support process and passenger support process, such as flight data, passenger data, baggage data, production data, various resources data, facilities and equipment data, etc.

A. Aircraft Support Capability

The aircraft operation safety support capability assessment of civil transport airport mainly involves the following departments: flight zone management department, terminal management department, special vehicle management department, aircraft engineering department, aviation safety guard department (enclosure management), etc.

In order to quantitatively assess aircraft support capability, some important aircraft support factors and processes should be identified. For an airport, typical support factors and processes can be illustrated as Fig. 3.

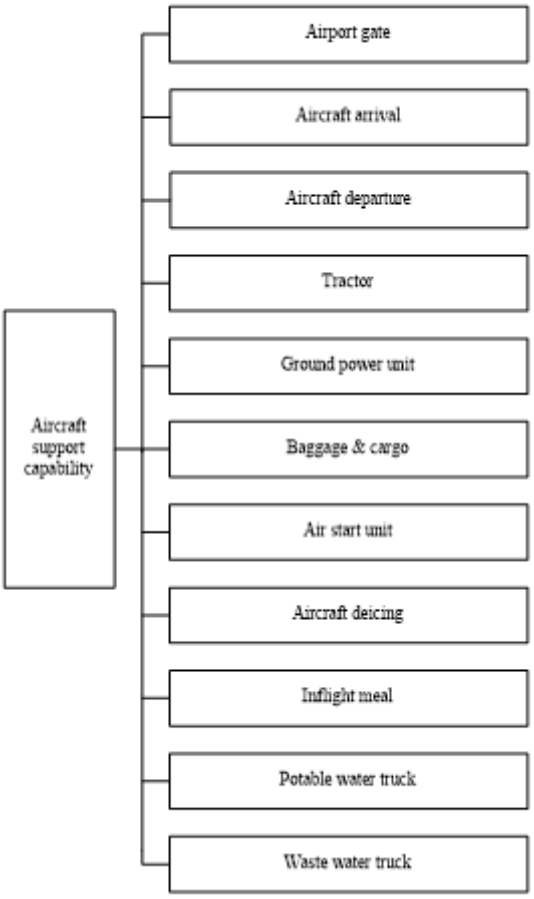

Fig.3 Typical influencing factors and processes of aircraft support capability

The aircraft support capabilities of parking apron, aircraft arrival, aircraft departure, tractor, ground power unit, baggage & cargo, air start unit, aircraft deicing, inflight meal, potable water truck, and waste water truck can be quantitatively assessed by collecting historical operation data. Thus, the maximum aircraft support capability under normal operating conditions can be obtained.

B. Passenger Service Support Capability

The passenger service operation safety support capability assessment of civil transport airport mainly involves the following departments: passenger service department, terminal management department, airport security department, special vehicle management department, baggage handling department, aviation security guard department, etc.

In order to quantitatively assess passenger service support capability, some important passenger service support factors and processes should be identified. Typical support factors and processes can be illustrated as Fig. 4.

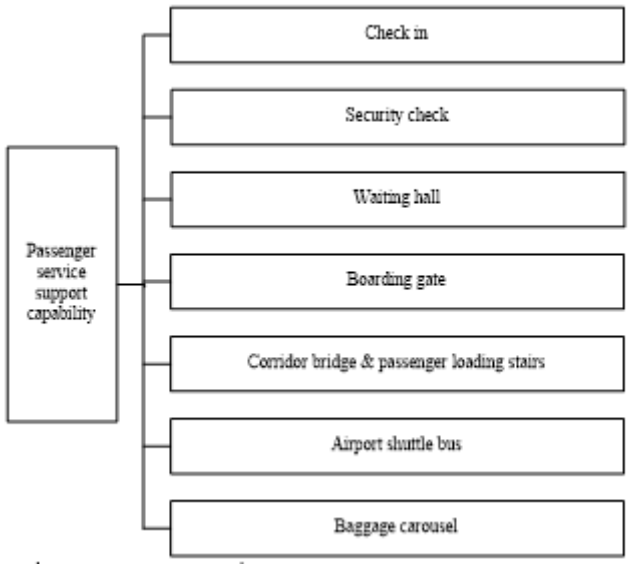

Fig.4 Typical influencing factors and processes of passenger service support capability

The main processes of passenger service include check-in, security check, waiting hall, boarding gate, corridor bridge and passenger loading stairs, airport shuttle bus, baggage carousel, etc. The passenger service support capabilities of check-in, security check, waiting hall, boarding gate, corridor bridge and passenger loading stairs, airport shuttle bus, baggage carousel can be quantitatively assessed by collecting historical operation data. Thus, the maximum aircraft support capability under normal operating conditions can be obtained.

C. Airport Support Capability Assessment Method

As mentioned above, the airport support capabilities can be assessed by calculating aircraft support capability and passenger service support capability in peak hour. Then, the aircraft support capability (N_{asc}) can be calculated as follow.

$$N_{asc} = \min\{N_{pa}, N_{aa}, N_{ad}, N_t, N_{gpu}, N_{bc}, N_{asu}, N_{ade}, N_{im}, N_{pwt}, N_{wwt}\} \quad (1)$$

where N_{pa} is the maximum support capacity of parking apron, N_{aa} is the maximum support capacity of aircraft arrival, N_{ad} is the maximum support capacity of aircraft departure, N_t is the maximum support capacity of tractor, N_{gpu} is the maximum support capacity of ground power unit,

N_{bc} is the maximum support capacity of baggage & cargo, N_{atu} is the maximum support capacity of air start unit, N_{ade} is the maximum support capacity of aircraft deicing, N_{im} is the maximum support capacity of Inflight meal, N_{pwt} is the maximum support capacity of potable water truck, and N_{wwt} is the maximum support capacity of waste water truck.

The passenger service support capability (N_{pssc}) can be calculated as follow.

$$N_{pssc} = \min\{N_{ci}, N_{sc}, N_{wh}, N_{bg}, N_{cb}, N_{asb}, N_{bc}\} \quad (2)$$

where N_{ci} is the maximum support capacity of check in, N_{sc} is the maximum support capacity of security check, N_{wh} is the maximum support capacity of waiting hall, N_{bg} is the maximum support capacity of boarding gate, N_{cb} is the maximum support capacity of corridor bridge & passenger loading stairs, N_{asb} is the maximum support capacity of airport shuttle bus, and N_{bc} is the maximum support capacity of baggage carousel.

Then, the airport support capability (N_a) can be calculated as follow.

$$N_a = \min\{N_{asc}, N_{pssc}\} \quad (3)$$

IV. Case Study

In order to verify the proposed assessment method, a case of a civil airport is studied. There are flight zone management department, terminal management department, special vehicle management department, aircraft engineering department, aviation safety guard department, passenger service department, airport security department, and baggage handling department in this airport.

A. Aircraft Support Capability Assessment

Numbers of parking apron, aircraft maintenance crew for aircraft arrival & departure, tractor, ground power unit, baggage & cargo truck, air start unit, aircraft deicing unit, inflight meal truck, portable water truck, and waste water truck are presented in Table I.

TABLE I. Numbers of Important Influencing Factors of Aircaft Support Capability

Influencing factors	Number
Parking apron	42
Aircraft maintenance crew for aircraft arrival & departure	9
Tractor	15
Ground power unit	18
Baggage & cargo truck	26
Air start unit	4
Aircraft deicing unit	26
Inflight meal truck	22
Portable water truck	16
Waste water truck	11

For each important influencing factors list in Table I, the operation time of support a certain aircraft should be collected and estimated according to historical operation data. Airport staffs collect a lot of operation time for each important influencing factor. Then the average operation time is calculated based on the collected operation data. Table II presents the average operation time for these influencing factors.

TABLE II. Operation Time of Important Influencing Factors of Aircaft Support Capability

Influencing factors	Operation time (minute)
Parking apron	86
Aircraft arrival	26
Aircraft departure	14
Tractor	12
Ground power unit	90
Baggage & cargo truck	38
Air start unit	7
Aircraft deicing unit	14
Inflight meal truck	40
Portable water truck	11
Waste water truck	15

While the number of facilities, equipment and aircraft maintenance crew and average operation time of influencing factors are obtained, the maximum aircraft support capability of these important influencing factors can be calculated according to available time and average operation time.

TABLE III. Maximum Support Capabilities of Important Influencing Factors of Aircaft Support Capability

Influencing factors	Maximum support capability
Parking apron	29
Aircraft arrival	20
Aircraft departure	38
Tractor	75
Ground power unit	37
Baggage & cargo truck	27
Air start unit	59
Aircraft deicing unit	111
Inflight meal truck	33
Portable water truck	87
Waste water truck	44

B. Passenger Service Support Capability Assessment

In order to assess passenger service support capability, operation data related to passenger service is collected. Numbers of check-in counter, self-service check-in machine, security check channel, seats in the waiting hall, boarding gate, corridor bridge and passenger loading stairs, airport shuttle bus, baggage carousel are presented in Table IV.

TABLE IV. NUMBERS OF IMPORTANT INFLUENCING FACTORS OF PASSENGER SERVICE SUPPORT CAPABILITY

Influencing factors	Number
Check-in counter	118
Self-service check-in machine	40
Security check channel	44
Seats in the waiting hall	2274
Boarding gate	40
Aorridor bridge	36
Passenger loading stairs	37
Airport shuttle bus	36
Baggage carousel	12

For each important influencing factors list in Table IV, the historical operation data are collected and analyzed. Then, the maximum passenger service support capability of these factors can be calculated.

TABLE V. MAXIMUM SUPPORT CAPABILITIES OF IMPORTANT INFLUENCING FACTORS OF PASSENGER SERVICE SUPPORT CAPABILITY

Influencing factors	Maximum support capability
Check-in	52
Security check	35
Seats in the waiting hall	22
Boarding gate	27
Aorridor bridge & passenger loading stairs	43
Airport shuttle bus	45
Baggage carousel	20

The maximum airport support capability can be obtained by comparing maximum support capabilities of important influencing factors of aircraft support capability and passenger service support capability.

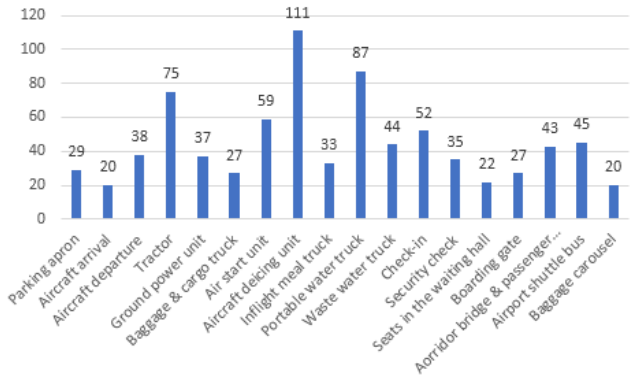

Fig.5 Maximum support capabilities of important influencing factors of aircraft support capability and passenger service support capability

Fig. 5 presents the comparison result of aircraft support capability and passenger service support capability. It can be found that the airport support capability is 20 because the minimum support capability of all these important influencing factors is 20. The support capabilities of parking apron, aircraft arrival, baggage & cargo truck, seats in the waiting hall, boarding gate, and baggage carousel should be strengthened to improve the operation safety support capability of this airport.

V. CONCLUSIONS

In order to quantitatively assess the support capability of an airport, an airport support capability assessment procedure is presented and discussed. Important influencing factors of aircraft support capability include parking apron, aircraft arrival, aircraft departure, tractor, ground power unit, baggage & cargo, air start unit, aircraft deicing, inflight meal, potable water truck, and waste water truck. In addition, important influencing factors of passenger service support capability include check-in counter, self-service check-in machine, security check channel, seats in the waiting hall, boarding gate, corridor bridge and passenger loading stairs, airport shuttle bus, and baggage carousel. An airport operation safety support capability assessment method based on the identified important influencing factors and historical operation data is proposed. An airport is used as case study to illustrate the flexibility and efficiency of the proposed airport support capability assessment method. It is found that several important influencing factors of aircraft support capability and passenger service support capability should be strengthened.

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