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The Sector Capacity Evaluation Considering the Controller's Workloads

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Abstract

In order to further verify the relation between the controller's workloads and the sector capacity, the types of the controller's workloads were firstly refined based on the workload model. the data collection ways were researched to get the effective weight values and improve the weight value. The statistic algorithms of aircrafts numbers entering the sector, leaving the sector, within the sector, at the waypoint, and in the route segment were secondly designed. Finally, taking Shanghai approach airspace as an example, and the example verified that the controller's workloads and the number of aircrafts had very strong correlation using regression analysis method.

***Keywords**: sector; waypoint; workloads; aircraft; weight value; statistics*

1. Introduction

1.1. The Domestic and Foreign Research Dynamic

With the growth of civil aviation traffic and flights, extreme weather, the fault of navigation communication and other hardware facilities, air traffic is becoming more and more crowded, which makes the airspace resources more insufficient, which leads to more flight delays ,and brings a great number of economic losses. Meanwhile because of the limit airspace resources and the increase of aircrafts, the air-traffic controllers' pressure is more great .In some regions, for example three big airports and three big airspaces, controllers' workloads usually is beyond their capabilities, which leads to the air control error and accident when providing the air control service for the aircrafts, and so hidden danger is buried, which it maybe cause flight accident symptoms, the worse maybe cause flight accident.

So it is important whether the traffic in air control region and the workloads of air controllers is balanced each other. The core content of the balance is to measure air controllers' workloads effectively and arrange the traffic flow and work-time in air control regions reasonably in order to reduce the pressure of air controllers which the air traffic brings.

The capacity evaluation problems had been researched in Europe and the United States in the early 60's, and many research results had been obtained. Focus of the research was from single runway capacity model to regional capacity model. In 1979, Bowen and Pearcey [1] put forward the earliest single runway capacity model, and Blumstein, Newell et al. [2] successively improved the model. In 1966, airspace could be designed, evaluated and analyzed from airport to route by graphical airspace design environment(GRADE) and simmod plus software [3]. The research about the airspace capacity was relatively late. In 1970, R.S.Ratner firstly expanded the runway capacity concept to the terminal

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area and route [4]; In 1981, M.Janic and Vojin Tosic further studied the problem [5]. In 1999, Banavar Sridhar and Gano B. Chatterji improved the prediction method by adding the Multiple neural network model [6][7]. Now western countries have developed the airspace evaluation and simulation system on the basis of these theoretical research. In 2002, A.Majumdar and W.Y. Ochieng did Composite evaluation about the workload of controller [8]. In 2006, H.Sehchang studied the relation between the traffic flow and the workload [9].

At home, capacity assessment study was firstly studied in nanjing university of aeronautics and astronautics, and after several years of work, important achievements in theory and application aspects were achieved, and achievements have been applied to Shanghai hongqiao international airport and Beijing capital international airport capacity evaluation [10-12].

Through the domestic and foreign researches, the capacity evaluation generally was researched by computer simulation technology and mathematical models, but air-controllers' workloads were not considered in these ways. So the control sectors capacity evaluation would be discussed on the base of the above researches from the view of air-controllers' workloads.

1.2 The Classification of Controller's Workload

The controllers' work includes two parts, one is telecommunication, for example pilots' sky talk, control coordination and handover among controllers in different sectors, another is non-telecommunication, for example filling in flight progress strip *etc*.

1.2.1 The Non-Telecommunication Workloads

The non-telecommunication workloads must be obtained by field measurement, and it is a kind of workloads which the controllers need manually handle some works. In some large airports, radar control way basically has been used in area control and approach control, so the workloads of filling flight progress strip is relatively small for controllers [13].

1)The workloads of filling a flight progress strip: It is shown in formula (1).

$$\overline{F_{f_i}} \times N_{f_i}(t) \tag{1}$$

$\overline{F_{fi}}$: The consumed time by filling flight progress strip (unit:second/ each paper). Every aircraft crosses a waypoint or changes the height, the controller must fill a flight progress strip.

$N_{fi}(t)$: The number of flight progress strip required when the aircraft crosses the waypoints within the given time slot (unit: each paper).

2) The workloads of operating the equipment: It is shown in formula(2).

$$\overline{F_{ha}} \times N_{ha}(t) \tag{2}$$

$\overline{F_{ha}}$: The consumed time by the controllers' operating equipment once (unit: second/time).

$N_{ha}(t)$: The number of operating the equipment within the given time t.(unit: time)

1.2.2. The Telecommunication Workloads

The most time that the controllers spend in controlling the aircraft is telecommunication works, but because the radar control way basically has been realized in some airports, the time that controller spend on the telecommunications works can be obtained directly from the radar voice recorder. The controllers' telecommunication works mainly are used in radar identification, radar vector, conflict resolve, coordination *etc.*, so the telecommunication workloads can be divided into the following categories:

1) The radar identification workloads: Before providing radar control service to aircraft, the controllers should give the aircraft radar identification confirmation and inform the crews that the aircraft has been identified and keep the identification until the radar control service is over. If the controllers lost identification, they should immediately notify the aircraft and identify the aircraft again or stop the radar service. The controllers must inform the aircraft once again to identify the aircraft.

It is shown in formula (3).

$$\overline{F_{id}} \times N_{\text{int}\,o}(t) \tag{3}$$

$\overline{F_{id}}$: The consumed time that each aircraft entering the control sector completes a radar identification (unit: second/sortie).

$N_{\text{int}\,o}(t)$: The number of the aircraft entering the control sector within the given time t (unit: sortie).

2) The radar vector workloads: The controllers use radar information to guide the aircraft to fly according to the specified heading, the purpose is to reduce the aircrafts delays in the air, accelerate the traffic flow and solve flight conflicts.

It is shown in formula (4).

$$\overline{F_{ra}} \times N_{in}(t) \tag{4}$$

$\overline{F_{ra}}$: The consumed time completing radar vector once for each aircraft in the control sector (unit: second/sortie).

$N_{in}(t)$: The number of the aircraft entering in the control sector within the given time slot (unit: sortie). (caution: the difference with $N_{\text{int}\,o}(t)$).

3) The conflict resolving workloads: Sometimes controllers provide control service in order to solve the possible or potential flight conflict within the control sector, while conflict resolution needs all kinds of information exchange between the controller and controller, pilots and controllers.

It is shown in formula(5).

$$\overline{F_{cf}} \times (N_{poi}(t) + N_{seg}(t)) \tag{5}$$

$\overline{F_{cf}}$: The consumed time of solving a flight conflict once. The controllers solve the conflict through issuing commands when the aircrafts are in conflict. (unit: second/time).

$N_{poi}(t)$: The number of the flight conflict occur in the waypoint within the given time(unit: time).

$N_{seg}(t)$: The number of the flight conflict occur in the route segment within the given time(unit: time).

4) The coordination workloads: An aircraft maybe cross over multiple sectors during the whole flight, in every crossing sector, information must be exchanged between one controller and another controllers, meanwhile between one controller and one pilot, then

the aircraft can be handed over from one sector to another sector. So the control-coordination includes two parts of works, one is when the aircraft enters the sector, another is when the aircraft leaves the sector. It is shown in the formula (6).

$$\overline{F_{\text{int}\,o}} \times N_{\text{int}\,o}(t) + \overline{F_{out}} \times N_{out}(t) \tag{6}$$

$\overline{F_{\text{int}\,o}}$: The consumed time of the information exchange between controllers and pilots when each aircraft enters the sector (unit: second/sortie).

$\overline{F_{out}}$: The consumed time of the information exchange between controllers and pilots when each aircraft leaves the sector (unit: second/sortie).

$N_{out}(t)$: The number of the aircraft leaving the sector within the given time slot (unit: sortie).

2. The Calculation of the Controller's Workloads and the Analysis of the Algorithm Procedure

In this paper, the following workload model would be established which can evaluate the size of the controllers' workloads within each time slot in the sector.

$$\begin{aligned} F &= \overline{F_{id}} \times N_{\text{int}\,o}(t) + \overline{F_{ra}} \times N_{in}(t) \\ &+ \overline{F_{\text{int}\,o}} \times N_{\text{int}\,o}(t) + \overline{F_{out}} \times N_{out}(t) \\ &+ \overline{F_{cf}} \times (N_{poi}(t) + N_{seg}(t)) \\ &+ \overline{F_{f\,i}} \times N_{f\,i}(t) + \overline{F_{ha}} \times N_{ha}(t) \end{aligned} \tag{7}$$

F : The total cost of the workloads.

t : The time when the time slot start.

In this model, there are two kinds of parameters, one is the weight value whose unit is time, another is the frequency statistic whose unit is frequency.

2.1. The Weight Value Analysis and the Data Collection

(1) The weight value analysis

According to the workloads model built above, in order to evaluate the controllers' workloads, the weight value firstly should be known in the workload model ,that is $\overline{F_{id}}$, $\overline{F_{ra}}$, $\overline{F_{\text{int}\,o}}$, $\overline{F_{out}}$, $\overline{F_{cf}}$, $\overline{F_{f\,i}}$, $\overline{F_{ha}}$. The unit of the workloads is the time that the controllers spend on the corresponding works.

$\overline{F_{id}}$ ：The time consumed identifying an aircraft when an aircraft is entering a sector (unit: second/sortie).

$\overline{F_{ra}}$ ：The time consumed by the radar guiding an aircraft when an aircraft is flying in a sector (unit: second/sortie).

$\overline{F_{\text{int}\,o}}$ ：The time consumed coordinating an aircraft when an aircraft is entering the sector (unit: second/sortie).

$\overline{F_{out}}$ ：The time consumed coordinating an aircraft when an aircraft is leaving the sector (unit: second/sortie).

$\overline{F_{cf}}$ ：The time consumed solving the aircraft conflict when conflict happens in the sector (unit: second/sortie).

$\overline{F_{fi}}$ ：The time consumed filling progress strip (unit: second/sortie).

$\overline{F_{ha}}$ ：The time consumed operating the equipment (unit: second/sortie).

(2) The data collection

The weight value mainly comes from the practical work because of the close relationship between them. Air traffic control work include radar recognition, radar guide, control transfer into the sector and out of the sector transfer, conflict resolution, filling in the strip, equipment operation, etc.

Under the different conditions, the times of issuing an order and completing the manual work are both different. For example, when the number of aircrafts in the sector is increased, the speed of speak and movement will accelerate, and the control language will increase because of the fixed work time. But it is different when the number of aircrafts in the sector is a little. In addition, when an emergency or bad weather occurs, controls language will change obviously. So the weight value is different because of the effect of different factors.

In order to get stable and reliable data, the data collection should be in a typical navigation environment, and the enviroment will have the following features:

①Navigation environment needs to have a complete navigation equipments, a clear sector boundaries, and a precise airport position and so on.

②The selected example must be representative, that is, all flights over or into the airspace must have related flight plans.

③All of the airspace parameters (control process and technology) must be able to reflect the real working conditions. Each predefined tasks must give the weight value in time unit according to the implementation process.

After choosing the typical navigation environment, we will record the voice of the control process from some senior controllers. These weight values mainly are obtained from the data acquisition in the controllers' practical works, and these data mainly come from the controllers' communication record. According to the regulations of the civil aviation administration, every control command should be recorded and saved for a period of time, so the data can be obtained from the automatic recording facilities. After recording the needed control command, classifying them according to the mentioned above, through calculating the consumed time which the extracted several controllers issue different categories of control commands, the average of the 10 times same command is the relative value.

2.2. The Frequency Statistics and Algorithm Process Analysis

2.2.1 The Frequency

From the above, the size of the ATC workloads is the number of aircrafts which air-controller can guide. So we will calculate the following numbers in the slot which are separately the number of the aircrafts entering/ leaving the sector, the number of the aircrafts when radar guiding and instrument operating, the number of the aircrafts within the sector, the number of the waypoints over the sector when filling the strip, and the number of the conflicts when solving the conflicts.

The following data should be needed during the number statistics:

FPL message: flight number, aircraft style, departure airport, arriving airport, EDT (Expected departure time), ADT (actual departure time), AAT (actual arriving time), delayed time, the path, runway number, *etc*.

The height of the waypoint and aircraft speed: aircraft style, departure airport and runway, the import point passing by, fly speed an height in these points.

The waypoints data: the segment code, original point, end point, name of the segment, whether it is main route.

The sector information: the sector name and the boundary name.

After getting the flight information from the above data, we can find the corresponding detailed airway information, especially can get some information about the transfer-of-control points and the points in and out of the terminal area.

2.2.2. The Algorithm Analysis

The air traffic flow include those which are entering, leaving the sector, and within the sector, and in the waypoints.

(1) the flow entering the sector $N_{into}(t)$. It is used to calculate the workloads during the radar recognition and coordination into the sector. It indicates the number of the aircraft entering the sector within the given time (t). As long as knowing when the aircraft appears in the counted sector, the moment the number of aircrafts can be known by counting. But it is important that the time of the aircraft appearing must be within a given time slot.

The algorithm process is shown as Figure 1. As long as the number of aircrafts within the given time slot into the sector can be counted, the $N_{into}(t)$ can be calculated.

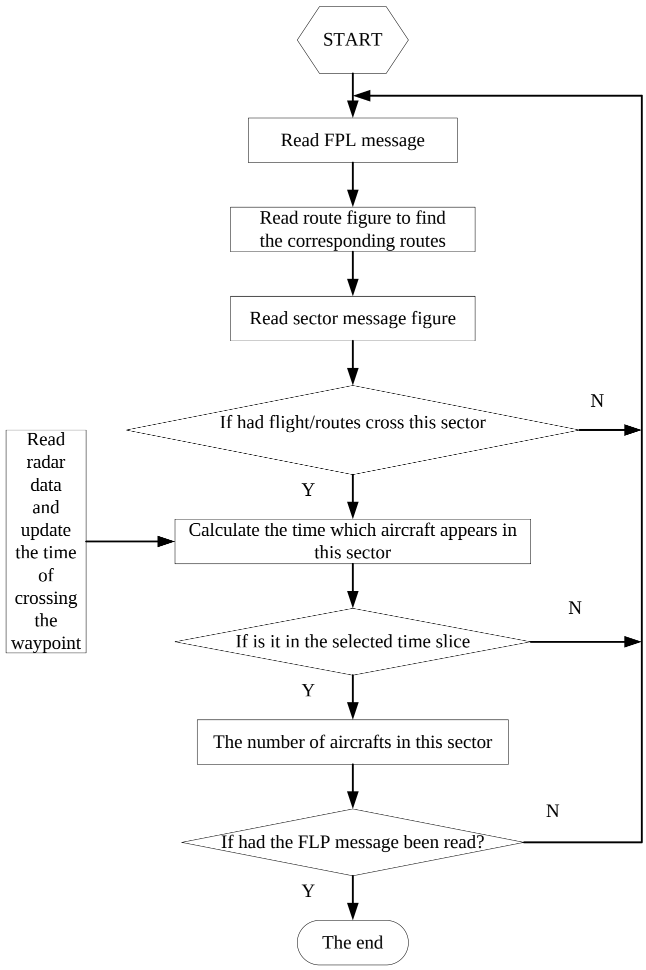

Figure 1. The Flow Chart of In-Sector Flow Statistics

(2) the flow leaving the sector $N_{out}(t)$. It is used to calculate the workloads during the coordination out of the sector. It indicates the number of the aircraft leaving the sector within the given time (t). According to the same process of counting $N_{into}(t)$, $N_{out}(t)$ can be calculated. The algorithm process is shown as Figure 2.

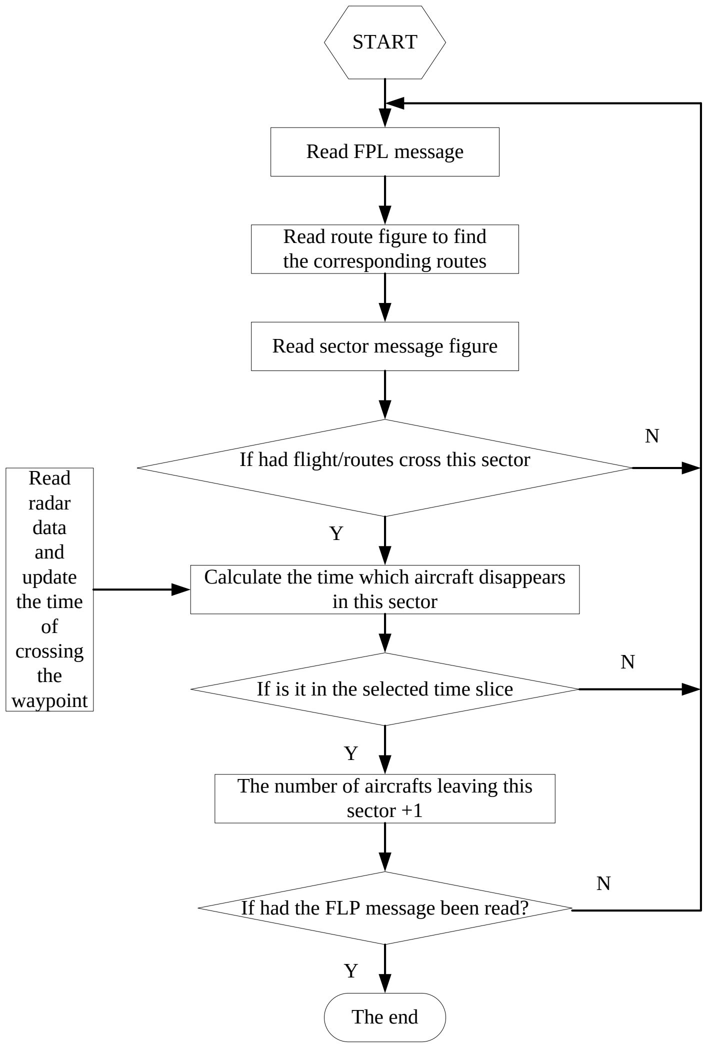

Figure 2. The Flow Chart of the Number of Aircrafts Leaving from the Sector

(3) The flow within the sector $N_{in}(t)$. It need to calculate the frequency of radar guiding and instrument operation through counting the number of aircrafts within the sector within the given time (t). the number includes 2 parts, one is the number of aircrafts entering the assessed sector within the given time, another is the number of aircrafts at the beginning of the time. The algorithm process is shown as Figure 3.

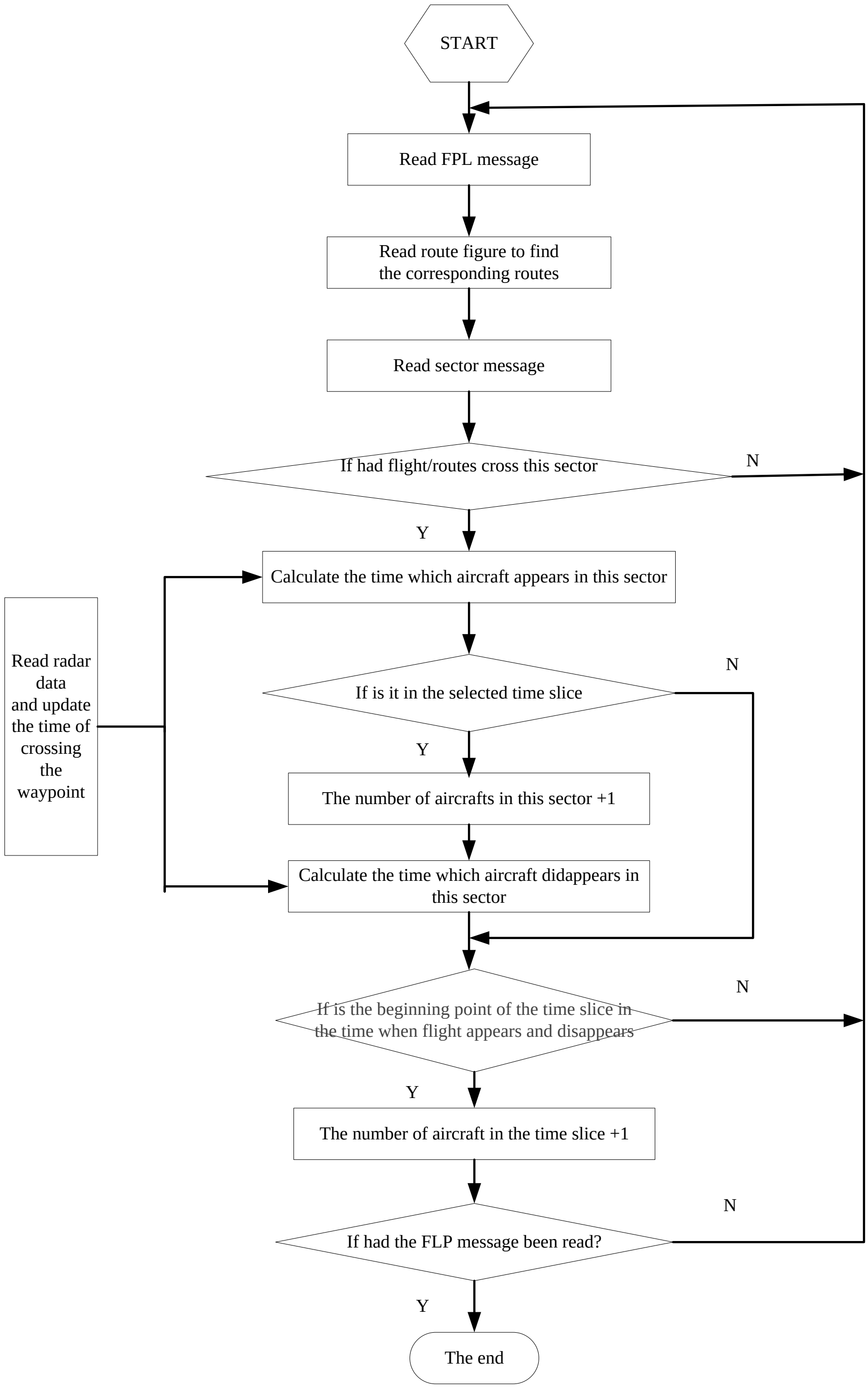

Figure 3. The Flow Chart of the Number of Controlled Aircrafts

(4) The flow in the waypoints $N_{fi}(t)$. In order to get $N_{fi}(t)$, the number of filling the strip and waypoints aircraft passing by are needed. That is also how many flights are passing by the waypoints within the given time. The algorithm process is shown as Figure 4.

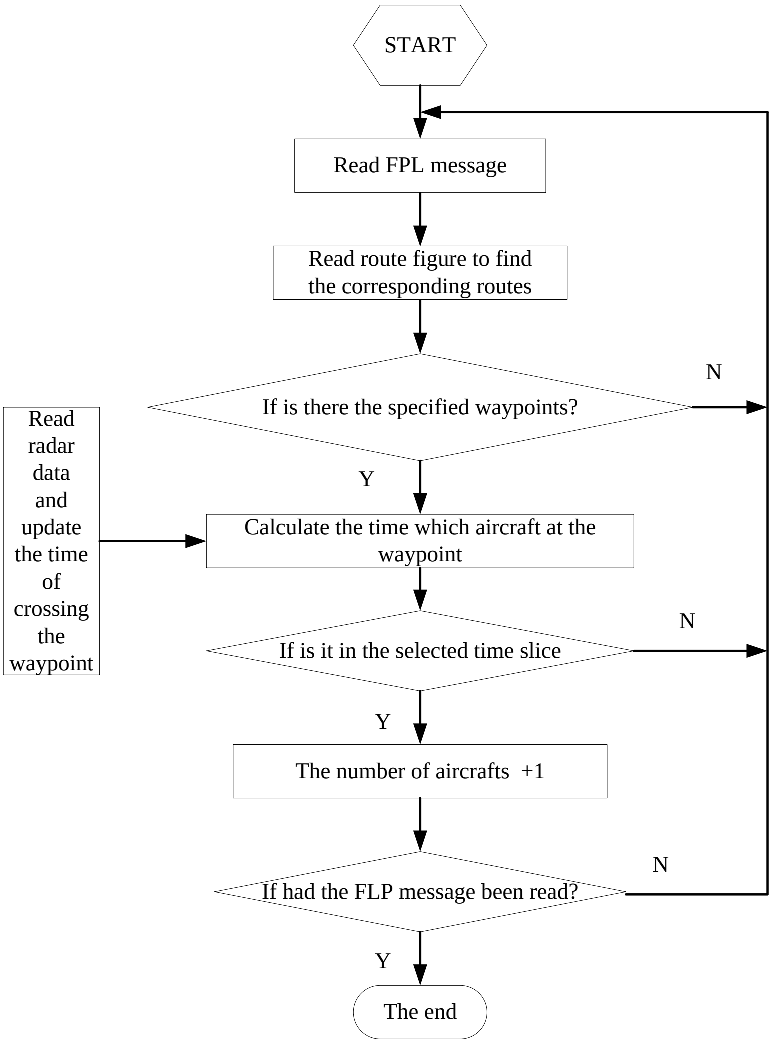

Figure 4. The Flow Chart of Flow Statistics at the Waypoint

2.3. The Conflicts Detection Analysis and the Statistics of the Conflicts Frequency

The frequency of conflicts happened in the waypoints and in the routes should be got in order to assess the workloads of the conflicts control, that is defined $N_{poi}(t)$ and $N_{seg}(t)$.

2.3.1. The Conflicts Detection Analysis

Conflict detection algorithm is divided into two classes that are deterministic algorithm and the algorithm based on probability. Conflict algorithm based on probability is based largely on pre-assess expectations of the track and error distribution to calculate the probability of the conflict which is relatively complicated.

The idea of the deterministic algorithm is to determine the track model, forecast the track of the flight in the future period of time (20 minutes to 30 minutes), and then compare the two aircraft flight path to judge whether there is conflict according to the aircraft performance, the current flight status and the flight plan. Because this algorithm is relatively simple, we will use this algorithm in this paper.

Conflict detection will be carried out by judging whether the interval between aircrafts meet the requirements. This interval is defined according to the following formula (8). In this paper, the method of detecting the current distance and height difference between the two paths will be used.

$$R_T = 2 \times T_A \times V_{mh} + R_{th} \tag{8}$$

T_A : Conflict prediction time , V_{mh} :The greatest possible fly speed, R_{th} : the allowed spacing

The limit of height difference

$$Z_T = 2 \times T_A \times V_{Nm} + A_{acp} \tag{9}$$

V_{Nm} : The greatest possible lifting speed, A_{acp} : the allowed height difference

When the distance between two aircrafts satisfies the two conditions, we can judge potential conflict path, and then we will discuss the conflicts under different conditions.

F_a : flight a , F_b : flight b , A , B : the two endpoints of segment; C : some point in the segment; Tx : the time passing by x .

There mainly are the following kinds about the conflicts of aircrafts within the sector:

(1) the conflicts when aircraft is at the waypoint within the sector

Ta_1 :the time when flight a is passing by A point,

Tb_1 : the time when flight b is passing by B point.

If Ta_1-Tb_1 can not satisfy the safety interval, the conflict will happen at the A point. if they can satisfy the safety interval, but Ta_2-Tb_2 cannot satisfy the interval, the conflict will happen at the B point as shown in the Figure 5.

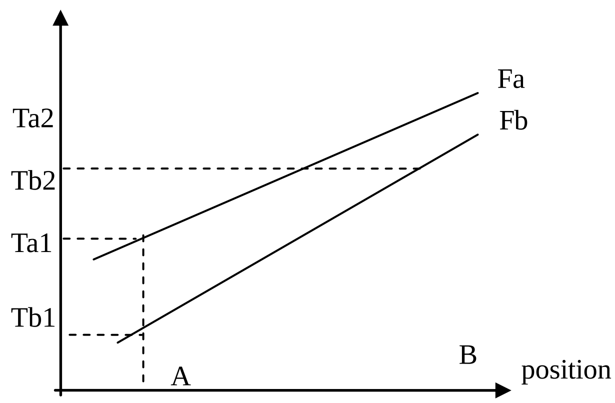

Figure 5. The Conflict at the Waypoint

(2) The conflicts when aircraft is passing by the segment within the sector. There are two kinds of situation, one is that the conflict happens when two aircrafts are in the same segment, and another is when two aircrafts are flying at the same direction in the same segment.

①The current aircraft is beyond the post aircraft

F_a : the post aircraft, F_b : the current aircraft

Flight a than flight b is later for about Ta_1-Tb_1 at the A point. If Ta_1-Tb_1 can satisfy the safety interval, then Flight b than flight a is later for about Tb_2-Ta_2 at the B point. we assume that Tb_2-Ta_2 can satisfy the safety interval. although two endpoints can both satisfy the safety interval and no conflicts happen at the waypoint, but conflict happen at the middle of the segment that is C point , in this condition, we can think that flight a than flight b is beyond as shown in the Figure 6.

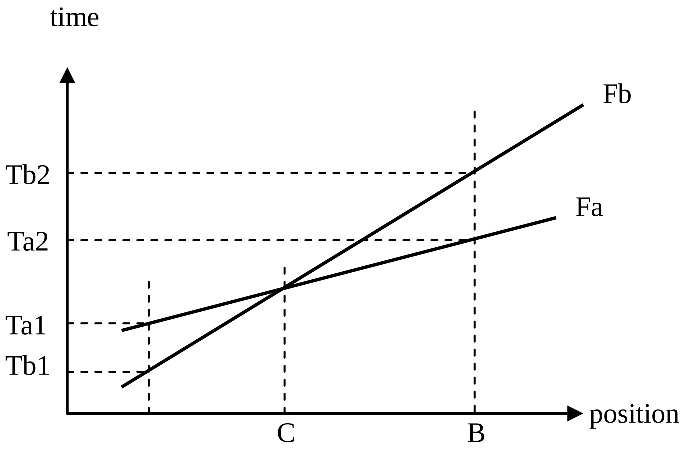

Figure 6. The Poster Aircraft is beyond the Current Aircraft

②The current aircraft is beyond the previous aircraft

F_a : the previous aircraft, F_b : the current aircraft

Supposing that flight b than flight a is later for about Tb_1-Ta_1 at the A point., and Tb_1-Ta_1 can satisfy the safety interval demand, flight b than flight a is earlier for about Ta_2-Tb_2 at the B point, and Ta_2-Tb_2 can satisfy the safety interval. Although two endpoints in the segment both can satisfy the safety interval demand, but conflict happen at the middle of the segment C point, so we can think that flight b than flight a is beyond as shown in the Figure 7.

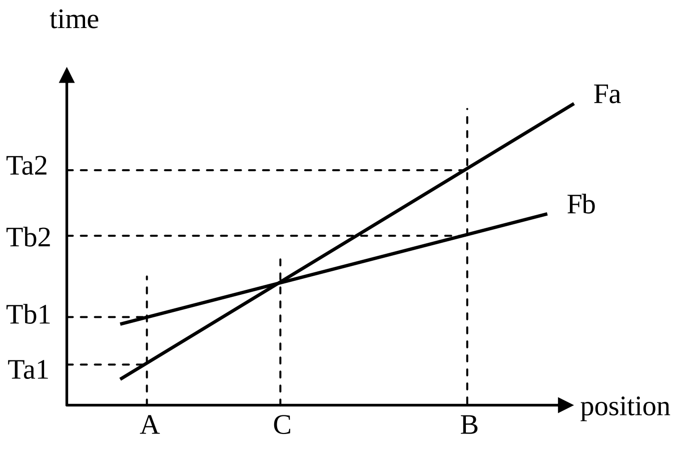

Figure 7. The Current Aircraft is beyond the Previous Aircraft

The conflict of two aircrafts flying at the different direction in the same segment: Supposing that flight a is flying from A point to B point, and flight b is flying from

B point to A point, conflict will happen at the C point. It is shown in the Figure 8.

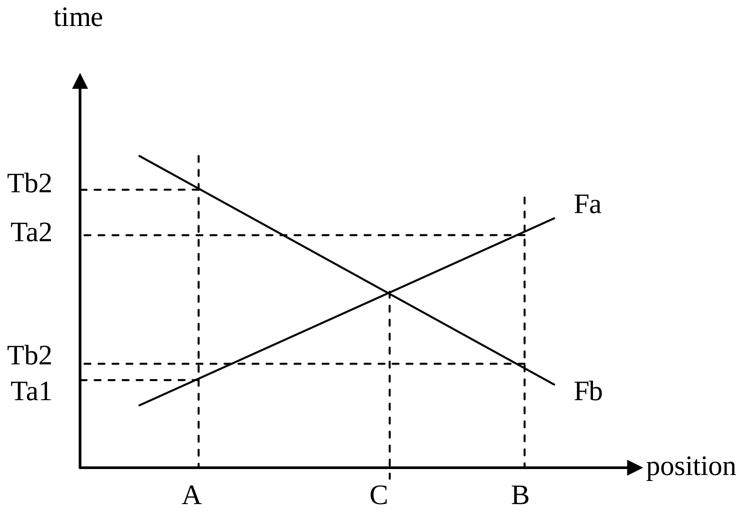

Figure 8. The Conflict of Two Aircrafts at the Different Direction

The conflict of two aircrafts in the different segment: Flight a and flight b are flying at the different segment, but there are intersections within the sector. Supposing that the time when flight a first passes by the point is Ta, and the time when flight b secondly passes by the point is Tb, if $Tb - Ta$ can not satisfy the safety interval demand, the conflict will happen at the common endpoint.

2.3.2. The Frequency Statistics of the Conflicts within the Sector

(1) The frequency of conflicts at the waypoint within the sector. Firstly, calculating the time when aircraft passes by the waypoint within the time, and then sort the time. Comparing the height in order to judge whether they are the same, then we can judge whether the distance is shorter than the safety interval, if so, it indicates that the conflict will happen, the number of the conflict adds 1. Finally, adding all the number of the conflicts at all waypoints, we can get the total number of waypoint conflicts within the sector in the time slot. The algorithm is shown in Figure 9.

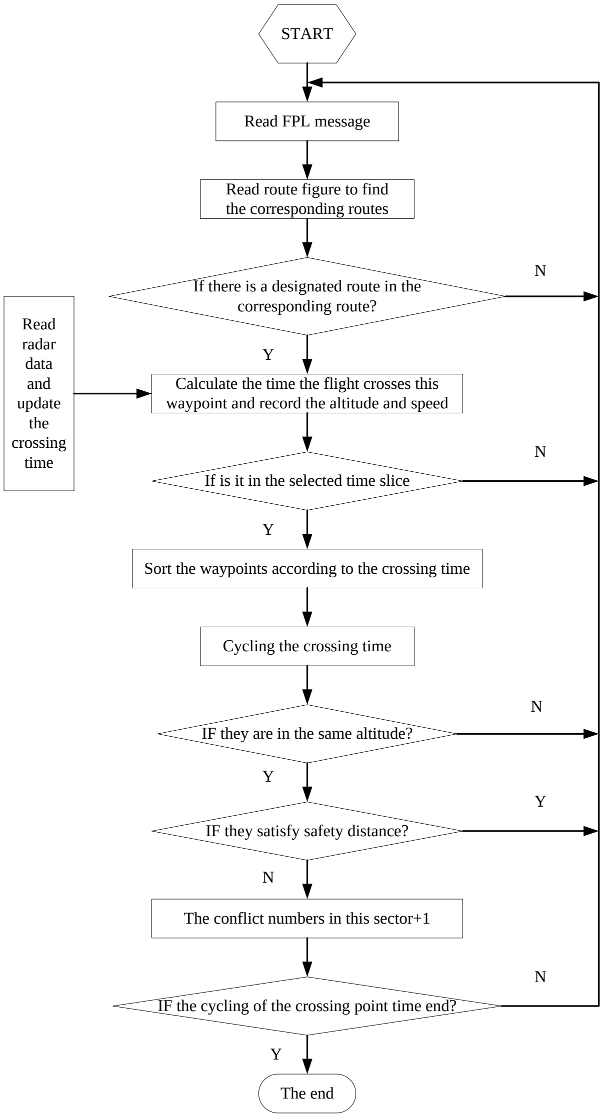

Figure 9. Algorithm of Waypoint Conflict Judgment (I)

(2) The frequency of conflicts in the segment within the sector. When aircrafts are flying in the segment, and the endpoints of segment can satisfy the safety interval, the conflict will happen in the middle of the segment. So in addition to calculate the number of waypoint conflicts, we should calculate the number of conflicts in the segment. The algorithm is as shown in the Figure 10.

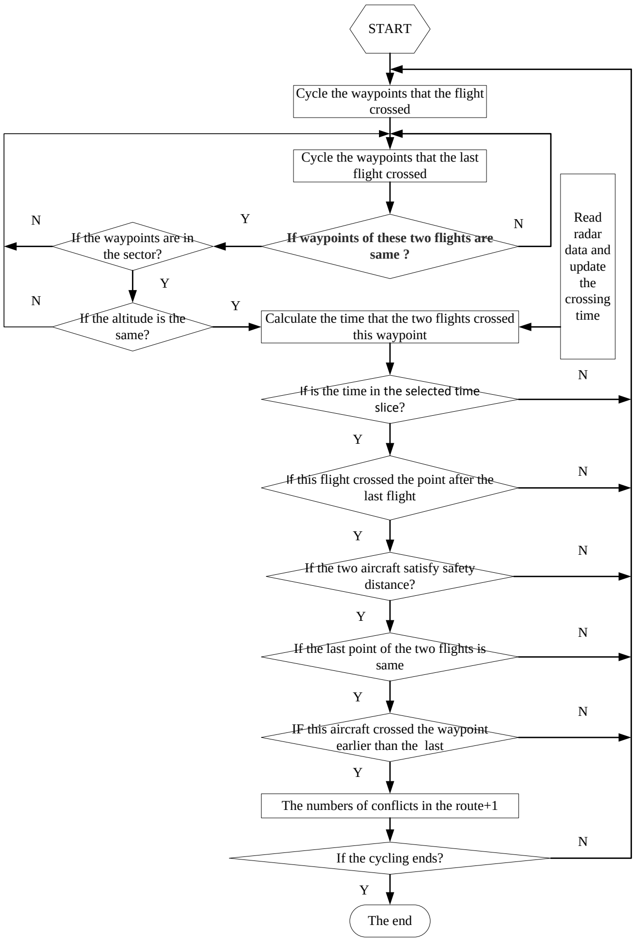

Figure 10. Algorithm of Waypoint Conflict Judgment (II)

2.4. The Methods of the Capacity Assessment

The controllers' workloads are relative with the number of the controlled aircrafts, so the regression analysis method should be used to explore the relationship between them in this paper.

Capacity evaluation method——"DORATASK": When the number of aircrafts reaches the maximum, the controllers' workloads must be below 80% of the value. To the contrary, when the controllers' workloads reaches 80% of the maximum value of the aircraft number, the corresponding number of aircraft is the capacity of the control sector.

In the paper, the least square method would be applied because of its easiness and convenience, meanwhile the mean square error between data and model is the least[14]. After the regression analysis using the least square method, a quadratic equation of one variable between the number of aircraft and workload of controller would be get.

2.5. The Analysis of Evaluation Method

In this paper, the subjective evaluation method considering the controllers' workloads should be used because of its following advantages:

1) The workloads is more applicable to the sector which the navigation environment is typical.

2) Take the Shanghai approach for example, the Shanghai approach airspace is one of the three national approach control centers which the feature is busy and typical. In this environment, the relationship between controller's workload and the aircraft number is

clear, and the capacity value of the sector can be get easily and precisely using the regression method.

3) To those non-typical airspace, it is hard to calculate the relationship between controllers' workloads and the number of aircrafst through the simple scatter diagram.

4) The objective assessment method can only guarantee its correctness in a short time.

In the view of development, due to the controllers' subjective ability is inferior to the improve speed of objective environment, controllers can be unbearable no matter the objective evaluation method optimizes the result, and the controllers' work ability is limited, once the workloads beyond his capacity, the control efficiency should decrease to affect the flight safety no matter whether the number of the aircraft reach the capacity of the sector.

It can be confirmed that the controllers' workloads is the most significant factor effecting sector capacity, so it's appropriate to build the method based on the controllers' workloads in the sector capacity assessment.

2.6. The Case Analysis

In the process of case analysis, the software VC＋＋6.0 and Microsoft Access 2003 should be used to design program.

Background: there are three approach sectors in the Shanghai approach airspace, take the sector 01 for example, the statistical data come from flight plan one day.

Process:

1) Count the number of aircraft, conflict, waypoint flow, route segment flow entering the 01 sector all day.

2) Record the approach controllers' communication time in one hour from the selected Hongqiao Airport and PuDong airport separately, and statistics of the content of the control.

3) Classify the content of the control by the mentioned above in order to calculate the communication time of the different kinds of the content of the control as a weight value, the weight values are shown in Table 1:

Table 1. Communication Workload Times

The category		The weight	The number of statistics	The average time
The communication operation (got from the automatic recording facilities)	The radar identification	$\overline{F_{id}}$	80	12.3 seconds
	The radar vector	$\overline{F_{ra}}$	80	15.8 seconds
	The control coordination(into the sector)	$\overline{F_{\text{int}\ o}}$	80	16.4 seconds
	The control coordination(out of the sector)	$\overline{F_{out}}$	80	14.5 seconds
	The conflict control	$\overline{F_{cf}}$	40	15.2 seconds
The non-communication operation(actual measurement)	Filling flight strip	$(\overline{F_{fi}})$	125	0.9 seconds
	Operating equipment	$(\overline{F_{ha}})$	80	2.0 seconds

$$F = 12.3 \times N_{int\ o}(t) + 15.8 \times N_{in}(t)$$
$$+ 16.4 \times N_{int\ o}(t) + 14.5 \times N_{out}(t)$$
$$+ 15.2 \times (N_{poi}(t) + N_{seg}(t))$$
$$+ 0.9 \times N_{fi}(t) + 2.0 \times N_{ha}(t) \quad (10)$$

Counting the data such as $N_{int\ o}(t)$, $N_{out}(t)$, $N_{in}(t)$, $N_{fi}(t)$ according to the Table 1 and formula (10). These data mainly come from every day's FPL. When these data has been obtained, the sector controllers' workloads can be get. The changing curve is shown in Figure 11.

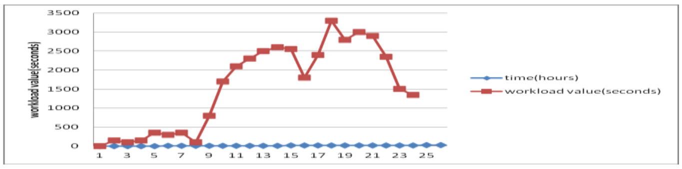

Figure 11. The Change of Workload with Times

In the Figure 11, the minimum of sector workload is 0 which occurs in 24:00 and the maximum is 3146 which occurs from 17:00 to 18:00 that accounted for 89% of all time beyond 80% by the DORATASK method mentioned above. So it can be seen that the sector controllers were in the overloads during the rush hour.

In this case, it can be seen that the relationship between workloads and the number of the aircrafts as shown in Figure 12.

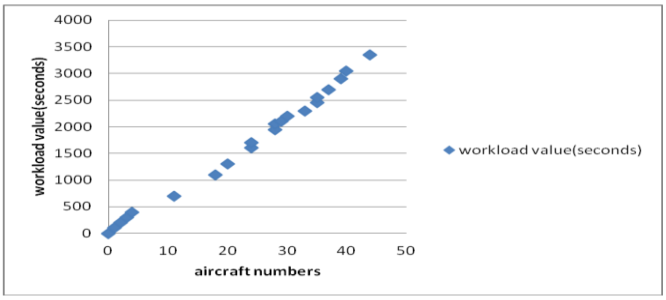

Figure 12. The Scatter Diagram of the Workloads and the Aircraft Numbers

From Figure 12, there is obvious linear relationship between number of aircrafts and the workloads. So a simple binomial can be built as shown formula (11) to calculate the workloads and sector capacity.

$$80\% F_{max} = a_0 + a_1 N + a_2 N^2 \quad (11)$$

N: The aircraft number.

F_{max} : The maximum workloads.

The minimum regression analysis method should be used to obtain the a_0, a_1, a_2 through matlab software[15]. In this case, the peak workloads F_{max} is near to 3300 seconds, the capacity value N=36 sortie.

3. Conclusion

1) Evaluating the capacity has a certain accuracy in a short period of time through the computer simulation technology and complex mathematical model. But in the long run, whatever the airspace structure change, and no matter how to optimize the simulation model results, the controller can not quickly improve his own ability, and can not bear the results of the optimization of the method. In addition, because any controllers have their bearing limit that is the limit control ability, once the control workloads exceeds the limit control ability, no matter whether to reach the capacity value of sector, the controller's control efficiency will reduce, or seriously will affect the flight safety. As a result, the controller's workloads is the biggest factor that influence sector capacity.

2) Human behavior is extremely complex. How to classify and quantify the controller workloads, and calculate the sector capacity based on controller workloads statistics are particularly important. In this paper, the statistics of times used nearly 200 statements, the control instruction on the basis of detailed analysis puts forward a new controller workloads classification methods.

3) There are many airspace capacity constraints, among which the limited controller's ability is one of the main factors. Sector capacity, therefore, should be evaluated based on sector control workloads, and will be in conformity with the actual capacity value. The capacity value achieved based on the control workloads had a certain use value, and the correctness was verified by the example of the Shanghai approach area 01 sector evaluation.

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