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Research on the Optimal Problem of Receiving Passengers Based on Airport Taxi

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Abstract: *The optimal taxi pick-up for airport taxis is to save passengers' waiting for costs, reduce the no-load rate of taxis, and maximize the profit of taxi drivers in order to achieve reasonable allocation of traffic and people.*
For the first problem: Analyze the relevant decision-making factors affecting taxi drivers by using AHP and related analysis methods, and use Matlab to combine qualitative and quantitative analysis, systematic and hierarchical analysis, conduct consistency test and solve its weight. .
For the second problem: Take Nanjing Lukou International Airport as an example, check the relevant information and collect the annual throughput of Lukou Airport as of 2018 and the number of taxis in Nanjing, simulate the simulation, and finally give the choice of the taxi driver of the airport. , as well as the rationality of the program and its dependence on relevant factors.
For the third problem: computer simulation based on the queuing theory and the position of the car entering the storage pool and the pick-up point, reasonably arranging the taxis and passengers, and making the overall ride efficiency the highest under the conditions of ensuring the safety of the vehicles and passengers. And set the reasonable passenger pick-up point and the driver's reasonable stop.
For the fourth problem: give priority to the taxis that return to passengers on short-distance returns, use Arcgis to simulate the Shenzhen city network, find out the dense areas and sparse areas where the taxis are located, and judge the distance between the airport and the dense and sparse areas. To prove the rationality of the program.
The established model is scientific and rigorous, has a reasonable structure, has strong practicability, is reliable and accurate in calculation, can meet practical applications, and has certain reference value.

Keywords: *Taxi scheduling;Analytic hierarchy process; Simulation; Queuing theory; ArcGIS*

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I. Model Background And Problem Retelling

A. Model background

Taxi is one of the main means of transportation. Taxi pick-up at the airport often faces two problems: one is to queue up in the storage pool area to wait for the passengers to return to the urban area, and the other is to directly vent to return to the city to pull passengers. In the first case, the number of taxis and passengers queued affects the revenue of the taxi driver. In the second case, the idle cost of the taxi driver and the potential loss of passenger passengers may be considered. Therefore, in order to maximize the driver's revenue cost, it is necessary to make the airport taxis the best.

B. Restatement of the problem

Question one:
It is required to comprehensively consider the change law of the number of passengers in the airport and the income analysis of the taxi driver to influence the relevant factors of the decision of the taxi driver, and establish a decision model to give the driver decision strategy.
Question 2:
It is necessary to collect relevant data of a taxi in a certain domestic airport and its city, give a choice of taxi drivers and explain the rationality and dependence of related factors.
Question three:
According to the existing two parallel lanes in the “car zone” of the airport, reasonable arrangements for car rental stops and passenger pick-up points will maximize the total ride efficiency.
Question 4:

According to the passenger's destination is far and near, giving priority to taxi drivers who carry short-distance passengers, so that the taxi driver's income is as balanced as possible.

II. Problem Analysis

A. Analysis of problem one

In question 1, a taxi driver selection decision model is established and a taxi driver's selection strategy is given. First, collect factors that may affect the decision of the taxi driver, including the number of flights arriving at a certain time (potential traffic), the number of vehicles waiting in the storage pool, etc. Secondly, using the analytic hierarchy process to analyze and compare the indicators at different levels. In turn, the factors that influence the decision-making weight of taxi drivers are the most important, and help drivers make reasonable decisions.

B. Analysis of problem two

1. Assume that the terminal of Nanjing Lukou International Airport is not repaired. Either sex
2. The weather is fine and there is no natural disaster such as typhoon. The airport entry and exit conditions are normal.
3. Taxi must wait in line at the designated “parking pool” and queue up to pick up passengers according to “first come, then arrive”.

C. Analysis of problem three

In question three, the starting point of the problem is to improve the efficiency of passengers riding. The potential point of the problem is two parallel lanes. The design point of the problem is to set up reasonable passenger pick-up points, so that the passengers and drivers are safe. The total ride efficiency is the highest.

D. Analysis of problem four

1. Short-haul passengers returning to the airport can use the green channel to preferentially enter the passenger boarding area for long-distance passengers.
2. Set up a vehicle dispatcher in the passenger waiting area to facilitate the diversion of short-distance passengers and long-distance passengers.
3. Install a photo recognition system at the exit of the passenger area.

III. Symbolic description and basic assumptions

A. Symbol Description

Symbol	Meaning
d_0	Taxidriver waiting
d_1	Taxi driver does not wait
T	Taxi driver's work cycle
t_1	spends time on the way home
t	Pick up waiting time
m_1	Driver earns income at the airport
m_2	Driver earns income in the urban area
p_1	Probability of receiving people in urban unit time
p_2	Probability of receiving people in the unit time
a_0	Average passenger flow at an airport during that time of day
s	Income

B. Basic Assumption

1. There were no special human acts such as riots and terrorist attacks.
2. The fuel fee is fixed and there is no sharp increase or decrease.
3. There is no major change in the taxi management system, major modes of transportation, and urban structure.
4. The annual average disposable income growth of urban residents is relatively stable.

IV. Model establishment and solution

A. Question one

Analysis of the problem-model analysis

The hierarchical analysis model of taxi driver selection decision is established, and the decision problem is divided into three levels: that is, the target layer is A, the criterion layer is $B_1B_2B_3B_4B_5$, and the scheme layer is C_1C_2. Let A={maximum taxi driver revenue}; B_1={number of flights arriving per unit time}; B_2={number of vehicles in storage pool}; B_3={other vehicles}; B_4={weather}; B_5={special Time}; C_1={waiter}; C_2={no guest}. Each layer has several elements, and the relationship between the elements of each layer is represented by a connected line, as shown in Figure 1. By comparing the structural judgment matrices with each other, the different influences of different criteria on the target weights are determined, and finally the quantitative results of the decision problems are given.

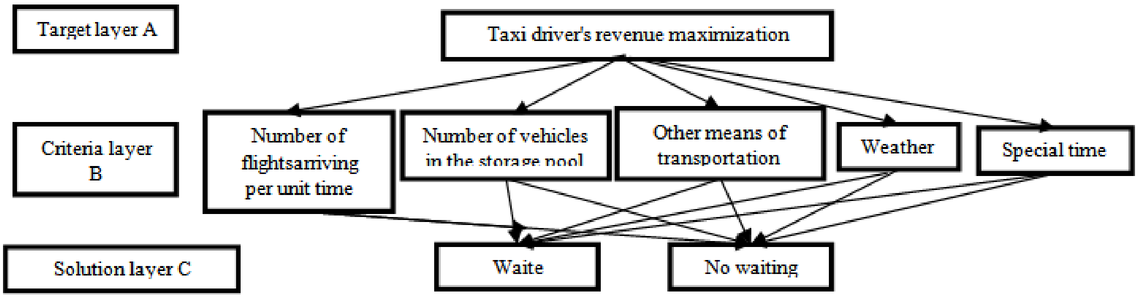

Figure 1 : Taxi driver's revenue maximization

Problem-model solution

Table no 1: ShowsScale meaning.[1]

Scaling	Meaning
1	Expressing the same importance compared to two factors
3	Compared with the two factors, the former is slightly more important than the latter.
5	Compared with the two factors, the former is obviously more important than the latter.
7	Compared with the two factors, the former is more important than the latter.
9	Compared with the two factors, the former is more important than the latter.
2,4,6,8	Indicates the intermediate value of the above adjacent judgment
Reciprocal	If the ratio of the factor i to the importance of the factor j is a_{ij} , then the ratio of the factor j to the importance of the factor i is a_{ij} =1/ a_{ij}

Assume

$$A = \begin{bmatrix} x_1x_1 & x_1x_2 & x_1x_3 & x_1x_4 & x_1x_5 \\ x_2x_1 & x_2x_2 & x_2x_3 & x_2x_4 & x_2x_5 \\ x_3x_1 & x_3x_2 & x_3x_3 & x_3x_4 & x_3x_5 \\ x_4x_1 & x_4x_2 & x_4x_3 & x_4x_4 & x_4x_5 \\ x_5x_1 & x_5x_2 & x_5x_3 & x_5x_4 & x_5x_5 \end{bmatrix}$$

According to B_1={number of arrivals per unit time}; B_2={number of vehicles in storage pool}; B_3={other means of transport}; B_4={weather}; weight of B_5={special time} assumes maximum return of income, ieB_1= {Number of flights arriving per unit time}, B_2={number of vehicles in the storage pool}, B_3={other vehicles} less, B_4={weather} sunny, B_5={special time} Festivals, exhibitions and other major events, Get the following results:

$$A = \begin{bmatrix} 1 & 1 & 3 & 9 & 7 \\ 1 & 1 & 2 & 8 & 7 \\ 1/3 & 1/2 & 1 & 4 & 3 \\ 1/9 & 1/8 & 1/4 & 1 & 1/2 \\ 1/7 & 1/7 & 1/3 & 2 & 1 \end{bmatrix}$$

After running through Matlab, the eigenvalue of A is obtained$\lambda_{max} = 5.041$,
$\omega = (0.392,0.353,0.158,0.037,0.059)^T$~Weight vector,CI $= \frac{5.041-5}{5-1}$=0.01025, the random consistency index RI=1.12 (check table), and CR=CI/RI=0.00915<0.1, then the consistency test is passed.

According to the above-mentioned indicators affecting the driver's decision, it is assumed that the taxi driver decides to wait for the decimal to be referred to as d, d is 0 or 1 is not equal or wait, one cycle of each taxi driver's work is T, the driver is at the airport The income earned by the person is m_1 yuan, the income earned in the urban area is $m_2$yuan, the probability of receiving the person in the urban unit time is p_1, the time on the return road is t_1, and the probability of receiving the person at the airport is p_2, the waiting time for receiving people is t. p_1 and p_2 are determined by the number of people a taking a taxi. Suppose a_0 is the average passenger flow for an airport at that time of day. $P_2$is approximately equal to the number of taxis a / the total number of people arriving at the station a_0.

The idling cost is the energy cost m_e consumed by the returning distance from the urban area. Since there is a certain return when the passenger taxi returns at the airport, the return is higher than the loss, and no emphasis is placed here.

When d=1, the taxi waits at the airport, and the income obtained is $S_1=p_2*m_1+(T-t-t_1)*p_1*m_2$

When p_2 is fixed, the waiting for the passengers cannot be received. The number of vehicles in the storage pool directly determines the waiting time t of waiting for the vehicle, that is, the fewer the vehicles in the storage pool, the shorter the waiting time.

When d=0, the obtained income $S_2=(T-t_1)*p_1*m_2-m_e$, $S=\max(S_1,S_2)$

B. Question two

Analysis of the problem model

Taking Nanjing Lukou International Airport as an example, through data collection, the annual throughput of Nanjing Airport in 2017 is about 25 million/person. In 2018, the annual throughput of Nanjing Airport is 28.58 million/person, ranking the first in Jiangsu Province. One. As of February 2018, the number of taxis in Nanjing was 14,628, with an average of 17.76 per 10,000 people.

According to the annual throughput of Nanjing Lukou International Airport in 2017 and 2018, the annual throughput of Nanjing Lukou International Airport in 2019 is predicted.

According to the number of taxis in Nanjing and the large-scale first-tier cities in China (the proportion of taxis in Beijing Capital International Airport is 37%, Shanghai Pudong Airport is 26%, Shanghai Hongqiao Airport is 27%, and Nanjing Lukou is estimated. The international airport collects and dispatches taxis at a rate of 30%.[2] The probability of picking up passengers from the airport to the airport, as well as the taxis' alternatives such as subways and airport buses, and comprehensive analysis of the relevant factors, the driver is selected to enter The car pool lined up to pull the passengers or go back to the city.

Problem-model solution

1. Set the total simulation time = 10, the maximum queue length = 10000000000 (approximate maximum).
2. According to the negative exponential distribution, each passenger arrives at a time interval, and the arrival time of each passenger = the cumulative sum of time intervals.
3. According to the negative exponential distribution, the passenger service time is generated, and the number of simulated passengers is calculated, that is, the number of passengers at the arrival time in the simulation time.
4. Calculate the first information arriving at the passenger, assuming that one passenger is riding a taxi and one taxi is carrying one passenger, that is, one-to-one correspondence. The first passenger enters the waiting area and accepts the service directly without waiting. The departure time is equal to the sum of the arrival time and the service time.
5. The second person arrives at the waiting area near the storage pool and waits for the waiting time of the first passenger. The third passenger arrives at the waiting area near the storage pool and waits for the waiting time of the first and second passengers, and so on. When the passenger arrives at the waiting area near the storage pool, it is necessary to wait for the waiting time of the n-1th passenger.
6. If the waiting area is full, the i-th customer is rejected and its flag is 0. At the end of the simulation, the total number of customers entering the waiting area is calculated and the output result is as follows.

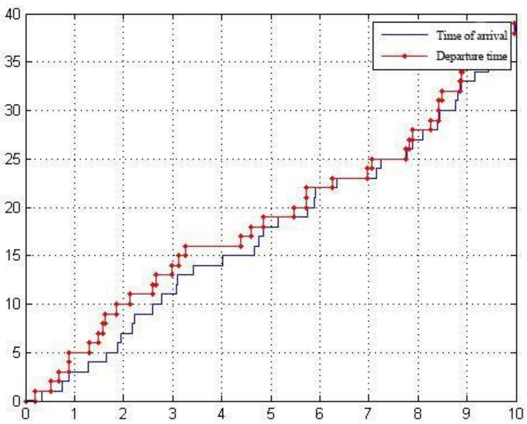

Figure 2 : Passenger arrival time and departure time

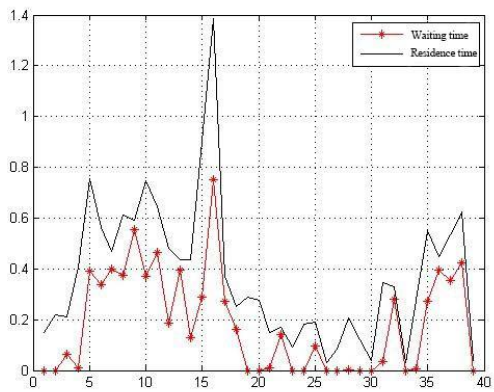

Figure3 : Passenger waiting time and stay time

As shown in Figure 2, the simulation time in 10 minutes is consistent with the increase in passenger arrival time and departure time, which increases with the number of passengers. According to Figure 3, when the number of passengers increases, the waiting time and the waiting time of the passengers in the waiting area are dynamic.

C. Question three

Analysis of the problem model

Suppose a taxi corresponds to a passenger, and a passenger also happens to correspond to a taxi, and the objective function is that the passenger has the shortest walking distance and the highest efficiency. S is assumed to be the distance of the boarding point relative to the exit port, Wq is the average waiting time, mu is the service rate, lambda is the arrival rate, ro=lambda/mu, ros=ro/s.

Problem-model solution

Using the queuing theory algorithm, the average number of people waiting in line is 0.12. The average number of people in the system is 0.87, the average stay time is 17.45 minutes, and the average waiting time is 2.45 minutes.

According to the answer of the previous queuing theory, in the case where the values of mu and lambda are unchanged, the relationship between Wq and S can be obtained as: Wq=(S-3)/(4*S-3), by obtaining the most The way to solve the problem is to get a reasonable boarding point location program.

Using fminbnd to find the minimum value of S in the nonlinear function Wq within a certain range, the result is S_0, and Wq is reversed, at which time Wq is a negative value. Since Wq cannot be a negative value, after the value that does not satisfy the condition is rounded off, the S value with the smallest Wq value is 3, that is, the boarding point is located at 3 m of the queuing port.

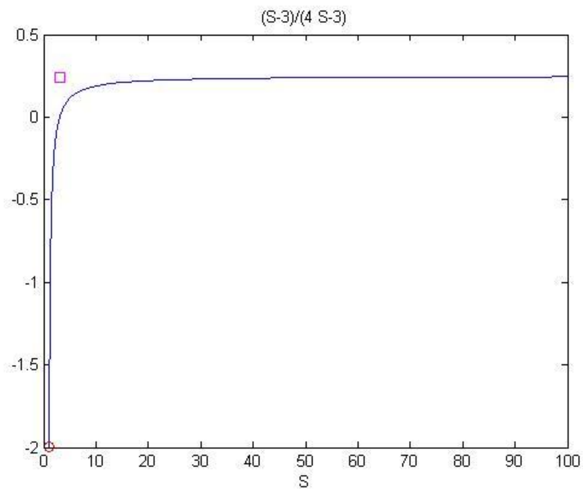

Figure4 : Best boarding point

In order to further verify the correctness of the model, based on the assumptions and the data obtained, the position of the car into the storage pool and the pick-up point was simulated and simulated by computer. Assume that the two side-by-side lanes of the storage tank are 50m long and the length of the vehicle is 5m. The safe distance between the vehicles and the car is 2m. Each road can stop 6 vehicles, and 6 pick-up points can be set. A total of 12 boarding points.

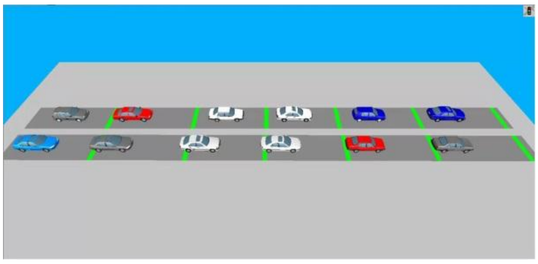

Figure5 :VISSIM-based vehicle simulation (1)

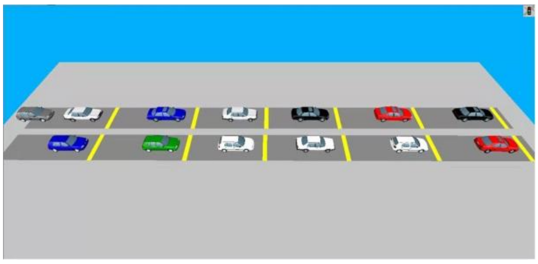

Figure6 :VISSIM-based vehicle simulation (2)

D. Question four

Analysis of the problem model

The so-called "priority" refers to the right of the short-haul passenger taxis to enjoy priority passengers when they enter the airport again. The “priority” here can be understood as a taxi that is returned by a short-haul passenger. The green channel can preferentially enter the passenger boarding area to carry long-distance passengers, and the long-distance and short-distance taxis can be diverted and managed.

Problem-model solution

According to the distance from the passenger to the destination, the airport will provide long-distance and short-distance taxi service, define the passenger destination within a certain range of the airport, and take a taxi to and from the airport within one hour, otherwise it will be a long distance. According to this situation, the vehicle dispatcher can ask the passengers for the travel destination in advance, the dispatcher issues a "short-distance ticket" for the short-distance taxi, sets the camera monitoring system at the passenger's pick-up point, records the short-distance taxi license plate number, the exit time, etc. Information, record the taxi driving data through the GPS system, install another camera monitoring system when the short-distance bus returns to the airport taxi entrance, retrieve the last GPS driving track of the vehicle, exit and arrival time, and determine whether it meets the requirements. Short-distance request, adopt double-bar interception mode, if it meets short-distance, open the green channel, short-distance taxis can not wait in the storage pool to wait in line, directly enter the short-distance queuing area, that is, the slow-loading area to queue; if it does not meet the short-distance requirements, Then, it is judged that the last trip is a long distance, and the long-distance queuing area, that is, the storage pool railing is opened, so that it is queued in the storage pool to wait for passengers.

The airport taxi dispatcher can learn the flight dynamic information and the number and distribution of taxi waiting, so as to facilitate the rapid deployment of taxis. On the one hand, the dispatchers in the slow-load area and the storage pool count the number of waiting taxis by GPS data, and on the other hand, the administrator who receives the passenger-loading area grasps the number of flights to be arrived and the number of passengers, according to past experience. The number of taxis required by passengers is estimated to be the number of taxis. It is estimated that the number of taxis will be transferred, and the slow-loading zone and the storage tank vehicles will be allocated reasonably and efficiently.

Shenzhen taxi starting price, mileage price, return air fee (23:00-6; 00+1 more than 25 kilometers, 30% per kilometer of the above-mentioned mileage price plus return air fee, over 50 km part, per kilometer The return fee is charged at 60% of the above mileage price. The night surcharge is as follows.

Name	Unit
Starting price	Starting price
Mileage price (over 2 km)	2.6 yuan
Return fee	30% or 60%
Night surcharge	30% of the starting price and mileage above

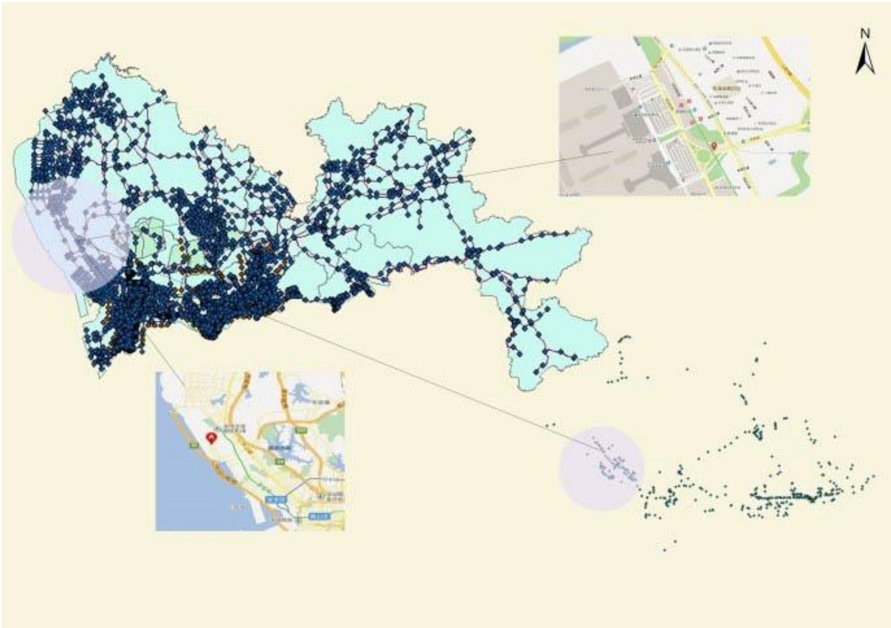

Figure 7 : Shenzhen City, 2014 taxi traffic can view

After normalizing the GPS data of taxis in Shenzhen in 2014, the coordinate information, that is, the latitude and longitude information, is extracted and imported into ArcGIS to perform coordinate display points to obtain GPS point maps. Load the obtained Shenzhen road network and related vector data into ArcGIS, analyze the distribution of road network, find the location of Shenzhen Guoan Airport, and the density of the line near the airport, measure the distance from the airport to the dense center and the larger area of people, as a judgment The basis for passengers to travel long distances. Join the North Arrow, the legend, etc., and make a map of the urban road network in Shenzhen.

By comparing the GPS points with the Shenzhen road network map, you can find the taxi density in a certain operating radius, which is represented by the purple circle radius in the final combination chart. Combine the map and combine the two maps with satellite electronic map to compare the two information more accurately and clearly.

V. Discussion

Further discussion of the first problem model

In question 1, it is based on the number of flights arriving at a certain time, the number of queues in the storage pool, the weather, etc. How to choose the driver, using the analytic hierarchy process to find out which indicators are needed to influence the decision-making, according to the corresponding indicator driver Choose and make sound decisions to maximize the benefits of the taxi driver.

Further discussion of the second problem model

1. The annual throughput forecast of Nanjing Lukou International Airport in 12019=[(2858/2500)-1]*2858+2858≈326.27 million/person.
2. In July, the forecast of the throughput of Nanjing Lukou International Airport in July was =3267.27/12*31≈87,800/person, which was assumed on July 1.There is no major change in the taxi management system, major modes of transportation, and urban structure.
3. According to the July data of Nanjing Lukou International Airport provided by Fei Changzhun and Airsavvi, the actual passenger flow of Lukou Airport on July 1 was 56,199/person.

According to the 2017 and 2018 throughput forecasts, there is a certain error between the airport passenger traffic and the actual passenger traffic on July 1, 2019. There is a certain difference in the number of models selected.

Further discussion of the third problem model

In question three, the taxis queued in the storage pool and the passengers waiting in the waiting area are dispatched. If there is no reasonable dispatch of the vehicle, it is easy for the passenger to choose the taxi nearest to him after leaving the terminal. It may happen that the passenger who has previously exited the station does not get on the bus, and then the passenger who leaves the station first rides the car, and when the passenger runs to the other side, it is prone to safety hazard. Consider the above situation, set the best reasonable boarding point.

Further discussion of the forth problem model

In question four, this kind of priority planning route for short-distance taxis may not be suitable for all airports. Each airport can properly plan green channel routes and use land resources efficiently according to actual construction.

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