INTEGRATE BUS TIMETABLE AND FLIGHT TIMETABLE FOR GREEN TRANSPORTATION – ENHANCE TOURISM TRANSPORTATION FOR OFF-SHORE ISLANDS

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ABSTRACT

Green transportation has gradually become more important in saving energy and carbon. This paper integrates bus and flight timetables to plan and modify the bus timetable and to determine the maximum number of flights that a bus timetable can serve, to allow a more ecological use of transportation. The study focuses on the connections between the bus timetable and the flight timetable, to improve the bus service. The paper considers those constraints that hinder the integration of the bus timetable and the flight timetable; the acceptable waiting time for a bus, the handling time for passengers' luggage and the time between arrival for flight check and flight take-off to construct the framework and parameters for passengers' inbound/outbound schedules. This study employs a bi-level mathematical model to determine the relationship flight arrival time and bus departure time and the flight departure time and the bus arrival time. Passenger waiting time and the bus routes used are established using a questionnaire. The optimal solution for the model shows that the current schedule, whereby 23 scheduled buses serve 148 scheduled flights, must be improved. The optimal bus timetable is better than the current bus timetable, not only in terms of the minimum total connection time, but also in terms of maximum coverage of flights. This paper suggests that the transportation administration of local government only modify the bus timetable to serve more flight passengers' needs. This is an easy way to increase bus serving effects.

Keywords: bus timetable, flight timetable, off-shore island airport, passenger waiting time

INTRODUCTION

Passengers rely on the taxis, tourist buses, or cars to access most off-shore island airports, not because they are unwilling to take a scheduled bus, but because the bus schedule is infrequent and transportation modes shortage. This results in a waste of transportation resources an creates a bad image of public transportation. However, public transportation

saves energy and decreases carbon consumption in the summer tourism season, so the efficiency of bus transportation to be a very important issues for airport access; it influences passenger satisfaction and the consumption of resources. There has been much research which has identified bus scheduled planning, related approaches, such as purchasing vehicles, constructing new transit modes to enhance transit service quality. However, these methods either incur huge expenditures or have some impacts on the environment. Therefore, this paper in the short term, understanding how to make the better planning between an bus's airport timetable existing limited vehicles and passengers' take-off/landing flights timetable to enhance available bus scheduled timetable. Because off-shore islands is short of financial resource and transport environment limits, this paper will be potentially the most effective means of enhancing green public transportation for passenger access convenience of off-shore islands airports. In order to evaluate the performance of bus timetable and determine whether current bus timetable is being utilized effectively, it is necessary to develop a practical model to integrate bus and flight timetables. As a short term solution to these problems, this study proposes a bus timetable that is convenient for passengers, by modifying the present timetable. There is also a literature review, an examination of the relationship between flight arrival time and bus departure schedules and between flight departure time and bus arrival schedules and an analysis of the relationship between the bus timetable and the flight timetable.

The connection between the bus and flight timetables for arrivals and departures at any time should allow a minimum connection time, to save time for passengers and to improve the efficiency of flight and bus transportation. Therefore, this paper proposes integration of the bus and flight timetables, to lessen the connection time for the bus/flight timetable. To ensure maximum efficiency for the public transportation service, this study also aims to maximize the coverage of flights by the bus schedule. The two objectives of minimum connection time for the passenger and a maximum coverage for the bus service are integrated, to aid passengers. The study focuses on the connection between the bus timetable and the flight timetable, to make ecologically sound use of the bus service.

To ensure more ecological use of the transportation, two representative measures are used; the flight embarkation and bus procedure and the acceptable waiting time for a bus, as these influence a passenger's decision to take the bus. This study uses a bi-level programming model to determine the frequency of the bus timetable, to improve efficiency. The upper level of the bi-level model is used to design the optimal bus timetable and the lower level determines the maximum number of flights that a bus timetable can serve in an ecological manner. The coverage of an optimal bus timetable is firstly discussed new strategies are then proposed for planning the bus timetable.

The outline of this paper is as follows: firstly the importance of the airport bus schedule issues is assessed. Section 2 provides a brief overview of measurements and reviews the connection issues for the flight timetable and the bus timetable. This section also develops a measurement strategy for the connection time between the flight timetable and the bus timetable and the important points connecting constraints or factors. In section 3 the upper level of bi-level mathematic framework is constructed, using important variables and

parameters for the bus timetable and the flight timetable, and the acceptable waiting time for passengers is used to determine the maximum number of buses required to serve flights and to construct a lower level measurement model. The bi-level mathematical model minimizes the connection time between the flight timetable and the bus timetable and maximizes the coverage of the flight schedule by buses. Section 4 utilizes an April 2012 flight timetable, bus timetable and a questionnaire concerning the waiting time for bus passengers. This section also compares the optimal bus timetable and the current bus timetable. Section 5 summarizes the results and draws major conclusion.

MEASUREMENT OF PASSENGER WAITING TIME AND THE CONNECTION TIME BETWEEN THE FLIGHT AND BUS TIMETABLE

This study reviews the literature for bus timetable planning and operation for inter-city transportation, including routes allocation and passenger waiting times for buses and a discussion of the flight/bus timetable. In general, flight delays have five sources; passenger processing delays, delays in aircraft ground operations, aircraft technical delays, traffic control and airport delays and weather delays. The sources of delay impact the punctuality of flights. Li proposed a measurement model for delays and found that flight delays are minor complications for off-shore island timetables. Therefore, this study aims to address the frequency of the bus timetable and flight timetable, using the connection time issues for the bus timetable and the flight timetable to established the mathematical model for the bus schedule. A measurement method is created to incorporate the time issues for the bus timetable and the flight timetable to establish a mathematical model for the bus schedule.

The aims of green transportation require two representative objective measurements. One objective is to design the timing of the optimal bus timetable to ensure a minimum connection time between flight and bus timetables. The other objective is maximum the number of flights covered by the bus timetable, to satisfy green transportation objectives. In order to show the sequential decision-making for these two objectives, with the constraints of connection time for bus and flight timetables and passenger processing at the airport, this study proposes a bi-level programming model to determine the frequency of the bus timetable, and to ensure a greener use of transportation. The upper level of bi-level model determines the minimum connection time between flight and bus timetables, Firstly, the coverage of the optimal bus timetable is discussed and new strategies are proposed for planning the bus timetable.

This study examines how the process for passenger embarkation and bus procedures and the acceptable waiting time for a bus, influences a passenger's decision to take the bus. Figure 1 shows that, under normal circumstances, according to airline regulation, passengers who take the bus arrive at the airport 30 minutes before flight departure to check in and complete formalities at the airport, if there are no flight delays or technical delays, so travelers taking a bus or car must arrive at the airport 30 minutes before flight departure. The arriving passengers may be subject to flight delays or technical delays and they may need to negotiate baggage claim and walk from the terminal to the bus station and wait for the bus.

This study was to define the relationship between bus schedules and flight schedules for passengers traveling from/to the airport, as shown in Figure 1. These constraints or factors for the acceptable connection time between the airport bus timetable and the flight timetable include the acceptable waiting time for a bus, the time required for luggage claim and the minimum arrival time for check in before departure flight and these are used to construct an analysis framework and to determine the parameters for the schedule for passengers' inbound/outbound procedures in Taiwan domestic airports.

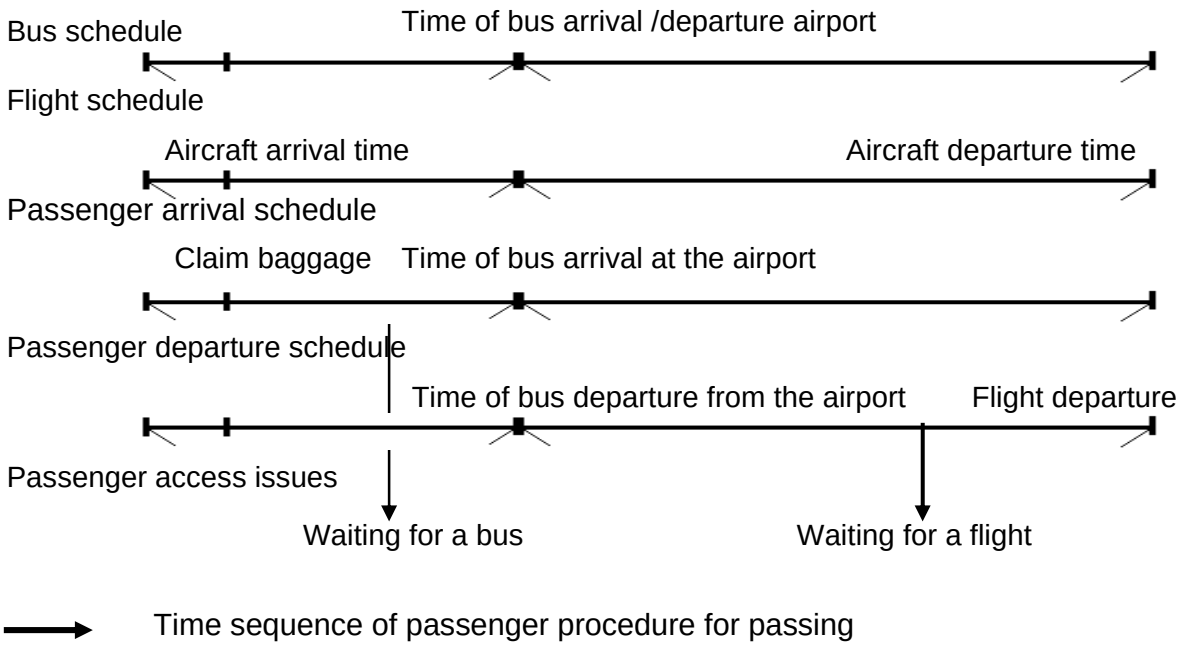

Figure 1 The relationship between bus, flight and passenger schedules

THE PLANNING MODEL FOR THE BUS TIMETABLE

This study constructs a bi-level programming model to modify an existing bus timetable to allow it to serve the maximum number flights under current constraints for bus operation. The notation and description of the parameters and variables is as follows:

Notation and Descriptions

X_{ij} : whether scheduled flight i can be served by scheduled bus j

BT_j : the scheduled time for bus j arrival at the airport

BT_j^0 : the current scheduled time for bus j arrival at the airport

FT_i^a : the current scheduled time for flight i arrival/departure

FT_i^d : the current scheduled time for flight i arrival/departure

$BFTA$: the time for arriving passengers to claim luggage and walk to the airport bus stop and wait for the bus

$BFTA^0$: the time for arrival passengers to claim luggage and walk to the airport bus stop and wait for the bus (at least 15 minutes)

$BFTD$: the time for departing passengers arriving airport check-in counters before departing flights at the airport bus stop 30 minutes before the departure of flight i

$BFTD^0$: the time for departing passengers arriving airport check-in counters before departing flights at the airport bus stop (according to airline regulation at least 30 minutes before flight take-off in domestic airports)

BS :the serving arrival/departure flight numbers of bus serving level

$BSOT$: the bus company's operational capacity to change to the modified schedule from the current schedule time

WT^a : the acceptable waiting time for a bus for arriving passengers

WT^b : the time for departure passengers are willing to take a bus to arrive early at the airport to visit the airport except the airline regulation at least 30 minutes before flight take-off in domestic airports.

Model assumption and Formulation

Firstly, this study defines the bus schedules as not being a constraint and that traffic flows freely and assumes no flight or technical delays. The minimum connection time between the bus timetable and the flight timetable is assumed to be the upper level of the model and the maximum number of flights that the bus timetable can serve is the lower level.

Upper level Mode

This upper level is concerned with total connection time, the bus schedule to serve the maximum number of arrival/departure flights. Function 1, the connection time between bus arrival/departure at the airport and flight take-off/arrival must take account of passengers' departure/arrival procedure at the airport. This paper considers the bus company of penghu county government should improve to the total connection time to minimize and meet the passenger's convenience needs. Therefore, the total connection time for arrival/departure buses and departing/arriving flights must be smaller more better. Function 2 and function 3 indicate whether a passenger for an arrival/departure flight wants to take the bus and consider the constraints of the time for baggage claim and check-in thirty minutes before flight departure. If the buffer time for baggage claim and walking to the bus stop at the airport are not included, the passenger will not catch the bus. For departing passengers taking the bus to airport, the travel time and before flight take-off 30 minute buffer at the airport must be included, to ensure that they can check in and catch the flight. Function 4 indicates the minimum service level for each scheduled bus serving a number of arrivals / departures. Function 5 indicates that every modified bus timetable must not exceed available operation time of bus company capacity and working hours. Function 6 represents the available operation time of bus company capacity and working hours must larger than 0. Function 7 represents each time point of the optimal bus schedule must be larger than 0. Function 8 represents each scheduled bus serving each arrival / departure with integer values of zero or one. Function 9 represents the variables of time point in the optimal bus scheduled with the

integer variables. Function 10 represents the available operation time of bus company capacity and working hours with the integer variables.

$$MIN \quad \sum_{i=1}^{n}\sum_{j=1}^{m} X_{ij} \cdot \left|BT_j - FT_i^a - BFTA\right| + \sum_{i=1}^{n}\sum_{j=1}^{m} X_{ij} \left|BT_j - FT_i^d + BFTD\right| \tag{1}$$

$$S.T. \quad BFTA \geq BFTA^0 \tag{2}$$

$$BFTD \geq BFTD^0 \tag{3}$$

$$\sum_{i=1}^{n}\sum_{j=1}^{m} X_{ij} \geq BS \tag{4}$$

$$X_{ij} \cdot \left|BT_j - BT_j^0\right| \leq BSOT \tag{5}$$

$$BSOT > 0 \tag{6}$$

$$BT_j > 0 \tag{7}$$

$$X_{ij} \in 0-1 \ Integer \tag{8}$$

$$BT_j \in Integer \tag{9}$$

$$BSOT \in Integer \tag{10}$$

Lower level Mode

Function 11 represents the maximum number of flights that the bus timetable can serve, as the objective of a lower level. Function12 represents the acceptable waiting time for a bus at the airport. Function 13 represents an acceptable early arrival time of departing passengers at the airport bus stop and visit the airport. Function 14 represents the time constraints of arrival flight must comply with BFTA parameter minutes and less equal than the bus departure time. Function 15 represents the time constraints of departing flight must be in keeping with BFTD parameter minutes and more equal than the bus arrival time. Function 16 represents each scheduled bus serving each flight arrival / departure with integer values of zero or one.

$$MAX \quad \sum_{i=1}^{n}\sum_{j=1}^{m} X_{ij} \tag{11}$$

$$S.T. \quad X_{ij} \cdot (BT_j - FT_i^a - BFTA) \leq WT^a \tag{12}$$

$$X_{ij} \cdot (BT_j - FT_i^d + BFTD) \leq WT^d \tag{13}$$

$$X_{ij} \cdot BT_j - X_{ij} \cdot (FT_i^a + BFTA) \geq 0 \tag{14}$$

$$X_{ij} \cdot BT_j - X_{ij} \cdot (FT_i^d - BFTD) \leq 0 \tag{15}$$

$$X_{ij} \in 0-1 \ Integer \tag{16}$$

The Composition of the bi-level Model

This study seeks to determine the minimum connection time and to maximize the number of flights served. In order to improve the current bus timetable, this study proposes a bi-level programming model to modify and evaluate the bus timetable.

In general, a bi-level programming problem is defined following functions (17) to (20). $U1)$ is defined as an upper level problem and $L1)$ a lower level problem. The planner at the upper level influences the lower level decision maker by setting x, thus restricting the feasible constraints set for the lower level decision maker. The upper level decision maker also

interacts with the lower level decision maker via the objective function of the lower level planner. The decision variable for the lower level problem is expressed as a function of the decision variable at the upper level ($y(x)$).

$$U1) \quad \min_{x} \quad F(x,y) \tag{17}$$

$$s.t. \quad G(x) \le 0 \tag{18}$$

Where $y(x)$ is implicitly defined by

$$L1) \quad \min_{y} \quad f(x,y) \tag{19}$$

$$s.t. \quad g(x,y) \le 0 \tag{20}$$

THE MODEL APPLICATION

Taiwan Makung airport of off-shore island is more traffic in July 2011 and 2012 with 287,918/303,219 visitors for that month. There are 4,170 flights in July 2012, or approximately 148 flights per day. The peak hours of scheduled flight have three periods such as 8:00-10:00, 13:00-15:00, and 18:00-20:30. Passengers access the airport always using taxis and tour buses, but not public buses. The off-shore island buses are not convenience. There are some tourism routes including the routes of Pengh bus, such as Longmen, Jianshan, Taiwu, Qingluo and Wukan. The Penghu bus routes from the airport stop to the city center are very fast only 15 minutes or 30 minutes routes of good views to see. Many passengers complain of the bus waiting times not bus travel times.

According to 300 copies of passenger questionnaire as Table 1, the maximum acceptable waiting time for a bus is 15 minutes.

Table 1 The waiting time of taking departing bus and departing flight schedule for survey

Waiting bus time of arrival flight passenger (minutes)	Number of passenger	Percent	Waiting flight time of ahead departing flight schedule(minutes)	Number of passenger	Percent
5-10	114	38.00%	35-40	120	40.00%
11-15	129	43.00%	41-45	118	39.33%
16-20	52	17.33%	46-50	57	19.00%
21-	5	1.67%	51-	5	1.67%
Total	300	100.00%	Total	300	100.00%

This study also surveys baggage claim time to nearly about 10-12 minutes at the Makung airport and the passengers walking time from terminal to bus stop only 2-3 minutes. According airline regulation all passengers before departure flight take-off 30 minutes must arrival airport to check in for domestic schedule flights. Therefore, this study take these parameters for and thirty minutes before departure for check-in, as a connection time between the bus and the flight timetable. Therefore, this study uses the $BFTA$ parameter to assign at least 15 minutes for arriving passengers' baggage claim and walking to the airport bus stop and waiting for a bus. $BFTD$ parameter assigns at least 30 minutes for departing

passengers to arrive at the airport and board the departing flight. This study follows above mention function 1 to function 20 and uses Lingo software for calculations. Therefore, this model also designs the passenger's different acceptable waiting times to discuss the impact of timetable acceptable.

THE RESULTS AND DISCUSSION

This section will discuss the outcome performance. The results are shown in Table 2. An optimal bus schedule can improve the current bus schedule and provide a smoother airport transit than the current bus timetable. The numbers of flights served are up to the minimum connection time between flight and bus timetable and the passengers willing to accept waiting time for bus waiting or flight waiting. The smaller the connection time between the bus and the flight timetable, the more convenient transit mode, the more passengers are willing to take the bus. The time point of optimal bus timetable modifies the time point of current bus timetable to be less equal than 35 minutes of the operational capacity time for bus timetable. This model finds the 9:30 and 15:05 two time point of bus arrival/departure time is the same the time-point design of optimal bus timetable.

Table 2 The times for the current and optimal bus timetable

Bus service	Current schedule	Optimal schedule	Modification	Bus service	Current schedule	Optimal schedule	Modification
DRAGO1	07:10	06:35	-35	DRAGO13	12:35	12:33	-2
DRAGN2	07:20	06:45	-35	JIAN14	12:50	13:15	25
JIAN3	07:25	06:50	-35	DRAGO15	14:25	14:30	5
DRAGN4	08:20	07:45	-35	JIAN16	15:05	15:05	0
DRAGO5	08:30	08:25	-5	TAIWU17	16:45	16:20	-25
JIAN6	09:25	09:00	-25	JIAN18	16:50	16:51	1
DRAGN7	09:30	09:30	0	DRAGN19	17:10	17:30	20
TAIWU8	10:30	10:05	-25	DRAGO20	17:35	18:00	25
JIAN9	11:00	10:45	-15	DRAGN21	18:10	18:45	35
DRAGO10	11:10	11:00	-10	JIAN22	18:10	18:30	20
TAIWU11	11:50	11:25	-25	DRAGO23	18:55	19:14	19
JIAN12	12:25	12:10	-15				

The Performance of the Optimal Bus Timetable

Thought, the maximum acceptable waiting time for a bus is 5-20 minutes from the passenger questionnaire, this paper considers design the passenger's different acceptable waiting times not only can show the timetable design question also can discuss the passenger acceptability to bus timetable. Owing This study uses 5, 10,15,20,25 and 30 minutes as 6 scale waiting time, this study finds the small scale of waiting time only one flight one bus serving, if the waiting time exceed some time point of bus schedule, the situation of the one flight one more buses served happen. Therefore, this study use two optimal outcomes to emphasize the model are reasonable acceptability for physical operation, one outcome is one flight one bus served, the other is one flight one more(1-2) buses served. The Table 3 shows the serving flight number of optimal bus timetable is always better than current bus

timetable, no matter in number of arriving flights served, number of departing flights served, and total number of flights served. Table 3 shows that the optimal bus timetable which serves 148 schedule flights more than the current timetable.

This study compares the performance of Table 4 and Table 5 also to show the optimal bus timetable is better than current bus timetable for Total passenger connection bus time, Total flight serving number, and average connection time between bus and flight. With the 300 copies of passenger questionnaire, the passenger acceptable waiting time for a bus of 10-15 minutes, it is seen that some departing passengers will not take the bus if their *BFTD* connection time exceeds 30-45 minutes. Some arriving passengers will not take the bus if their *BFTA* connection time exceeds 15-30 minutes. Meanwhile, the optimal bus timetabled can supply 76-78 flights served and better than 51 flights served of current timetable. Table 4 and Table 5 also show the connection times of smaller scale waiting time are better than the connection times of larger scale waiting time. This means the bus serving quality must be in keeping with passenger waiting time of smaller scale to improving the connection time between bus and flight. If passenger waiting time is very short in ten minutes, we can find the passenger can choose the nearly time-point of bus schedule to arrival/departure airport. If the waiting time over 10 minutes of waiting time, they can take one more buss of the chance. However, passengers don't choose too long waiting of above thirty minutes, they will change another access mode to arrival/ departure airport.

Table 3 The number of flights covered by the current and optimal bus timetable

Bus timetable	Number of arriving flights served						Number of departing flights served						Total number of flights served					
	Passenger waiting time (minutes)						Passenger waiting time (minutes)						Passenger waiting time (minutes)					
	5	10	15	20	25	30	5	10	15	20	25	30	5	10	15	20	25	30
Number of flights covered by current bus timetable	10	18	22	28	34	38	18	21	29	39	42	46	28	39	51	67	76	84
Number of flights covered by optimal bus timetable 1*	21	29	37	40	47	49	26	30	39	44	50	56	47	59	76	84	97	105
Number of flights covered by optimal bus timetable 2*	21	29	37	40	50	57	26	30	41	47	54	70	47	59	78	87	104	127

1*: one flight one bus serving

2*: one flight one more buses served

Table 4 The performance of current bus timetable

Performance	Passenger waiting time (minutes)					
	5	10	15	20	25	30
Total passenger connection bus time	60	170	350	670	895	1135
Total flight serving number	28	39	51	67	76	84
Average connection time between bus and flight	2.14	4.36	6.86	10.00	11.78	13.51

Table 5 The performance of new optimization bus timetable

Performance	One flight one bus serving						One flight one or two bus serving					
	Passenger waiting time (minutes)						Passenger waiting time (minutes)					
	5	10	15	20	25	30	5	10	15	20	25	30
Total connection bus time	58	176	427	579	900	1137	58	176	457	629	1048	1733
Total flight serving number	47	59	76	84	97	105	47	59	78	87	104	127
Average connection time between bus and flight	1.23	2.98	5.62	6.89	9.28	10.83	1.23	2.98	5.86	7.23	10.08	13.65

The improvement current timetable shortage of the Optimal Bus Timetable

The outcome of this model not only can show the coverage rate of flight served, but also can show improving effects. From Table 6-7 show the coverage rate of flight service for current bus timetable and optimal timetable. The serving coverage rate of the current bus timetable is lower than optimal timetable in the peak hours such as 8:00-10:00, 13:00-15:00, and 18:00-20:30. However, this model shows the transport resources require at least an hourly frequency for buses. The optimal bus timetable is not only arranged the total connection smallest, but also each time-point cover biggest coverage rate of flight served. Therefore, the time-point of optimal timetable are higher and easier to serve flight schedule in peak hours. Another scheduled problem point out the issues of no bus assignment to 18:00-20:30 periods. This problem not only modify bus timetable but also increase the number of bus scheduled.

Table 8-9 show improving current service flight number of new optimization bus timetable for different waiting time.The number of arriving flights served is greater than the number of departing flights served. This outcome is convenient to the tourists to first visit the Penghu off-island, also show only change the bus arrival airport timetable can improve the service level shortage, and the bus company don't add driver wage, hours of service and budget. Therefore, this paper suggests that the transportation administration of should modify the bus timetable to improve its service to passengers and make greener use of its resources. Another side, the residents are free to take the bus to airport at off-island, but they don't take the bus, the bus is not convenient. The young persons will take and try, if the bus is convenient, there will attract many young tourists.

Table 6 The service coverage rate of current bus timetable for different waiting time

Time period	Flight scheduled (Frequency)	Passenger waiting time (minutes)					
		5	10	15	20	25	30
07:00-07:59	4	0.00%	25.00%	50.00%	75.00%	75.00%	100.00%
08:00-08:59	15	26.67%	26.67%	33.33%	46.67%	53.33%	53.33%
09:00-09:59	12	41.67%	41.67%	58.33%	58.33%	66.67%	75.00%
10:00-10:59	8	50.00%	75.00%	87.50%	87.50%	87.50%	100.00%
11:00-11:59	9	33.33%	33.33%	66.67%	66.67%	88.89%	100.00%
12:00-12:59	6	33.33%	50.00%	50.00%	100.00%	100.00%	100.00%
13:00-13:59	13	7.69%	15.38%	15.38%	15.38%	23.08%	38.46%
14:00-14:59	10	10.00%	10.00%	20.00%	30.00%	30.00%	30.00%
15:00-15:59	9	33.33%	33.33%	33.33%	33.33%	33.33%	44.44%
16:00-16:59	10	10.00%	20.00%	30.00%	30.00%	70.00%	70.00%
17:00-17:59	9	11.11%	44.44%	55.56%	77.78%	77.78%	88.89%
18:00-18:59	11	18.18%	36.36%	36.36%	63.64%	63.64%	63.64%
19:00-19:59	17	5.88%	5.88%	11.76%	35.29%	35.29%	35.29%
20:00-20:59	13	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
21:00-21:59	2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total	148	18.92%	26.35%	34.46%	45.27%	51.35%	56.76%

Table 7 The service coverage rate of new optimization bus timetable for different waiting time

Time period	Flight scheduled (Frequency)	Passenger waiting time (minutes)					
		5	10	15	20	25	30
07:00-07:59	4	0.00%	0.00%	25.00%	50.00%	75.00%	75.00%
08:00-08:59	15	26.67%	40.00%	53.33%	53.33%	73.33%	80.00%
09:00-09:59	12	50.00%	58.33%	83.33%	100.00%	100.00%	100.00%
10:00-10:59	8	50.00%	62.50%	75.00%	75.00%	87.50%	100.00%
11:00-11:59	9	66.67%	77.78%	88.89%	88.89%	100.00%	100.00%
12:00-12:59	6	50.00%	50.00%	66.67%	66.67%	83.33%	83.33%
13:00-13:59	13	23.08%	23.08%	23.08%	30.77%	30.77%	38.46%
14:00-14:59	10	20.00%	20.00%	50.00%	60.00%	60.00%	80.00%
15:00-15:59	9	33.33%	33.33%	33.33%	33.33%	44.44%	66.67%
16:00-16:59	10	30.00%	30.00%	30.00%	30.00%	60.00%	70.00%
17:00-17:59	9	22.22%	55.56%	66.67%	77.78%	88.89%	88.89%
18:00-18:59	11	36.36%	72.73%	100.00%	100.00%	100.00%	100.00%
19:00-19:59	17	41.18%	41.18%	47.06%	47.06%	52.94%	52.94%
20:00-20:59	13	0.00%	0.00%	0.00%	15.38%	15.38%	15.38%
21:00-21:59	2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total	148	31.76%	39.86%	51.35%	56.76%	65.54%	70.95%

Table 8 The improving flight serving number of new optimization bus timetable for different waiting time (One flight one bus served)

One flight one bus served	Passenger waiting time (minutes)											
	5		10		15		20		25		30	
Bus time point	A	D	A	D	A	D	A	D	A	D	A	D
06:35	0	0	0	0	0	0	0	0	0	0	0	0
06:45	0	0	0	0	0	0	0	0	0	0	0	0
06:50	0	-1	0	-1	0	-2	0	-3	0	-3	0	-3
07:45	-1	0	-2	0	-3	2	-4	2	-4	2	-5	3
08:25	1	0	1	0	2	-2	3	0	4	0	4	-1
09:00	0	1	2	1	2	2	1	2	2	2	2	2
09:30	0	0	1	0	1	0	1	0	2	0	2	0
10:05	1	-1	0	-1	2	-3	2	-3	1	-2	1	-2
10:45	-2	2	-3	2	-3	2	-3	2	-2	2	-2	2
11:00	2	-2	3	-1	3	0	3	-2	3	-2	3	-2
11:25	3	2	3	1	3	1	3	0	1	0	0	0
12:10	0	0	0	0	-1	0	-1	1	-1	1	-1	1
12:33	0	0	0	0	1	0	1	0	1	0	1	1
13:15	0	2	0	1	0	3	0	3	1	2	1	3
14:30	1	0	1	0	1	0	1	0	1	1	0	1
15:05	0	0	0	0	0	0	0	0	0	0	0	0
16:20	2	-1	2	0	1	0	1	0	-1	1	0	1
16:51	0	0	0	0	0	0	0	0	1	0	1	0
17:30	1	2	0	3	1	2	1	0	1	0	2	0
18:00	1	-1	1	-1	1	0	1	0	1	0	1	0
18:30	0	2	1	2	1	2	1	2	1	2	1	2
18:45	2	2	2	2	2	3	1	1	1	2	0	2
19:14	0	1	-1	1	1	0	0	0	0	0	0	0
Total	11	8	11	9	15	10	12	5	13	8	11	10

Table 9 The improving flight serving number of new optimization bus timetable for different waiting time (One flight one more buses served)

One flight one more buses served	Passenger waiting time (minutes)											
	5		10		15		20		25		30	
Bus time point	A	D	A	D	A	D	A	D	A	D	A	D
06:35	0	0	0	0	0	0	0	0	0	0	0	0
06:45	0	0	0	0	0	0	0	0	0	0	0	0
06:50	0	-1	0	-1	0	-2	0	-3	0	-3	0	-3
07:45	-1	0	-2	0	-3	2	-4	2	-4	2	-5	3
08:25	1	0	1	0	2	-2	3	0	4	0	4	-1
09:00	0	1	2	1	2	2	1	2	2	2	2	4
09:30	0	0	1	0	1	0	1	0	2	0	3	0
10:05	1	-1	0	-1	2	-3	2	-3	1	-2	1	-2
10:45	-2	2	-3	2	-3	2	-3	2	-2	3	-2	4
11:00	2	-2	3	-1	3	0	3	-2	3	-2	3	0
11:25	3	2	3	1	3	1	3	0	2	0	2	0
12:10	0	0	0	0	-1	0	-1	1	-1	1	-1	1
12:33	0	0	0	0	1	0	1	0	2	0	2	1
13:15	0	2	0	1	0	3	0	3	1	2	1	3
14:30	1	0	1	0	1	0	1	0	1	1	0	1
15:05	0	0	0	0	0	0	0	0	0	0	0	0
16:20	2	-1	2	0	1	0	1	0	-1	1	0	1
16:51	0	0	0	0	0	0	0	0	1	0	1	0
17:30	1	2	0	3	1	2	1	0	1	0	2	0
18:00	1	-1	1	-1	1	0	1	0	1	0	1	2
18:35	2	2	2	2	2	3	1	1	2	2	1	4
18:45	0	2	1	2	1	4	1	5	1	5	2	6
19:14	0	1	-1	1	1	0	0	0	0	0	2	0
Total	11	8	11	9	15	12	12	8	16	12	19	24

CONCLUSION

The preliminary results and recommendations of this study are summarized as follows:

The optimal model shows that the current 23 scheduled buses serving 148 scheduled flights must be improved. The optimal bus timetable is better than the current bus timetable, in terms of minimizing the total connection time and maximizing the coverage of flights. If the passenger waiting time is less than 15 minutes, the optimal bus timetable serves 76 more schedule flights than the current timetable. The number of arriving flights (37) served is different than the number of departing flights (39) served in 15 minutes of waiting time.

The outcomes also show only change the bus arrival airport timetable can improve the service level shortage, and the bus company don't add driver wage, hours of service and budget. This study also in the upper level find the optimal available operation time of bus company capacity and working hours are 35 minutes. This model can use this figure to check the time point of bus arrival/departure time are suitable or not. This model finds the 9:30 and 15:05 two time point of bus arrival/departure time is the same the time-point design of optimal bus timetable, The smaller the connection time between the bus and the flight timetable, the smaller the number of schedule flights are served, but passengers' waiting need must be satisfied with the smaller connected time to improve the bus service performance. With the constraint of a maximum acceptable waiting time for a bus of 15 minutes, some departing passengers do not take the bus if their connection time exceeds 45 minutes and some arriving passengers do not take the bus if their connection time exceeds 30 minutes.

This paper suggests that the transportation administration of should modify the bus timetable to improve its service to passengers and make greener use of its resources. This is an easy way to increase bus serving effects. This study only focuses on the airport bus stop schedules and the needs of passengers. Services passing Makung airport from Tai Wu, Eagle's Nest, Wu Kan, Lung Mun and Tsing Lo and other bus routes, the demands of community services, the overall capacity of the bus fleet, and staff scheduling were not considered. It is recommended that any future research expand the scope of this study to the management of public transportation.

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