Domestic Flight Timetabling to Increase Connecting Passenger

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ปัจจุบัน ธุรกิจสายการบินมีการแข่งขันที่สูงขึ้นเนื่องจากจำนวนคู่แข่งที่เพิ่มขึ้นอย่างต่อเนื่องในช่วงหลายปีที่ผ่านมา อีกทั้งยังมีการแข่งขันในเรื่องของราคา คุณภาพของการให้บริการ และ ความหลายหลายของเส้นทางบิน ดังนั้น เพื่อพัฒนาศักยภาพทางการแข่งขัน สายการบินจึงต้องการกลยุทธ์และการวางแผนที่เชิงปฏิบัติการที่ดี อันเป็นรากฐานสำหรับการพัฒนาในอนาคต

สายการบินกรณีศึกษาในงานวิจัยนี้ เป็นสายการบินย่อยในประเทศไทย ที่เปิดให้บริการด้วยจุดประสงค์หลักในการเป็นผู้กระจายผู้โดยสารให้แก่สารการบินหลัก ดังนั้น การจัดตารางบินที่เหมาะสมเพื่อรองรับความต้องการของผู้โดยสารจากสายการบินหลักจึงเป็นสิ่งที่จำเป็น ดังนั้น งานวิจัยชิ้นนี้จึงจัดทำขึ้นเพื่อพัฒนาตารางบินภายในประเทศให้สอดคล้องกับกลยุทธ์ในการบริหารงานของสายการบินกรณีศึกษา ในการจัดตรางบินสำหรับงานวิจัยชิ้นนี้ โครงสร้างแบบคลื่น (Wave-system Structure) ได้ถูกนำมาใช้ร่วมกับ การค้นหาแบบฮิวริสติก อันได้แก่ วิธี บรานช์ แอน บาวด์ (Branch-and-Bound) และ อัลกอริธึมแบบละโมบ (Greedy Algorithm) เพื่อช่วยในกระบวนการตัดสินใจ นอกจากนั้น Holt-Winter's Model ยังถูกนำมาใช้ในงานวิจัยนี้ เพื่อช่วยในการพยากรณ์อุปสงค์ของผู้โดยสารต่อเครื่องโดยอิงจากข้อมูลในอดีต

จากผลการวิจัยพบว่า หลังจากที่ปรับเปลี่ยนตารางบินใหม่นั้น สายการบินจะมีผู้โดยสารต่อเครื่องเพิ่มขึ้นถึง 46.67% เมื่อเทียบกับจำนวนผู้โดยสารเฉลี่ยในระยะเวลา 5 ปีที่ผ่านมา อีกทั้งยังเป็นการเพิ่มความหลากหลายในเส้นทางการให้บริการอีกด้วย นอกจากนั้นแล้ว การจัดตารางบินภายในประเทศใหม่นี้ ยังช่วยลดเวลาพักเครื่อง ซึ่งส่งผลให้สายการบินใช้เครื่องบินที่มีอยู่ได้อย่างมีประสิทธิภาพยิ่งขึ้น

ภาควิชา	ศูนย์ระดับภูมิภาคทางวิศวกรรมระบบการผลิต	ลายมือชื่อนิสิต ....
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In the air transportation market, the competition has been increasingly intense throughout the period in term of price, service quality and route variety. In order to create the competitive advantage, the strategy is the core competency that use to build the appropriate operation planning for the future development.

The case studied airline is the subsidiary of the Thai airline, and the objective is to increase connecting passenger from the main airline. Therefore, the appropriate flight timetabling is necessary to effectively and efficiently serve passengers' desires. This project is developed to generate the corresponding flight timetable to the business strategy by using the Wave-System Structure and heuristic approach; Branch-and-Bound, Greedy Algorithm, which help in the decision-making process. Moreover, Holt-Winter's model are also used to forecast market demand base on the historical passenger demand's behaviour.

From the result of project, the new flight timetabling development has increased the connecting passenger by 46.67% and also increase the variety of connecting destination as well. The benefit of the new flight timetabling would positively affect the aircraft utilisation.

Department:	Regional Centre for Manufacturing Systems Engineering	Student's Signature	....
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Finally, I would like to dedicated this thesis to my partner in crime who is always besides me throughout the study. I am truly thanks for the encouragement, guidance, and tremendous support that he gave me in every aspect. Without him, I could not imagine how this accomplishment possible.

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CHAPTER 1: INTRODUCTION

This research is created with an objective to develop the new domestic flight timetable to increase connecting passenger between two airlines. The whole research process took almost a year in total, started from December 2015 and finished in November 2016. For this research, the subsidiary airline in Thailand is used as a case study where airline's background, problems and expectation from the study can be explored in this section.

1.1 Company Background

In the mid of 2012, a primary airline which a flag carrier launched a subsidiary company for low-cost services with an aim to improve the group's profitability. At the beginning, this subsidiary airline used sub-brand model for the operation and help the primary airline to redeploy the capacity by taking over short and medium range flights in both domestic and international market. But after received the securing and air operators' certificate (AOC) from Thai authorities in 2014 (CAPA, 2014), this subsidiary airline became independent with the new strategy of "3S: SMART – SABAI – SMILE" with an aim to be the leader for premium full-service regional airlines and satisfies travelers who is looking for the convenience.

For SMART which is the first S in airline strategy, the subsidiary developed online reservation and check-in system with mobile application to allows more ease of access and booking. The second S is SABAI which means convenience that the airline represents in term of the route variety, seamless connectivity, comfort cabin and other additional services.

Currently, the subsidiary airline uses all new A320 airbus to provide services in 10 domestic and 11 international routes with the dual-based airport at Suvarnabhumi International Airport and Don Muang International Airport. Besides, the subsidiary airline has just added some more fleet in 2015 which make the total aircrafts equal to 20, in order to support the flight operation in new routes and increase flight frequency of the existing routes. Furthermore, the airline has Lounge where foods and beverages service is offered for the passenger including with the in-flight convenience by giving the snack and minimum 30 kg. of baggage loaded with free of charge. Aside from in-flight service, the airways also accommodate the passenger whose destination is on the island in such Samui and Pa Ngun by providing no-charge transfer service as well.

The last S in strategy is SMILE. With the service-excellent of flight attendances and selected menu from many leading restaurants around Bangkok, the passenger will receive smile and memorable flying experience. These are the intention of an organisation that strive to improve customer's satisfaction to become Asia's favourite airline in near future (Anon, 2015).

1.2 Statement of The Problem

1.2.1 High cost of operation

At the early stage of business running, this subsidiary airline put itself in low-cost market segment but full-service is provided in such baggage load, in-flight meal. Besides, the airline uses all new aircrafts with wider cabin spaces compared with the competitor. With this reason, the operation cost of the subsidiary is much higher than the rivals in the same market segment. Since the cost of operation influences to the ticket price, as the result, the airline has to set air fare higher than the competitors accordingly in order to obtain the profitability. This is a very big problem because in low-cost market, price is the major concern but the subsidiary cannot satisfy passenger at this point. Therefore, the company cannot compete with other airlines and lose market share.

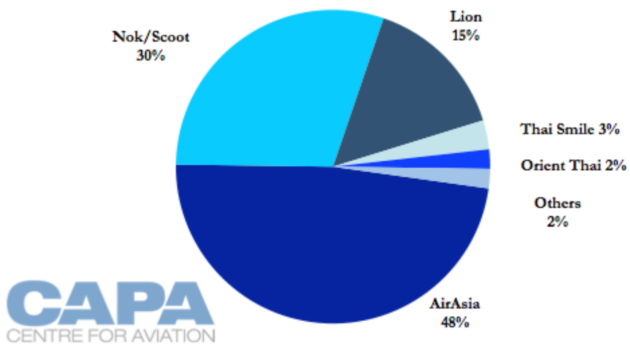


Figure 1: Domestic capacity share (% of seats) by carrier: 20-Jul-2015 to 27-Jul-2015 (CAPA, 2015)

Besides, when the number of passenger is too low to cover fixed operation cost, the company has lost in almost every route in last year. Refer to the airline's financial report in 2015, the average passenger of all flights was quite low at 41% of maximum aircraft capacity as shown in *Table 1*. Therefore, the company is looking for more passenger from other sources in such the partner like the primary airline. Regarding to the decision management team, the airline will collaborate with the primary airline by turning into feeder and help the primary airline distribute passenger in domestic.

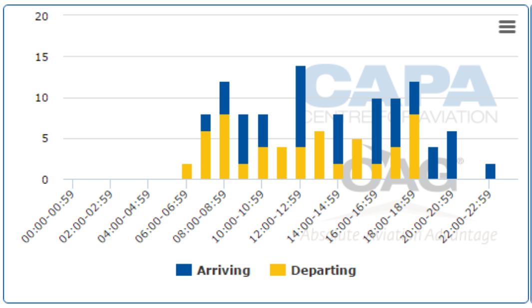
Table 1: Percentage of the subsidiary airline's passenger compared with maximum aircraft capacity in 2015

Route	% passenger/ flight
DMK-CNX-DMK	79.22
CNX-HKT-CNX	4.51
CNX-HKT	13.79
DMK-KKC-DMK	55.44
DMK-HKT-DMK	61.80
BKK-CEI-BKK	69.91
BKK-CNX-BKK	30.46
BKK-KKC-BKK	36.44
BKK-UTH-BKK	73.86
BKK-UBP-BKK	55.40

BKK-HKT-BKK	49.69
BKK-HDY-BKK	78.48
BKK-KBV-BKK	9.16
BKK-URT-BKK	36.97
BKK-NAW-BKK	13.44
BKK-MFM-BKK	23.01
BKK-RGN-BKK	6.21
Average	**41.05**

1.2.2 Lack of connectivity between primary and subsidiary airline

As mentioned earlier, since the subsidiary airline planned to be the feeder for the primary airline in domestic, then flight connectivity between two airlines became the major concern. Regarding to current flight timetable of both subsidiary and primary airline in *Figure 2* and *3*, it is obviously seen that the subsidiary airline mainly operates day-flight while the primary operate flights almost all day. Therefore, the subsidiary airline surely cannot serve the primary airline's passengers in night time and early morning. Besides the proportion of arriving and departing flight of the subsidiary airline is not rather good, compared with passenger flow from the primary. For the example, focus on 10:00 – 10:59 which is the period that has many arriving flights from the primary airline, and plus 1.5 hours of minimum required passenger time at Suvarnabhumi International Airport, the number of departing flights of the subsidiary airline between 11:30 – 12:29 should be frequently operated accordingly, in order to support international passenger from primary airline. But currently, proportion of arriving flight in this period is higher than departing as shown in *Figure 2* and *3*.



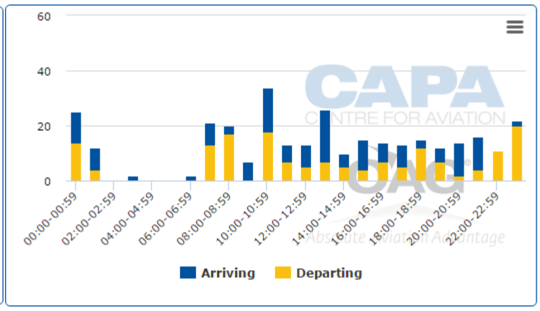


Figure 2 : The subsidiary airline frequency at Suvarnabhumi International Airport (Left)

Figure 3: The primary airline frequency at Suvarnabhumi International Airport (Right)

(CAPA, 2015)

By putting all current flights into bank chart for the connectivity estimation, the result reveals that the level of connectivity between primary and subsidiary airline is very poor due to the large number of overlapped flights in arrival and departure side. Considering at the current arrival flight timetable of the primary airline to Suvarnabhumi airport, there are 115 flights per day in total with 22 domestic flights while the number of departure flight which provided by subsidiary airline is much less than that.

For the departure side from Suvarnabhumi airport, currently, the subsidiary airline operates 2 and 31 flights for international and domestic respectively. Considered at these 33 flights, almost 70% has seamless connection with the primary airline's inbound flights. But from the primary airline's perspective, only 55% of total arriving flights can be connected within the maximum acceptable waiting time which is equal to 3 hours.

Similar to the arrival side, the percentage of connectivity of the primary and subsidiary airline is around 57% and 97% from the primary and subsidiary airline's perspective respectively. Although the connectivity rate looks healthy from the subsidiary side because almost of all flights has opportunity to get the passenger from primary airline, contradictory, passenger would not think so because the passenger comes with primary airline so the primary's perspective reflects the satisfaction of passenger. With this reason, in order to satisfy the passenger from primary airline and gain more connecting passenger, the connectivity rate from primary airline's point of view should be improved.

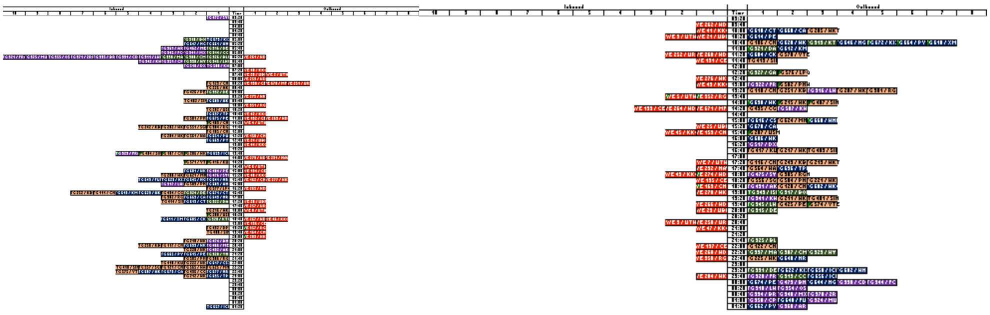


Figure 4: Bank chart of subsidiary airline's flights at Suvarnabhumi Airport (Left is departure, right is arrival)

However, in term of connectivity, not only the number of possible connections is concerned but also market demand. To obtain high level of connectivity, the flight timetable should fulfil customer needs, otherwise, the number of connected flights would be worthless. For the example, according to Star Alliance's research in Q3 of 2015, Phuket International Airport (HKT) is the third popular destination for primary airline's passenger from Hong Kong International Airport and the airline dominated rather high market share in this route at 32% approximately.

Dom Mkt Al	Dom Op Al	Orig	Dest	Passengers	Passengers Share
TG	TG	HKG	BKK	91,987	66%
TG	TG	HKG	HKT	22,673	16%
TG	TG	HKG	ICN	11,081	8%
TG	TG	HKG	ISB	1,690	1%
			OTHER	11,181	8%
			TOTAL	138,612	100%

Figure 5: Primary Airline's Passenger in Hong Kong - Phuket route compared with other routes (Alliance, 2016)

Dom Mkt Al	Dom Op Al	Orig	Dest	Passengers	Passengers Share
TG	TG	HKG	HKT	22,673	32%
KA	KA	HKG	HKT	18,123	26%
FD	FD	HKG	HKT	15,451	22%
UO	UO	HKG	HKT	10,350	15%
CX	CX	HKG	HKT	2,794	4%
			OTHER	1,591	2%
			TOTAL	70,982	100%

Figure 6: Primary Airline's passenger share in Hong Kong - Phuket route compared with competitors (Alliance, 2016)

With this reason, the flight from Suvarnabhumi International Airport (BKK) to Phuket International Airport (HKT) should be placed following to arrival flight from Hong Kong in order to obtain high level of passenger flow. But currently, the subsidiary airline allocated this flight after arrival flight from Dubai (DXB) and Helsinki (HEL) which has not much demand from the primary airline as shown in *Figure 7* and *8*. Therefore, even the subsidiary operates a flight to Phuket International Airport which offers the seamless connection, only few passenger connectivity is gained.

Dom Mkt Al	Dom Op Al	Orig	Dest	Passengers	Passengers Share
EK	EK	DXB	HKT	5,318	84%
TG	TG	DXB	HKT	623	10%
MH	MH	DXB	HKT	157	2%
QR	QR	DXB	HKT	148	2%
			OTHER	59	1%
			TOTAL	6,305	100%

Figure 7: Primary Airline's passenger share in Dubai - Phuket route (Alliance, 2016)

Dom Mkt Al	Dom Op Al	Orig	Dest	Passengers	Passengers Share
AY	AY	HEL	HKT	103	53%
SU	SU	HEL	HKT	43	22%
CX	CX	HEL	HKT	39	20%
MH	MH	HEL	HKT	4	2%
KL	KL	HEL	HKT	3	2%
			OTHER	1	1%
			TOTAL	193	100%

Figure 8: Primary Airline's passenger share in Helsinki - Phuket route (Alliance, 2016)

1.2.3 Low utilisation rate of aircrafts

In the case study airline, one of the major fixed cost of operation comes from aircraft leasing which cost about £240,00 – 280,000 per month. Therefore, the less utilisation refers to the more fixed cost of operation per flight. However, the subsidiary airline did not efficiently use the resource at all as shown in *Table 2*, the average utilisation hour of last year (2015) is about 39% of the maximum capability which is the very small number. Therefore, the fixed operation cost per flight was so high that made the profitability lost. With this reason, the airline need to capture more passenger in order to increase income and compensate with the high fixed operation cost.

Table 2: Number of aircraft and utilisation hour in 2015

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No. of A/C	15	17	17	19	19	20	20	20	20	20	20	20
Utilisa-tion	08:17	08:24	08:38	08:30	09:49	09:59	09:59	10:00	09:59	10:01	10:17	10:17

1.3 Current Process for Flight Planning

Currently, the flight schedule is revised twice a year for both summer and winter season by management team, regarding to company's performance and historical market demand. The rough decision about routes and frequency of flights will be decided and then forward to planning team. Normally, both management and planning team use the flight schedule of the same season in the previous year as a reference and adjusted it following to the new strategy.

Start of the flight scheduling process, the planner considers the requirement from management team as the first priority to developed the new flight schedule, then compare the historical demand with seat capacity. Besides, the market environment also explored and considered for future trend prediction. After that, the flight schedule is adjusted according to analysed result. If the seats capacity is insufficient, the additional flight is required. The distance for that particular flight will be defined with the minimum required travel time which called block hour and allocated to available time slot which provided by the Airports of Thailand public company limited (AOT).

To visualise and evaluate the level of connection between inbound and outbound flights, currently, the planning team uses bank chart as an only method. With this tools, the number of possible connections are identified for each time slot and it is used as a score to assess the efficiency of time slot as well. The current flight will be independently considered and randomly shifted up/down within the limited timeframe to find the highest number of possible connecting airports for each flight.

Lastly, after all flight are allocated and the final schedule is constructed, the subsidiary airline will upload the flight schedule into program called Merlot for fleet rotation and assignment bases on the existing aircraft capacity and standard ground time. As a result, the timetable for each aircraft is generated with an optimal solution in term of utilisation hour.

1.4 Objectives Research Objective

This research aim to increase number of connecting passenger between the primary and subsidiary airline at Suvarnabhumi International Airport for winter period (end of October to mid of March).

1.5 Scope of Study

This research focuses on connectivity between the primary and subsidiary airline only, therefore, all flight at Don Muang International Airport will be ignored because the primary airline does not operate flight at this airport. As the company plan to collaborate with the primary airline, therefore, this project should offer benefit to both sides.

Considered at the primary airline, it mainly operates international flights while the subsidiary does the opposite way; 75% of all flight has the domestic destination. With this reason, the subsidiary airline plans to help primary airline distribute passengers within the country. Thus, only domestic flight will be considered in this study. According to the subsidiary airline's objective to provide seamless connectivity for the international passenger from the primary airline, only the connection within passenger's acceptable waiting time is considered. At the first stage of implementation, the subsidiary airline only concentrates on winter season which is the high-demand period.

However, the improvement of connectivity unavoidably causes the impact on utilisation of aircraft which leads to the cost of operation as explained in section 1.2.2, therefore, the utilisation rate is also included in the consideration. However, since the main objective is to increase connecting passenger, the utilisation is considered as the second priority.

Aside from utilisation, the flight scheduling also effect to resource as well. Regarding to the airline's requirement, the company has no intention to invest more on aircraft. Therefore, the developed flight timetable must not consume more than 5 aircrafts which is the number of current available fleet. However, the investment in other type of resources such as new time slot, additional cabin crew are allowed so these is excluded from consideration in this project.

Lastly, since the main purpose of connecting passenger increment is to add up the total of passenger volume per flight, therefore, the point-to-point demand must be remained. In the other word, the new flight schedule must not cause the negative impact on the existing passenger demand of both primary and subsidiary airline.

1.6 Expected Benefits

From the result of this research, an increased volume of connecting passenger is expected for the subsidiary airline's domestic flights and this would bring about the higher profit accordingly. In additional, the air network would expand due to the more variety of possible connected destination airports which are offered through the new flight timetable. Besides, fleet utilisation should be improved by the additional flight operations.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In order to provide the more understanding about in aviation industry and flight scheduling process, the published papers and journals are reviewed. In the first section, 2.2, hub and spoke (H&S) network is introduced. Then the approach to develop the network is explored accordingly. In section 2.3, wave-system structure that helps to create hub is explained. To develop the hub, information is essential so the approaches to obtained information are discovered. The interview and forecasting methods with error measurement tools are explored and discussed in section 2.4 and 2.5 accordingly. Since the objective of this project is to increase connecting passenger through flight scheduling, therefore, the scheduling model are studied and described in section 2.6. Additionally, the heuristic search; Branch-and-Bound and Greedy algorithm which helpful for scheduling problem are explained in this section as well. Lastly, the approach to measure minimum required resource is explored in section 2.7.

2.2 Hub and Spoke

In recent years, airline network and scheduling are playing a key role in marketing. Hub-and-Spoke (H&S) model which had been developed by Delta Airline is used to configure the air network and maximise the number of destinations under the restriction of the airline’s capacity (Scholz, 2012). The concept of the H&S system is to concentrate traffic at one airport called hub and then distribute to connecting cities which considered as the spokes. Therefore, the passenger can travel between any two airports in system with one stop or in the other word, “from anywhere to everywhere” (Hannson et al., 2002). The characteristic of H&S network in many different aspects are briefly described in comparison with Point-to-Point (P2P) as in following Table.

Table 3: Characteristics of Hub-and-Spoke and Point-to-Point Route systems (Cook and Goodwin, 2008)

Attribute	Hub and Spoke	Point-to-Point
Scope	Optimized by connecting service to wide geographical area and many destinations	Each route serves a single city-pair. Individual routes may be dispersed.
Connectivity	Most passengers connect at hub(s) for a continuing flight(s) to destination	No connections provided (although incidental or "rolling hub" connections are common)
Dependence	Each route highly dependent on other routes for connecting passengers	Routes operate independently, traffic is not affected by demand from other routes
Demand	Varying demand in any given city-pair may be offset by demand from other markets	Only varying frequency and pricing available to counter demand variance
Market Size	Efficiently serves cities of greatly varying size	Requires high density markets with at least one end-point being a high demand origin/destination
Frequency	Supports high daily frequency to all destinations	Generally lower frequency depending on market type and density
Pricing	Frequency and coverage appeal to business travelers providing a margin for higher business fares	Both business and leisure passengers are generally price-seeking
Asset Utilization	Limited by network geography, connection timing, and hub congestion	No network constraints on utilization
Cost of Operation	Hub connections significantly increase cost per available seat mile, somewhat offset by use of larger mainline aircraft	Lowest cost per available seat mile per city-pair
Fleet Requirement	Large range in seating capacity is necessary to match capacity with traffic, usually requires more than one fleet type	Suited to a single fleet type

Regarding to PwC's air traffic demand modelling professionals in London, the airline business model can be classified into three broad categories; low-cost carrier, network carrier, and hybrid as show in *Figure 9*. For the LCCs, P2P network system is used. Furthermore, there is not much variety of destinations offered, but with the ability of low-fare, LCCs extend market and enhance connectivity by providing the service from and to secondary airport which is not previously served instead. Consequently, the H&S network system seems to have no significant advantage to this carrier type. Thus, this model is only applicable for network and hybrid carrier where the flights to wide range of destinations are operated with high frequency.

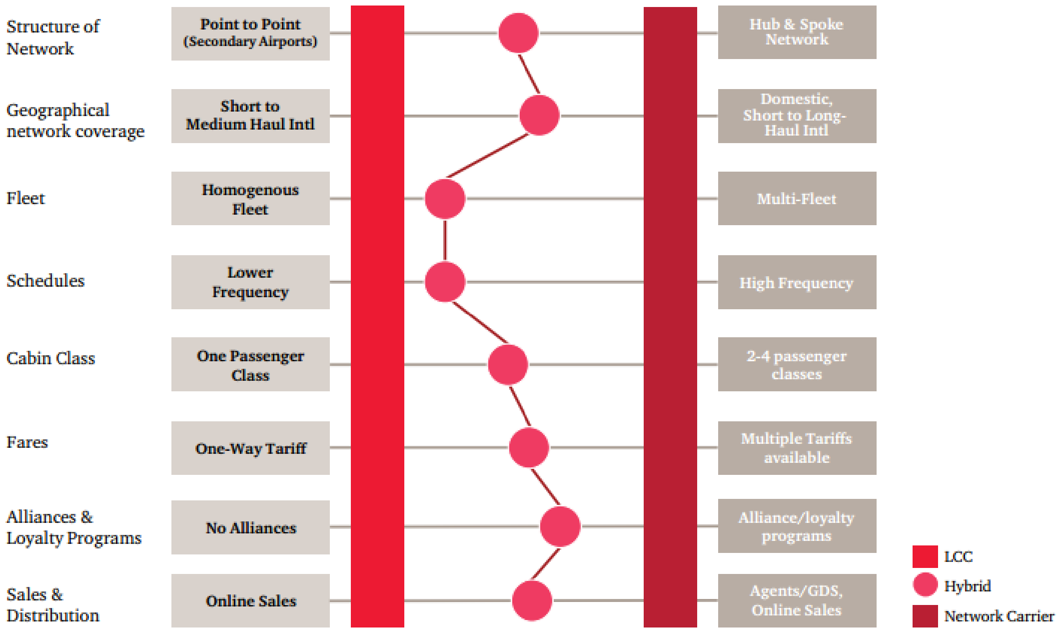


Figure 9: Types of airline business models (Morphet and Bottini, 2013)

For network carriers, since the wide range of destinations is provided, some route has low density so a hub-and-spoke model is used to unite air traffic (Morphet and Bottini, 2013). Delta Airline is a good example for this. The airline provides flight from Charleston, SC to Memphis, TN but the demand in this route is not sufficient. Thus, the airline split this flight and stop at Hartsfield Atlanta International Airport which is the hub for airline's system in order to consolidate the traffic. Apart from this, there was another study by Wei & Hansen about passenger demand in H&S network. The result revealed that by using H&S with higher flight frequency, the number of connecting passenger demand also raise and this is more efficient than the aircraft capacity increment. Besides, this research also confirms about an importance of local service for connecting passenger that the first flight leg services are more attractive to passengers than the second flight segment (Wei and Hansen, 2006).

In additional, H&S network also offers demand advantages through the wider range of indirect destination and higher flight frequency. In single hub network with n spokes, there are $n(n-1)/2$ offered indirect destinations which is much more attractive for passengers than point-to-point where only one destination is offered. Besides, H&S

system provides the most efficient way to connect many points with the lowest required routes (Anon, 2016). For an instance, 8 routes are required in H&S network to link 9 points while 28 routes are required in point-to-point (P2P) system. Therefore, the fewest number of aircraft is required for any given level of frequency and number of destinations (Button, 2002). From airline perspective, this is another way to improve utilisation of asset and expand market into new destinations by using the left aircrafts. With wider coverage area, the airline would obtain more competitive advantage accordingly (Gillen and Morrison, 2005).

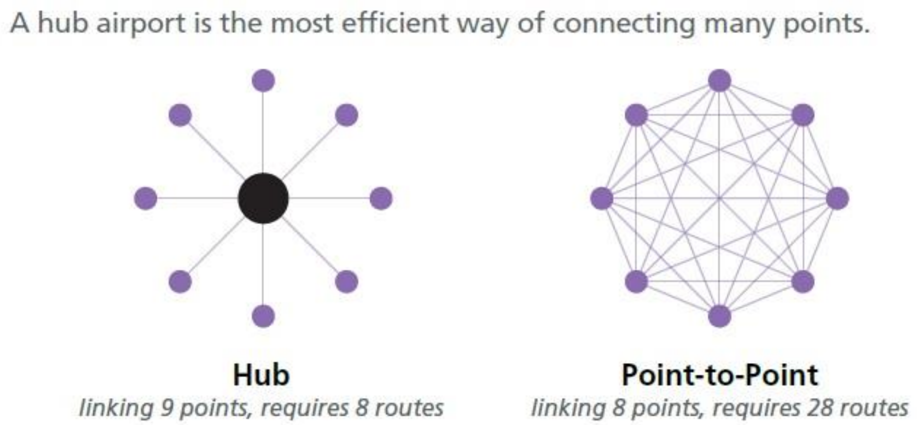


Figure 10: Linkage among all nodes in hub network compare with point-to-point network (Anon, 2016)

Within H&S network, waiting time at the hub is unavoidable and this result in certain passenger demand loss. However, this drawback can be minimised by a wave-system structure in flight schedule. Through this structure adoption, the number of indirection destinations will be increased. Furthermore, the density of traffic is also raised from consolidation as well. Besides, the hub congestion which could bring about entire network delay is another challenge for the airlines (Lederer and Nambimadom, 1998).

2.3 Wave-System Structure

In high competitive market, the airlines operate a hub wave-system in order to maximise the number of connecting opportunities (Bootsma, 1997). In term of quality, service frequency and time are considered because unsynchronised incoming and outgoing flights can bring about passenger lost due to long waiting period. With this reason, wave-system structure is applied to visualise the connectivity and find the optimal frequency of indirect flight which could give the best performance in term of connection including with appropriate time window for each flight (Danesi, 2006) . At first, all incoming and outgoing flights are represented in the chart as shown in *Figure 11* then the parameter for wave-system is constructed with (Bejan and Merkx, 2007);

1. The specific number of flight waves
2. The timing of waves or hub-repeat cycle (Dennis, 1994)
3. The structure of the individual waves

These 3 interrelated elements are represented in the triple *(N, H, S)* where *N* is the number of waves, *H* is hub repeat cycle, and *S* is a dummy variable. For example, S = 0 or 1 when continental fleet stays overnight at the hub or spoke accordingly. (Danesi, 2006)

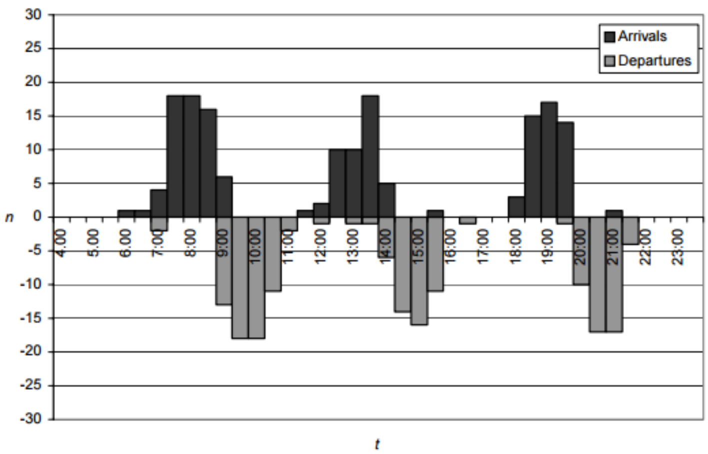


Figure 11: Schedule wave-structure of departure and arrival flights at hub airport (Danesi, 2006)

Ideally, the connection wave for hub should correspond to the time-window in which arrival/departure flights are schedule at the hub and the transfer period for both passenger and baggage. Therefore, two elements which are minimum connect time and trade-off exist between maximum acceptable connecting time for passenger and maximum number of flight in time-period are involved in consideration. By applying the following theoretical definition of ideal wave, the actual wave-system can be efficiently constructed (Burghouwt, 2003).

- ICA-arriving window: $[C - T_i + 0.5T_c\ ,\ C - M_i + 0.5M_c]$
- ICA-departing window: $[C + M_i - 0.5M_c\ , C + T_i - 0.5T_c]$
- EUR-arriving window: $[C - 0.5T_c\ , C - 0.5M_c]$
- EUR-departing window: $[C + 0.5M_c\ , C + 0.5T_c]$

Where T_i is the maximum connecting time involve intercontinental flights

T_c is the maximum connecting time involving European flights

M_i is the minimum connecting time involving intercontinental flights

M_c is the minimum connecting time involving European flights

C is the wave centre

In practical term, competitors' frequency or profitable opportunities to increase utilisation of aircraft must be induced in decision making for flight timetable construction within hub-and-spoke network. Furthermore, in relation to a wave-system structure, complexity costs are associated with the relatively low aircraft utilisation and reduced utilisation of resources (Bootsma, 1997, Franke, 2004). According to many case studies, in term of indirect connections, there are the evidences show that the airline hubs with wave-system structure had better performance than the hubs without a wave-system (Bejan and Merkx, 2007). Iberia, the first Spanish flag-carrier that fly from Europe to South America, adopted hub-and-spoke network to relieved the financially trouble. Therefore, the wave-structure was implemented at Madrid in 1996/1997 and turned this airport into a hub in a strict sense. However, due to the inappropriate flight time, Iberia missed the opportunity for carrying local, high-yield business traffic. Therefore, in July 1999, the airline change morning flight time from 10 to 8.20 am. instead which satisfy passenger. Moreover, the new flight time also synchronise with domestic and international flights to/from Barcelona. As a result, this system created quite a large number of frequencies on Madrid-Barcelona route which has the largest capacity in 2003 (Burghouwt, 2005). Consequently, the airline's competitiveness was significantly improved with regard to the hub connections.

2.4 Interviews in Conducting a Research

Data gathering is one essential element in the research conduction. Data accumulation and collection can be assembled from various sources, which incorporate records, the work environment, the Internet studies, centre gatherings, field notes, polls and taped social communication or interviews (Knox and Burkard, 2009, Polkinghorne, 2005). The interviews are generally utilised as a method of data gathering, in particular organised interviews, semi-organised interviews, unstructured interviews and non-order interviews, and a portion of the moral issues required in leading interviews (Kajornboon, 2005). Data gathering is a key segment to directing exploration and it is an entangled and hard errand (Jol and Bristow, 2003). It is the part of the analyst to make inquiries and the inquiries should inspire substantial reaction from respondents (Richardson and St. Pierre, 2008). The double objectives of rousing the respondent to give full and exact answers while avoiding predispositions coming from social allure, congruity, or different builds of lack of engagement. Interviewers that have been appropriately prepared, and assume the correct part of the interviewers alongside very much composed inquiries can lead a decent interview. It is vital for the scientist to get ready before the real interview. The interview begins before the interview really starts.

2.5 Demand Forecasting & Error Measurements

Forecast is a fundamental of strategic planning and decision making in supply chain management. Since the organisation knows the demand in market, the effective plan can be created to serve the demand with optimal resources and this could help the organisation to obtain high benefit from market accordingly. However, in practical term, there are many factors from both internal and external that influenced to customer's demand and some are uncontrollable or unpredictable. With this reason, error is unavoidable in forecast but it can be reduced by using the proper methods. According to Chopra and Meindl, there are 6 basic steps which could help to improve the efficient of forecasting (Chopra and Meindl, 2007).

1. Identify the objectives and scope time period
2. Systematically collect data
3. Classify products or services by demand characteristic in order to select the proper tools for each segment
4. Identify constrains and effecting factors
5. Choose the most appropriate forecasting methods based on the data and situation
6. Accuracy measurement and continual adjustment.

2.5.1 Forecasting Methods

2.5.1.1 Moving Average (MA)

Due to the difference objectives, concerning time period, and data pattern, many forecasting techniques were developed. Moving Average is a very simple forecasting method where the weight of all data value is assumed as the equal. However, in order to obtain the best fit to the data value N is applied in this method. If the time-series data slowly changes, N value should be small. Contradictory, if there is the fluctuation change in the data, N value should be high. With this method, large amount of data is required for data pattern analysis and proper N value setting. All equations that used for MA forecast are shown below (Chopra and Meindl, 2007).

$$Systematic\ Demand = Level$$

Equation 1: The systematic demand for MA

$$L_t = (D_t + D_{t+1} + \cdots D_{t+n+1})/N$$

Equation 2: The level parameter for MA

$$F_{t+1} = L_t$$
$$F_{t+n} = L_t$$

Equation 3: The forecasted value of MA

Where: F_t is a forecasted value for time period t

L_t is a level value for time period t

2.5.1.2 Exponential Smoothing (ES)

Regarding to the weak point of equal weight, Exponential Smoothing (ES) was developed from MA. For ES, the most recent data is considered with the highest weight and exponentially decreasing for the following data. The smoothing constant called α with value from 0 to 1 is involved in calculation instead of N. With this reason, the number of required value is decreased to 3; (1) current data, (2) previous forecasted data, (3) smoothing constant. Since α value plays a key role in forecast, therefore, the proper configuration is important. There are some recommendations for constant valuation as following (Chopra and Meindl, 2007);

- If $\alpha = 1$, the forecasted value is considered as Naïve Forecast where the forecast in next period is same as currently
- If α value is great, the precedence is given to the most updated data so this is appropriate with fluctuate data set

- If α value is small, the precedence is given to the least updated data so this is appropriate with quite stable data set
- Since α value influences to the accuracy of forecasted result, therefore, in practical term sum square error is used in order to help the analyser pick the most appropriate smoothing constant by using the value which allow the minimum error.

The equations for this method are shown as below (Chopra and Meindl, 2007).

$$Systematic\ Demand = Level$$

Equation 4: The systematic demand for ES

$$L_{t+1} = \alpha(D_{t+1}) + (1-\alpha)L_t\ ;\ \alpha = 0.1$$

Equation 5:The level parameter for ES

$$F_{t+1} = L_t$$

$$F_{t+n} = L_t$$

Equation 6: the forecasted value for ES

Where: F_t is a forecasted value for time period *t*

L_t is a level value for time period *t*

2.5.1.3 Holt's Model

As mentioned earlier, the ES still has drawback due to the defection of data tends. With this reason, Holt extended ES to linear ES where forecasting data with trends is allowed. Thus, the trend is added in systematic demand in *Equation 7*. Two constants, α and β are used in additional where $0 < \alpha, \beta < 1$. The purpose of α is same as ES and constants β is especially involved for trend-adjust smoothing (Chopra and Meindl, 2007).

$$Systematic\ Demand = Level + Trend$$

Equation 7: The systematic demand for Holt's model

$$L_{t+1} = \alpha(D_{t+1}) + (1-\alpha)(L_t + T_t)$$

Equation 8: The level parameter for Holt's model

$$T_{t+1} = \beta(L_{t+1} - L_t) + (1-\beta)T_t$$

Equation 9: The trend parameter for Holt's model

$$F_{t+1} = L_t + T_t$$
$$F_{t+n} = L_t + nT_t$$

Equation 10: The forecasted value for Hotl'ts model

Where: F_t is a forecasted value for time period t

L_t is a level value for time period t

T_t is a trend value for time period t

2.5.1.4 Holt-Winter's Model

Naturally, the demand of any products or services often has seasonal pattern. There is a tendency that demand will repeatedly exhibit the same behaviours in every N periods. Therefore, Holt-Winter's model (HW) was developed regarding to this concern. As both trends and seasonality are considered in this method, the third smoothing constant γ for seasonality is introduced where $0 < \gamma < 1$.

$$Seasonal\ Factor\ (SF) = Actual\ demand\ /Deseasonalise\ Demand$$

Equation 11: The seasonal factor parameter for Holt-Winter's model

$$Systematic\ component\ of\ demand = (Level + Demand) \times SF$$

Equation 12: The systematic demand for Holt-Winter's model

From the above *Equation 11*, deseasonalise demand ($\overline{D_t}$) is used in the calculation. The purpose of this is to eliminate the fluctuation from seasonal changes and smooth data with the following equation.

$$\overline{D_t} = \begin{cases} \left[D_{t-(p/2)} + D_{t+(p/2)} + \sum_{i=t+1-(p/2)}^{t-1+(p/2)} 2D_i \right] \Big/ 2p \ \ for\ p\ even \\ \sum_{i=t-\lfloor p/2 \rfloor}^{t+\lfloor p/2 \rfloor} D_i \ \ for\ p\ odd \end{cases}$$

Equation 13: The deseasonlised demand equation for Holt-Winter's model

Additionally, seasonal index is also used in this method to indicates how much the considered period typically deviates from the average. Since HW model concern about trends and seasonality, this is the most coverage method among all mentioned techniques (Chopra and Meindl, 2007).

The HW model can be classified in to 2 sub types depending on the type of seasonality which are Multiplicative and Additive Seasonal Model. For the properly type classification, the different between multiplicative and additive must be addressed. By considering at the demand in same period of cycle, the type of demand can be identified. For example, during the month of April, the air traffic from Bangkok, Suvarnabhumi International Airport to Phuket International Airport is increased by 10 thousand every year. Thus, this number should be added into the forecasts for every April to account the fluctuation. In this case, the seasonality is additive. But, if the traffic is proportionately increased based on the previous demand, it is multiplicative. Regarding to the different behaviours of data, the time series model (y_t) for multiplicative and additive with related forecast equations were differently formulated as shown in the following section (Kalekar, 2004).

a) Multiplicative Seasonal Model

$$y_t = (\bar{D}_{t-1} + \bar{G}_{t-1})\bar{S}_{t-L}$$

Equation 14: The forecasted demand value of multiplicative seasonal model

$$\bar{D}_t = \alpha(y_t/\bar{S}_{t-L}) + (1-\alpha)(\bar{D}_{t-1} + \bar{G}_{t-1})$$

Equation 15: The estimated deseasonalised level of multiplicative seasonal model

$$\bar{G}_t = \beta(\bar{S}_t + \bar{S}_{t-1}) + (1-\beta)\bar{G}_{t-1}$$

Equation 16: The estimated trend of multiplicative seasonal model

$$\bar{S}_t = \gamma(y_t/\bar{S}_t) + (1+\gamma)\bar{S}_{t-L}$$

Equation 17: The estimated seasonal index of multiplicative seasonal model

b) Additive Seasonal Model

$$y_t = (\bar{D}_{t-1} + \bar{G}_{t-1} + \bar{S}_{t-L})$$

Equation 18: The forecasted demand value of additive seasonal model

$$\bar{D}_t = \alpha(y_t - \bar{S}_{t-L}) + (1-\alpha)(\bar{D}_{t-1} + \bar{G}_{t-1})$$

Equation 19: The estimated deseasonalised level of additive seasonal model

$$\bar{G}_t = \beta(\bar{S}_t + \bar{S}_{t-1}) + (1-\beta)\bar{G}_{t-1}$$

Equation 20: The estimated trend of additive seasonal model

$$\bar{S}_t = \gamma(y_t - \bar{S}_{t-L}) + (1+\gamma)\bar{S}_{t-L}$$

Equation 21: The estimated seasonal index of additive seasonal model

Where: y_t is the forecasted value of time period *t*

$\bar{D}_t$ is the estimated of the deseasonalised level of time period *t*

$\bar{G}_t$ is the estimated of the trend of time period *t*

$\bar{S}_t$ is the estimated of seasonal component (seasonal index) of time period *t*

L is the length of seasonal period

2.5.2 Error measurement techniques

Since the goal of forecast is to find out the most accurate result for further planning or use. Thus, the error must be assessed in order to ensure the correctness of forecasted value. There are many tools and techniques to evaluate the accuracy of forecast, but in this section, only 3 common techniques (Silver et al., 1998) are explained.

2.5.2.1 Mean Absolute Deviation (MAD)

This technique use the average error to assess the accuracy in same unit as the data which helps conceptualise the amount of error and helpful in assessing cost.

$$MAD = \frac{1}{n}\sum_{t=1}^{n}|e_t|$$

Equation 22: Mean absolute deviation

Where e_t is the error value of period *t* and *n* is number of considered time period.

2.5.2.2 Mean Squared Error (MSE)

This technique use the average of sum squared forecast errors to measure the accuracy of calculation.

$$MSE = \frac{\sum e_t^2}{n}$$

Equation 23: Mean squared error

Where e_t is the error value of period *t* and *n* is number of considered time period.

2.5.2.3 Mean Absolute Percentage Error (MAPE)

Differently from the above two methods, MAPE express accuracy in percentage, thus, it can be easier to understand. Regarding to the formula that shown in Equation 24, actual value is involved in calculation which make this technique has more advantage in comparative term than MAD and MSE (Stadtler, 2005). Sine the MAPE is scale sensitive so care needs to be taken when using it with low-volume items.

$$MAPE = \frac{\sum \left| \frac{e_t}{y_t} \right| \times 100}{n}$$

Equation 24: Mean absolute percentage error

Where e_t is the error value of period t

y_t is the actual value of period t

n is number of considered time period.

2.5.3 Case Study

There was a study for Lufthunsa Airline in 2010 where four quantitative forecasting methods are applied. In this paper, moving average (MA), exponential smoothing (ES), Holt's model, and Winter's model are used for passenger traffic forecasting to find out the most efficient method. Generally, both MA and ES are employed in the only level situation like deseasonalised demand. But passenger demand is seasonal, thus forecasting errors from these two method are rather high as show in *Figure 12* and 13, even smoothing constant (alpha) was applied in order to reduce error from ES calculation (Singh and Das, 2010).

Four Period Moving Average Method								
Period(t)	Quarters	Traffic (D)	Level (L)	Forecast (F)	Error (E)	Absolute Error (AE)	Mean Squared Error (MSE)	Mean Absolute Deviation (MAD)
1	2006 Q- 4	13232000						
2	2007 Q- 1	12339000						
3	2007 Q- 2	14629000						
4	2007 Q- 3	15501000	13925250					
5	2007 Q- 4	13977000	14111500	13925250	-51750	51750	2678062500	51750
6	2008 Q- 1	12989000	14274000	14111500	1122500	1122500	6.31342E+11	587125
7	2008 Q- 2	15386000	14463250	14274000	-1112000	1112000	8.33076E+11	762083.3333
8	2008 Q- 3	15218000	14392500	14463250	-754750	754750	7.67219E+11	760250

% Error	MAPE
0.37025113	0.37025113
8.64192779	4.50608946
7.22734954	5.41317615
4.95958733	5.29977895

	Forecasted Traffic	
	F9=F10=F11=F12=14392500	

	Formula used	
	Systematic demand = Level	
	$L_t = (D_t + D_{t-1} + \ldots D_{t-N+1})/N$	
	$F_{t+1} = L_t \quad F_{t+n} = L_t$	

Figure 12: Forecasting through 4-Period Moving Average & Forecasting Errors (Singh and Das, 2010)

Simple Exponential Smoothing Method								
Period(t)	Quarters	Traffic (D)	Level (L)	Forecast (F)	Error (E)	Absolute Error (AE)	Mean Squared Error (MSE)	Mean Average Deviation (MAD)
0			14158875					
1	2006 Q- 4	13232000	14066187.5	14158875	926875	926875	8.59097E+11	926875
2	2007 Q- 1	12339000	13893468.75	14066187.5	1727187.5	1727187.5	1.92114E+12	1327031.25
3	2007 Q- 2	14629000	13967021.88	13893468.75	-735531.25	735531.25	1.46109E+12	1129864.583
4	2007 Q- 3	15501000	14120419.69	13967021.88	-1533978.1	1533978.125	1.68409E+12	1230892.969
5	2007 Q- 4	13977000	14106077.72	14120419.69	143419.688	143419.6875	1.35139E+12	1013398.313
6	2008 Q- 1	12989000	13994369.95	14106077.72	1117077.72	1117077.719	1.33413E+12	1030678.214
7	2008 Q- 2	15386000	14133532.95	13994369.95	-1391630.1	1391630.053	1.42021E+12	1082242.762
8	2008 Q- 3	15218000	14241979.66	14133532.95	-1084467	1084467.048	1.38969E+12	1082520.798

% Error	MAPE
7.00479897	7.00479897
13.9977916	10.5012953
5.02789835	8.67682963
9.89599461	8.98162087
1.02611209	7.39051912
8.60018261	7.5921297
9.04478131	7.79965136
7.12621269	7.71547153

Forecasted Traffic
F9=F10=F11=F12=14241980

Formula used	
Systematic demand = Level	
$F_{t+1}=L_t$	$F_{t+n}=L_t$
$L_{t+1}=alpha(D_{t+1})+(1-alpha)L_t$	
alpha=0.1	

Figure 13: Forecasting through Simple Exponential Smoothing & Forecasting Errors (Singh and Das, 2010)

The other left 2 methods; Holt's and Winter's Model, were developed from ES but in Holt's Model, regression analysis wherein time period was considered. Additionally, all characteristic features of demand data in such level (Lt), trend (Tt), and seasonality (St) are observed in Winter's model to make the output more accurate. Therefore, the forecasting errors from these models were less than first 2 techniques.

Period(t)	Quarters	Traffic (D)	Trend(T)	Level (L)	Forecast (F)	Error (E)	Absolute Error (AE)	Mean Squared Error (MSE)
0			270154.762	12943178.57				
1	2006 Q - 4	13232000	270528.095	13215200	13213333.33	-18666.67	18666.66667	348444444.4
2	2007 Q - 1	12339000	247593.533	13371055.29	13485728.1	1146728.1	1146728.095	6.57667E+11
3	2007 Q - 2	14629000	267800.557	13719683.94	13618648.82	-1010351	1010351.181	7.78714E+11
4	2007 Q - 3	15501000	298070.867	14138836.04	13987484.49	-1513516	1513515.506	1.15672E+12
5	2007 Q - 4	13977000	288872.729	14390916.22	14436906.91	459906.91	459906.9118	9.67677E+11
6	2008 Q - 1	12989000	255056.95	14510710.05	14679788.95	1690788.9	1690788.949	1.28286E+12
7	2008 Q - 2	15386000	267461.61	14827790.3	14765767	-620233	620232.9957	1.15455E+12
8	2008 Q - 3	15218000	269916.571	15107526.72	15095251.91	-122748.1	122748.0864	1.01211E+12

Mean Average Deviation (MAD)	% Error	MAPE
18666.66667	0.141072148	0.141072148
582697.381	9.293525369	4.717298758
725248.6476	6.906495187	5.447030901
922315.3622	9.763986233	6.526269734
829833.6721	3.290455117	5.879106811
973326.2183	13.0170833	7.068769558
922884.3294	4.031151668	6.634824146
822867.299	0.806598018	5.90629588

L8=15107527	T8=269916.6
Forecasted Traffic	
F9	15377443
F10	15647360
F11	15917276
F12	16187193

Formula used	
Systematic demand =	Level + Trend
$F_{t+1}=L_t+T_t$	$F_{t+n}=L_t+nT_t$
alpha =0.1	Beta = 0.2
L_{t+1} = alpha(D_{t+1})+(1-alpha)(L_t+T_t)	
T_{t+1}= beta($L_{t+1}-L_t$)+(1-beta)T_t	

Figure 14: Forecasting through Holt's Model & Forecasting Errors (Singh and Das, 2010)

Table 4: Regression Analysis for Finding out the Deseasonalised Demand (Singh and Das, 2010)

X (Period)	Y (Deseasonalized demand)(D_{dt})
3	14018375
4	14192750
5	14368630
6	14427880
140439.5	13619931
T_0	L_0

Table 5: Calculation of Seasonal Factors of Winter's Model (Singh and Das, 2010)

Period(t)	Quarters	Actual demand (D_t)	Deseasonalized demand (D_{dt})	D_t=L+Tt	Seasonal factors (D_t / D_t)
0					
1	2006 Q- 4	13232000		13760370.5	0.961602015
2	2007 Q- 1	12339000		13900810	0.887646116
3	2007 Q- 2	14629000	14018375	14041249.5	1.041858846
4	2007 Q- 3	15501000	14192750	14181689	1.093029187
5	2007 Q- 4	13977000	14368630	14322128.5	0.97590243
6	2008 Q- 1	12989000	14427880	14462568	0.898111594
7	2008 Q- 2	15386000		14603007.5	1.053618578
8	2008 Q- 3	15218000		14743447	1.032187385

Table 6: Determination of Level, Trend, and Seasonal Factors (Winter's Model) (Singh and Das, 2010)

Period(t)	Quarters	Actual Traffic (D_t)	Deseasonalized demand (D_{dt})	Estimated deseasonalized demand ($\check{D}_t$)	Seasonality S_t	Level(L)	Trend(T)
0						13619931	140439.5
1	2006 Q- 4	13232000		13760370.5	0.968752222	13755292.34	139931.6844
2	2007 Q- 1	12339000		13900810	0.892878855	13891430.02	139552.284
3	2007 Q- 2	14629000	14018375	14041249.5	1.047738712	14027555.72	139209.6254
4	2007 Q- 3	15501000	14192750	14181689	1.062608286	14187811.57	141314.2474
5	2007 Q- 4	13977000	14368630	14322128.5	0.968072702	14334567.79	141858.4444
6	2008 Q- 1	12989000	14427880	14462568	0.892415518	14480348.88	142250.709
7	2008 Q- 2	15386000		14603007.5	1.047252432	14626058.49	142596.5999
8	2008 Q- 3	15218000		14743447	1.065603208	14744278	140158.8902
9					0.968770988		
10					0.892874843		
11					1.047722994		
12					1.062255808		

Forecast(F)	Error(E)	Absolute Error(AE)	Mean Squared Error (MSE)	Mean Average Deviation (MAD)	% Error	MAPE
13330389.5	98389.50148	98389.50148	9680494002	98389.50148	0.743572411	0.743572411
12406751.72	67751.71749	67751.71749	7135394612	83070.60949	0.549085967	0.646329189
14700803.33	71803.33314	71803.33314	6475502625	79314.85071	0.490828718	0.594495699
15053722.24	-447277.7569	447277.7569	54870974917	171305.5772	2.885476788	1.167240971
13871635.54	-105364.4571	105364.4571	46117113697	158117.3532	0.753841719	1.084561121
12918987.41	-70012.58968	70012.58968	39247888533	143433.226	0.539014471	0.993636679
15313552.98	-72447.01855	72447.01855	34390843099	133292.3392	0.470863243	0.91895476
15737526.24	519526.2416	519526.2416	63830427174	181571.577	3.413893032	1.230822044

L8=14407445	T8=3284577

Forecasted traffic	
F9	14419610.62
F10	13415083.6
F11	15888462.17
F12	16257733.32

Formula used
Systematic component of demand =(level+demand)*seasonal factor
$F_{t+1} = (L_t+T_t)S_{t+1}$ $F_{t+l}=(L_t+lT_t)S_{t+l}$
L_{t+1} = alpha (D_{t+1}/S_{t+1})+(1-alpha)(L_t+T_t)
T_{t+1}= Beta $(L_{t+1} - L_t)$ + (1- Beta)T_t
S_{t+p+1}= gamma (D_{t+1}/L_{t+1}) + (1-gamma)S_{t+1}
Alpha = 0.05 beta=0.1 gamma=0.1

Figure 15: Forecasting through Winter's Model & Forecasting Errors (Singh and Das, 2010)

In this paper, the errors were calculated by four methods; Absolute error (AE), Mean squared error (MSE), Mean absolute deviation (MAD), and Mean absolute percentage error (MAPE). From all assessment tools, the result represented that Winter's model is the most effective one among four forecasting methods. Moreover, from the comparative analysis that shown in *Figure 16*, the output from this model also reflected the best manner to historical demand pattern.

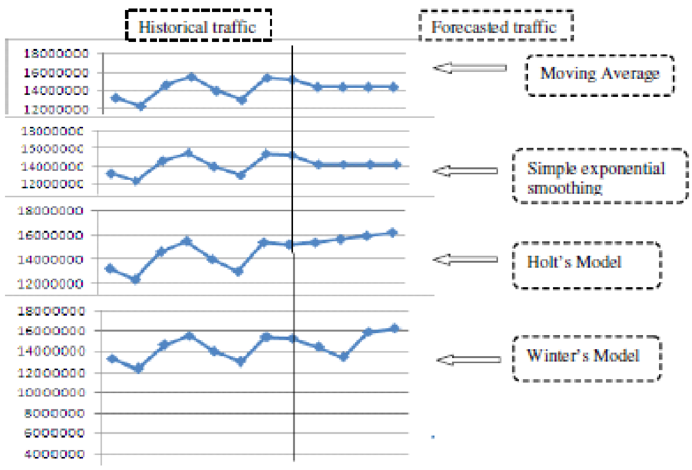


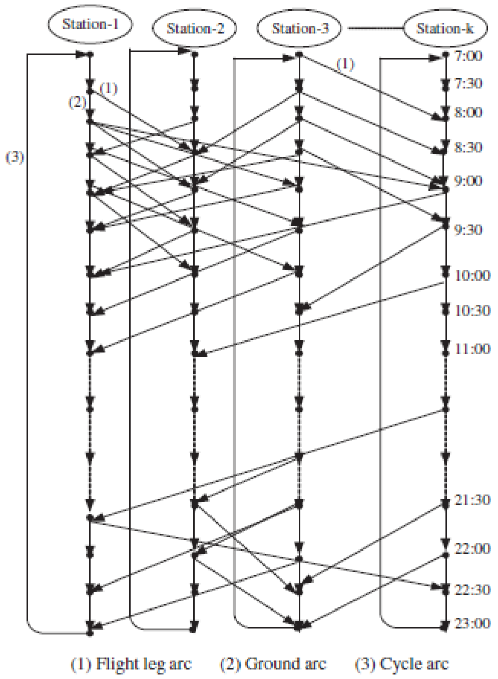
Figure 16: Comparative forecasted traffic from 4 forecasting methods (Singh and Das, 2010)

Regarding to this research, passenger demand for Lufthunsa airline was considered as seasonal and Winter's Model is the best forecasting method because it gave the most accurate result.

2.6 Variable Market Share Flight Scheduling Model (VMSFM)

Few decades ago, Yan and Young developed a set of network models for effective short term flight scheduling problem solving and help to route fleet following the draft timetable under all operation constraints. Their model was studied and improved since then. Yan and Tseng incorporated the two phase into a single framework and developed an integrate scheduling model for multi-fleet routing and flight scheduling with an aim to maximise profit. Unfortunately, this model was developed under fixed constraints, projected market share, and demand which is totally different from real market. Therefore, Yan, et al. (2005) constructed a new model called variable market share flight scheduling model (VMSFSM) with the similar objective to help Taiwan Airline maximise profit (Yan et al., 2005).

According to this study, the major elements of this model were built by using time-space networks, passenger model, and the mathematic formulation. Consider at the time-space network, there are 2 sub-network inside which are fleet-flow time-space network and the passenger-flow time-space network. These two network represent the flow of fleet and passenger by using node and arc as shown in *Figure 17* and *18* respectively.



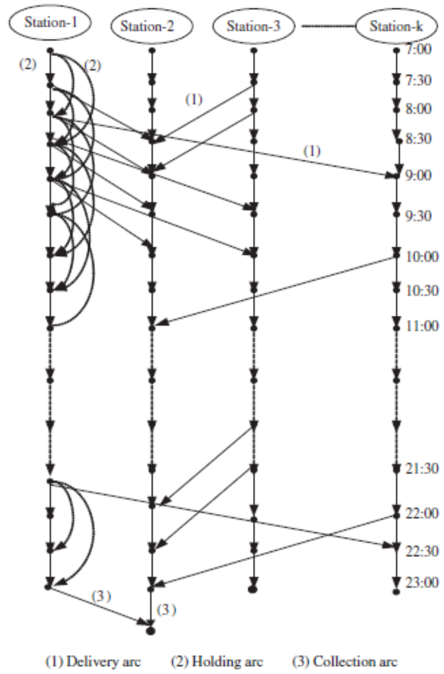


Figure 17: Fleet-flow time-space network (Yan et al., 2005)

Figure 18: Passenger-flow time-space network (Yan et al., 2005)

After the network is created, passenger demand is predicted with passenger choice model by using the probability function (Yan et al., 2005) as shown in *Equation 25 and 26*.

$$v_{ia}^{n} = \alpha_1^n dv_a^n + \alpha_2^n ff_{ia}^n + \alpha_3^n at_a^n + \alpha_4^n wt_{ia}^n + \alpha_5^n tt_{ia}^n$$

Equation 25: The utility value for passenger choice model

$$Prob_a^n(i) = \frac{e^{v_{ia}^n}}{\sum_{d \in D_i^n} e^{v_{ia}^n}}$$

Equation 26: The probability value for passenger choice model

Where:

v_{ia}^n the utility value for passenger arriving at node *i* who will choose airline *a* in the *n*th passenger network.

dv_a^n the dummy variable of airline *a* in *n*th passenger network

ff_{ia}^n the flight frequency for airline *a* at node *i* in the *n*th passenger network

at_a^n the average ticket fare for the target airline *a* in *n*th passenger network

wt_{ia}^n the waiting time for passenger arriving at node *i* who choose the next departing flight of airline *a* in *n*th passenger network

tt_{ia}^n the travel time for passenger arriving at node *i* who choose the next departing flight of airline *a* in *n*th passenger network

α_c^n the *c*th parameter associated with the choice attribute in *n*th passenger network

$Prob_a^n$(i) probability value for passenger arriving at node *i* who choose the airline *a* in the *n*th passenger network

D_i^n Set of the airline that provide flight at node *i* in *n*th passenger network

In this study, four major factors; flight frequency, ticket air fare, waiting time, and travel time are involved in the calculation.

Regarding to time-space network and result from passenger choice model, the functional equations are formulated as shown in *Appendix A* with an aim to simultaneously flow both fleet and passenger in network at the minimum cost. Since the model was formulated as a non-linear mixed integer program, it is more difficult to be solved than integer or mixed integer linear programs. With this reason, a heuristic approach is applied for efficient problem solving. The solution process is outlined as follows:

1. Set the draft timetable and market demand of the airline and its competitors
2. Apply passenger choice model to calculate market share
3. Transfer VMSFSM into fixed market share flight scheduling model (FMSFSC) which is linear mixed integer model and solve it to obtain fleet flows.
4. Calculate passenger flows under fleet flows

These steps were repeatedly processed from step 2 until the better solutions cannot be found. Additionally, in order to evaluate the effectiveness of heuristic algorithm, the lower bound solution also involved in the calculation (Yan et al., 2005).

However, the algorithm was constructed for single-fleet operation. Even it could be extended to multiple fleet, it cannot efficiently solve large-scale problems. Besides, the conditions of any markets are different so the passenger choice model might not applicable, thus, it must be specifically modified following to the target market characteristic.

2.7 Minimum fleet determining

According to Rajotia et al., the deterministic case of the minimum required vehicle determination was studied. A mixed integer programming model was discussed with load handling time, empty travel time, waiting and congestion time consideration. The objective of this model is to minimise empty trips. Regarding to the result from analytic method compare with simulation, an underestimated vehicle fleet size is given (Rajotia et al., 1998). In 2003, Iris, Rene, and Martin also studied about this problem and developed their own integer linear programming model. By considering to work processes and constraints then transformed this information into mathematic functions. Release, due, travel, and arrival time were considered for vehicle planning including with the travel route. Therefore, graph was also applied to help for path choosing. After the model was developed, it had been efficiently solved by heuristic approach. Although the calculated result was underestimated, it was close to the result from simulation under various conditions (Vis et al., 2003).

2.8 Heuristic Approach

This is the basic concept for problem solving and decision making which developed by Israeli psychologists Amos Tversky and Daniel Kahneman (Kahneman et al., 1982). Although the researches in early stage mainly focused on psychological aspect, the thinking process had been continually studied and developed since then until it became the fundamental of many decision-making theories nowadays.

To apply heuristic approach, there is no fixed or standard procedure. In the other word, no exact starting point, processing steps, or conditions is required for this technique and the exact numeric output cannot be identified either.

The travelling salesman problem (TSP) is a classic example to demonstrates the application and advantage of heuristic approach. The problem describes a salesman who must travel to N cities (only one time for each) and come back to the start point with the minimum cost. The best and most expensive solution is to simply try all $(N-1)!$ possibilities, but in this case, only a half is count since each route has an equal route in reverse. Therefore, possible route (R) can be formulated as below equation.

$$R = \frac{(N-1)!}{2}$$

Equation 27: Possible route for TSP

If the number of target cities (N) is 10, there will be possible 181,440 routes and if one more city is added the possible route will be increased to nearly 2 million. This is obviously seen that even the small change can make the problem much more complex and difficult to be resolved because all alternative ways must be checked to find the solution. With this reason, the problem is not possible to be answered within the polynomial time. In the other word, this is categorised as NP-hard problem. Thus, to solve this in the shorter time and lower cost, the heuristic concept is used instead. With this approach, there is no need to check all possibilities but focus only some solutions that better than the reference, so the execution time can be enormously decreased.

Practically, even this approach is very helpful for complex problems in term of cost and time, Facione (2006) warned that heuristic is only shortcut, not fail-safe rules because it frequently refers to a trail-and-error rule or rule of thumb. With this reason, the approach is commonly used in cost-and-time-sensitive industries (Baldauf et al., 2009).

2.8.1 Branch and bound

To optimised the result from heuristic search, many algorithms were developed. Brach-and-bound (BnB) is the one of well-known heuristic search algorithm that widely-used for many problems solving. By using BnB technique, one solution for considered problem is set as an objective. If the better solution can be found during the searching process, the objective will be replaced by that particular solution. The process will be continually done until all possible solution is checked. However, the completed path is no need for BnB then the execution time can be reduced (Hartmann, 1999, Edelkamp and Schrödl, 2012).

To explain how BnB works, the TPS is used as an example. With the given distance between each city as shown in *Table 7*, the first route is set as following;

$$A \longrightarrow B \longrightarrow C \longrightarrow D = 10+15+10 = 35$$

Therefore, if the selected route give more value than 35 since the beginning then it can be ignored which help for time reduction. In this case, all route from A to D is neglected because the distance between A and D is 50 which is higher than objective value.

Table 7: Distance between all city within sample scenario for branch-and-bound

City	A	B	C	D
A	0	10	30	50
B		0	15	20
C			0	10
D				0

However, branch and bound still takes long time in large data set because all alternatives needed to be checked and compared.

2.8.2 Greedy Algorithm

To relieve the weakness from non-optimal guarantee, developed. Greedy Algorithm which is kind of best-first search algorithm was developed. With this approach, the best node always selected so at least there is a guarantee that the output for every single step is the best choice.

To explain how this algorithm works, TSP is once used. In this case N is equal to 4 and distance between each city are shown in *Figure 19*. Let A is the origin, there are 3 possible destination which are B, C, and D. The distance from A to B is the smallest so B is picked as the next node. In following steps, the destination will become the new origin and this repeatedly search until all cities are reached (Edelkamp and Schrödl, 2012).

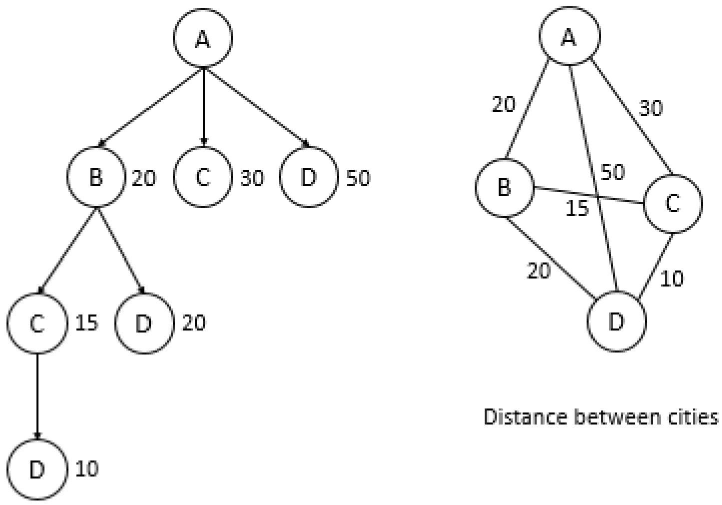


Figure 19: Sample scenario for the travelling salesman problem solving

Due to the flexibility, heuristic is widely adopted in many situations where decision is needed. For aviation industry, this is usually applied to help the management and planning activities such as flight scheduling, resource planning, inventory management, etc.

2.9 Conclusion

According to the literature review, VMSFSM seems to be the appropriate method for flight timetable development but profit is an objective of this model while the aim of this study is to increase number of connecting passenger without profitability concern. Therefore, only the main concept will be applied. The time-space network which is used to visualise passenger flow in this model will be replaced with wave-system structure because this method concern about connectivity between inbound and outbound flight while the passenger time-space network is not. Moreover, the passenger choice model in VMSFSM will not be used because the historical demand is available and this offer more accuracy in forecast than passenger choice model. Lastly, since the fleet assignment and rotation are excluded from the scope of study, fleet-flow network will be replaced with minimum required vehicle measuring model just to ensure the capability of the existing resource.

CHAPTER 3: METHODOLOGY

3.1 Introduction

In this chapter, the methods and approaches that have been used to achieve the objective of research are described throughout to the methodology flowchart that shown in *Figure 20*. The whole process is broken down according to its purpose. Since the author aim to find the most efficient timetable for connecting flight. Therefore, the information which related to flight scheduling in such operation constraints, airline's requirement and concerns, historical demand was obtained and gathered through the proper methods at the beginning. Then the information was analysed and transformed into mathematical equation to formulate the scheduling models. The approaches to developed these models are explained and discussed with the solution-finding procedures. To finalise the most appropriate timetable under airline's requirements and limitations, the result was combined from two timetabling models with the performance analysis for improvement evaluation. After, the result is obtained, feasibility check was done to ensure the capability of airline's resource. The model that used for required aircraft measurement is described in the last section.

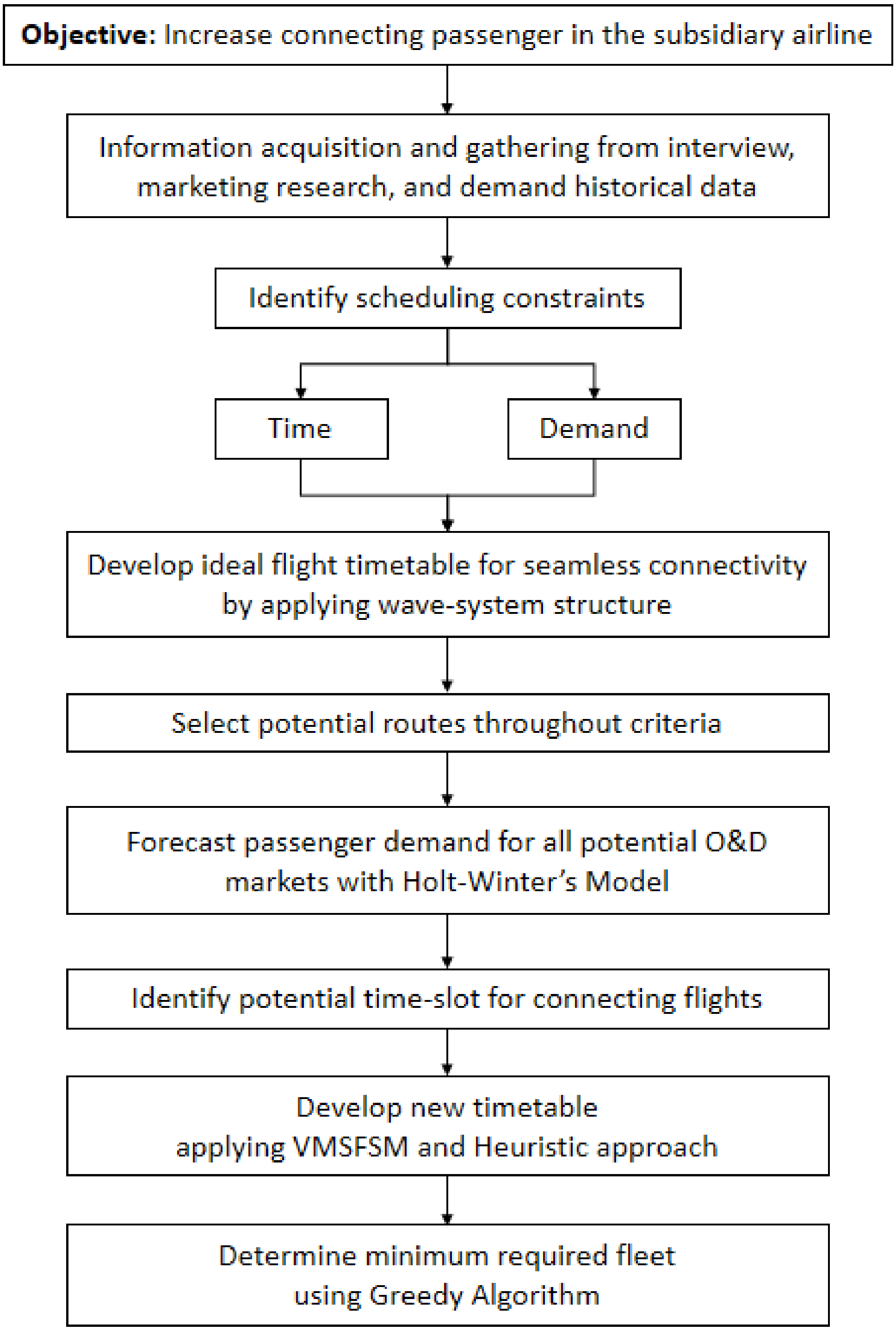


Figure 20: The methodology flowchart

3.2 Background Information Acquisition

At the first stage, the author aimed to obtain more understanding about airline business and flight timetabling process. For the quantitative data, such as historical demand, the data was obtained from company's internal database. While qualitative data was acquired from interview and online research. For general data like market environment, seat capacity, rules and regulations, the data can be found from CAPA and AOT website. But for specific data which used by the airline only, interview was needed.

3.2.1 Interview

An individual interview with flight planning manager was arranged at the company's head office with an aim to acquire more understanding about airline's requirement. From this interview, the subsidiary airline's objective and strategic plan which related to flight planning department were informed. Additionally, flight scheduling process that the company currently using is also explained and discussed to pointed out the scheduling constraints and the factors that must be aware in timetable development. The form that used for this interview is shown in Appendix B.

3.3 Identify scheduling constraints

To develop the new scheduling model, all constraints must be identified base on airline's requirements and operational conditions. These constraints were created by using the information that acquired from interview in previous session. The authors classified scheduling constraints into 2 types as below.

3.3.1 Time Constraints

3.3.1.1 Airline's Perspective

From airline's perspective, when aircraft reaches the destination airport, many activities need to be done by ground staffs in such fuel refill, aircraft checking and maintenance, bagged loading. Therefore, the aircraft must wait at the gate before continue the next flight. With this reason, the earliest departure time of the next flight which operated by the same aircraft must greater or equal to the arrival time of previous flight including with ground time. However, the longer idle time at the airport refers to the lower utilisation hours. Therefore, the aircraft must not stop at province airport too long. In order to ensure the utilisation of aircraft, the maximum idle time was specified by the airline's expert and this will be used to find the appropriate gap time between two consequent flights which are operated by the same aircraft. As a result, 2 time constraints were formulated as below.

Time Constraint 1:

$$Departure\ Time \geq Arrival\ Time + Standard\ Aircraft\ Groundtime$$

Equation 28: Connecting flight departure time constraint

Time Constraint 2:

$$|at_i - dt_j| \leq Maximum\ Acceptable\ Waiting\ Time\ for\ Aircraft, \qquad j = i + 1$$

Equation 29: Constraint for gap time between roundtrip flight

Where at_i and dt_i is the arrival and departure time of *i*th flight respectively.

*Note: Time constraint 2 only applicable for province airports

In marketing and financial viewpoint, the new flight time must offer benefits to both primary and subsidiary airlines. Therefore, any activities that could cause negative impact on business should be aware and avoided. With this reason, the minimum gap time between each flight in same O&D market must be set to prevent customer scrambling between the primary and subsidiary airline. Consequently, the third constrains was defined as following.

Time Constraint 3:

$$ft_{is} \notin PT_i$$

$$PT_i = \{t |\, ft_{ip} - Minimum\ Gap\ Time\ < t <\ ft_{ip} + Minimum\ Gap\ Time\}$$

Equation 30: Time constraint for new added flight

Where ft_{is} is the departure time of subsidiary's flight at the *i*th airport

ft_{ip} is the arrival time of primary's flight at the *i*th airport

PT_i is a set of primary airline's reserved time

3.3.1.2 Passenger's Perspective

Focus on passenger side, due to the transit procedures by going through passport checking at immigration office and travel time between arrival and departure terminal, the passenger need to take some times within the airport before continue the next flight. In every commercial airport, the minimum connecting time (MCT) which required for transit passenger is differently set according to in advance agreement between airline and airport authority. Consequently, the flight time must be allocated base on this constraint.

Time Constraint 4:

$$Arrival\ Time + MCT\ \leq Departure\ Time\ of\ Connecting\ Flight$$

Equation 31: Passenger connecting time constraint

Generally, no one need to waste time at the airport but prefers to reach the destination with the shortest time. Therefore, the maximum acceptable waiting time is defined to limit the gap between arrival flight and connecting flight. In order to sustain the connectivity performance, departure time of connecting flight must be scheduled following *Equation 32*.

Time Constraint 5:

$$Departure\ Time\ of\ Connecting\ Flight \leq Arriaval\ Time + Maximum\ Acceptable\ Waiting\ Time$$

Equation 32: Maximum acceptable waiting time constraint

3.3.2 Demand Constraints

Aside from proper flight time, the sufficient passenger demand is also essential because this influences the airline's profit. To ensure the efficiency of provided flights, the number of minimum required passenger per routes and roundtrip flights must be determined. Then the non-potential flights that have high risk of failure can be avoided. Therefore, 2 constraints of demand were set as following.

Demand Constraint 1:

$$Demand\ per\ Route\ \geq Minimum\ Required\ Passengers\ per\ Route$$

Equation 33: Constraint for passenger demand per route

Demand Constraint 2:

$$Demand\ per\ Roundtrip\ Flight \geq Minimum\ Required\ Passengers\ per\ Roundtrip\ Flight$$

Equation 34: Constraint for passenger demand per flight

3.4 Potential connecting route and flight time selection

3.4.1 Develop ideal flight timetable

To make the flight timetable visualise and easy to assess, draft timetable is needed. Generally, at this step, fleet-flow and passenger-flow are constructed base on the current flight timetable in order to match the market demand with airline's resource. But due to the major focus of this research on connectivity, wave-structure is more appropriate because it offers the relative picture between inbound and outbound flow at the hub airport. In additional, the ideal flight time for high level of connectivity can be identified through this method. Therefore, the author used wave-system structure to create a draft timetable instead of time-space network.

In additional, by using this method, the ideal flight timetable for perfect connection can be defined as well. To make the ideal timetable more efficient and particle, all time constraints in section 3.2.1 is involved in construction. Normally, the ideal time of second-flight will be assigned into one best time-slot only, but in this research, since departure time of connecting flight can be any within the acceptable range thus the ideal time was allocated into the range of suitable time-slot accordingly.

3.4.2 Passenger Demand Forecast

According to VMSFSM, after the drafted timetable had been created, demand value was assigned to each arc in passenger flow for fleet size measuring and income prediction. This value generally obtained from passenger choice model where the competitor's information is strongly needed. By using the same concept, passenger demand is assigned to each time-slot in wave-system structure as well but the demand in this research come from Holt-Winter model instead. The author used historical data from 2011-2015 in Star Alliance's database to forecast demand in each potential O&D market for target period. Excel template that shown in *Appendix C* was created to help for calculation.

However, the aim of passenger demand forecast in this study is not wholly similar to VMSFSM because profit is not considered. The main purpose of demand forecast in this case is to evaluate the efficiency each time-slot since sometimes the high number of connections does not always refer to the high demand if the offered connection cannot satisfy passenger.

Currently, the primary airline provide service at over 62 airports in worldwide and the subsidiary operates domestic flight at 12 airports. Therefore, more than 700 O&D markets need to be explored. With the wide range of consideration, the analytic process takes long time. Thus, the scope of target market must be narrowed down in order to eliminate unnecessary work and save time. Consequently, non-potential O&D market were filtered out before forecast by using constraint about demand (*Equation 33*) that formulated in section 3.3.2.

Due to the data transition in 2014 and critical environmental change in some markets, there will be some abnormality among collected data which could lead to the inaccuracy forecast result. Therefore, the prerequisite task is strongly needed for the outliers elimination. For any abnormal data record, the value will be case-by-case explored in detail.
By using Holt-Winter's model instead of passenger choice model, the accuracy of result can be quantitatively evaluated with 4 forecast error measurement tools which explained in section 2.5.1.

3.5 Determine the potential flight time

In this research, the new time table is developed with 2 main methods regarding to airline's requirement. First is new fight adding and the second is flight time adjustment. The detail of both methods can be explored below.

3.5.1 By flight adding

Even though all ideal time-slot had already identified in section 3.4.1, in practical term, airline is not possible to operate all ideal flight due to the limitation of resource and profitability concern from financial aspect. Therefore, 2 roundtrip flights which offer the greatest connectivity performance regarding to company's objective was select in this step.

To find the most efficient flight time, forecasted connecting demand in all possible O&D market was summed up and assigned to each time-slot. The total demand was used as a score for time-slot ranking. Apart from demand, number of offered connections was used as the second criteria in case that more than one time-slot have equal demand. With these two criteria, the ranking lists of potential time were created for outbound and inbound flights. Then, the most efficient time-slot was selected under all scheduling constraints that previously identified in section 3.3. However, there is an exception for the second constraints. If the added flight is in very late night, this constraint is omitted because the long idle time is still better than overnight parking without any use.

To summarise, the model is formulated as following:

$$D_{it} \geq Minimum\ required\ demand\ per\ route, \qquad \forall t \in DT_i$$

$$\sum_{i=1}^{n} D_{it} \geq Minimum\ required\ demand\ per\ flight$$

$$ft_{is} \notin PT, \qquad PT_i = \{t \mid ft_{ip} - 30\ mins < t < ft_{ip} + 30\ mins\}$$

$$|at_i - ft_{is}| \leq 1\ hour, \qquad \forall at_i \in AT_i$$

Equation 35: Flight timetabling model for additional flight

The explanation of all used notations and symbols are shown below.

DT_i	set of potential time-slot for departure flights at *i*th node airport
AT_i	set of potential time-slot for arrival flights at *i*th node airport
PT_i	set of primary airline's reserved time at *i*th node airport
D_{it}	Forecasted connecting demand at *i*th node airport for time-slot *t*
$\overline{D}$	Averaged total connecting demand in past 5 years
MC	Maximum aircraft capacity
ft_{ip}	Departure time of primary airline's flight at *i*th node airport
ft_{is}	Departure time of subsidiary airline's flight at *i*th node airport
at_i	Arrival time of the nearest previous flight at *i*th node airport

To solve this model problem, the solution process is outline as follows:

Step 1: Create a set of potential time slot, DT_i

Step 2: Pick any time-slot in set DT_i to be the departure time of the new first flight in roundtrip

Step 3: Calculate possible arrival time at_i for all departure time ft_{is}, in set DT_i

Step 4: Solve the problem in developed model to find the best time slot in term of demand, number of possible connections, and utilisation of aircrafts

Step 5: Update the objective value with result in Step 4

Step 6: If the number of iteration in which better solution cannot be found exceed number of time-slot in set DT_i then stop. Otherwise, return to step 2. The best solution obtained during process becomes the final solution

Step 7: Repeat all step 1 to 6 again but focus on second departure flight of roundtrip instead in order to find the best departure time

Step 8: Compare result from both ways and select the best final solutions.

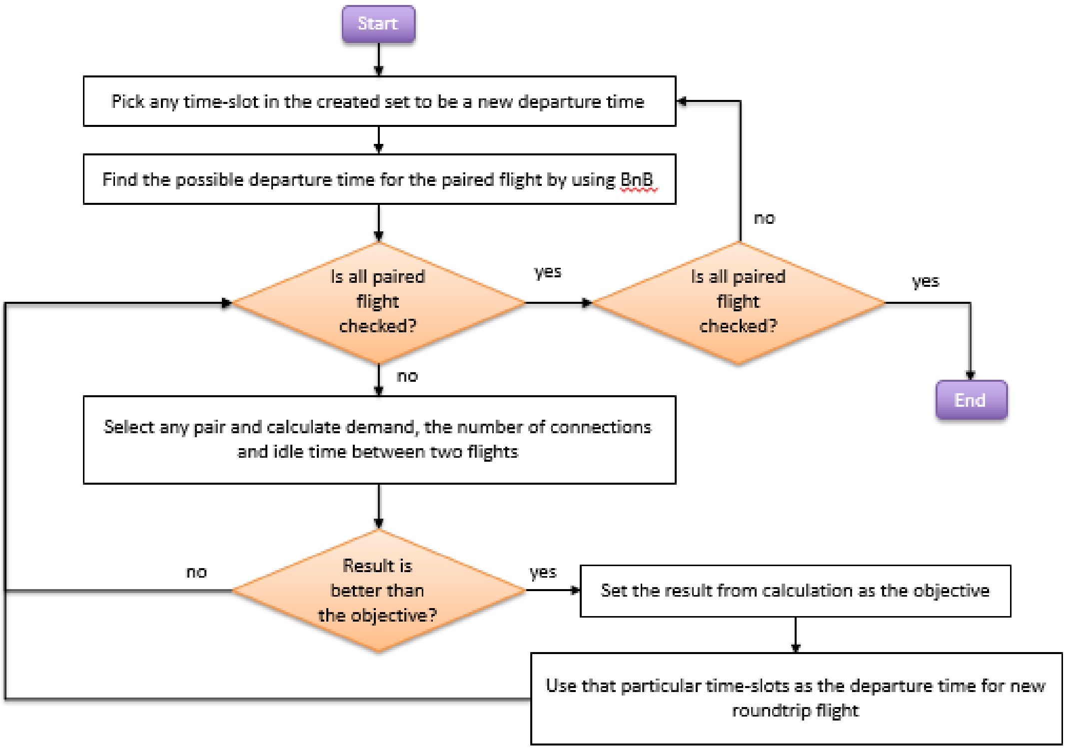


Figure 21: New added flight time determination flowchart

3.5.2 By flights time adjustment

Apart from add-on flights, flight time adjustment could also help to increase connecting passenger. However, the new flight time might cause negative impacts on point-to-point demand and fleet utilisation. According to the mentioned problem in Introduction, one of the reason that the subsidiary airline want to turn itself into feeder is an insufficient demand in point-to-point market, so the airline aim to add the demand up by satisfying connecting passenger. Thus, if the point-to-point passenger lose due to flight adjustment, the increment of connecting traffic might be useless because the total demand per flight is not actually increased but just replaced by another target group of passenger. With this reason, the changes on flight time must be aware so the maximum acceptable change that will not cause significantly impact on point-to-point demand was identified to scope the range of proper flight time. Consequently, the criteria for time-slot selection is formulated as below.

Condition 1:

$$t_c - maximum\ acceptable\ change\ \le t_n$$
$$t_n \le t_c + maximum\ acceptable\ change$$
$$\forall t \in T$$

Equation 36: Flight timetabling model for adjusted flight

Where: T is a set of all available time-slot
t_c is the current flight time
t_n is the new flight time

To find the best flight time within acceptable change time-period, the current flight time was continually shifted by 5 minutes which is the length of each time-slot. If the result from adjustment is better than currently, it will be marked for futher consideration. Otherwise, that time-slot will be ignored.

In this reseach, the efficiency of flight time has been evaluated by 2 criteria. Sorted by the given priority from expert, demand is the first one. The flight time will be shifted only if forecasted connecting passenger would be increased or remained in the worst case.

Condition 2:

$$\sum_{i=1}^{n} D_{it}^{n} \ge \sum_{i=1}^{n} D_{it}^{c}$$

Equation 37: Ensure the connecting demand

Where: D_{it}^{n} is the new connecting demand at *i*th airport, time-slot *t*
D_{it}^{c} is the current connecting demand at *i*th airport, time-slot *t*

Second is competitor's flight frequency. According to the advice from experts, flight frequency within 15 minutes earlier and later could influence passenger demand. Therefore, the author only considered competitive flights within this period. After the adjustment, total flights frequency from competitor and primary airline must not higher than the existing because it is possibly lead to passenger-share drop.

Condition 3:

$$CFF_n \leq NFF_n$$

Equation 38: Ensure the competitors' flight frequency

Where: CFF_{it} is a set of current flight frequency at *i*th airport, time-slot *t*

NFF_{it} is a set of new flight frequency *i*th airport, time-slot *t*

According to all metioned conditions above, the flight timetabling model by flight time adjustment was implemented as following;

$$ft_{io} - \max acceptable\ change \leq ft_{in} \leq ft_{io} + \max acceptable\ change$$

$$\forall ft_{in}, ft_{on} \in DT_i, AT_i$$

$$\sum_{i=1}^{n} D_{it}^{n} \geq \sum_{i=1}^{n} D_{it}^{c}$$

$$CFF_n \leq NFF_n$$

Equation 39: Flight timetabling model for adjusted flight

The explanation of all used notations and symbols are shown below.

DT_i set of current departure flights time at *i*th node airport

AT_i set of current arrival flights time at *i*th node airport

D_{it}^{n} is the new connecting demand at *i*th airport, time-slot *t*

D_{it}^{c} is the current connecting demand at *i*th airport, time-slot *t*

CFF_{it} is a set of current flight frequency at *i*th airport, time-slot *t*

NFF_{it} is a set of new flight frequency *i*th airport, time-slot *t*

ft_{io} old departure or arrival flight time at *i*th node airport

ft_{in} new departure or arrival flight time at *i*th node airport

To determine the new flight time, the process is shown in *Figure 22* with briefly explaination.

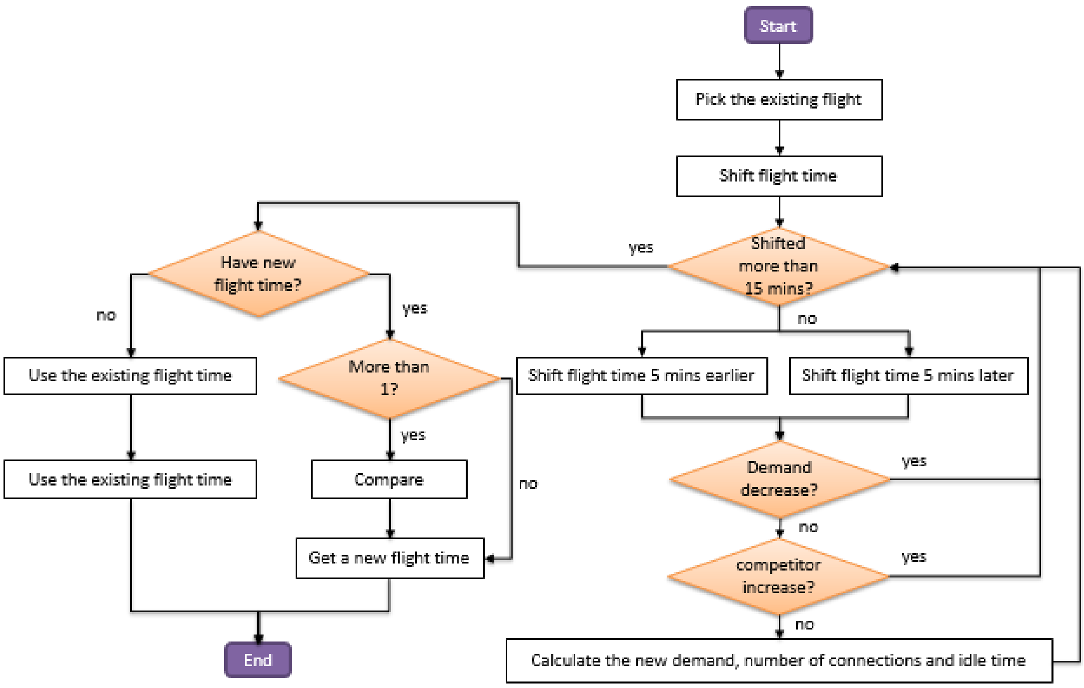


Figure 22: Adjusted flight time determination flowchart

Step1: Pick any current roundtrip flight

Step2: Shift the departure time of the first flight in roundtrip by 5 minutes

Step3: Check the performance of new flight time in term of demand and the number of competitors

Step4: Calculate the idle time between first and second flight's departure time

Step5: If the result is better than current, marked as the shifted time as a new flight time and set demand of this time-slot as the objective

Step6: Repeat from step 2 until all possible time is checked

Step7: Consider the departure time of second flight instead and repeat from step 2

Step8: Compare all possible solution to find the best result

3.6 Develop the connecting flight timetable solution

The aim of this section is to summarise result into the complete timetable for each potential O&D market. Regarding to the result from section 3.5, the final timetable was created by combining the new additional flight and adjusted flight together. To do so, the author firstly construct the new timetable by inserting the additional flights which especially add to serve connecting passenger then insert the adjusted table flight later. Regarding to the objective of research, the adjusted flights are considered as the secondly importance because the flights are inflexibility due to the involvement of point-to-point demand concern. At the end, the author compared the developed timetable with the current one in 3 major aspects which are demand, connections, and aircraft utilisation to evaluate the performance of improvement.

3.7 Measure the minimum required fleet for the proposed solution

Although the subsidiary airline is willing to invest on the new timetable implementation, additional aircrafts purchasing is excluded. Therefore, the minimum required number of aircraft must not exceed the available fleet capacity. From this limitation, the 7th constraint was built as below.

Constraint 7:

$$Minimum\ Required\ Aircraft\ \leq Available\ Aircrafts$$

Equation 40: Ensure fleet capability

With this reason, the minimum required aircrafts must be determined in order to ensure the capability of current resource.

According to the literature review in section 2.7, the author adapted Iris, Rene, and Martin’s vehicle measuring model to developed the minimum fleet determination model for this airline. Compare with the reviewed model, the containers and vehicles can match with flights and aircrafts in this research respectively. However, there are some different points between containers and flights, therefore, the model must be adapted for compatible use. In the reference research, there is no need to transport the containers immediately. Thus, the start time can be allocated to any time-window within the range from release to due time. But for the flights, departure time is fixed so release time and due time are ignored. Furthermore, the time of lift and put down a load is constant so this can be included in travel time but for the flights, ground time is varied, depends on airport. Therefore, the new parameter must be added for this.

With the various of possible start times for container transportation, graph is used to represent time point and find the efficient start time but this is not essential in this case because the only objective of this step is to find the compatible flights for any aircraft in order to ensure the capability of existing resource.

Let;

N is a set of all considered flight in new timetable

K is a set of all potential airports

A is a set of available aircrafts

These following parameters are defined for each flight *i*;

dt_{ip} departure time of flight *i* from origin airport *p*

tt_{ipd} travel time of flight *i* from origin airport *p* to destination airport *d*

at_{id} arrival time of flight *i* at destination airport *p*

gt_{id} standard ground time of flight *i* at the destination airport *d*

rt_{id} release time, the point of time at flight *i* completely ends and the aircraft is back in use

$$\therefore\ rt_{id} = at_{id} + gt_{id}$$

Equation 41: Release time of aircraft

Practically, one aircraft should operate several flights. Therefore, if any two flights can be operated by the same aircraft it is called “compatible”. Flight *i* and j will be compatible if arrival time of flight *i* plus minimum ground time at the airport is equal or earlier than the departure time of flight *j* where origin of flight j and the destination of flight *i* are same. Otherwise, an empty aircraft need to travel to the next starting point which is waste in term of time and cost.

As the result, the new measuring model is developed as below.

$$rt_{id} = at_{id} + gt_{id}, \qquad \forall i \in N, \forall d \in K$$

$$rt_{id} \leq dt_{jp}, \qquad d = p,\ \forall d \in K$$

$$\sum_{i=1}^{n} tt_{ipd}^{a} + \sum_{i=1}^{n} gt_{id}^{a} \leq 24\ hours, \qquad \forall a \in A$$

Equation 42: Minimum required aircraft measuring model

To get the minimum required number of fleet, Greedy algorithm is applied with the model as shown in *Figure 23*. Start off the process, all interested flights are ordered by time from the earliest to the latest (start at 3:00 AM). Then the flight that has the earliest time is picked and assigned to fleet no.1. If there is a compatible flight, it will be assigned to the existing fleet. If not, another fleet will be added for this incompatible flight. Time slot for each aircraft is also reserved according to start and end time of flight operation. After finish checking, the flight which has already assigned to a fleet is marked as deleted and the new earliest flight is consider next. If the picked flight can be assigned to the existing fleet, there is no need to increase number of aircraft, but if not a new one will be continually added until all flight in the list has its own resource. At the end, the number of minimum required aircraft can be identified.

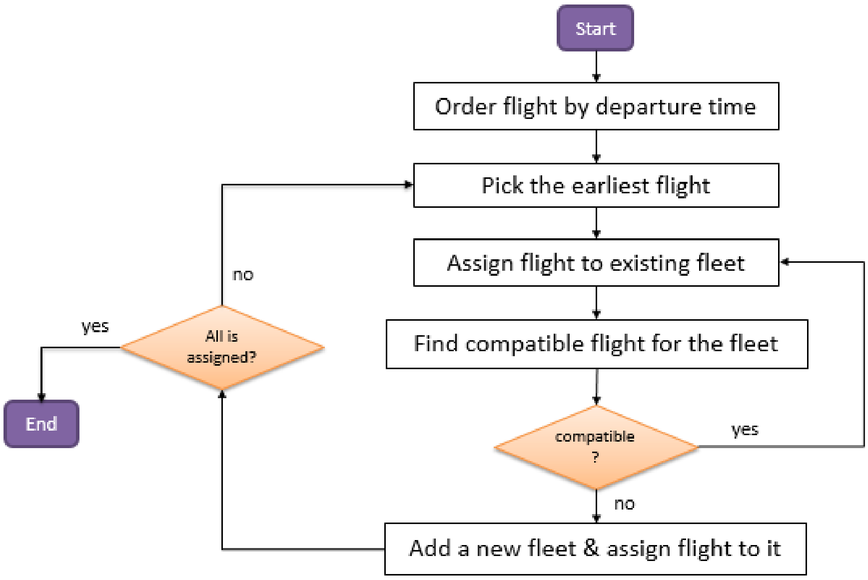


Figure 23: Flowchart of minimum require fleet measurement

In case that the existing resource is not enough, a new flight timetable must be reconsidered until the total 20 aircrafts are sufficient for all flight operation.

CHAPTER 4: RESULT

4.1 Introduction

The result that obtained from approaching process and method which explained in Chapter 3 will be explained in this chapter. Firstly, the information that acquired from interview is explained in section 4.2. From the received information, the ideal timetable was constructed for flight-flow visualisation in section 4.3. In additional, to make the ideal timetable complete, the author forecasted demand with Holt-Winter's model and assigned the summary of connecting passenger demand into each time-slot. The result from forecast with error measurement can be explored in section 4.4. In section 4.5, the models for flight timetabling are shown with the final solution. Lastly, the number of minimum required aircraft for new timetable implementation is calculated and shown in section 4.7 to ensure that current available aircraft is sufficient.

4.2 Constrains

According to the interview, there are many constrains in airline business operation, but for flight timetabling in this reserch only time and demand constraints are concerned.

4.2.1 Time constraints

For time, it can be classified into 2 sub-types regrading to perspectives. From airline's viewpoint, the time which required in flight operation processes must be concerned and followed. At Suvarabhumi International Airport, the standard ground time for A320 is equal to 50 minutes while the province airport required only half an hour. However, in order to maintain the utilisation rate of aircrafts, during the day, aircrafts must not stay idle at any airport more than 1 hour. Aside from operational consern, on marketing side, the unappropriate flight tim could cause the negative impact on demand and profit. To prevnt this issue, any new flight with less than 30 minutes far from the primary's airline flights must be avoided. In passenger's perspective, they requires some times to finished all immigration process and travel between arrilval and departure terminal which is called passenger connecting time. In thailand, the standard connecting time is 1 hour and 15 minutes. Consequently, the connecting flight must not depart from airport earlier than 1.15 hour from the arrival time of connecting passengers. However, the too long wainting time is not good in term of connectivity performance. In ordre to limit the gap between each two connecting flights, maximum accpetable waiting time was given at 3 hours. With this reason, the new added connecting flight must allocated in range of 1.15 to 3 hour from the arrival flights.

4.2.2 Demand constraints

Another constraint is demand, in order to ensure the profitability from flight operation, the demand in new added roundtrip flights must be higher than 60% of maximum aircraft's capacity which is equal to 101 seats. Additioanlly, the minimum required demand in each O&D market is 0.5% of average total connecting demand from past 5 years which is equal to 293 and 274 per month for Thailand's inbound and outbound leg respectively. Otherwise, the demand in that market will be considered as insignificant and neglected from the consideration.

4.3 Ideal connecting flight timetable

In this step, the wave-system structure is adapted for ideal connecting flight time table development. The timetable was created with reference to current flight timetable of the primary's airline and time constraints which obtained from the interview. Since the minimum connecting time (MCT) for passenger is longer than standard ground time for aircraft, thus, the MCT is used for ideal connecting flight time allocation. As explained in section 3.4.1, the ideal flight time is represented in range. Therefore, the upper bound of ideal time is limited by maximum acceptable waiting time for passenger which is equal to 3 hours.

For the example, the primary airline operates flight from Incheon International Airport that arrives Bangkok, Suvarnabhumi International Airport at 1:20 am. Due to the time constraints, the earliest arrival time of connecting flight is 2:35 am. However, flight time must not later than 4:20 am. Therefore, the ideal time range of connecting flight is 2:35 am. – 4:20 am. as shown in *Figure 24*.

Inbound			Time	Outbound		
3	2	1		1	2	3
		ICN	1:20			
			1:25			
			1:30			
			1:35			
			1:40			
			1:45			
			1:50			
			1:55			
			2:00			
			2:05			
			2:10			
			2:15			
			2:20			
			2:25			
			2:30			
			2:35	ICN		
			2:40	ICN		
			2:45	ICN		
			2:50	ICN		
			2:55	ICN		
			3:00	ICN		
			3:05	ICN		
			3:10	ICN		
			3:15	ICN		
			3:20	ICN		
			3:25	ICN		
			3:30	ICN		
			3:35	ICN		
			3:40	ICN		
			3:45	ICN		
			3:50	ICN		
			3:55	ICN		
			4:00	ICN		
			4:05	ICN		
			4:10	ICN		
			4:15	ICN		
			4:20			

Figure 24: Ideal flight time range for seamless connectivity

The wave structure is individually constructed for both inbound and outbound leg as shown in Appendix D, with completed ideal arrival/ departure time range for all primary airline’s flights.

4.4 Potential markets

After the ideal connecting flight timetable was created, the connectivity performance of each time-slot must be evaluated by using demand. Therefore, the passenger demand would be forecasted and assigned to each time-slot in this step. However, due to the large number of O&D markets which offered by both primary and subsidiary airline, the markets with insignificant demand will be filtered.

As the subsidiary airline mainly operate domestic flight and plan make Suvarnabhumi International Airport as a hub to distribute connecting passenger within country. Therefore, the author focus on domestic airports only to find the potential origin and destination markets. In this study, the information from CAPA was mainly used for marketing analysis with the 5-year historical demand from Star Alliance's database. The demand is partly shown in Appendix C because this is confidential.

4.4.1 Domestic airports

Currently, the subsidiary airline provides service at 9 domestic airports as following;

1. Chiang Rai International Airport (CEI)
2. Chiang Mai International Airport (CNX)
3. Hat Yai International Airport (HDY)
4. Phuket International Airport (HKT)
5. Khon Kaen Airport (KKC)
6. Narathiwat Airport (NAW)
7. Ubon Ratchathani Airport (UBP)
8. Udon Thani International Airport (UTH)
9. Surat Thani Airport (URT)

But due to the *demand constraints 1*, 6 airports are filtered out from consideration because connecting demand from/to the airports are so poor. Therefore, only 3 potential airports are considered and explored as below.

4.4.1.1 Phuket International Airport (HKT)

This airport is located in major province of Thailand's southern part where many fascinating tourist attractions are around here. Currently, there are 42-airline services which allow more than thousand connecting destinations in worldwide as shown in *Figure 25*.

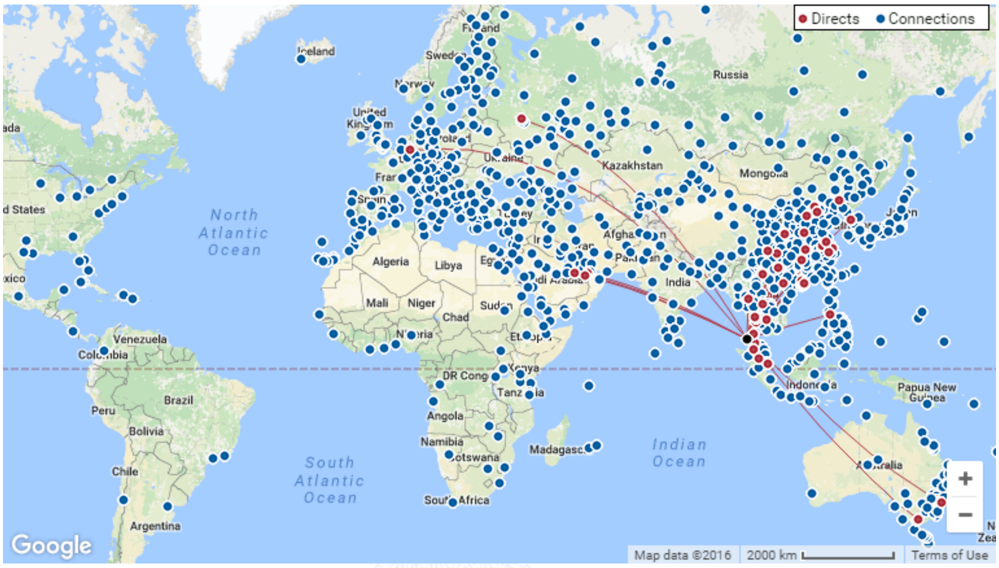


Figure 25: Phuket International Airport connection points (CAPA, 2015)

Furthermore, the total seat capacity at this airport is the third high after Suvarnabhumi and Don Muang International Airport with more than 50% from international flights and the market trend is also increasing in every year regarding to past-4-year historical data. With this reason, the airport is considered as a potential hub.

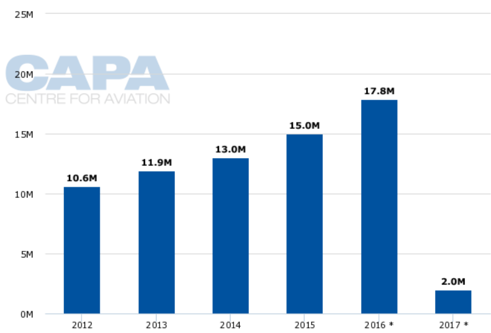


Figure 26: Phuket International Airport seats capacity year-on-year (CAPA, 2015)

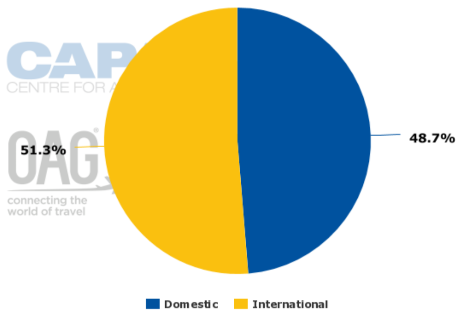


Figure 27: Phuket International Airport international vs domestic capacity share (CAPA, 2015)

Considered at the connecting demand for both inbound and outbound leg. The demand in almost of all routes from/to Phuket International Airport has cyclic pattern which is repeated every 5 months as partly shown in *Figure 28-35*.

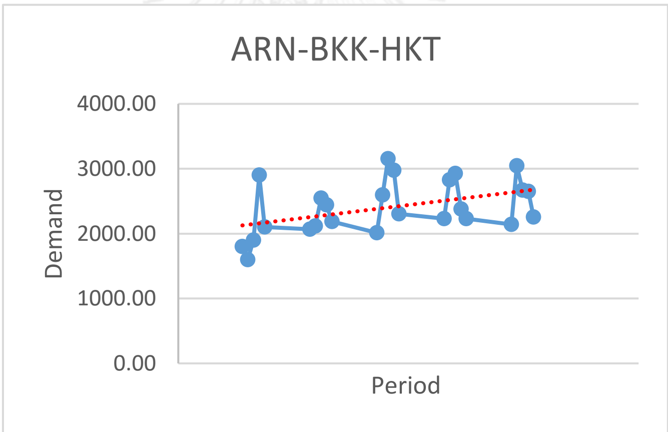


Figure 28: Connecting demand from Stockholm Arlanda Airport to Phuket International Airport (Alliance, 2016)

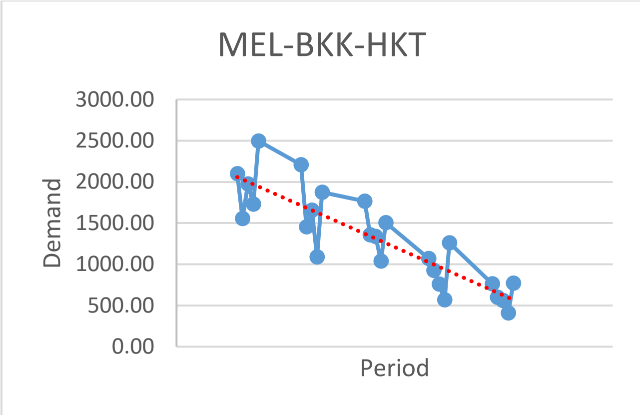


Figure 29: Connecting demand from Melbourne Airport to Phuket International Airport (Alliance, 2016)

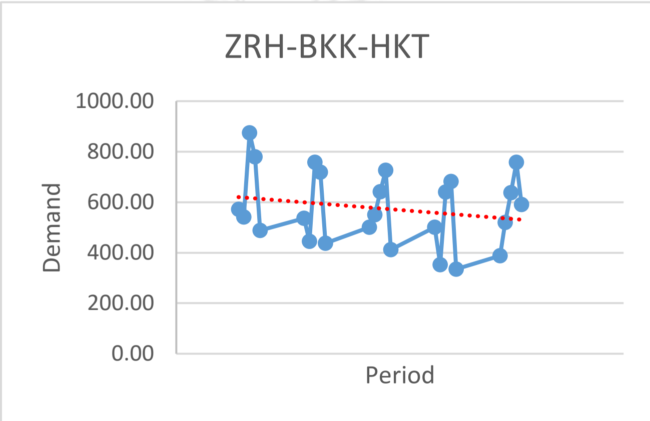


Figure 30: Connecting demand from Zurich Airport to Phuket International Airport (Alliance, 2016)

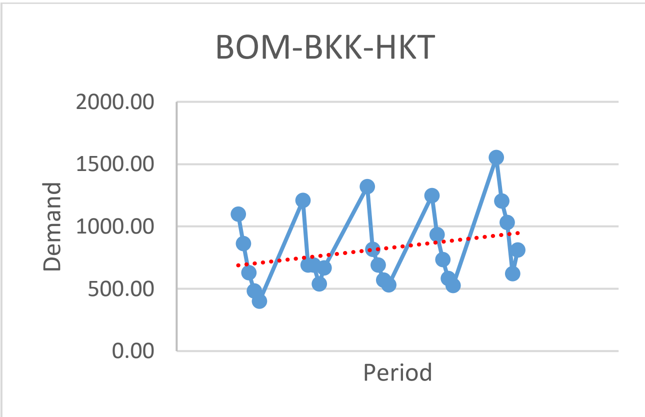


Figure 31: Connecting demand from Chhatrapati Shivaji International Airport to Phuket International Airport (Alliance, 2016)

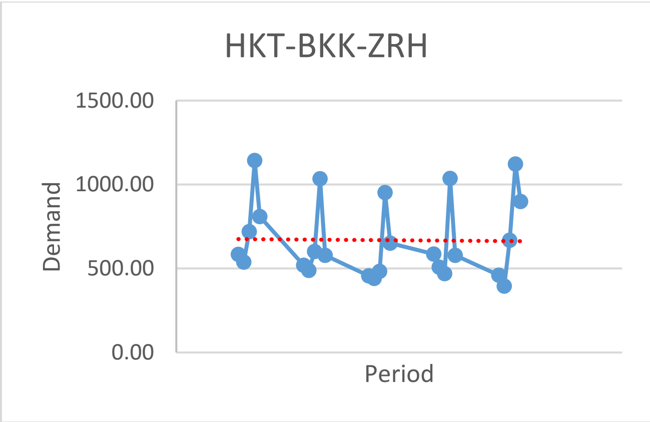


Figure 32: Connecting demand from Phuket International Airport to Zurich Airport (Alliance, 2016)

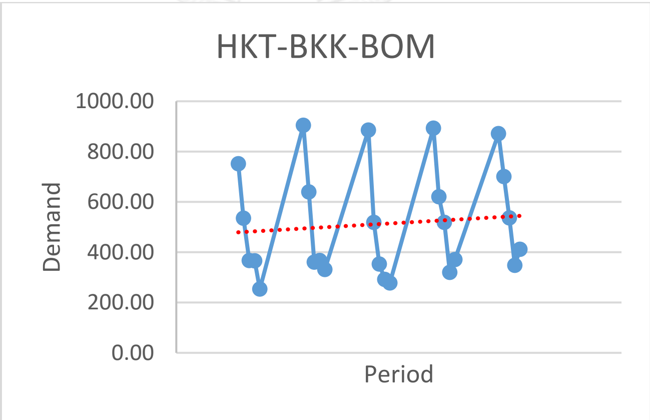


Figure 33: Connecting demand from Phuket International Airport to Chhatrapati Shivaji International Airport (Alliance, 2016)

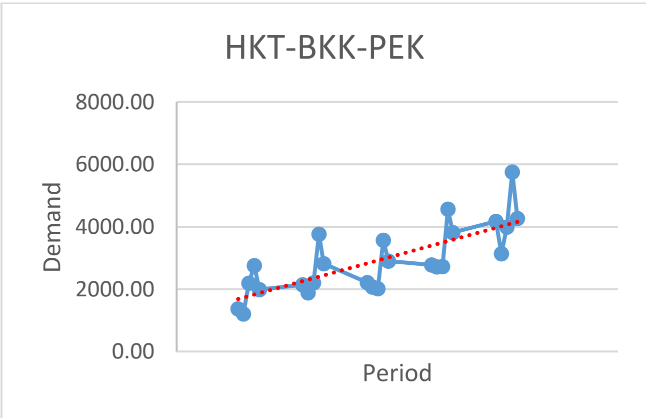


Figure 34: Connecting demand from Phuket International Airport to Beijing Capital International Airport (Alliance, 2016)

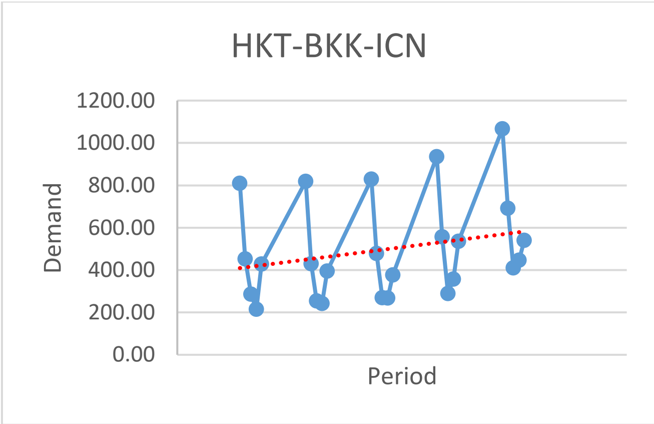


Figure 35: Connecting demand from Phuket International Airport to Inchoen International Airport (Alliance, 2016)

**Note: The case study airline has many competitors, therefore, connecting demand must keep as confidential. However, the data is available on request.*

a) Perth Airport

From all considered routes to Phuket International Airport, Perth Airport is the only origin where demand behavior is abnormal because the connecting passenger number sharply dropped in 2012 as shown in *Figure 36*.

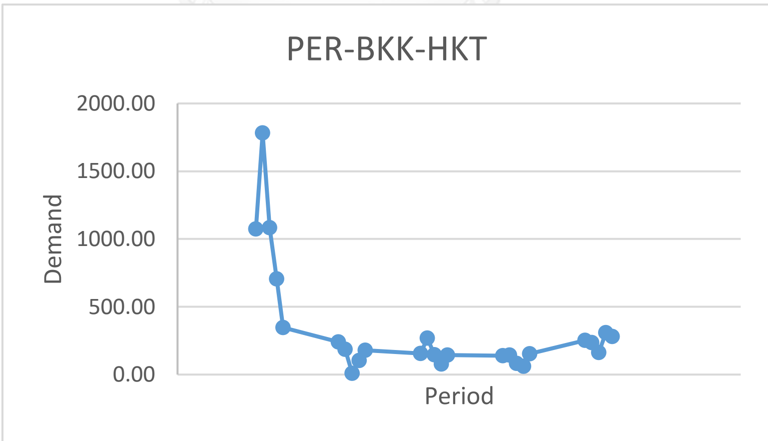


Figure 36: Connecting demand from Perth Airport to Phuket International Airport in 2011-2015's winter (Alliance, 2016)

According to the interview, the expert mentioned that seat capacity and competitors are the major affecting factors on demand. Therefore, the authors checked these two external factors first. As checked, the seats capacity and competitors in route BKK-HKT was quite stable as shown in *Figure 37.*

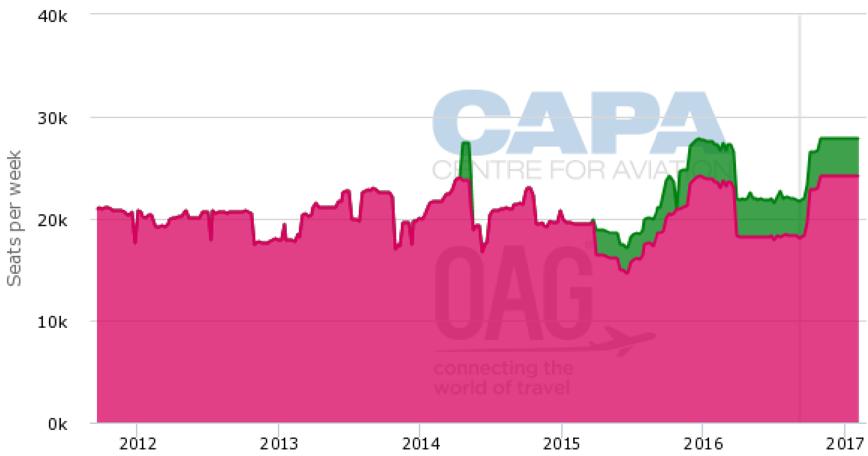


Figure 37: Seats capacity per week of the primary and subsidiary airline from 2011-2017 in BKK-HKT route (CAPA, 2015)

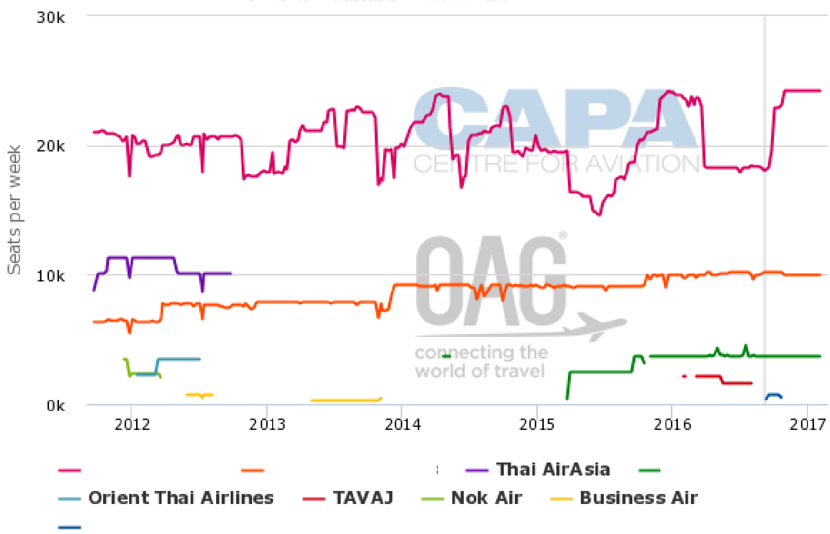


Figure 38: Airlines in Bangkok Suvarnabhumi International Airport to Phuket International Airport market (CAPA, 2015)

In route PER-HKT, the author found direct flights operation by the primary airline and Virgin Australia. Focus on winter's period of 2011, at that time the primary airline had already provided direct flight service but connecting demand still high, thus, this might not be the root cause of demand lost. From *Figure 36*, the low-demand period stared from winter'12 which was the same time that Virgin Australia increased seats capacity around 30% from previous as shown in *Figure 39*.

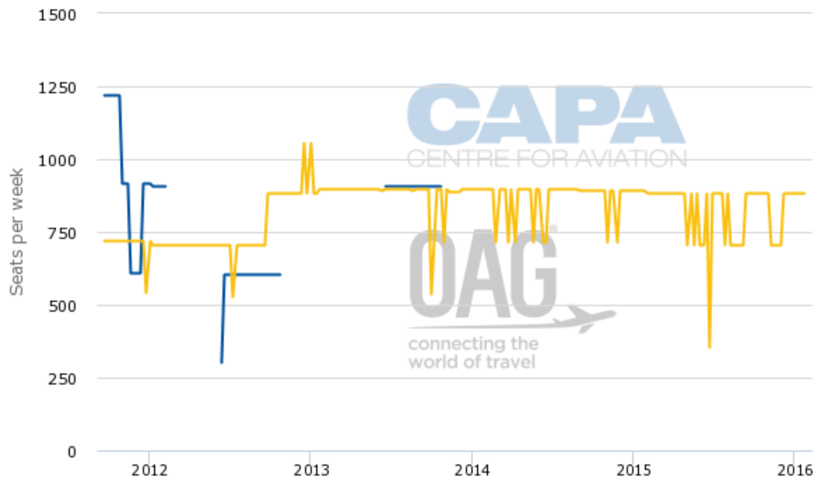


Figure 39: Seats capacity of direct flight from PER to BKK by airlines (19th Sep, 2011 – 31st Jan, 2016) (CAPA, 2015)

On the outbound side from Phuket International Airport to Perth Airport, the demand behaved in the same and market environment also similar. With this reason, the author conclude that cause of demand drop in both ways are same.

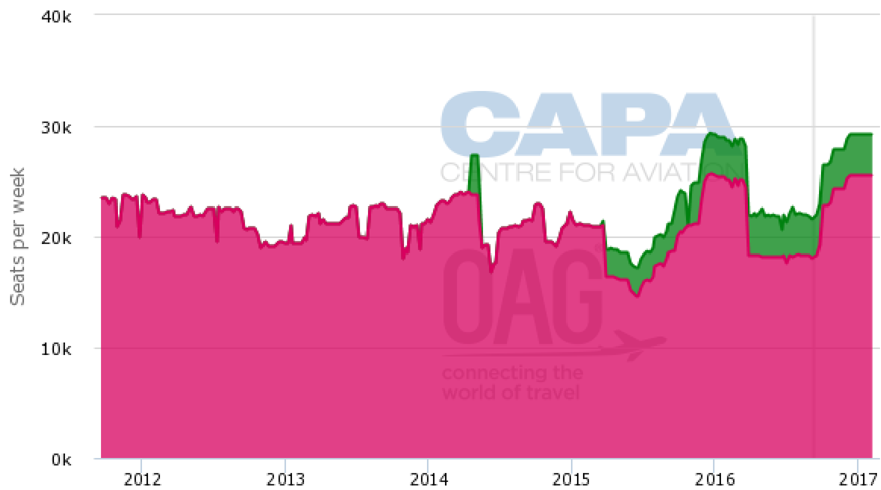


Figure 40: Seats capacity per week of the primary and subsidiary airline from 2011-2017 in HKT-BKK route (CAPA, 2015)

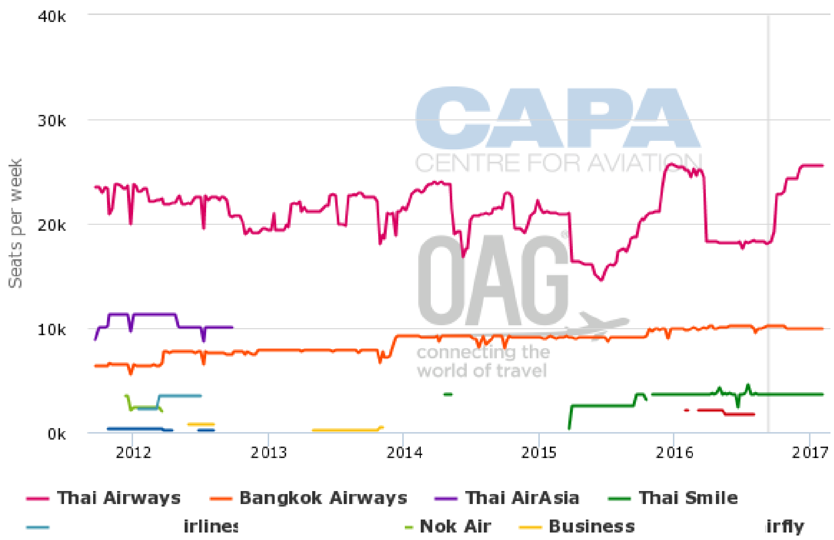


Figure 41: Airlines in Phuket International Airport to Bangkok Suvarnabhumi International Airport market (CAPA, 2015)

However, since virgin had ditched the direct flights in this route already due to the insufficient demand (O'Sullivan, 2015), the historical data in the period which market environment is same as currently is not enough for efficiently forecast with Holt-Winter's model. Thus, the writer discussed with the airline expert and decided to neglect this O&D market from consideration because the connecting demand is not very high. Besides, the primary airline is going to operate direct flight in this route and does not want the subsidiary airline to seize the market demand as well.

4.4.1.2 Chiang Mai International Airport (CNX)

The busiest airport in the Northern which located in a major province, Chiang Mai. There are 22 airlines providing service at this airport in total; 4 airlines operating domestic flights only while the others also provide services in the international routes. From this airport, the passenger can travel to many destinations around the world as shown in *Figure 42*.

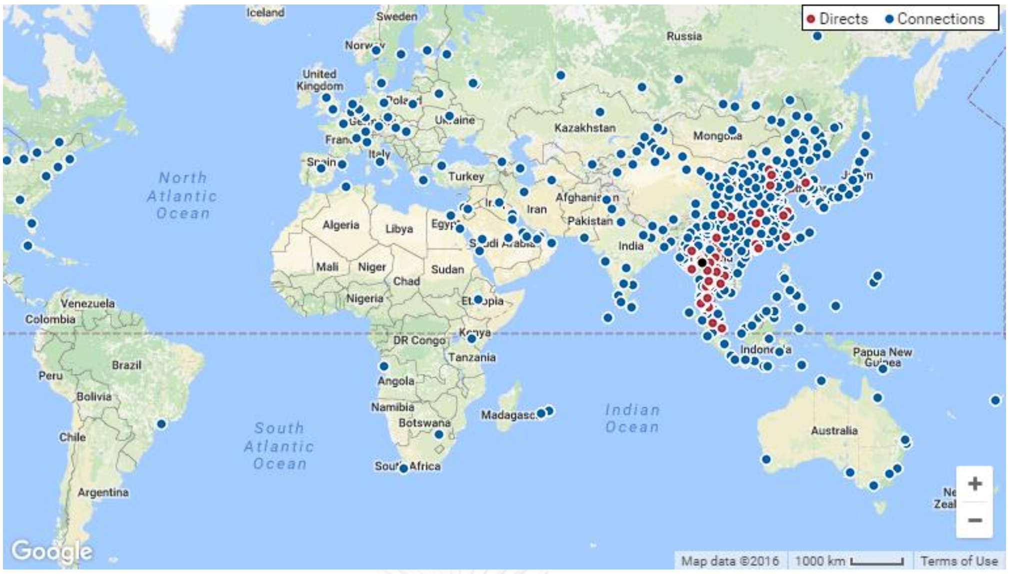


Figure 42: Chiang Mai International Airport connection points (CAPA, 2015)

The seats capacity trend of this airport is about 19% (average) growing up in every year since 2012 and it seems to be continue. Almost a quarter of total seats capacity comes from international and the most popular origin/destination country is China.

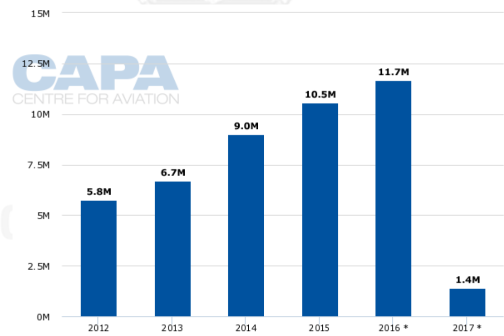


Figure 43: Chiang Mai International Airport seats capacity year-on-year (CAPA, 2015)

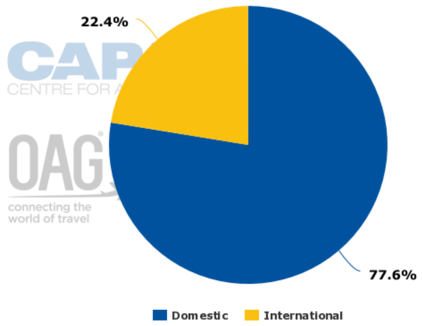


Figure 44: Chiang Mai International Airport international vs domestic capacity share (CAPA, 2015)

Considered at the connecting demand in both inbound and outbound legs, cyclic pattern is consisted in all routes as partly shown in *Figure 45-48*, except for Hong Kong international airport which will be discussed in the next section.

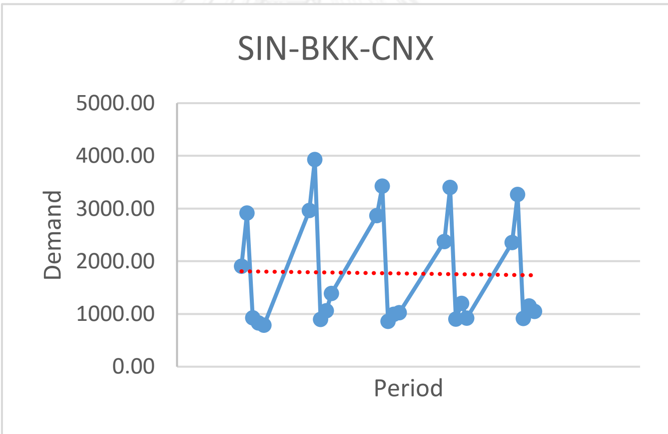


Figure 45: Connecting demand from Singapore Changi Airport to Chiang Mai International Airport (Alliance, 2016)

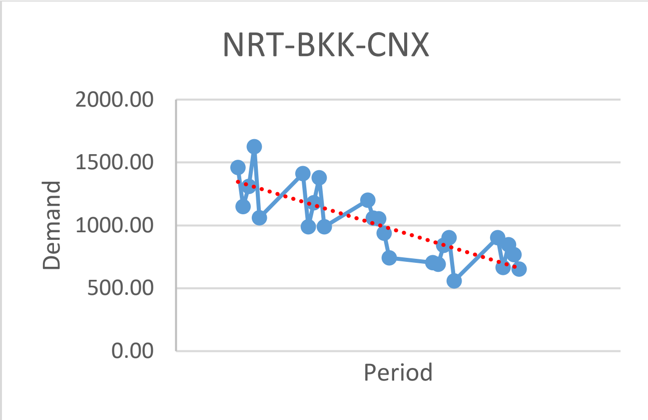


Figure 46: Connecting demand from Narita International Airport to Chiang Mai International Airport (Alliance, 2016)

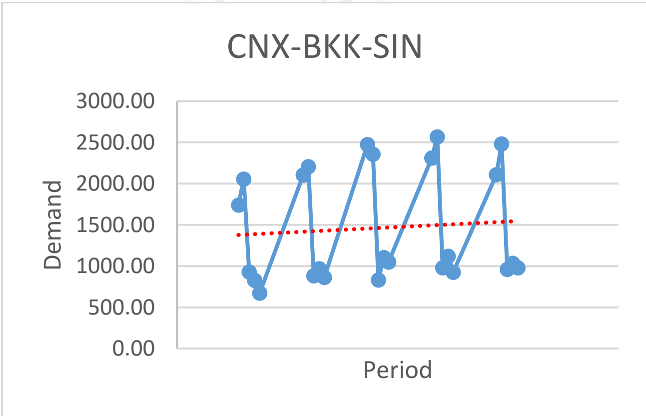


Figure 47: Connecting demand from Chiang Mai International Airport to Singapore Changi Airport (Alliance, 2016)

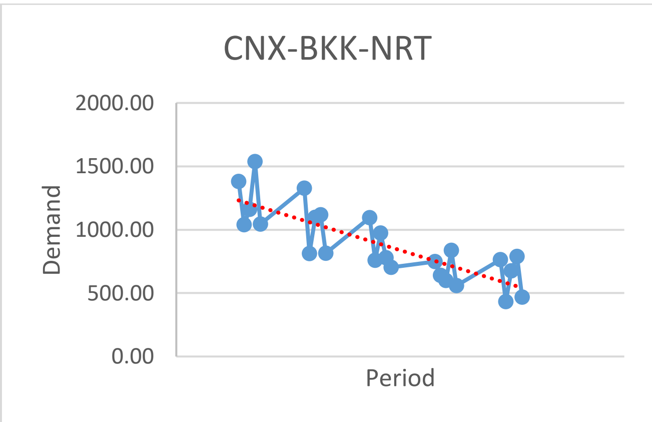


Figure 48: Connecting demand from Chiang Mai International Airport to Narita International Airport (Alliance, 2016)

a) Hong Kong International Airport

The connecting demand between Chiang Mai International Airport and Hong Kong International Airport obviously decrease in past 4 years as shown in *Figure 49* and *50* even the seats capacity from Bangkok, Suvarnabhumi International Airport to Chiang Mai International airport has been remained at the same level.

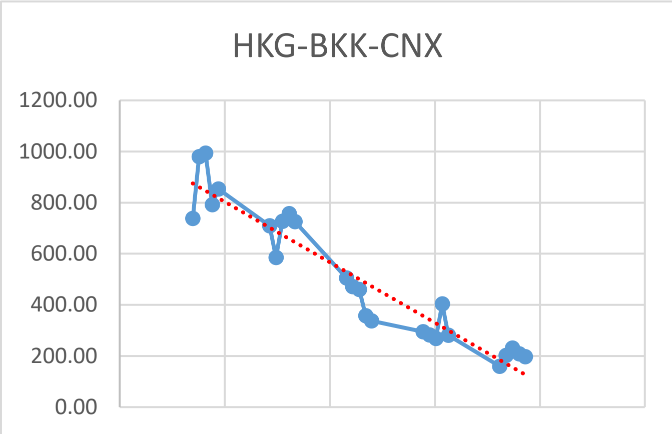


Figure 49: Connecting demand from Hong Kong International Airport to Chiang Mai International Airport (Alliance, 2016)

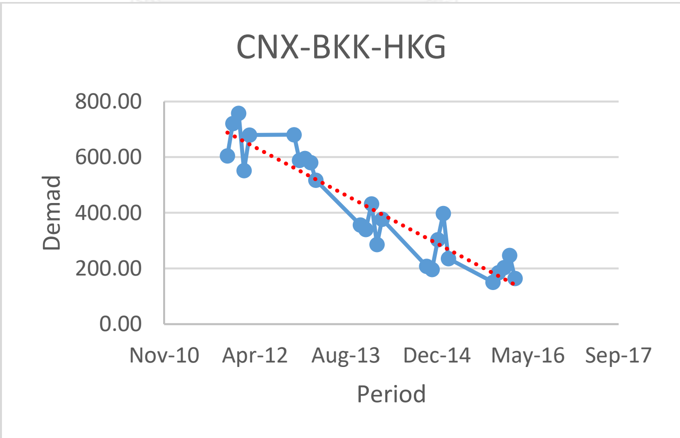


Figure 50: Connecting demand from Chiang Mai International Airport to Hong Kong International Airport (Alliance, 2016)

Currently, there are only 2 competitors in route BKK-CNX and CNX-BKK but former, 5 were play in this market. As hypothesis, since the competitors can snatch seats capacity share, they could also drop the market share accordingly. But in fact, connecting demand was not significantly decreased following the number of competitors in any potential route. With this reason, it can be claimed that a number domestic competitive carriers has no impact on demand.

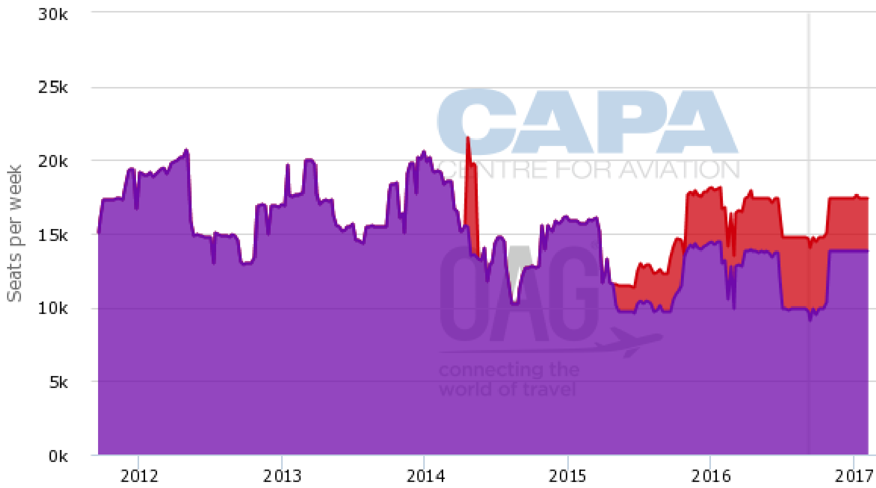


Figure 51: Seats capacity per week of the primary and subsidiary airline from 2011-2017 in CNX-BKK route (CAPA, 2015)

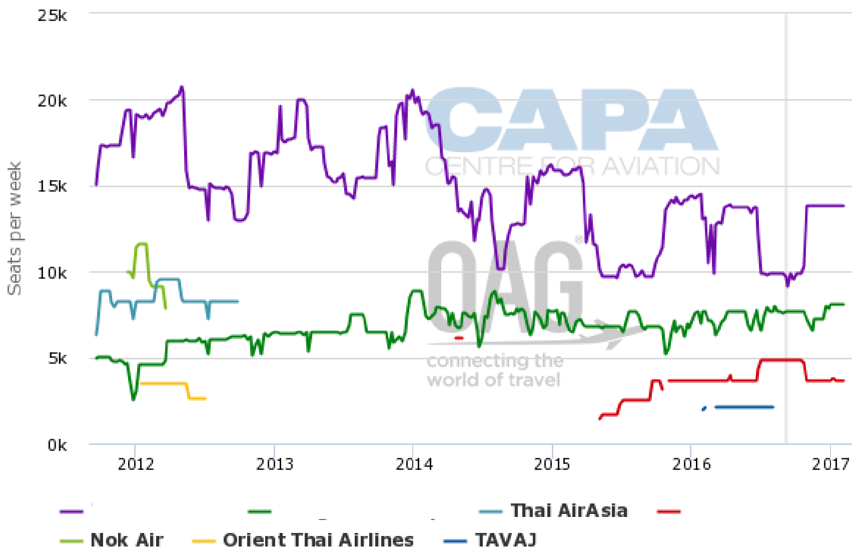


Figure 52: Seats capacity and share for Bangkok Suvarnabhumi International Airport to Chiang Mai International Airport (CAPA, 2015)

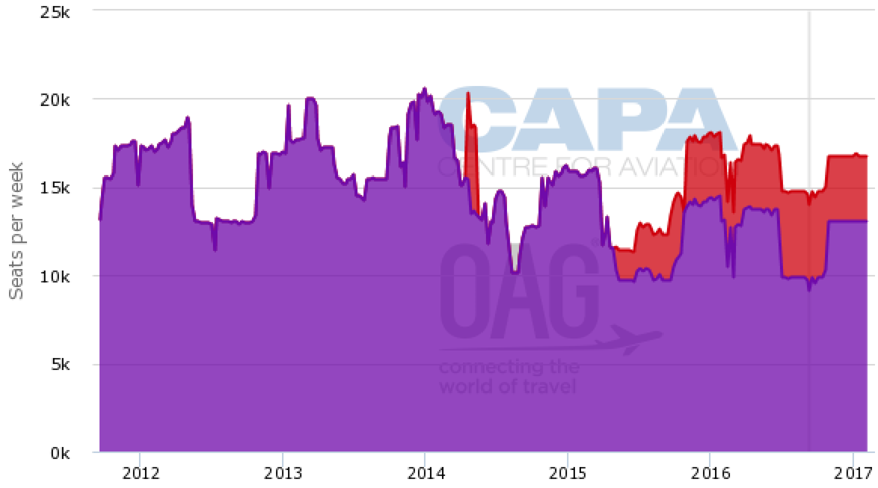


Figure 53: Seats capacity per week of the primary and subsidiary airline from 2011-2017 in BKK-CNX route (CAPA, 2015)

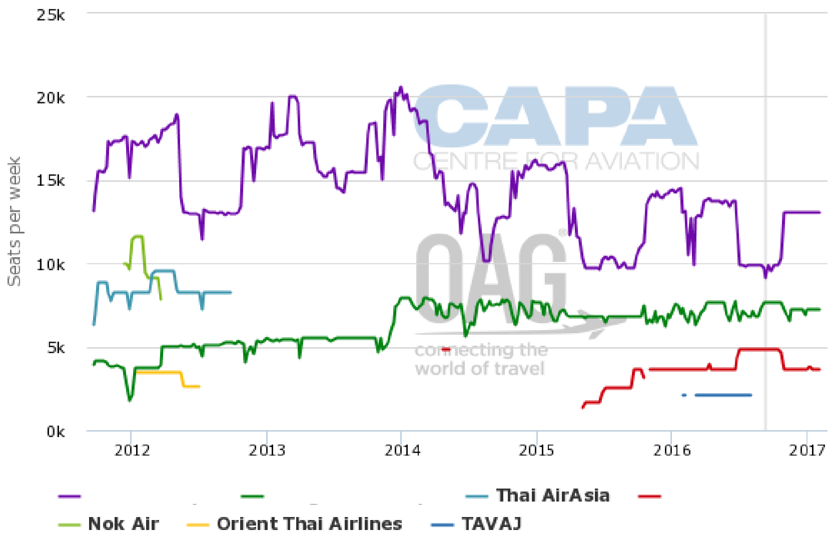


Figure 54: Seats capacity and share for Bangkok Chiang Mai International Airport to Suvarnabhumi International Airport (CAPA, 2015)

Since the market environment on domestic side did not cause the significant impact on demand then the effect might come from international side. As checked, the author found that, in mid-2012, Dragonair started operating direct flight from Hong Kong International Airport to Suvarnabhumi International Airport then many more low-cost carriers entered this market later as shown in *Figure 55*. With this reason, the direct flight's ticket fare is much cheaper than connecting. Moreover, the travel time from Hong Kong International Airport to Chiang Mai International Airport is much shorter since there is no detour at Suvarnabhumi International Airport. With these reasons, many passengers prefer to use direct flight service than connecting which bring about the regression of connecting demand. According to expert's opinion, these carriers will continue providing service in long term due to the attractive market size and profit. Therefore, Hong Kong International Airport is considered as a non-potential origin in this case.

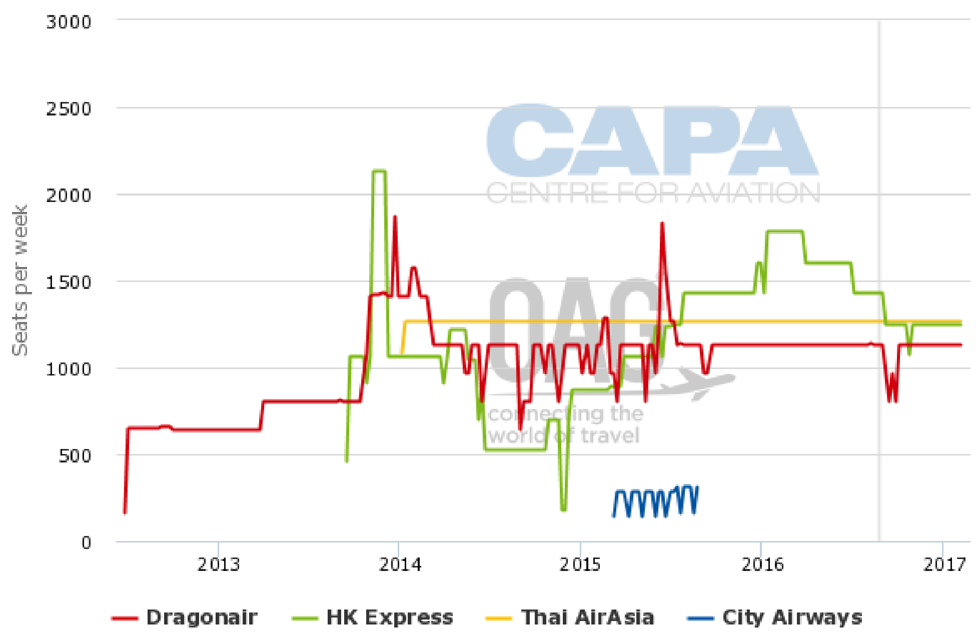


Figure 55: Seats capacity of direct flight from HKG to CNX by airlines (25th Jun, 2012 to 12nd Feb, 2017) (CAPA, 2015)

4.4.1.3 Chiang Rai International Airport (CEI)

This airport locates in Chiang Rai which is the second major province in the northern part of Thailand. Air services at this airport are provided by 6 airlines and only 1 carrier operate international flights from/to here. This makes the share of international capacity is rather low when compare with other 2 potential airports that mentioned earlier. However, there are many connecting flights from/to international origins/destinations especially in North East Asia as shown in *Figure 56*. With these connections, the airport is still attractive even there is very low connection with Africa and none with South America.

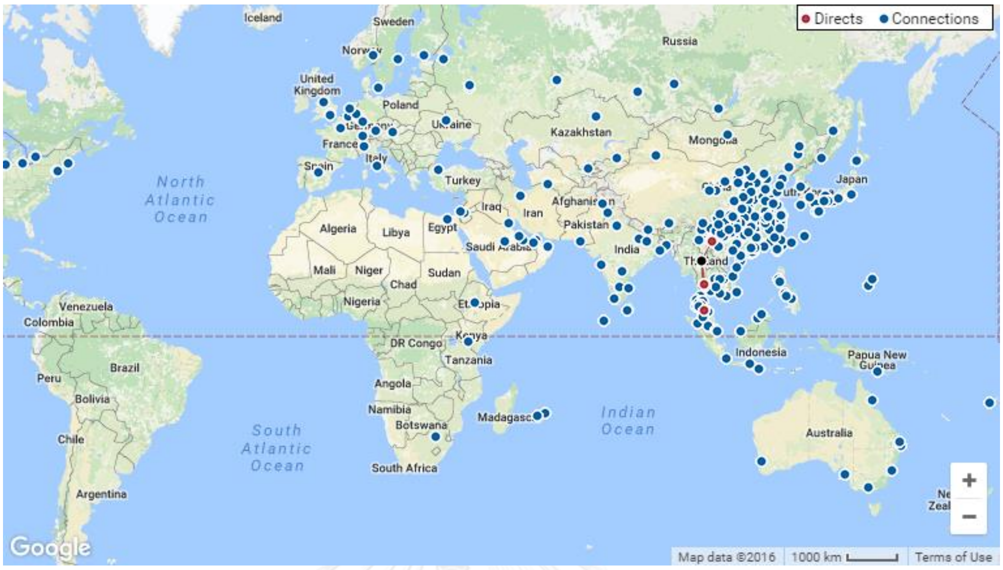


Figure 56: Chiang Rai International Airport connection points (CAPA, 2015)

The trend of market capacity is also good. Since 2012 to 2016, the average growth rate is about 19% as same as Chiang Mai. The majority of an international demand is from China because there is no direct flight from other country from/to this airport.

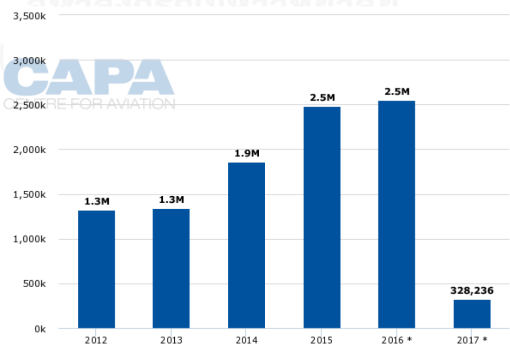


Figure 57: Chiang Rai International Airport seats capacity year-on-year (CAPA, 2015)

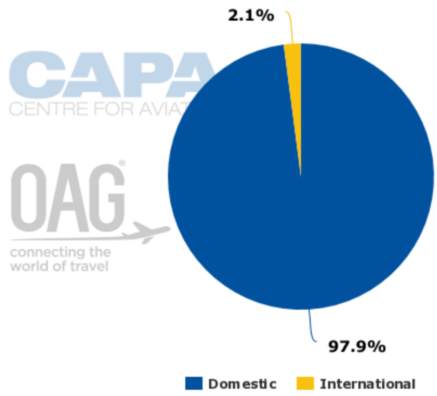


Figure 58: Chiang Rai International Airport international vs domestic capacity share (CAPA, 2015)

a) Singapore Changi International Airport

Singapore Changi International Airport is the only origin where demand is above 0.5% of average total connecting demand. Although the demand trend is going down in last five years, expert do not recommend to cut this airport out from potential points because currently there is no direct flight from Singapore Changi Airport to Suvarnabhumi International Airport unlike HKG-CNX-HKG. Therefore, connecting flight is the only way to reach this destination.

Regarding to the study about market environment, there is an evidence that reveals the relation between capacity and demand. As the demand in route BKK-CEI increased in 2013, the capacity was raised accordingly. In winter's 2014 which was the transition period for both primary and subsidiary airline, the demand also dropped following to seats capacity. Lastly in winter'15, seats capacity was added back at 107,358, demand also slightly increased. In order to confirmed this assumption, seats capacity in route SIN-BKK also checked. The capacity from Singapore was quite stable except in late February to October 2014. Compare with demand in in same period, it did not drop according to the capacity. Besides, when the seats were added back in winter'14, demand was still going down. With this evidence, it can be concluded that demand in route SIN-BKK has no importantly effect on connecting demand.

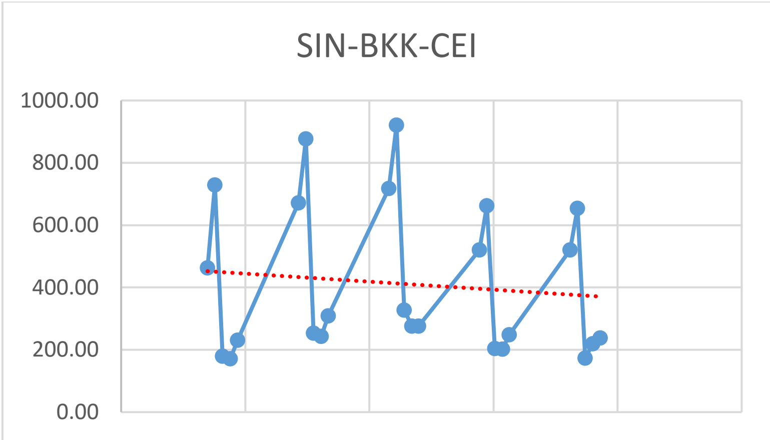


Figure 59: Connecting demand from Changi International Airport to Chiang Rai International Airport (Alliance, 2016)

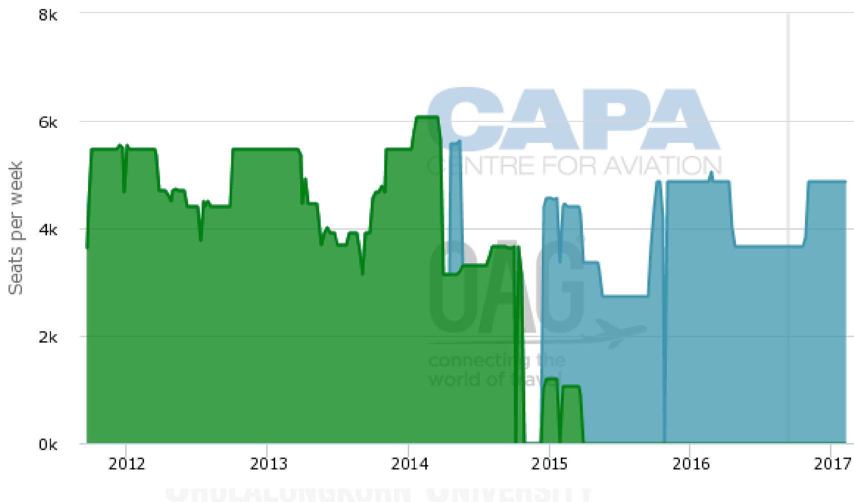


Figure 60: Seats capacity per week of the primary and subsidiary airline from 2011-2017 in CEI-BKK route (CAPA, 2015)

Apart from seats capacity, competitors in market also concerned. Refer to the historical data from CAPA, many carriers came in and out of market along past 5 years but there is no clear relation between this and connecting demand. As the result, this factor is eliminated from consideration.

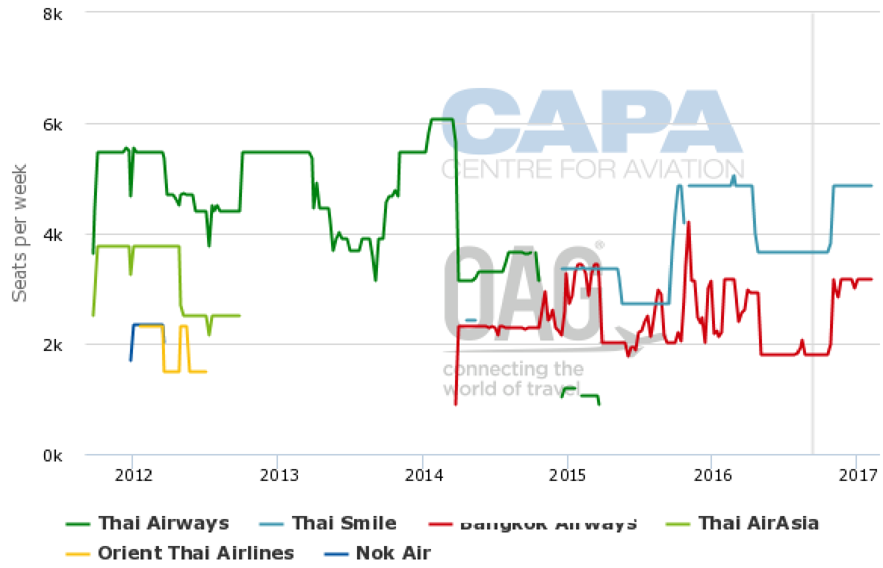


Figure 61: Seats capacity and share of flights from BKK to CEI by airlines (19th Sep, 2011 – 12nd Feb, 2017) (CAPA, 2015)

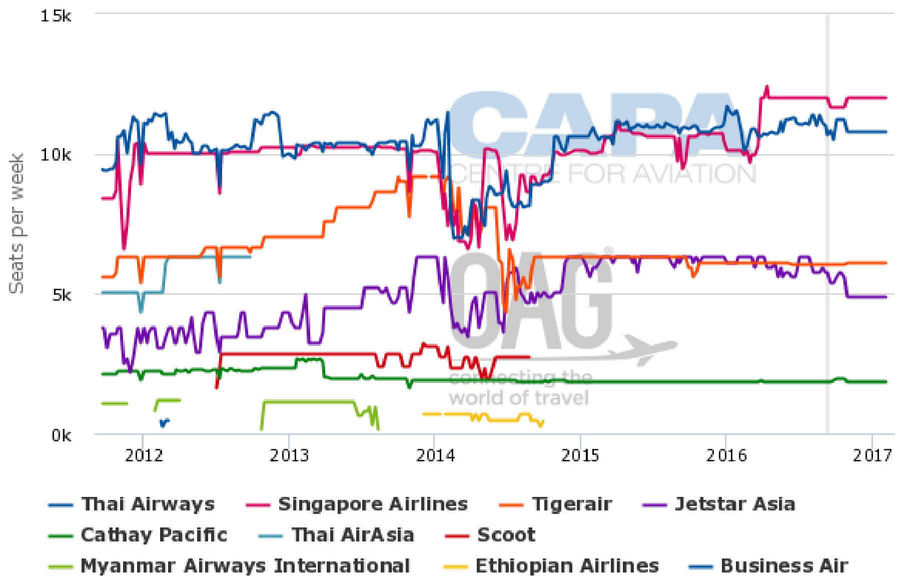


Figure 62: Seats capacity and share of flights from SIN to BKK by airlines (19th Sep, 2011 – 12nd Feb, 2017) (CAPA, 2015)

4.4.2 Demand Forecast

The connecting demand in every considered route were forecasted by multiplicative Holt-Winter's model to predict the connecting passenger demand in the next winter period. The reason that author used this method because demand behavior in every route has a seasonal pattern and the trend is multiple change from previous period. The alpha, beta, and gamma value that used in calculation were calculated case by case in order to obtain the most accurate result. The considered period is 5 because the peak period is repeat in every 5 months and this is the number of month in considered season as well.

The calculation was done with excel template as shown in Appendix C. However, the result is not allowed to disclose because the airline is in high competitive market and this information leak could be beneficial to the rival and cause negative impact on the airline. Therefore, the forecasted demand must be confidential keep. With this reason, the result of forecasted demand per month is partly shown in *Table 8* and *9*.

Table 8: Forecasted demand for BKK's inbound flights

Destination	Origin	Forecaste[redacted]	α	β	γ	% MAPE
HKT	ARN	13,804.61	0.15	0.30	0.05	9.62
HKT	BLR	[redacted]	0.05	0.05	0.05	11.95
HKT	BOM	5,694.08	0.05	0.05	0.05	10.82
HKT	BRU	3,652.10	0.05	0.05	0.05	9.84
HKT	CAN	2,148.65	0.05	0.05	0.95	19.40
HKT	CCU	[redacted]	0.05	0.05	0.05	10.94
HKT	CDG	[redacted]	0.05	0.05	0.05	10.38
HKT	CPH	10,329.10	0.05	0.05	0.05	10.25
HKT	CTU	[redacted]	0.05	0.05	0.05	10.68
HKT	DEL	11,312.36	0.05	0.05	0.05	10.58
HKT	FCO	[redacted]	0.05	0.05	0.25	13.32
HKT	FRA	[redacted]	0.25	0.30	0.50	13.25
HKT	HKG	[redacted]	0.15	0.45	0.05	10.10
HKT	HND	9,509.82	0.05	0.05	0.05	8.87
HKT	KIX	4,323.01	0.05	0.05	0.05	9.38
HKT	KMG	[redacted]	0.05	0.05	0.05	12.82
HKT	LHR	11,095.71	0.2	0.35	0.45	17.10
HKT	~~MEL~~	[redacted]	~~0.05~~	~~0.05~~	~~0.05~~	~~10.33~~
HKT	MUC	4,964.97	0.05	0.05	0.05	10.00
HKT	MXP	4,676.48	0.05	0.05	0.05	12.48
HKT	NGO	3,050.95	0.05	0.05	0.05	9.61
HKT	NRT	[redacted]	0.20	0.30	0.35	13.52
HKT	OSL	[redacted]	0.10	0.05	0.05	9.83
HKT	PEK	12,044.32	0.05	0.05	0.05	14.28
HKT	PVG	1,692.72	0.05	0.05	0.05	12.18
HKT	SYD	2,158.27	0.05	0.05	0.05	10.11
HKT	TPE	2,071.62	0.05	0.05	0.05	9.71
HKT	ZRH	[redacted]	0.05	0.05	0.05	10.13
CNX	HND	6,554.20	0.05	0.05	0.05	10.53
CNX	KIX	4,310.55	0.05	0.05	0.05	9.61
CNX	LHR	2,182.45	0.10	0.35	0.05	13.03
CNX	NGO	2,724.80	0.05	0.05	0.05	10.36
CNX	NRT	[redacted]	0.25	0.10	0.05	9.80
CNX	SIN	10,678.26	0.05	0.05	0.45	18.18
CNX	TPE	[redacted]	0.05	0.05	0.05	12.83
CEI	SIN	2,417.74	0.05	0.05	0.15	20.26

Table 9: Forecasted demand for BKK's outbound flights

Origin	Destination	Forecasted Demand	α	β	γ	% MAPE
HKT	ARN	[redacted]	0.05	0.05	0.05	9.64
HKT	BNE	1,839.15	0.05	0.05	0.05	10.24
HKT	BOM	3,318.44	0.05	0.05	0.05	11.59
HKT	BRU	[redacted]	0.05	0.05	0.05	10.65
HKT	CAN	2,153.39	0.05	0.05	0.95	15.95
HKT	CDG	[redacted]	0.20	0.05	0.05	9.98
HKT	CPH	[redacted]	0.05	0.05	0.20	12.07
HKT	DEL	6,746.12	0.05	0.05	0.05	11.27
HKT	FCO	4,666.03	0.05	0.05	0.60	16.02
HKT	FRA	[redacted]	0.05	0.05	0.05	9.58
HKT	HKG	1,566.73	0.05	0.05	0.05	10.00
HKT	HND	[redacted]	0.25	0.10	0.05	4.92
HKT	ICN	3,779.05	0.05	0.05	0.05	13.29
HKT	KIX	4,051.18	0.05	0.05	0.05	10.57
HKT	LHR	[redacted]	0.2	0.4	0.05	13.80
HKT	MEL	2,033.56	0.05	0.05	0.05	11.37
HKT	MUC	[redacted]	0.05	0.05	0.05	9.96
HKT	MXP	[redacted]	0.05	0.05	0.35	14.00
HKT	NGO	2,663.34	0.05	0.05	0.05	10.98
HKT	~~NRT~~	~~1,168.56~~	~~0.20~~	~~0.35~~	~~0.05~~	-
HKT	OSL	4,614.29	0.05	0.05	0.05	11.08
HKT	PEK	[redacted]	0.05	0.05	0.05	9.40
HKT	PUS	4,730.20	0.05	0.05	0.05	9.27
HKT	PVG	[redacted]	0.05	0.05	0.45	14.46
HKT	SYD	2,203.55	0.05	0.05	0.05	9.68
HKT	TPE	3,451.38	0.05	0.05	0.05	10.24
HKT	ZRH	3,173.00	0.05	0.05	0.05	12.69
CNX	HND	[redacted]	0.05	0.05	0.05	12.12
CNX	KIX	3,697.38	0.05	0.05	0.05	8.70
CNX	NRT	1,973.76	0.05	0.25	0.05	8.80
CNX	PEK	3,341.07	0.05	0.05	0.05	17.66
CNX	PVG	4,223.44	0.10	0.75	0.35	15.11
CNX	SIN	[redacted]	0.05	0.05	0.75	11.00
CNX	TPE	2,196.83	0.05	0.05	0.05	13.03

To make the ideal connecting flight timetable complete, the forecasted demand is summed up and assigned into each time-slot. However, the forecasted demand is demand per day but in the real situation some O&D markets have more than 1 flight per day. In this case, the author assumed that every flight in that particular route has an equal passenger demand so the total demand in each flight is equal to total demand per day divided by the number of flight per day.

4.5 Potential flight time

4.5.1 By flight adding

According to forecasted demand in previous section, the author found that only HKT-BKK and BKK-HKT have the sufficient demand for new additional flight. Therefore, in this section, only Phuket international airport is considered.

Due to time constraint 3 (*Equation 30*), the flight which could seize the primary airline's demand must be avoided. For the example, if departure time of the primary airline's flight is 11:00, the subsidiary airline is not allowed to add any new flight between 10:30 – 11:30.

According to the primary's flight time table in *Appendix E*, therefore, the subsidiary airline is not allowed to operate new flight between the time-period that show in *Table 10* and *11*.

Table 10: Unavailable departure time-period for new HKT's inbound flight

Route	Departure Time	Unavailable Time
BKK-CNX	07:50	07:20 - 08:20
BKK-CNX	08:45	08:15 - 09:15
BKK-CNX	13:15	12:45 - 13:45
BKK-CNX	17:20	16:50 - 17:50
BKK-HKT	07:45	07:15 - 08:15
BKK-HKT	08:30	08:00 - 09:00
BKK-HKT	10:00	09:30 - 10:30
BKK-HKT	13:20	12:50 - 13:50
BKK-HKT	14:05	13:35 - 14:35
BKK-HKT	16:45	16:15 - 17:15
BKK-HKT	17:25	16:55 - 17:55

Table 11: Unavailable departure time-period for new HKT's outbound flight

Route	Departure Time	Arrival Time
HKT-BKK	12:15	11:45 - 12:45
HKT-BKK	13:55	13:25 - 14:25
HKT-BKK	15:45	15:15 - 16:15
HKT-BKK	16:25	15:55 - 16:55
HKT-BKK	19:00	18:30 - 19:30
HKT-BKK	19:35	19:05 - 20:05
HKT-BKK	20:35	20:05 - 21:05
HKT-BKK	21:25	20:55 - 21:55
CNX-BKK	15:20	14:50 - 15:50
CNX-BKK	19:20	18:50 - 19:50
CNX-BKK	20:50	20:20 - 21:20

After filtered the unavailable time-period out and list the top 10 time-period by forecasted demand. The result shows that HKT's inbound flights have more demand than outbound flights in average. However, it cannot be concluded that the flight with the highest demand is the best choice because paired leg also influences to the final output. Sometimes, the best-fit inbound flight might have very low demand and pulled total demand of roundtrip down until it is insufficient for operation. Thus, all flight time which would offer the highest demand in both legs that listed in *Table 12* and *13* are individually considered.

Table 12: Top 10 best flight time for inbound leg

Rank	Dpt. Port	Dpt. Time	Arv. Port	Arv. Time	Demand / Day	Connections
1	BKK	09:00 - 09:09	HKT	10:25 - 10:34	335.25	18
2	BKK	09:10 - 09:14	HKT	10:35 - 10:39	312.66	17
3	BKK	07:10 - 07:14	HKT	08:35 - 08:39	261.75	9
4	BKK	09:15 - 09:19	HKT	10:40 - 10:44	239.83	14
5	BKK	07:05 - 07:09	HKT	08:30 - 08:34	230.98	8
6	BKK	07:00 - 07:04	HKT	08:25 - 08:29	208.63	7
7	BKK	09:20 - 09:24	HKT	10:45 - 10:49	183.55	12
8	BKK	09:25 - 09:29	HKT	10:50 - 10:54	124.43	9
9	BKK	06:55 - 06:59	HKT	08:20 - 08:24	117.81	6
10	BKK	06:40 - 06:54	HKT	08:05 -08:19	93.00	4

Table 13: Top 10 best flight time for HKT's outbound leg

Rank	Dpt. Port	Dpt. Time	Arv. Port	Arv. Time	Demand / Day	Connections
1	HKT	22:05 - 22:14	BKK	23:30 - 23:39	216.02	5
2	HKT	06:45 - 06:49	BKK	08:10 - 08:14	138.62	12
3	HKT	06:30 - 06:44	BKK	07:55 - 08:09	138.62	11
4	HKT	06:20 - 06:29	BKK	07:45 - 07:54	138.62	9
5	HKT	06:15 - 06:19	BKK	07:40 - 07:44	129.86	8
6	HKT	06:10 - 06:14	BKK	07:35 - 07:39	116.53	7
7	HKT	22:15 - 22:24	BKK	23:40 - 23:49	110.06	3
8	HKT	22:25 - 22:34	BKK	23:50 - 23:59	110.06	2
9	HKT	06:05 - 06:09	BKK	07:30 - 07:34	84.55	7
10	HKT	05:45 - 06:04	BKK	07:10 - 07:29	82.49	5

To find the best new roundtrip flight time, developed model in section 3.5.1 was used with algorithm as explained below.

Firstly, the time-slot which would offer the highest demand is picked and the set of possible paired flight under formulated constraints are listed as following.

Table 14: Possible paired flight for BKK-HKT 09:00 – 10:25

No.	Route	Dpt. Time	Arv. Time	Demand	Connections	Idle Time
1	HKT-BKK	10:55	12:20	32	7	30
2	HKT-BKK	11:00	12:25	39	8	35
3	HKT-BKK	11:05	12:30	39	8	40
4	HKT-BKK	11:10	12:35	39	8	45
5	HKT-BKK	11:15	12:40	39	7	50
6	HKT-BKK	11:20	12:45	39	7	55
7	HKT-BKK	11:25	12:50	37	6	60

By using BnB algorithm, the possible flight time in Table 14 was individually checked, started from the first record. Then the objective was set as 32 for demand per flight, 7 for connections, and 30 minutes for idle time. Then the second record was considered, in this case, the demand from second record was higher than objective, therefore, the current objective was replaced by new demand which is equal to 39. After that, the third record was checked but the demand and connections were same only idle time was increased by 5 minutes. Since this option was not better than the objective value, thus, the objective was remained. Each possible flight time in the set will be considered until all is checked and then the next departure flight will be picked. In this case, BKK-HKT 09:05 – 10:30 is considered next with the same process.

As the result, the objectives from flight time determing process are shown in below *Table 15* and *16*. If all first flights of roundtrip is fixed, the available outbound flights are explored as shown in *Table 15*. The best roundtrip flight in every aspect is a solution from option 5. The total demand for roundtrip is equal to 247 or about 73% of aircraft maximum capacity. The number of connection is 16 and 6 for inbound and outbound fight respectively.

Table 15: The departure time of second flight in roundtrip

Option	Dpt. Port	Dpt. Time	Arv. Port	Arv. Time	Demand	Connections	Idle Time
1	BKK	09:00	HKT	10:25	168	18	35
	HKT	11:00	BKK	12:25	39	8	
	Total				207	26	35
2	BKK	09:05	HKT	10:30	168	18	30
	HKT	11:00	BKK	12:25	39	8	
	Total				207	26	30
3	BKK	09:10	HKT	10:35	168	18	30
	HKT	11:05	BKK	12:30	39	8	
	Total				207	26	30
4	BKK	07:10	HKT	08:35	168	9	30
	HKT	09:05	BKK	10:30	77	5	
	Total				245	14	30
5	BKK	07:10	HKT	08:35	168	9	60
	HKT	09:35	BKK	11:00	79	7	
	Total				247	16	60

After the result from fixed inbound flight is acquired, the author repeat all problem-solving process again, but this time, HKT's outbound flights were fixed instead. As a result, best roundtrip flight is shown in *Table 15*.

Table 16: The potential departure time of first flight in roundtrip

Option	Dpt. Port	Dpt. Time	Arv. Port	Arv. Time	Demand	Connections	Idle Time
1	BKK	19:40	HKT	21:05	115	9	60
	HKT	22:05	BKK	22:30	168	5	
	Total				283	14	60

To conclude, there are 2 new roundtrip flight to serve connecting passenger from the primary airline. One is in the morning and another is in the late night. For the morning roundtrip flight, the forecasted demand is about 72.92% of maximum aircraft capacity and the night flight the demand would be about 84.22% for roundtrip. The offered connections is 16 and 14 international airports for morning and night flight respectively with the same idle time at 1 hour.

4.5.2 By flight adjustment

To ensure that point-to-point passenger would not be stolen by competitors, the subsidiary airline prefer to shift flight time within the range of 15 minutes from/to the current flight time that shown in *Appendix E* wihtout competitors's flight frequency increment. The competitor's flight timetable can be discovered in Appendix G. Then, the set of possible arrival/departure time is created. The best-first search which is the one of heuristic to find the best pair of flight within the created data set. Then use the obtained solution as an objective and repeatedly check other flight pairs until the best piar between departure and arrival time set is found.

For the example, roundtrip flight BKK-CNX 08:45 – 10:00 and CNX-BKK 10:35 – 11:50. At the beginning, the second leg flight CNX-BKK was fixed. The flight time for BKK-CNX was shifted 5 minutes up and down within 15 minute. Before using best-first search, all possible new time is listed as shown in *Table 17*.

Table 17: Possible adjusted flight time for flight BKK-CNX 08:45 – 10:00

No.	Dpt. Time	Arv. Time	Demand	Connections	Competitors	Idle Time
1	08:30	09:45	7	23	1	50
2	08:35	09:50	7	23	1	45
3	08:40	09:55	7	23	1	40
4	08:45	10:00	7	21	1	35
5	08:50	10:05	7	20	1	30
6	08:55	10:10	7	19	1	25
7	09:00	10:15	7	18	1	20

From all possible new departure time, 08:45 gives the best outcome in term of demand which is the first priority. Therefore, 08:45 is marked as a new flight time. For the last two record, the idle time is less than standard ground time at province airport, therefore, the time only applicable when the second-leg flight time is shifhted till depature time is after 10:40. However, this is not the final solution so the process is once done to find the best flight time for second-leg flight as shown in *Table 18*.

Table 18: Possible adjusted flight time for flight CNX-BKK 10:35 – 11:50

No.	Dpt. Time	Arv. Time	Demand	Connections	Competitors	Idle Time
1	10:20	11:35	11	8	0	20
2	10:25	11:40	11	6	0	25
3	10:30	11:45	11	6	0	30
4	10:35	11:50	29	9	0	35
5	10:40	11:55	29	9	0	40
6	10:45	12:00	29	9	0	45
7	10:50	12:05	29	8	0	50

Similar to the first-leg flight, departure time in first two records will available only if the first-leg flight is shifted up 5 and 10 minutes respectively. Considered at the result from both legs adjustment, record no.3 and 4 gives the highest demand for inbound and outbound leg of Chiang Mai International Airport and the idle time between these 2 flights is less than 1 hour. Consequently, this pair will be used instead of the existing.

According to the result from flight scheduling model in section 3.5.2, new flight time are replaced as shown in *Table 19*.

Table 19: Adjusted flight time for all flights in potential O&D markets

Route	Old		New		Demand		Competitors		Connections		Idle time	
	Dpt.	Arv.	Dpt.	Arv.	Old	New	Old	New	Old	New	Old	New
BKK-CNX	08:45	10:00	08:40	09:55	7.18	7.18	1	1	21	23	35 mins	40 mins
CNX-BKK	10:35	11:50	-	-	29.93	29.93	0	0	9	9		
Total					37.11	37.11	1	1	30	30		
BKK-CNX	10:20	11:35	10:35	11:50	0	0	0	0	2	2	45 mins	35 mins
CNX-BKK	12:20	13:30	12:25	13:35	18.34	29.93	0	0	6	7		
Total					18.34	29.93	0	0	8	9		
BKK-CNX	15:40	16:55	15:25	16:40	14.05	14.05	0	0	7	7	30 min	30 min
CNX-BKK	17:25	18:40	17:10	18:25	0	0	0	0	2	3		
Total					14.05	14.05	0	0	9	10		
BKK-CNX	19:45	21:00	-	-	16.88	16.88	1	1	11	11	-	-
CNX-BKK	06:45	08:00	06:55	08:10	37.04	37.04	1	1	11	12		
Total					53.92	53.92	2	2	22	23		
BKK-HKT	11:50	13:15	12:00	13:25	66.38	73.19	0	0	4	4	60 mins	60 mins
HKT-BKK	14:15	15:40	14:25	15:50	20.66	20.66	1	1	7	9		
Total					87.04	93.85	1	1	11	13		
BKK-HKT	15:35	16:55	15:25	16:45	31.81	31.81	0	0	6	7	45 mins	60 mins
HKT-BKK	17:40	19:05	17:45	19:10	0	0	1	1	1	2		
Total					31.81	31.81	1	1	7	9		
BKK-CNX	07:45	09:00	08:00	09:15	51.88	51.88	2	2	25	25	50 mins	35 mins
CNX-HKT	09:50	11:35	-	-	-	-	-	-	-	-	-	-
HKT-CNX	12:35	14:30	-	-	-	-	-	-	-	-	-	-
CNX-BKK	15:00	16:15	15:10	16:25	7.23	18.82	1	1	11	11	0 min	40 mins
Total					7.23	18.82	3	3	11	11	50 mins	75 mins
BKK-HKT	19:35	21:00	19:25	21:10	149.53	149.53	1	1	11	12	35 mins	45 mins
HKT-HGH	21:35	03:45	-	-	-	-	-	-	-	-	-	-
HGH-HKT	06:40	10:45	-	-	-	-	-	-	-	-	-	-
HKT-BKK	11:35	13:00	11:20	12:45	40.96	40.96	0	0	6	7	50 mins	35 mins
Total					190.49	190.49	1	1	17	19	85 mins	80 mins

For Chiang Mai International Airport, the total connecting passenger demand would be increased from 162.18 to 173.1 per day or almost 7% and the number of connections is raised to 72 airports in total which is 4.35 % more than currently. Moreover, idle time which exceed standard ground time also reduced at 10 minutes in total which makes the aircrafts more utilise.

For Phuket, with the current flight timetable, the total connecting passenger demand is about 315 with 35 possible connections. But after this timetable improvement, the total demand would increase around 2.7% to 324 approximately and the 6 connections is added. However, the total utilise hour is decreased 10 minutes in total.

4.6 Flight timetable to increase connecting passenger

To summarise the result from both solutions, a final time table is developed as below. The highlighted rows are new added flights while the rest are adjusted flights based on current timetable.

Table 20: New flight timetable for all potential O&D markets

Dpt. Port	Dpt. Time	Arv. Port	Arv. Time
BKK	08:40	CNX	09:55
CNX	10:35	BKK	11:50
BKK	10:35	CNX	11:50
CNX	12:25	BKK	13:35
BKK	15:25	CNX	16:40
CNX	17:10	BKK	18:25
BKK	19:45	CNX	21:00
CNX	06:55	BKK	08:10
BKK	08:00	CNX	09:15
CNX	15:10	BKK	16:25
BKK	07:10	HKT	08:35
HKT	09:35	BKK	11:00
BKK	12:00	HKT	13:25
HKT	14:25	BKK	15:50
BKK	15:25	HKT	16:45
HKT	17:45	BKK	19:10
BKK	19:25	HKT	21:10
HKT	11:20	BKK	12:45
BKK	19:40	HKT	21:05
HKT	22:05	BKK	22:30

With the new developed timetable, the total connecting passenger demand would be increase about 46.76% from 491.87 to 1,051.86 and the number of connections from the primary airline's perspective is raised from 140 to 179 which is 78.21% more than previous. Furthermore, the utilisation also increased 3 hours from the new added turnaround flights.

4.7 Minimum required fleet

Apart from time and demand constains the mentioned earlier, resource is also important. Nowadays, the subsidiary own 20 aircrafts in total and 5 aircrafts are totally available. Therefore, the required fleet for new timetable must not exceed 5.

By using Greedy Algorithm which is a kind of best-first search to measure the number of minimum required aircrafts, the result shows that at least 5 aircrafts are needed to operate all flights in the new time table. The fleet assignment for each flight is done as shown in *Figure 63*.

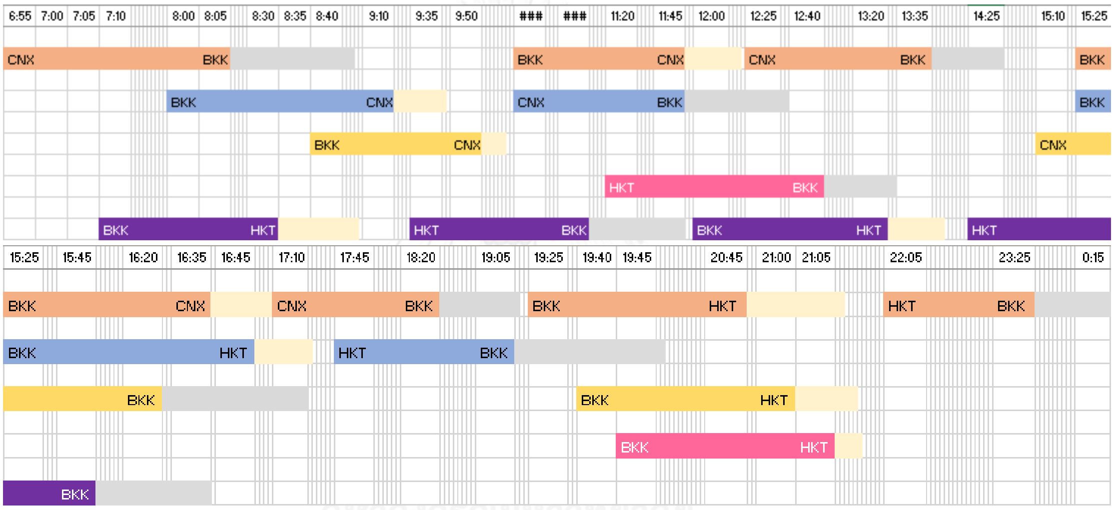


Figure 63: Fleet assignment to all flights in new developed timetable

CHAPTER 5: ANALYSIS & DISCUSSION

5.1 Overview

To recap the flight timetable development process in this study is separated into 3 phases following the purposes. The first phase is preparation. All information that required for flight timetable construction is obtained and gathered. Ideal timetable was created in step with the forecasted demand in each time-slot. During data clarification and demand forecast, the author found important factor that cause the significantly impact on connecting demand which will be described below. After that, the new flight timetable was developed in the second phase with the aim to increase connecting passenger. The ideal timetable was used as reference to find the best solution for flight time adding and adjustment. Lastly, the feasibility check was done to ensure the sufficient of capability. For the last two phases, heuristic plays a key role in development and checking. The author found some limitation of this approach in during the actual adaptation and the limitation will be discussed in this chapter.

5.2 Limitations of findings

5.2.1 Affecting factors on connecting demand

According to the problem from previous flight timetable which was developed based on the number of connections only, therefore, in the study, the demand in targeted O&D market had been involved in the consideration. Before the research process starts, the author presumed that passenger demand in O&D market is the main factor which drives connecting demand in between that particular origin and destination. Differently from the hypothesis, from the research, the historical demand reveals that the demand in O&D market is not always reflect on connecting demand but the competitors in direct market always do. According to the demand in route HKG-BKK-CNX, after the competitor start operating direct flight in this market, the demand was significantly dropped until connecting demand is so poor. Apart from the competitor, the study reveal that seat capacity also influences to connecting demand as well. However, the competitors and seat capacity are not always effect to connecting demand in every market. Therefore, the thoroughly study about these factors including with others affecting external factors would help for accuracy improvement in forecast.

5.2.2 Heuristic search algorithm

To solve the flight timetabling problems, the author adopted an optimal heuristic search namely, Branch-and-Bound. By using this technique, the author aims to obtain the best solution regarding to airline’s objective with less time than optimal search process. However, practically, this method was not help to reduce total execution time since all possible time-slot need to be individually checked. The reason is because of the data. According to literature review in section 2.8.1, since complete path is not required for BnB, the execution time can be reduced from this point. However, in this research, the weight of each arc which is demand is not much different so completed path need to be done for the comparison. Besides, due to the small size of data set, heuristic and optimal search do not provide the significant difference. However, if this model is applied to larger data set with the wide range of demand in considered time-slots, the total execution time for problem solving in both method might significantly different.

Another searching algorithm that employed in this study is Greedy algorithm which is a kind the easiest best-first search. In the last step of timetabling development, the author used this algorithm to measure the minimum required fleet. However, the plan that obtained from this section cannot practically used for fleet assignment and allocation because the utilisation rate of aircraft will be so poor.

Regarding to the *Figure 63* in chapter 4, section 4.7, the aircraft which would travel along the provided route in the first row has to start the trip at Chiang Mai International Airport and finished at Phuket International Airport. Besides, there is no route start from Phuket International Airport and back to Chiang Mai International Airport. As a result, empty flight operation is needed to bring the aircraft back to the start point. Practically, airline does not appreciate to operate flight without any benefit, therefore, the circumstance like this must be avoided. With this reason, the additional constraints are strongly needed to ensure that no empty flight operation is required and makes the plan more practical.

5.3 Company feedback

From the result of this study, the airline could increase the high volume of connecting passenger and the number of connection without utilisation loss. Thus, the airline is very appreciated. However, the airline worry that proposed flight time might not available and must be checked with the airports' officers.

The evaluation form with feedback from the airline's manager of flight planning department is shown in *Appendix E*.

CHAPTER 6: CONCLUSION

6.1 Conclusion

The statement of this research is to increase connecting international passenger through the flight timetable development. Start off the study, the problem that subsidiary airline is facing which bring about this project were discussed. With an aim to extend air network for more competitive advantage, the subsidiary airline planned to collaborate with the primary airline by playing a role of feeder who provides seamless connectivity between international and domestic flights and help the primary airline to distribute passenger within country.

The individual interview session with airline's planning manager was set in order obtain more understanding about current situation and scheduling process. From the interview, the author found that company only used the number of offered connections in each flight to estimate the connectivity performance and develop the new flight timetable to serve connecting passenger. However, this was not quite efficient as expected in practical term. The main reason is the number of connections does not always reflect on demand if the offered connections cannot satisfy passenger. As checked, apart from the lack of connectivity, demand was very poor in almost of all O&D markets where the subsidiary flight was offering. With this reason, the expert suggested to use demand as the first criteria for new flight timetable development.

However, there are some related constraints that must be considered and aware during the scheduling process are identified. The constraints can be classified into 2 aspects which are time and demand. For time constraints, 2 sub-types are explained base on perspective. First is from airline's viewpoint and the second comes from passenger's. For the airline, time constraints mainly come from operational activities. Since many sequential tasks are needed to be done after the aircraft reach the destination airport such as baggage loading, cabin clean up and preparation for the next flight, aircraft checking and maintenance. Therefore, at least 50 and 30 minutes are required at Suvarnabhumi International Airport and province airports respectively. Besides, since flight time would influences the utilisation of aircrafts, the gap time between two consequent flight at the same airport is limited at 1 hour in order to sustain the utilisation rate. Lastly, from marketing aspect, to prevent the competition on market share between the primary and subsidiary airline, the new added flight within the same range of 30 minutes which is the maximum acceptable time flexibility must be avoided. Another perspective belongs to passenger, due to the immigration and disembarkation process, passenger need some spare times before continue their travelling via the connecting flight. However, too long spare time will reduce connectivity performance. Therefore, the subsidiary airline limited maximum passenger acceptable waiting time at 3 hours refer to company's internal research.

Focus on demand, in order to scope down the number of considered O&D market, the average 5-year historical demand must higher that 0.5% of average total demand from 2011-2015 based on data in Star Alliance's database which are equal to 293 and 274 for inbound and outbound flight respectively while the market with lower demand than 0.5% of total average demand is considered as insignificant which can ignore. Furthermore, to ensure the new added flight would have sufficient demand to cover operation cost, at least 60% of maximum aircraft capacity or 100 passengers is required per flight. All mentioned time and demand constraints are transformed into mathematical equations for further application.

To determine the potential times for connectivity and network expansion, the ideal flight timetable was constructed by applying the concept of visualisation in wave-system structure including with passenger's time constraints. Then, the forecasted demand was summarised and assigned for each time-slot. To obtained forecasted demand, Holt-Winter model was adopted with 5-year historical demand from Star Alliance in all O&D markets except the market with insignificant demand as ruled earlier in section 3.3.2.

The reason that author use Holt-Winter model is because of seasonal demand characteristic which match the most with this method. Regarding to the completed ideal flight timetable with summary of forecasted demand, the top 10 time-slot were ranked base on two criteria which are demand and number of connections. The reason that demand was used as the first priority because this research aim to eliminate weakness from the flight time selection process that airline did before as explained earlier. However, the number of connections cannot be ignored since it refers to the possibility in market growth and expansion. Furthermore, the high demand O&D market does not good in long term if that market has already saturated.

In this research, the connecting flight timetable was developed by new flight adding and flight time adjustment. The reason that two techniques are used because even the airline aim to obtain more passenger, the point-to-point demand still important and must be remained. Otherwise the added connecting passenger from new developed timetable would be worthless. Therefore, two flight time tabling model were developed from formulated constraints and solved separately for each method. According to airline's requirement only one pair of flight which would offer the highest advantages to the airline is needed in the first phase of development. The model of flight timetable at this section was solve with heuristic approach called Branch-and-Bound algorithm. As the result, 2 new additional flights which would be operated with an aim to serve connecting passengers only were acquired from the first model. In term of efficiency, 3 factors; demand, connections, and utilisation of aircraft were assessed.

For the second method, all current flights were considered and allocated under time constraints that declared earlier. In this section, best-first search was applied for problem solving. To summarise, the final timetable was constructed from the combination of both methods' result. The first priority was given to additional flights because these especially developed to serve connecting passenger while the adjusted flight was just adjunct so it was considered as the second priority. To evaluate the performance of new timetable, 4 indicators were used which are demand, the number of competitors, connections, and utilisation hours. After combined the result from two timetabling methods together to construct the final flight timetable, the result shows that total connecting demand would raise around 46.76% from average demand of past 5 year and the number of possible connections from inbound and outbound flight are increased from 140 to 179 in total. Moreover, the utilisation hour would increase 3 hours.

Lastly, to ensure that the developed timetable is practical, the minimum required fleet was measured and compared with the existing aircraft resource. Greedy algorithm which is a kind of heuristic search was adopted for solution finding. As a result, the author found that at least 5 aircrafts are needed to operate all flights in the developed timetable which is equal the number of current available aircraft.

6.2 Contribution

According to many researches about flight scheduling where connectivity is the main concern, the complicated model was developed and employed. Due to the complexity, the model is not possible to be solved manually, thus programming calculation is strongly needed and this cost quite a lot to the company. For the new airline where large amount of investment has been paid in establishment already, therefore, it would be helpful if the capital investment on planning can be reduced. By using the timetabling model that provided in this study, the problem can be manually solved because the problem was broken down into many small sets. Then apply heuristic to find the proper solution.

6.3 Limitation of study

Since this study used heuristic as the main approaches to obtain the result, therefore, the developed timetable might not be the optimal one but just good enough according to the airline's objective. Furthermore, the flight scheduling model and solution that developed in this research are potentially useful for small scale problem, especially for the new subsidiary airline where operating route is not much.

Otherwise, the number of iteration in solution finding process would be so high that very long execution time is needed. Lastly, profit and cost are neglected in this research so the model is not applicable for any cases that cost is the main concern.

6.4 Future recommendation research

In the last step of flight timetable development in this research, the author just checked the minimum required fleet for only 2 potential airports which are Phuket International Airport and Chiang Mai International Airport. From the study, the author found that even greedy algorithm for fleet assignment always gives the best solution in every single step but the solution might not be the optimal if the start and end airport of the particular aircraft is different. With this reason, fleet rotation is very helpful for the problem solving. Since each aircraft can be rotated to more than 1 route. For an example, A32S-1 travel roundtrip between Bangkok, Suvarnabhumi International Airport and Chiang Mai International Airport. After that it could be assigned to international route like Cebu and finished there. At the same day, there is another fleet, A32S-2 which starts the travel from Cebu and ends at Bangkok, Suvarnabhumi International Airport. Therefore, these 2 aircrafts swap the route with each other on odd and even date. Furthermore, due to the relative rotation among aircraft, the changes in some flight could influence to the others within the network. Consequently, all flights must be involved in consideration for fleet planning to maximise the utilisation of aircraft.

Another concerning point is actual flight time. In this research the time was provided based on calculation and theory while this might not available in practical due to the limitation of airport time-slot and resource. Therefore, the provided solution can be only used as a guideline. Additional research on actual available time must be done to make this plan more practical.

In this study, the connection is limited between the primary and subsidiary airline only, but in the future, the subsidiary airline can extend the scope to satisfy passenger from others international airline as well in order to make the higher volume of connecting passenger which could bring about the higher profit accordingly.

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APPENDIX

Appendix A: Passenger Choice Model

Model VMSFSM

Min.

$$\sum_{ij\in A} c_{ij}X_{ij} + \sum_{n\in N}\sum_{ij\in B_n} t_{ij}^{n}Y_{ij}^{n}. \quad (3)$$

St.

$$\sum_{j\in NF} X_{ij} - \sum_{k\in NF} X_{ki} = 0, \quad \forall i \in NF, \quad (4)$$

$$\sum_{j\in NP_n} Y_{ij}^{n} - \sum_{k\in NP_n} u_{ki}^{n}Y_{ki}^{n} = b_i^{n},$$
$$\forall i \in NP_n, \forall n \in N, \quad (5)$$

$$b_i^{n} = p_i^{n}\frac{e^{v_{ia}^{n}}}{\sum_{d\in D} e^{v_{id}^{n}}}, \quad \forall i \in NP_n, \forall n \in N, \quad (6)$$

$$v_{ia}^{n} = \alpha_1^{n}dv_a^{n} + \alpha_2^{n}ff_{ia}^{n} + \alpha_3^{n}at_a^{n} + \alpha_4^{n}wt_{ia}^{n} + \alpha_5^{n}tt_{ia}^{n},$$
$$\forall i \in NP_n, \forall n \in N, \quad (7)$$

$$ff_{ia}^{n} = f_{ff}^{n}(X_{kj}, \forall kj \in TF_i^{n}, tf(i) \leqslant k \leqslant tf(i) + ut^{n}),$$
$$\forall i \in NP_n, \forall n \in N, \quad (8)$$

$$wt_{ia}^{n} = f_{wt}^{n}(X_{kj}, \forall kj \in TH_i^{n}, tf(i) \leqslant k \leqslant tf(i) + ut^{n}),$$
$$\forall i \in NP_n, \forall n \in N, \quad (9)$$

$$tt_{ia}^{n} = f_{tt}^{n}(X_{kj}, \forall kj \in TFH_i^{n}), \quad \forall i \in NP_n, \forall n \in N, \quad (10)$$

$$\sum_{ij\in CF} X_{ij} \leqslant af, \quad (11)$$

$$\sum_{ij\in s^g} X_{ij} \leqslant q^g, \quad \forall g \in SA, \quad (12)$$

$$\sum_{n\in N} Y_{ij}^{n} \leqslant kX_{ij}, \quad \forall ij \in FF, \quad (13)$$

$$u_{kj}^{n} = 1, \quad \forall kj \in NFF_n, TDF_n, \forall n \in N,$$
$$u_{kj}^{n} = 0, \quad \forall kj \in DF_n, CF_n, \forall n \in N,$$
$$u_{kj}^{n} = \frac{e^{v_{ja}^{n}}}{\sum_{d\in D_i^{n}} e^{v_{jd}^{n}}}, \quad \forall kj \in OF_n, \forall n \in N, \quad (14)$$

$$0 \leqslant X_{ij} \leqslant uf_{ij}, \quad \forall ij \in A, \quad (15)$$

$$0 \leqslant Y_{ij}^{n} \leqslant up_{ij}^{n}, \quad \forall ij \in B_n, n \in N, \quad (16)$$

$$X_{ij} \in I, \quad \forall ij \in A. \quad (17)$$

Notation and symbols

Sets:

N the set of all ODs;
A, NF the set of all arcs and nodes in the fleet network;
CF the set of all cycle arcs in the fleet network;
B_n, NP_n the set of all arcs and nodes in the nth passenger network;
FF the set of all flight leg arcs in the fleet network;
S^g the set of flight leg arcs at the gth station in the fleet network;
TF_i^n the set of all flight leg arcs that can deliver passengers from node i (departure station) to the arrival station within the passenger acceptable in the nth passenger network;
TH_i^n the set of all holding arcs at the departure station from node i to later nodes within the passenger acceptable waiting time in the nth passenger network;
TFH_i^n the set of all flight leg and holding arcs that can deliver passengers from node i (departure station) to the arrival station in the nth passenger network;
SA the set of all stations;
NFF_n the set of all delivery arcs in the nth passenger network;

TDF_n the set of holding arcs at all intermediate stations in the nth passenger network;
OF_n the set of holding arcs at the departure station in the nth passenger network;
DF_n the set of holding arcs at the arrival station in the nth passenger network;
CF_n the set of all collection arcs in the nth passenger network.

Decision variables:

X_{ij} arc(i, j) flow in the fleet network;
Y_{ij}^n arc(i, j) flow in the nth passenger network.

Functions and parameters:

$f^n_{fr}()$ the flight frequency function in the nth passenger network;

$f^n_{wt}()$ the passenger waiting time function in the nth passenger network;

$f^n_{tt}()$ the travel time function in the nth passenger network;

(Note that the flight leg arcs and/or holding arcs associated with the nth passenger network can be traced in functions $f^n_{fr}()$, $f^n_{wt}()$ and $f^n_{tt}()$).

$tf(i)$ the function that gives the time associated with node i;

N the nth OD pair (i.e. the nth passenger network);

p^n_i the number of passengers at node i in the nth passenger network;

c_{ij} arc(i, j) cost in the fleet network;

t^n_{ij} arc(i, j) cost in the nth passenger network;

af the number of available airplanes in the fleet network;

ut^n the acceptable time that passengers are willing to stay for a flight in the nth passenger network (represented as the number of nodes);

q^g the quota of flights approved for landing at the gth station;

K the aircraft capacity (note that a planning maximum load factor can be used in the planning stage to avoid overloaded of airplanes due to stochastic demands in operations);

uf_{ij} arc(i, j) flow's upper bound in the fleet network;

up^n_{ij} arc(i, j) flow's upper bound in the nth passenger network;

b^n_i the trip supplies at node i in the nth passenger network;

Appendix B: Interview

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Date: 7 Mar. 2016

Interview

Cadidate's name: Wotcharin Thatan

Interviewed by: Natravee Deewattanarkul

1. To increase the connecting passenger, which one is the most important thing in your opinion?
   - ☑ O&D Market demand
   - ☐ Number of possible connections
   - ☐ Other ....

2. From your experiences, what are the affecting factors which could significantly influence the connecting demand and must be concerned for this airline's flight timetabling?

   1. Waiting time : The seamless connectivity is the ideal connectivity to provide the fastest connecting flight ; however, every passenger would require the ground time about 1 hour and 15 minutes for the transition. But the maximum waiting time must not exeed 3 hours.
   2. Seat capacity : The seat capacity partially impacts the demand pattern because the demand could be reduced when the capacity is removed.

3. Suggestions

Afterall, the point of connectivity improvement is to increase the passenger demand in order to fill the loading factor; so that, the flight could be profitable. Where, the break-even loading factor of the new timetable should be around 60% of the aircraft.

(Interviewee Signature)

Appendix C: Forecasted Demand

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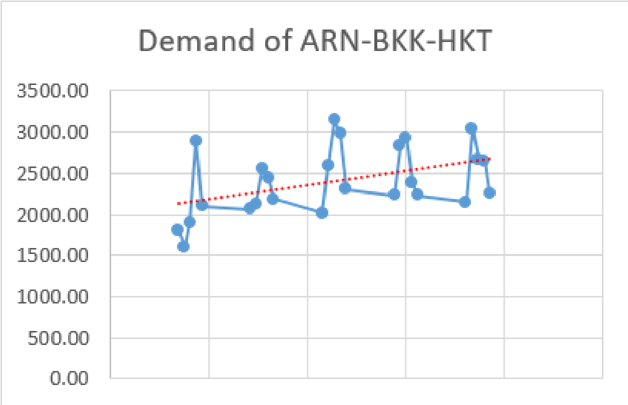

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22	2547
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T_0	L_0

Period	M/Y	Actual D	DD	Dt	SF
1	Nov-11	[redacted]		2165.51	[redacted]
2	Dec-11	1600.00		2188.42	0.73112
3	Jan-12	1900.00	2060	2211.32	[redacted]
4	Feb-12	2900.00	2113.4	2234.23	1.29799
5	Mar-12	[redacted]	[redacted]	2257.13	[redacted]
6	Nov-12	[redacted]	2346	2280.04	1.01182
7	Dec-12	2116.00	[redacted]	2302.95	0.91882
8	Jan-13	2547.00	2271.8	2325.85	[redacted]
9	Feb-13	2445.00	2260.8	2348.76	1.04098
10	Mar-13	[redacted]	[redacted]	2371.66	[redacted]
11	Nov-13	2012.00	[redacted]	2394.57	0.84023
12	Dec-13	2597.00	2584.2	2417.47	1.07426
13	Jan-14	[redacted]	2608.8	2440.38	1.24776
14	Feb-14	2976.00	2652.4	2463.29	1.20814
15	Mar-14	[redacted]	[redacted]	2486.19	[redacted]
16	Nov-14	2230.00	[redacted]	2509.1	0.88877
17	Dec-14	2826.00	[redacted]	2532	1.11611
18	Jan-15	2928.00	[redacted]	2554.91	1.14603
19	Feb-15	[redacted]	[redacted]	2577.82	[redacted]
20	Mar-15	2231.00	2545.4	2600.72	0.85784
21	Nov-15	2143.00	2493.4	2623.63	0.81681
22	Dec-15	[redacted]	2547	2646.53	0
23	Jan-16	2668.00	[redacted]	2669.44	[redacted]
24	Feb-16	[redacted]		2692.35	0
25	Mar-16	2255.00		2715.25	0.83049

Period	M/Y	AD	DD	Dt	St	Level	Trend	Forecast	E	AE	MSE	MAD	%Error	MAPE
0						2142.6	22.906							
1	Nov-11	[redacted]		2165.5	[redacted]	2183.6	24.717	[redacted]	55.23	55.228	3050.2	55.228	3.0682	3.0682
2	Dec-11	1600.00		2188.4	0.9982	2207.5	24.637	2204.3069	604.31	604.31	184119	329.77	37.769	20.419
3	Jan-12	1900.00	2060	2211.3	1.0783	2223.1	23.73	[redacted]	506.91	506.91	208397	388.81	26.679	22.506
4	Feb-12	2900.00	2113.4	2234.2	1.0908	2236.9	22.738	2450.8033	-449.20	449.2	206742	403.91	15.49	20.752
5	Mar-12	[redacted]	[redacted]	2257.1	0.8935	2273	24.07	[redacted]	-81.00	80.999	166706	339.33	3.8571	17.373
6	Nov-12	[redacted]	2346	2280	0.8535	2315.8	25.942	[redacted]	-106.53	106.53	140813	300.53	5.1537	15.336
7	Dec-12	2116.00	[redacted]	2302.9	[redacted]	2343.2	26.094	[redacted]	157.42	157.42	124237	280.08	7.4393	14.208
8	Jan-13	2547.00	2271.8	2325.9	1.0559	2361	25.261	2501.8043	-45.20	45.196	108962	250.72	1.7745	12.654
9	Feb-13	2445.00	2260.8	2348.8	1.1113	2372.6	23.897	[redacted]	206.95	206.95	101614	245.86	8.4641	12.188
10	Mar-13	[redacted]	[redacted]	2371.7	0.8965	2408.9	25.141	[redacted]	-35.43	35.429	91578	224.82	1.6222	11.132
11	Nov-13	2012.00	[redacted]	2394.6	[redacted]	2452	26.935	[redacted]	74.96	74.958	83764	211.19	3.7256	10.458
12	Dec-13	2597.00	2584.2	2417.5	0.9641	2480.4	27.078	2389.8618	-207.14	207.14	80359	210.85	7.9761	10.252
13	Jan-14	[redacted]	2608.8	2440.4	1.0582	2497.4	26.072	2653.4171	-498.58	498.58	93299	232.99	15.818	10.68
14	Feb-14	2976.00	2652.4	2463.3	1.1033	2508.9	24.618	[redacted]	-191.94	191.94	89267	230.06	6.4496	10.378
15	Mar-14	[redacted]	[redacted]	2486.2	[redacted]	2545.4	25.8	2273.9986	-33.00	33.001	83388	216.92	1.4305	9.7811
16	Nov-14	2230.00	[redacted]	2509.1	0.8537	2589.6	27.64	[redacted]	-34.97	34.974	78253	205.55	1.5683	9.2678
17	Dec-14	2826.00	[redacted]	2532	0.9724	2616.6	27.574	[redacted]	-281.14	281.14	78299	209.99	9.9485	9.3079
18	Jan-15	2928.00	[redacted]	2554.9	[redacted]	2630.4	26.197	2851.9403	-76.06	76.06	74271	202.55	2.5977	8.9351
19	Feb-15	[redacted]	[redacted]	2577.8	[redacted]	2639.7	24.509	[redacted]	572.90	572.9	87636	222.04	24.071	9.7317
20	Mar-15	2231.00	2545.4	2600.7	0.8984	2675.7	25.662	2393.5916	162.59	162.59	84576	219.07	7.2878	9.6095
21	Nov-15	2143.00	2493.4	2623.6	0.8544	2719.8	27.508	2308.1897	165.19	165.19	81848	216.51	7.7083	9.519
22	Dec-15	[redacted]	2547	2646.5	0.9831	2744.6	27.231	[redacted]	-344.02	344.02	83507	222.3	11.298	9.5999
23	Jan-16	2668.00	[redacted]	2669.4	[redacted]	2756.6	25.707	[redacted]	331.24	331.24	84647	227.04	12.415	9.7223
24	Feb-16	[redacted]		2692.3	[redacted]	2766.6	24.14	3034.2377	386.24	386.24	87336	233.67	14.586	9.9249
25	Mar-16	2255.00		2715.3	0.892	2803.4	25.407	[redacted]	234.25	234.25	86037	233.7	10.388	9.9434
26	Oct-16				0.8478			2398.2561						
27	Nov-16				[redacted]			[redacted]						
28	Dec-16				[redacted]			3083.0257						
29	Jan-17				[redacted]			[redacted]						
30	Feb-17				0.8832			[redacted]						

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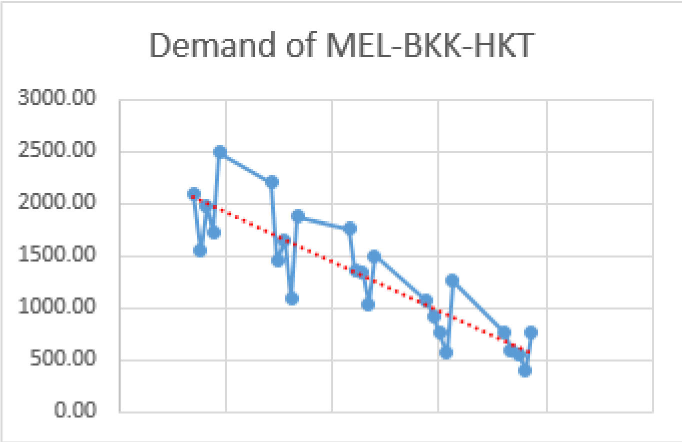

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T_0	L_0

Period	M/Y	Actual D	DD	Dt	SF
1	Nov-11	[redacted]		[redacted]	[redacted]
2	Dec-11	1555.00		2135.55	0.72815
3	Jan-12	1977.00	1971.6	2062.1	0.95873
4	Feb-12	1731.00	1993.8	1988.64	0.87044
5	Mar-12	[redacted]	[redacted]	[redacted]	[redacted]
6	Nov-12	2209.00	1910	1841.74	1.19941
7	Dec-12	[redacted]	[redacted]	[redacted]	[redacted]
8	Jan-13	1657.00	1656.8	1694.83	0.97768
9	Feb-13	1088.00	1568.2	1621.38	0.67104
10	Mar-13	1874.00	1548.4	1547.92	1.21065
11	Nov-13	[redacted]	[redacted]	[redacted]	[redacted]
12	Dec-13	[redacted]	[redacted]	[redacted]	[redacted]
13	Jan-14	1337.00	1400.4	1327.56	1.00711
14	Feb-14	1038.00	1261	1254.11	0.82768
15	Mar-14	1504.00	1175.2	1180.65	1.27387
16	Nov-14	[redacted]	[redacted]	[redacted]	[redacted]
17	Dec-14	928.00	965.6	1033.75	0.8977
18	Jan-15	[redacted]	[redacted]	[redacted]	[redacted]
19	Feb-15	569.00	855.4	886.841	0.6416
20	Mar-15	1260.00	790.2	813.387	1.54908
21	Nov-15	[redacted]	[redacted]	[redacted]	[redacted]
22	Dec-15	[redacted]	[redacted]	[redacted]	[redacted]
23	Jan-16	[redacted]	[redacted]	[redacted]	[redacted]
24	Feb-16	410.00		519.573	0.78911
25	Mar-16	[redacted]		[redacted]	[redacted]

Period	M/Y	AD	DD	Dt	St	Level	Trend	Forecast	E	AE	MSE	MAD	%Error	MAPE
0						2282.5	-73.45351							
1	Nov-11	[redacted]		[redacted]	[redacted]	2201.9	-74.16101	[redacted]	262.19	262.19	68743	262.19	12.497	12.497
2	Dec-11	1555		2135.6	0.8642	2144.9	-72.44444	1838.9	283.85	283.85	74658	273.02	18.254	15.376
3	Jan-12	1977	1971.6	2062.1	0.9361	2079	-71.79269	1940.1	-36.92	36.925	50226	194.32	1.8677	10.873
4	Feb-12	1731	1993.8	1988.6	0.76	2037.7	-68.74513	1525.4	-205.6	205.57	48235	197.13	11.876	11.124
5	Mar-12	[redacted]	[redacted]	[redacted]	[redacted]	1938.2	-71.81557	[redacted]	286.25	286.25	54975	214.96	11.464	11.192
6	Nov-12	2209	1910	1841.7	1.0569	1860.2	-72.43458	1972.6	-236.4	236.42	55128	218.53	10.703	11.11
7	Dec-12	[redacted]	[redacted]	[redacted]	[redacted]	1802.4	-70.97549	[redacted]	64.152	64.152	47841	196.48	4.4061	10.152
8	Jan-13	1657	1656.8	1694.8	0.9376	1735.2	-70.59435	1623.4	-33.64	33.64	42002	176.12	2.0302	9.1372
9	Feb-13	1088	1568.2	1621.4	0.7689	1686.8	-68.37439	1280	191.98	191.98	41430	177.89	17.645	10.082
10	Mar-13	1874	1548.4	1547.9	1.401	1592.8	-70.9425	2267.5	393.53	393.53	52774	199.45	20.999	11.174
11	Nov-13	[redacted]	[redacted]	[redacted]	[redacted]	1514.6	-71.66122	[redacted]	-137.7	137.73	49701	193.84	7.7992	10.867
12	Dec-13	[redacted]	[redacted]	[redacted]	[redacted]	1453.6	-70.59635	1220.8	-136.2	136.17	47104	189.03	10.035	10.798
13	Jan-14	1337	1400.4	1327.6	0.9393	1384.6	-70.44496	1299.1	-37.88	37.879	43591	177.41	2.8332	10.185
14	Feb-14	1038	1261	1254.1	0.7565	1331.3	-68.72697	994.16	-43.84	43.835	40615	167.87	4.223	9.7594
15	Mar-14	1504	1175.2	1180.7	1.3786	1242.3	-70.75767	1740.6	236.56	236.56	41638	172.45	15.729	10.157
16	Nov-14	[redacted]	[redacted]	[redacted]	[redacted]	1164.2	-71.48702	[redacted]	195.67	195.67	41429	173.9	18.304	10.667
17	Dec-14	928	965.6	1033.7	0.8548	1098.5	-70.90382	934.04	6.0439	6.0439	38994	164.02	0.6513	10.077
18	Jan-15	[redacted]	[redacted]	[redacted]	[redacted]	1027.2	-70.94469	[redacted]	210	210	39277	166.58	27.704	11.057
19	Feb-15	569	855.4	886.84	0.7588	966.91	-69.88281	725.68	156.68	156.68	38502	166.06	27.536	11.924
20	Mar-15	1260	790.2	813.39	1.3618	882.04	-71.38151	1221.6	-38.43	38.425	36651	159.68	3.0496	11.48
21	Nov-15	[redacted]	[redacted]	[redacted]	[redacted]	804.91	-71.95572	[redacted]	100.06	100.06	35382	156.84	13.131	11.559
22	Dec-15	[redacted]	[redacted]	[redacted]	[redacted]	735.34	-71.71744	[redacted]	23.792	23.792	33800	150.79	3.9521	11.213
23	Jan-16	[redacted]	[redacted]	[redacted]	[redacted]	662.62	-71.81802	[redacted]	49.564	49.564	32437	146.39	8.8193	11.109
24	Feb-16	410		519.57	0.7418	596.28	-71.26996	438.26	28.263	28.263	31119	141.47	6.8933	10.933
25	Mar-16	[redacted]		[redacted]	[redacted]	515.06	-72.26503	[redacted]	-53.53	53.534	29989	137.95	6.9345	10.773
26	Oct-16				1.0517			465.7						
27	Nov-16				0.8503			315.05						
28	Dec-16				0.9142			272.68						
29	Jan-17				0.7364			166.42						
30	Feb-17				1.3815			212.39						

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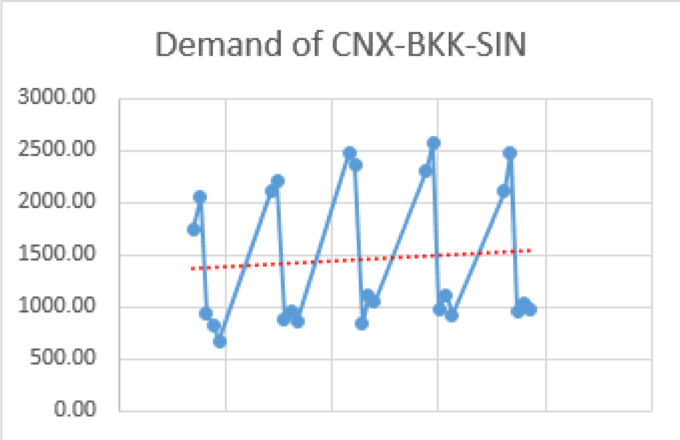

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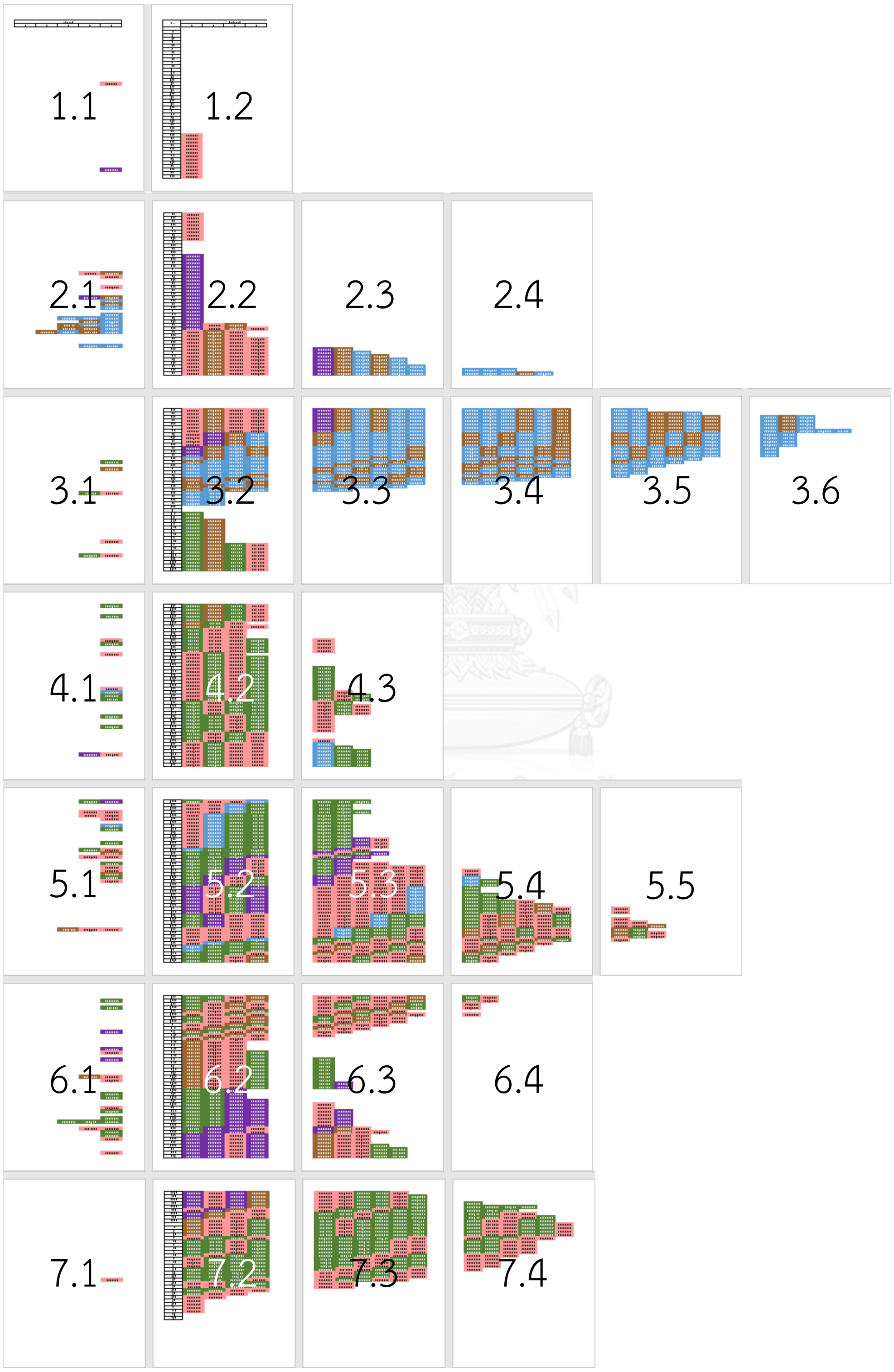
T_0	L_0

Period	M/Y	Actual D	DD	Dt	SF
1	Nov-11	1739.00		1327.64	1.30984
2	Dec-11	2055.00		1340.38	1.53315
3	Jan-12	[redacted]	[redacted]	[redacted]	[redacted]
4	Feb-12	[redacted]	[redacted]	[redacted]	[redacted]
5	Mar-12	673.00	1349.3	1378.59	0.48818
6	Nov-12	2107.00	1339.6	1391.33	1.51438
7	Dec-12	[redacted]	[redacted]	[redacted]	[redacted]
8	Jan-13	882.50	1404.85	1416.8	0.62288
9	Feb-13	967.00	1478.45	1429.54	0.67644
10	Mar-13	[redacted]	[redacted]	[redacted]	[redacted]
11	Nov-13	[redacted]	[redacted]	[redacted]	[redacted]
12	Dec-13	2356.00	1526.25	1467.76	1.60517
13	Jan-14	834.00	1564.1	1480.49	0.56333
14	Feb-14	1104.00	1531.3	1493.23	0.73934
15	Mar-14	[redacted]	[redacted]	[redacted]	[redacted]
16	Nov-14	2311.00	1602.5	1518.71	1.52169
17	Dec-14	2567.00	1605.3	1531.44	1.6762
18	Jan-15	[redacted]	[redacted]	[redacted]	[redacted]
19	Feb-15	[redacted]	[redacted]	[redacted]	[redacted]
20	Mar-15	927.00	1522.6	1569.66	0.59058
21	Nov-15	2109.00	1518.6	1582.39	1.33279
22	Dec-15	2480.00	1502	1595.13	1.55473
23	Jan-16	[redacted]	[redacted]	[redacted]	[redacted]
24	Feb-16	[redacted]	[redacted]	[redacted]	[redacted]
25	Mar-16	979.00		1633.34	0.59938

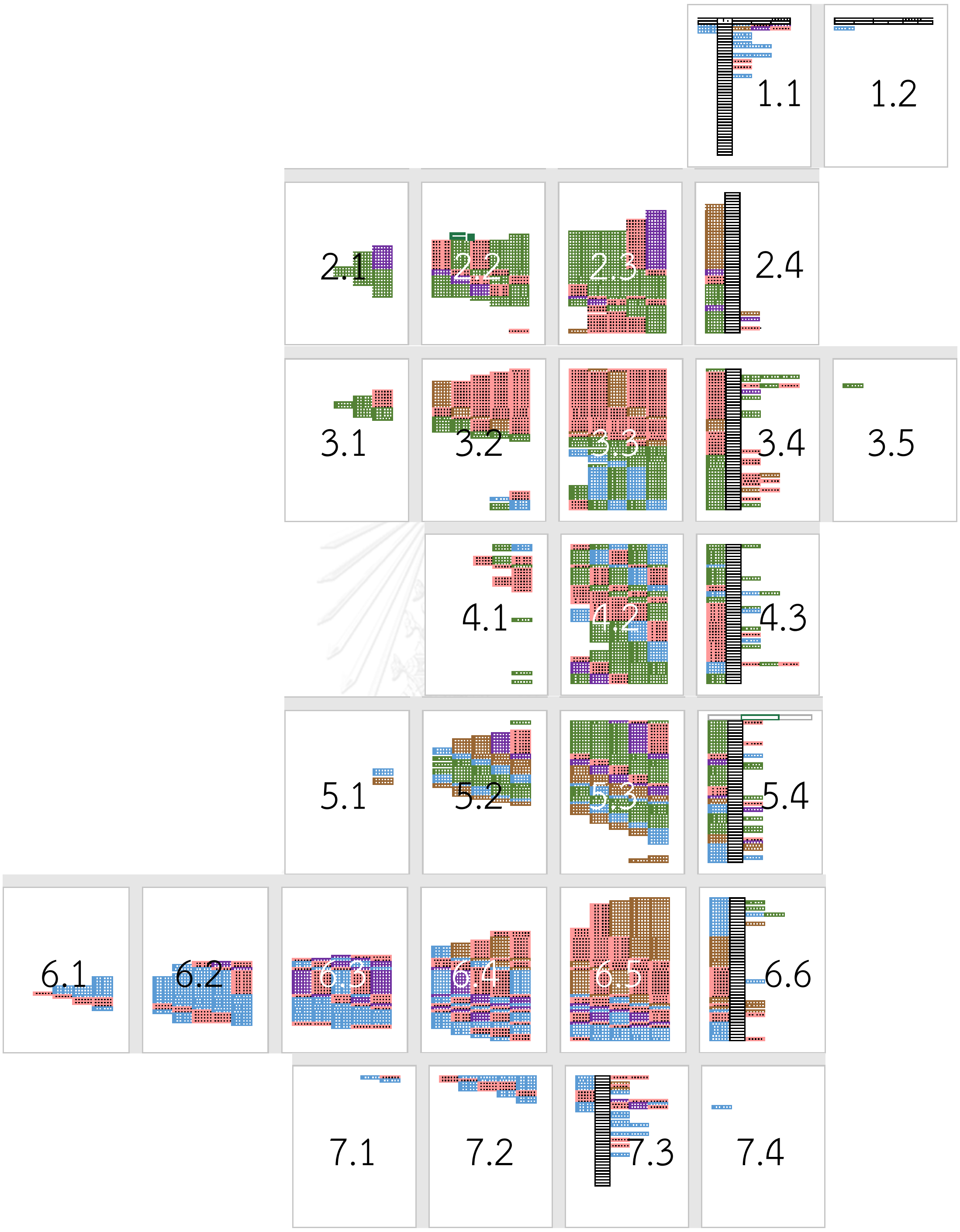
Period	M/Y	AD	DD	Dt	St	Level	Trend	Forecast	E	AE	MSE	MAD	%Error	MAPE
0						1314.9	12.737597							
1	Nov-11	1739		1327.6	1.4759	1306.2	10.596996	1959.5	220.52	220.52	48630	220.52	12.681	12.681
2	Dec-11	2055		1340.4	1.588	1293.2	8.2331481	2091.1	36.141	36.141	24968	128.33	1.7587	7.2199
3	Jan-12	[redacted]				1345.3	12.621787	[redacted]	-122.9	122.9	21680	126.52	13.2	9.2134
4	Feb-12					1391.1	15.934016		88.016	88.016	18197	116.89	10.604	9.5611
5	Mar-12	673	1349.3	1378.6	0.5948	1452.5	20.486987	836.93	163.93	163.93	19932	126.3	24.359	12.521
6	Nov-12	2107	1339.6	1391.3	1.4615	1447	17.88195	2152.8	45.771	45.771	16959	112.88	2.1723	10.796
7	Dec-12	[redacted]				1435.8	14.978293	[redacted]	120.84	120.84	16623	114.02	5.4789	10.036
8	Jan-13	882.5	1404.9	1416.8	0.628	1491	19.003851	911.16	28.658	28.658	14647	103.35	3.2473	9.1877
9	Feb-13	967	1478.5	1429.5	0.6681	1541.5	22.152195	1008.9	41.86	41.86	13215	96.515	4.3289	8.6479
10	Mar-13	[redacted]				1609.5	26.731159	[redacted]	47.324	47.324	12117	91.596	5.4884	8.3319
11	Nov-13					1604.2	23.529879		-84.6	84.602	11666	90.96	3.4183	7.8852
12	Dec-13	2356	1526.3	1467.8	1.5829	1592.7	20.027555	2576.5	220.53	220.53	14747	101.76	9.3603	8.0081
13	Jan-14	834	1564.1	1480.5	0.6244	1650.6	23.818745	1007	173.03	173.03	15915	107.24	20.747	8.988
14	Feb-14	1104	1531.3	1493.2	0.664	1703.2	26.690346	1111.9	7.8698	7.8698	14783	100.14	0.7128	8.3969
15	Mar-14	[redacted]				1773.8	31.08893	[redacted]	-53.21	53.211	13986	97.013	5.0605	8.1745
16	Nov-14	2311	1602.5	1518.7	1.4691	1766.4	27.232979	2651.7	340.69	340.69	20366	112.24	14.742	8.585
17	Dec-14	2567	1605.3	1531.4	1.5725	1752.6	23.134267	2820.5	253.53	253.53	22949	120.55	9.8764	8.6609
18	Jan-15	[redacted]				1813	26.860828	[redacted]	108.67	108.67	22330	119.89	11.1	8.7964
19	Feb-15					1865.4	29.412841		100.81	100.81	21690	118.89	9.0168	8.808
20	Mar-15	927	1522.6	1569.7	0.5787	1935.7	33.501582	1096.5	169.46	169.46	22041	121.42	18.28	9.2816
21	Nov-15	2109	1518.6	1582.4	1.4531	1925.2	29.100638	2861.4	752.36	752.36	47946	151.46	35.674	10.538
22	Dec-15	2480	1502	1595.1	1.5618	1907.6	24.436026	3052.1	572.13	572.13	60645	170.58	23.07	11.108
23	Jan-16	[redacted]				1968.3	28.05811	[redacted]	210.41	210.41	59934	172.31	21.94	11.579
24	Feb-16					2020	30.426064		274.87	274.87	60584	176.59	26.557	12.203
25	Mar-16	979		1633.3	0.5687	2091.5	34.534423	1166.1	187.07	187.07	59561	177.01	19.108	12.479
26	Oct-16				1.4173			3013.3						
27	Nov-16				1.5356			3317.8						
28	Dec-16				0.5935			1302.7						
29	Jan-17				0.6418			1430.9						
30	Feb-17				0.5586			1264.8						

Appendix D: Wave-System Structure

Inbound



Outbound


1.1
1.2
2.1
2.2
2.3
2.4
3.1
3.2
3.3
3.4
3.5
4.1
4.2
4.3
5.1
5.2
5.3
5.4
6.1
6.2
6.3
6.4
6.5
6.6
7.1
7.2
7.3
7.4

Inbound 1.1

Inbound				
5	4	3	2	1
				XX 657 / ICN
				XX 472 / SYD

Inbound 1.2

Time	Outbound			
	1	2	3	4
0:00				
0:05				
0:10				
0:15				
0:20				
0:25				
0:30				
0:35				
0:40				
0:45				
0:50				
0:55				
1:00				
1:05				
1:10				
1:15				
1:20				
1:25				
1:30				
1:35				
1:40				
1:45				
1:50				
1:55				
2:00				
2:05				
2:10				
2:15				
2:20				
2:25				
2:30				
2:35	XX 657 / ICN			
2:40	XX 657 / ICN			
2:45	XX 657 / ICN			
2:50	XX 657 / ICN			
2:55	XX 657 / ICN			
3:00	XX 657 / ICN			
3:05	XX 657 / ICN			
3:10	XX 657 / ICN			
3:15	XX 657 / ICN			
3:20	XX 657 / ICN			
3:25	XX 657 / ICN			
3:30	XX 657 / ICN			
3:35	XX 657 / ICN			

Inbound 2.1

			XX 673 / KIX	XX 318 / BOM
				XX 647 / NGO
				XX 661 / HND
			XX 462 / MEL	XX 316 / DEL
				XX 961 / ARN
				XX 314 / CCU
				XX 941 / MXP
				XX 945 / FCO
		XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC
			XX 326 / BLR	XX 911 / LHR
		XX 350 / ISB	XX 955 / OSL	XX 921 / FRA
		XX 308 / CMB	XX 338 / MAA	XX 931 / CDG
	XX 346 / LHE	XX 342 / KHI	XX 330 / HYD	XX 951 / CPH
			XX 518 / DXB	XX 508 / KHI

Inbound 2.2

3:40	XX 657 / ICN			
3:45	XX 657 / ICN			
3:50	XX 657 / ICN			
3:55	XX 657 / ICN			
4:00	XX 657 / ICN			
4:05	XX 657 / ICN			
4:10	XX 657 / ICN			
4:15	XX 657 / ICN			
4:20				
4:25				
4:30				
4:35				
4:40	XX 472 / SYD			
4:45	XX 472 / SYD			
4:50	XX 472 / SYD			
4:55	XX 472 / SYD			
5:00	XX 472 / SYD			
5:05	XX 472 / SYD			
5:10	XX 472 / SYD			
5:15	XX 472 / SYD			
5:20	XX 472 / SYD			
5:25	XX 472 / SYD			
5:30	XX 472 / SYD			
5:35	XX 472 / SYD			
5:40	XX 472 / SYD			
5:45	XX 472 / SYD			
5:50	XX 472 / SYD			
5:55	XX 472 / SYD			
6:00	XX 472 / SYD			
6:05	XX 472 / SYD			
6:10	XX 472 / SYD			
6:15	XX 472 / SYD			
6:20	XX 472 / SYD	XX 673 / KIX	XX 318 / BOM	
6:25	XX 472 / SYD	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO
6:30	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	
6:35	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	
6:40	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	XX 661 / HND
6:45	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	XX 661 / HND
6:50	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	XX 661 / HND
6:55	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	XX 661 / HND
7:00	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	XX 661 / HND
7:05	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	XX 661 / HND
7:10	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	XX 661 / HND
7:15	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	XX 661 / HND
7:20	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	XX 661 / HND
7:25	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	XX 661 / HND
7:30	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	XX 661 / HND

Inbound 2.3

XX 462 / MEL	XX 316 / DEL				
XX 462 / MEL	XX 316 / DEL	XX 961 / ARN			
XX 462 / MEL	XX 316 / DEL	XX 961 / ARN	XX 314 / CCU		
XX 462 / MEL	XX 316 / DEL	XX 961 / ARN	XX 314 / CCU	XX 941 / MXP	
XX 462 / MEL	XX 316 / DEL	XX 961 / ARN	XX 314 / CCU	XX 941 / MXP	
XX 462 / MEL	XX 316 / DEL	XX 961 / ARN	XX 314 / CCU	XX 941 / MXP	XX 945 / FCO
XX 462 / MEL	XX 316 / DEL	XX 961 / ARN	XX 314 / CCU	XX 941 / MXP	XX 945 / FCO
XX 462 / MEL	XX 316 / DEL	XX 961 / ARN	XX 314 / CCU	XX 941 / MXP	XX 945 / FCO

Inbound 2.4

XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC			
XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC	XX 326 / BLR	XX 911 / LHR	

Inbound 3.1

				XX 426 / PEN
				XX 332 / DEL
			XX 402 / SIN	XX 603 / HKG
				XX 637 / TPE
			XX 581 / PNH	XX 675 / PEK

Inbound 3.2

7:35	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	XX 661 / HND
7:40	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	XX 661 / HND
7:45	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	XX 661 / HND
7:50	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	XX 661 / HND
7:55	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	XX 661 / HND
8:00	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	XX 661 / HND
8:05	XX 673 / KIX	XX 318 / BOM	XX 647 / NGO	XX 661 / HND
8:10	XX 647 / NGO	XX 462 / MEL	XX 316 / DEL	XX 961 / ARN
8:15	XX 661 / HND	XX 462 / MEL	XX 316 / DEL	XX 961 / ARN
8:20	XX 661 / HND	XX 462 / MEL	XX 316 / DEL	XX 961 / ARN
8:25	XX 661 / HND	XX 462 / MEL	XX 316 / DEL	XX 961 / ARN
8:30	XX 462 / MEL	XX 316 / DEL	XX 961 / ARN	XX 314 / CCU
8:35	XX 462 / MEL	XX 316 / DEL	XX 961 / ARN	XX 314 / CCU
8:40	XX 462 / MEL	XX 316 / DEL	XX 961 / ARN	XX 314 / CCU
8:45	XX 961 / ARN	XX 314 / CCU	XX 941 / MXP	XX 945 / FCO
8:50	XX 314 / CCU	XX 941 / MXP	XX 945 / FCO	XX 935 / BRU
8:55	XX 941 / MXP	XX 945 / FCO	XX 935 / BRU	XX 971 / ZRH
9:00	XX 945 / FCO	XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC
9:05	XX 945 / FCO	XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC
9:10	XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC	XX 326 / BLR
9:15	XX 326 / BLR	XX 911 / LHR	XX 350 / ISB	XX 955 / OSL
9:20	XX 350 / ISB	XX 955 / OSL	XX 921 / FRA	XX 308 / CMB
9:25	XX 308 / CMB	XX 338 / MAA	XX 931 / CDG	XX 346 / LHE
9:30	XX 346 / LHE	XX 342 / KHI	XX 330 / HYD	XX 951 / CPH
9:35	XX 518 / DXB	XX 508 / KHI		
9:40	XX 518 / DXB	XX 508 / KHI		
9:45	XX 518 / DXB	XX 508 / KHI		
9:50	XX 518 / DXB	XX 508 / KHI		
9:55				
10:00				
10:05	XX 426 / PEN			
10:10	XX 426 / PEN			
10:15	XX 426 / PEN	XX 332 / DEL		
10:20	XX 426 / PEN	XX 332 / DEL		
10:25	XX 426 / PEN	XX 332 / DEL		
10:30	XX 426 / PEN	XX 332 / DEL		
10:35	XX 426 / PEN	XX 332 / DEL		
10:40	XX 426 / PEN	XX 332 / DEL		
10:45	XX 426 / PEN	XX 332 / DEL		
10:50	XX 426 / PEN	XX 332 / DEL	XX 402 / SIN	XX 603 / HKG
10:55	XX 426 / PEN	XX 332 / DEL	XX 402 / SIN	XX 603 / HKG
11:00	XX 426 / PEN	XX 332 / DEL	XX 402 / SIN	XX 603 / HKG
11:05	XX 426 / PEN	XX 332 / DEL	XX 402 / SIN	XX 603 / HKG
11:10	XX 426 / PEN	XX 332 / DEL	XX 402 / SIN	XX 603 / HKG
11:15	XX 426 / PEN	XX 332 / DEL	XX 402 / SIN	XX 603 / HKG
11:20	XX 426 / PEN	XX 332 / DEL	XX 402 / SIN	XX 603 / HKG
11:25	XX 426 / PEN	XX 332 / DEL	XX 402 / SIN	XX 603 / HKG

Inbound 3.3

XX 462 / MEL	XX 316 / DEL	XX 961 / ARN	XX 314 / CCU	XX 941 / MXP	XX 945 / FCO
XX 462 / MEL	XX 316 / DEL	XX 961 / ARN	XX 314 / CCU	XX 941 / MXP	XX 945 / FCO
XX 462 / MEL	XX 316 / DEL	XX 961 / ARN	XX 314 / CCU	XX 941 / MXP	XX 945 / FCO
XX 462 / MEL	XX 316 / DEL	XX 961 / ARN	XX 314 / CCU	XX 941 / MXP	XX 945 / FCO
XX 462 / MEL	XX 316 / DEL	XX 961 / ARN	XX 314 / CCU	XX 941 / MXP	XX 945 / FCO
XX 462 / MEL	XX 316 / DEL	XX 961 / ARN	XX 314 / CCU	XX 941 / MXP	XX 945 / FCO
XX 462 / MEL	XX 316 / DEL	XX 961 / ARN	XX 314 / CCU	XX 941 / MXP	XX 945 / FCO
XX 314 / CCU	XX 941 / MXP	XX 945 / FCO	XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC
XX 314 / CCU	XX 941 / MXP	XX 945 / FCO	XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC
XX 314 / CCU	XX 941 / MXP	XX 945 / FCO	XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC
XX 314 / CCU	XX 941 / MXP	XX 945 / FCO	XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC
XX 941 / MXP	XX 945 / FCO	XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC	XX 326 / BLR
XX 941 / MXP	XX 945 / FCO	XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC	XX 326 / BLR
XX 941 / MXP	XX 945 / FCO	XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC	XX 326 / BLR
XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC	XX 326 / BLR	XX 911 / LHR	XX 350 / ISB
XX 971 / ZRH	XX 925 / MUC	XX 326 / BLR	XX 911 / LHR	XX 350 / ISB	XX 955 / OSL
XX 925 / MUC	XX 326 / BLR	XX 911 / LHR	XX 350 / ISB	XX 955 / OSL	XX 921 / FRA
XX 326 / BLR	XX 911 / LHR	XX 350 / ISB	XX 955 / OSL	XX 921 / FRA	XX 308 / CMB
XX 326 / BLR	XX 911 / LHR	XX 350 / ISB	XX 955 / OSL	XX 921 / FRA	XX 308 / CMB
XX 911 / LHR	XX 350 / ISB	XX 955 / OSL	XX 921 / FRA	XX 308 / CMB	XX 338 / MAA
XX 921 / FRA	XX 308 / CMB	XX 338 / MAA	XX 931 / CDG	XX 346 / LHE	XX 342 / KHI
XX 338 / MAA	XX 931 / CDG	XX 346 / LHE	XX 342 / KHI	XX 330 / HYD	XX 951 / CPH
XX 342 / KHI	XX 330 / HYD	XX 951 / CPH	XX 518 / DXB	XX 508 / KHI	
XX 518 / DXB	XX 508 / KHI				

Inbound 3.4

XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC	XX 326 / BLR	XX 911 / LHR	XX 350 / ISB
XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC	XX 326 / BLR	XX 911 / LHR	XX 350 / ISB
XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC	XX 326 / BLR	XX 911 / LHR	XX 350 / ISB
XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC	XX 326 / BLR	XX 911 / LHR	XX 350 / ISB
XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC	XX 326 / BLR	XX 911 / LHR	XX 350 / ISB
XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC	XX 326 / BLR	XX 911 / LHR	XX 350 / ISB
XX 935 / BRU	XX 971 / ZRH	XX 925 / MUC	XX 326 / BLR	XX 911 / LHR	XX 350 / ISB
XX 326 / BLR	XX 911 / LHR	XX 350 / ISB	XX 955 / OSL	XX 921 / FRA	XX 308 / CMB
XX 326 / BLR	XX 911 / LHR	XX 350 / ISB	XX 955 / OSL	XX 921 / FRA	XX 308 / CMB
XX 326 / BLR	XX 911 / LHR	XX 350 / ISB	XX 955 / OSL	XX 921 / FRA	XX 308 / CMB
XX 326 / BLR	XX 911 / LHR	XX 350 / ISB	XX 955 / OSL	XX 921 / FRA	XX 308 / CMB
XX 911 / LHR	XX 350 / ISB	XX 955 / OSL	XX 921 / FRA	XX 308 / CMB	XX 338 / MAA
XX 911 / LHR	XX 350 / ISB	XX 955 / OSL	XX 921 / FRA	XX 308 / CMB	XX 338 / MAA
XX 911 / LHR	XX 350 / ISB	XX 955 / OSL	XX 921 / FRA	XX 308 / CMB	XX 338 / MAA
XX 955 / OSL	XX 921 / FRA	XX 308 / CMB	XX 338 / MAA	XX 931 / CDG	XX 346 / LHE
XX 921 / FRA	XX 308 / CMB	XX 338 / MAA	XX 931 / CDG	XX 346 / LHE	XX 342 / KHI
XX 308 / CMB	XX 338 / MAA	XX 931 / CDG	XX 346 / LHE	XX 342 / KHI	XX 330 / HYD
XX 338 / MAA	XX 931 / CDG	XX 346 / LHE	XX 342 / KHI	XX 330 / HYD	XX 951 / CPH
XX 338 / MAA	XX 931 / CDG	XX 346 / LHE	XX 342 / KHI	XX 330 / HYD	XX 951 / CPH
XX 931 / CDG	XX 346 / LHE	XX 342 / KHI	XX 330 / HYD	XX 951 / CPH	XX 518 / DXB
XX 330 / HYD	XX 951 / CPH	XX 518 / DXB	XX 508 / KHI		
XX 518 / DXB	XX 508 / KHI				

Inbound 3.5

XX 955 / OSL	XX 921 / FRA				
XX 955 / OSL	XX 921 / FRA	XX 308 / CMB	XX 338 / MAA	XX 931 / CDG	
XX 955 / OSL	XX 921 / FRA	XX 308 / CMB	XX 338 / MAA	XX 931 / CDG	XX 346 / LHE
XX 955 / OSL	XX 921 / FRA	XX 308 / CMB	XX 338 / MAA	XX 931 / CDG	XX 346 / LHE
XX 955 / OSL	XX 921 / FRA	XX 308 / CMB	XX 338 / MAA	XX 931 / CDG	XX 346 / LHE
XX 955 / OSL	XX 921 / FRA	XX 308 / CMB	XX 338 / MAA	XX 931 / CDG	XX 346 / LHE
XX 955 / OSL	XX 921 / FRA	XX 308 / CMB	XX 338 / MAA	XX 931 / CDG	XX 346 / LHE
XX 338 / MAA	XX 931 / CDG	XX 346 / LHE	XX 342 / KHI	XX 330 / HYD	XX 951 / CPH
XX 338 / MAA	XX 931 / CDG	XX 346 / LHE	XX 342 / KHI	XX 330 / HYD	XX 951 / CPH
XX 338 / MAA	XX 931 / CDG	XX 346 / LHE	XX 342 / KHI	XX 330 / HYD	XX 951 / CPH
XX 338 / MAA	XX 931 / CDG	XX 346 / LHE	XX 342 / KHI	XX 330 / HYD	XX 951 / CPH
XX 931 / CDG	XX 346 / LHE	XX 342 / KHI	XX 330 / HYD	XX 951 / CPH	XX 518 / DXB
XX 931 / CDG	XX 346 / LHE	XX 342 / KHI	XX 330 / HYD	XX 951 / CPH	XX 518 / DXB
XX 931 / CDG	XX 346 / LHE	XX 342 / KHI	XX 330 / HYD	XX 951 / CPH	XX 518 / DXB
XX 342 / KHI	XX 330 / HYD	XX 951 / CPH	XX 518 / DXB	XX 508 / KHI	
XX 330 / HYD	XX 951 / CPH	XX 518 / DXB	XX 508 / KHI		
XX 951 / CPH	XX 518 / DXB	XX 508 / KHI			
XX 518 / DXB	XX 508 / KHI				
XX 518 / DXB	XX 508 / KHI				
XX 508 / KHI					

Inbound 3.6

XX 342 / KHI	XX 330 / HYD	XX 951 / CPH			
XX 342 / KHI	XX 330 / HYD	XX 951 / CPH			
XX 342 / KHI	XX 330 / HYD	XX 951 / CPH			
XX 342 / KHI	XX 330 / HYD	XX 951 / CPH			
XX 342 / KHI	XX 330 / HYD	XX 951 / CPH	XX 518 / DXB	XX 508 / KHI	
XX 518 / DXB	XX 508 / KHI				
XX 518 / DXB	XX 508 / KHI				
XX 518 / DXB	XX 508 / KHI				
XX 518 / DXB	XX 508 / KHI				
XX 508 / KHI					
XX 508 / KHI					
XX 508 / KHI					

Inbound 4.1

				XX 551 / SGN
				XX 304 / RGN
				XX 651 / PUS
				XX 561 / HAN
				XX 663 / PVG
				XX 659 / ICN
				XX 923 / FRA
				WE 352 / RGN
				XX 404 / SIN
				XX 416 / KUL
				XX 571 / VTE
			XX 484 / PER	XX 601 / HKG

Inbound 4.2

11:30	XX 426 / PEN	XX 332 / DEL	XX 402 / SIN	XX 603 / HKG
11:35	XX 426 / PEN	XX 332 / DEL	XX 402 / SIN	XX 603 / HKG
11:40	XX 426 / PEN	XX 332 / DEL	XX 402 / SIN	XX 603 / HKG
11:45	XX 426 / PEN	XX 332 / DEL	XX 402 / SIN	XX 603 / HKG
11:50	XX 426 / PEN	XX 332 / DEL	XX 402 / SIN	XX 603 / HKG
11:55	XX 332 / DEL	XX 402 / SIN	XX 603 / HKG	
12:00	XX 332 / DEL	XX 402 / SIN	XX 603 / HKG	XX 637 / TPE
12:05	XX 402 / SIN	XX 603 / HKG	XX 637 / TPE	
12:10	XX 402 / SIN	XX 603 / HKG	XX 637 / TPE	
12:15	XX 402 / SIN	XX 603 / HKG	XX 637 / TPE	
12:20	XX 402 / SIN	XX 603 / HKG	XX 637 / TPE	XX 581 / PNH
12:25	XX 402 / SIN	XX 603 / HKG	XX 637 / TPE	XX 581 / PNH
12:30	XX 402 / SIN	XX 603 / HKG	XX 637 / TPE	XX 581 / PNH
12:35	XX 402 / SIN	XX 603 / HKG	XX 637 / TPE	XX 581 / PNH
12:40	XX 637 / TPE	XX 581 / PNH	XX 675 / PEK	
12:45	XX 637 / TPE	XX 581 / PNH	XX 675 / PEK	XX 551 / SGN
12:50	XX 637 / TPE	XX 581 / PNH	XX 675 / PEK	XX 551 / SGN
12:55	XX 637 / TPE	XX 581 / PNH	XX 675 / PEK	XX 551 / SGN
13:00	XX 637 / TPE	XX 581 / PNH	XX 675 / PEK	XX 551 / SGN
13:05	XX 637 / TPE	XX 581 / PNH	XX 675 / PEK	XX 551 / SGN
13:10	XX 637 / TPE	XX 581 / PNH	XX 675 / PEK	XX 551 / SGN
13:15	XX 637 / TPE	XX 581 / PNH	XX 675 / PEK	XX 551 / SGN
13:20	XX 637 / TPE	XX 581 / PNH	XX 675 / PEK	XX 551 / SGN
13:25	XX 637 / TPE	XX 581 / PNH	XX 675 / PEK	XX 551 / SGN
13:30	XX 637 / TPE	XX 581 / PNH	XX 675 / PEK	XX 551 / SGN
13:35	XX 637 / TPE	XX 581 / PNH	XX 675 / PEK	XX 551 / SGN
13:40	XX 637 / TPE	XX 581 / PNH	XX 675 / PEK	XX 551 / SGN
13:45	XX 637 / TPE	XX 581 / PNH	XX 675 / PEK	XX 551 / SGN
13:50	XX 581 / PNH	XX 675 / PEK	XX 551 / SGN	XX 304 / RGN
13:55	XX 581 / PNH	XX 675 / PEK	XX 551 / SGN	XX 304 / RGN
14:00	XX 581 / PNH	XX 675 / PEK	XX 551 / SGN	XX 304 / RGN
14:05	XX 581 / PNH	XX 675 / PEK	XX 551 / SGN	XX 304 / RGN
14:10	XX 551 / SGN	XX 304 / RGN	XX 651 / PUS	XX 561 / HAN
14:15	XX 551 / SGN	XX 304 / RGN	XX 651 / PUS	XX 561 / HAN
14:20	XX 551 / SGN	XX 304 / RGN	XX 651 / PUS	XX 561 / HAN
14:25	XX 551 / SGN	XX 304 / RGN	XX 651 / PUS	XX 561 / HAN
14:30	XX 551 / SGN	XX 304 / RGN	XX 651 / PUS	XX 561 / HAN
14:35	XX 304 / RGN	XX 651 / PUS	XX 561 / HAN	XX 663 / PVG
14:40	XX 304 / RGN	XX 651 / PUS	XX 561 / HAN	XX 663 / PVG
14:45	XX 304 / RGN	XX 651 / PUS	XX 561 / HAN	XX 663 / PVG
14:50	XX 651 / PUS	XX 561 / HAN	XX 663 / PVG	XX 659 / ICN
14:55	XX 651 / PUS	XX 561 / HAN	XX 663 / PVG	XX 659 / ICN
15:00	XX 651 / PUS	XX 561 / HAN	XX 663 / PVG	XX 659 / ICN
15:05	XX 651 / PUS	XX 561 / HAN	XX 663 / PVG	XX 659 / ICN
15:10	XX 651 / PUS	XX 561 / HAN	XX 663 / PVG	XX 659 / ICN
15:15	XX 651 / PUS	XX 561 / HAN	XX 663 / PVG	XX 659 / ICN
15:20	XX 651 / PUS	XX 561 / HAN	XX 663 / PVG	XX 659 / ICN

Inbound 4.3

XX 675 / PEK					
XX 675 / PEK					
XX 675 / PEK					
XX 675 / PEK					
XX 304 / RGN					
XX 304 / RGN					
XX 304 / RGN					
XX 304 / RGN					
XX 304 / RGN					
XX 304 / RGN					
XX 304 / RGN					
XX 304 / RGN	XX 651 / PUS				
XX 304 / RGN	XX 651 / PUS	XX 561 / HAN			
XX 304 / RGN	XX 651 / PUS	XX 561 / HAN			
XX 651 / PUS	XX 561 / HAN				
XX 651 / PUS	XX 561 / HAN	XX 663 / PVG			
XX 651 / PUS	XX 561 / HAN	XX 663 / PVG			
XX 651 / PUS	XX 561 / HAN	XX 663 / PVG			
XX 663 / PVG					
XX 663 / PVG					
XX 663 / PVG					
XX 663 / PVG					
XX 663 / PVG					
XX 659 / ICN					
XX 923 / FRA					
XX 923 / FRA	WE 352 / RGN				
XX 923 / FRA	WE 352 / RGN	XX 404 / SIN			
XX 923 / FRA	WE 352 / RGN	XX 404 / SIN			
XX 923 / FRA	WE 352 / RGN	XX 404 / SIN			
XX 923 / FRA	WE 352 / RGN	XX 404 / SIN			
XX 923 / FRA	WE 352 / RGN	XX 404 / SIN			

Inbound 5.1

			XX 621 / MNL	XX 476 / SYD
			XX 649 / FUK	XX 645 / NGO
			XX 623 / KIX	XX 641 / NRT
				XX 683 / HND
				XX 917 / LHR
				XX 583 / PNH
				XX 577 / LPQ
			XX 434 / CGK	XX 613 / KMG
				XX 324 / DEL
			XX 671 / CTS	XX 629 / HKG
				XX 302 / RGN
				XX 669 / CAN
				XX 643 / NRT
				XX 322 / DAC
				XX 414 / SIN
				XX 619 / CTU
		XX 320 / KTM	XX 611 / XMN	XX 685 / CKG

Inbound 5.2

15:25	XX 561 / HAN	XX 663 / PVG	XX 659 / ICN	XX 923 / FRA
15:30	XX 663 / PVG	XX 659 / ICN	XX 923 / FRA	WE 352 / RGN
15:35	XX 663 / PVG	XX 659 / ICN	XX 923 / FRA	WE 352 / RGN
15:40	XX 663 / PVG	XX 659 / ICN	XX 923 / FRA	WE 352 / RGN
15:45	XX 659 / ICN	XX 923 / FRA	WE 352 / RGN	XX 404 / SIN
15:50	XX 659 / ICN	XX 923 / FRA	WE 352 / RGN	XX 404 / SIN
15:55	XX 659 / ICN	XX 923 / FRA	WE 352 / RGN	XX 404 / SIN
16:00	XX 659 / ICN	XX 923 / FRA	WE 352 / RGN	XX 404 / SIN
16:05	XX 659 / ICN	XX 923 / FRA	WE 352 / RGN	XX 404 / SIN
16:10	XX 659 / ICN	XX 923 / FRA	WE 352 / RGN	XX 404 / SIN
16:15	XX 659 / ICN	XX 923 / FRA	WE 352 / RGN	XX 404 / SIN
16:20	XX 659 / ICN	XX 923 / FRA	WE 352 / RGN	XX 404 / SIN
16:25	XX 659 / ICN	XX 923 / FRA	WE 352 / RGN	XX 404 / SIN
16:30	XX 659 / ICN	XX 923 / FRA	WE 352 / RGN	XX 404 / SIN
16:35	XX 923 / FRA	WE 352 / RGN	XX 404 / SIN	XX 416 / KUL
16:40	WE 352 / RGN	XX 404 / SIN	XX 416 / KUL	XX 571 / VTE
16:45	XX 404 / SIN	XX 416 / KUL	XX 571 / VTE	XX 484 / PER
16:50	XX 416 / KUL	XX 571 / VTE	XX 484 / PER	XX 601 / HKG
16:55	XX 416 / KUL	XX 571 / VTE	XX 484 / PER	XX 601 / HKG
17:00	XX 416 / KUL	XX 571 / VTE	XX 484 / PER	XX 601 / HKG
17:05	XX 416 / KUL	XX 571 / VTE	XX 484 / PER	XX 601 / HKG
17:10	XX 416 / KUL	XX 571 / VTE	XX 484 / PER	XX 601 / HKG
17:15	XX 571 / VTE	XX 484 / PER	XX 601 / HKG	XX 621 / MNL
17:20	XX 571 / VTE	XX 484 / PER	XX 601 / HKG	XX 621 / MNL
17:25	XX 571 / VTE	XX 484 / PER	XX 601 / HKG	XX 621 / MNL
17:30	XX 484 / PER	XX 601 / HKG	XX 621 / MNL	XX 476 / SYD
17:35	XX 484 / PER	XX 601 / HKG	XX 621 / MNL	XX 476 / SYD
17:40	XX 484 / PER	XX 601 / HKG	XX 621 / MNL	XX 476 / SYD
17:45	XX 484 / PER	XX 601 / HKG	XX 621 / MNL	XX 476 / SYD
17:50	XX 484 / PER	XX 601 / HKG	XX 621 / MNL	XX 476 / SYD
17:55	XX 484 / PER	XX 601 / HKG	XX 621 / MNL	XX 476 / SYD
18:00	XX 484 / PER	XX 601 / HKG	XX 621 / MNL	XX 476 / SYD
18:05	XX 484 / PER	XX 601 / HKG	XX 621 / MNL	XX 476 / SYD
18:10	XX 621 / MNL	XX 476 / SYD	XX 649 / FUK	XX 645 / NGO
18:15	XX 621 / MNL	XX 476 / SYD	XX 649 / FUK	XX 645 / NGO
18:20	XX 621 / MNL	XX 476 / SYD	XX 649 / FUK	XX 645 / NGO
18:25	XX 621 / MNL	XX 476 / SYD	XX 649 / FUK	XX 645 / NGO
18:30	XX 649 / FUK	XX 645 / NGO	XX 623 / KIX	XX 641 / NRT
18:35	XX 649 / FUK	XX 645 / NGO	XX 623 / KIX	XX 641 / NRT
18:40	XX 649 / FUK	XX 645 / NGO	XX 623 / KIX	XX 641 / NRT
18:45	XX 623 / KIX	XX 641 / NRT	XX 683 / HND	XX 917 / LHR
18:50	XX 683 / HND	XX 917 / LHR	XX 583 / PNH	XX 577 / LPQ
18:55	XX 917 / LHR	XX 583 / PNH	XX 577 / LPQ	XX 434 / CGK
19:00	XX 917 / LHR	XX 583 / PNH	XX 577 / LPQ	XX 434 / CGK
19:05	XX 583 / PNH	XX 577 / LPQ	XX 434 / CGK	XX 613 / KMG
19:10	XX 577 / LPQ	XX 434 / CGK	XX 613 / KMG	XX 324 / DEL
19:15	XX 577 / LPQ	XX 434 / CGK	XX 613 / KMG	XX 324 / DEL

Inbound 5.3

WE 352 / RGN	XX 404 / SIN	XX 416 / KUL			
XX 404 / SIN	XX 416 / KUL				
XX 404 / SIN	XX 416 / KUL				
XX 404 / SIN	XX 416 / KUL	XX 571 / VTE			
XX 416 / KUL	XX 571 / VTE				
XX 416 / KUL	XX 571 / VTE				
XX 416 / KUL	XX 571 / VTE				
XX 416 / KUL	XX 571 / VTE				
XX 416 / KUL	XX 571 / VTE				
XX 416 / KUL	XX 571 / VTE				
XX 416 / KUL	XX 571 / VTE				
XX 416 / KUL	XX 571 / VTE	XX 484 / PER	XX 601 / HKG		
XX 416 / KUL	XX 571 / VTE	XX 484 / PER	XX 601 / HKG		
XX 416 / KUL	XX 571 / VTE	XX 484 / PER	XX 601 / HKG		
XX 571 / VTE	XX 484 / PER	XX 601 / HKG			
XX 484 / PER	XX 601 / HKG	XX 621 / MNL	XX 476 / SYD		
XX 601 / HKG	XX 621 / MNL	XX 476 / SYD			
XX 621 / MNL	XX 476 / SYD				
XX 621 / MNL	XX 476 / SYD	XX 649 / FUK	XX 645 / NGO		
XX 621 / MNL	XX 476 / SYD	XX 649 / FUK	XX 645 / NGO	XX 623 / KIX	XX 641 / NRT
XX 621 / MNL	XX 476 / SYD	XX 649 / FUK	XX 645 / NGO	XX 623 / KIX	XX 641 / NRT
XX 621 / MNL	XX 476 / SYD	XX 649 / FUK	XX 645 / NGO	XX 623 / KIX	XX 641 / NRT
XX 476 / SYD	XX 649 / FUK	XX 645 / NGO	XX 623 / KIX	XX 641 / NRT	XX 683 / HND
XX 476 / SYD	XX 649 / FUK	XX 645 / NGO	XX 623 / KIX	XX 641 / NRT	XX 683 / HND
XX 476 / SYD	XX 649 / FUK	XX 645 / NGO	XX 623 / KIX	XX 641 / NRT	XX 683 / HND
XX 649 / FUK	XX 645 / NGO	XX 623 / KIX	XX 641 / NRT	XX 683 / HND	XX 917 / LHR
XX 649 / FUK	XX 645 / NGO	XX 623 / KIX	XX 641 / NRT	XX 683 / HND	XX 917 / LHR
XX 649 / FUK	XX 645 / NGO	XX 623 / KIX	XX 641 / NRT	XX 683 / HND	XX 917 / LHR
XX 649 / FUK	XX 645 / NGO	XX 623 / KIX	XX 641 / NRT	XX 683 / HND	XX 917 / LHR
XX 649 / FUK	XX 645 / NGO	XX 623 / KIX	XX 641 / NRT	XX 683 / HND	XX 917 / LHR
XX 649 / FUK	XX 645 / NGO	XX 623 / KIX	XX 641 / NRT	XX 683 / HND	XX 917 / LHR
XX 649 / FUK	XX 645 / NGO	XX 623 / KIX	XX 641 / NRT	XX 683 / HND	XX 917 / LHR
XX 649 / FUK	XX 645 / NGO	XX 623 / KIX	XX 641 / NRT	XX 683 / HND	XX 917 / LHR
XX 623 / KIX	XX 641 / NRT	XX 683 / HND	XX 917 / LHR	XX 583 / PNH	XX 577 / LPQ
XX 623 / KIX	XX 641 / NRT	XX 683 / HND	XX 917 / LHR	XX 583 / PNH	XX 577 / LPQ
XX 623 / KIX	XX 641 / NRT	XX 683 / HND	XX 917 / LHR	XX 583 / PNH	XX 577 / LPQ
XX 623 / KIX	XX 641 / NRT	XX 683 / HND	XX 917 / LHR	XX 583 / PNH	XX 577 / LPQ
XX 683 / HND	XX 917 / LHR	XX 583 / PNH	XX 577 / LPQ	XX 434 / CGK	XX 613 / KMG
XX 683 / HND	XX 917 / LHR	XX 583 / PNH	XX 577 / LPQ	XX 434 / CGK	XX 613 / KMG
XX 683 / HND	XX 917 / LHR	XX 583 / PNH	XX 577 / LPQ	XX 434 / CGK	XX 613 / KMG
XX 583 / PNH	XX 577 / LPQ	XX 434 / CGK	XX 613 / KMG	XX 324 / DEL	XX 671 / CTS
XX 434 / CGK	XX 613 / KMG	XX 324 / DEL	XX 671 / CTS	XX 629 / HKG	XX 302 / RGN
XX 613 / KMG	XX 324 / DEL	XX 671 / CTS	XX 629 / HKG	XX 302 / RGN	XX 669 / CAN
XX 613 / KMG	XX 324 / DEL	XX 671 / CTS	XX 629 / HKG	XX 302 / RGN	XX 669 / CAN
XX 324 / DEL	XX 671 / CTS	XX 629 / HKG	XX 302 / RGN	XX 669 / CAN	XX 643 / NRT
XX 671 / CTS	XX 629 / HKG	XX 302 / RGN	XX 669 / CAN	XX 643 / NRT	XX 322 / DAC
XX 671 / CTS	XX 629 / HKG	XX 302 / RGN	XX 669 / CAN	XX 643 / NRT	XX 322 / DAC

Inbound 5.4

XX 683 / HND					
XX 683 / HND					
XX 917 / LHR					
XX 917 / LHR	XX 583 / PNH				
XX 917 / LHR	XX 583 / PNH				
XX 583 / PNH					
XX 583 / PNH					
XX 583 / PNH	XX 577 / LPQ				
XX 583 / PNH	XX 577 / LPQ				
XX 583 / PNH	XX 577 / LPQ	XX 434 / CGK	XX 613 / KMG		
XX 583 / PNH	XX 577 / LPQ	XX 434 / CGK	XX 613 / KMG	XX 324 / DEL	
XX 583 / PNH	XX 577 / LPQ	XX 434 / CGK	XX 613 / KMG	XX 324 / DEL	XX 671 / CTS
XX 583 / PNH	XX 577 / LPQ	XX 434 / CGK	XX 613 / KMG	XX 324 / DEL	XX 671 / CTS
XX 434 / CGK	XX 613 / KMG	XX 324 / DEL	XX 671 / CTS	XX 629 / HKG	XX 302 / RGN
XX 434 / CGK	XX 613 / KMG	XX 324 / DEL	XX 671 / CTS	XX 629 / HKG	XX 302 / RGN
XX 434 / CGK	XX 613 / KMG	XX 324 / DEL	XX 671 / CTS	XX 629 / HKG	XX 302 / RGN
XX 434 / CGK	XX 613 / KMG	XX 324 / DEL	XX 671 / CTS	XX 629 / HKG	XX 302 / RGN
XX 324 / DEL	XX 671 / CTS	XX 629 / HKG	XX 302 / RGN	XX 669 / CAN	XX 643 / NRT
XX 324 / DEL	XX 671 / CTS	XX 629 / HKG	XX 302 / RGN	XX 669 / CAN	XX 643 / NRT
XX 324 / DEL	XX 671 / CTS	XX 629 / HKG	XX 302 / RGN	XX 669 / CAN	XX 643 / NRT
XX 629 / HKG	XX 302 / RGN	XX 669 / CAN	XX 643 / NRT	XX 322 / DAC	XX 414 / SIN
XX 669 / CAN	XX 643 / NRT	XX 322 / DAC	XX 414 / SIN	XX 619 / CTU	
XX 643 / NRT	XX 322 / DAC	XX 414 / SIN	XX 619 / CTU		
XX 643 / NRT	XX 322 / DAC	XX 414 / SIN	XX 619 / CTU		
XX 322 / DAC	XX 414 / SIN	XX 619 / CTU			
XX 414 / SIN	XX 619 / CTU				
XX 414 / SIN	XX 619 / CTU				

Inbound 5.5

XX 629 / HKG					
XX 629 / HKG					
XX 669 / CAN					
XX 669 / CAN	XX 643 / NRT				
XX 669 / CAN	XX 643 / NRT	XX 322 / DAC			
XX 322 / DAC	XX 414 / SIN				
XX 322 / DAC	XX 414 / SIN	XX 619 / CTU			
XX 322 / DAC	XX 414 / SIN	XX 619 / CTU			
XX 619 / CTU					

Inbound 6.1

				XX 432 / DPS
				XX 408 / SIN
				XX 474 / BNE
				XX 466 / MEL
				XX 639 / HKG
				XX 492 / AKL
			XX 328 / VNS	XX 665 / PVG
				XX 615 / PEK
				XX 585 / PNH
				XX 306 / RGN
				XX 617 / CSX
				XX 418 / KUL
				XX 565 / HAN
		XX 557 / SGN	XX 410 / SIN	XX 625 / MNL
			XX 607 / HKG	XX 677 / NRT
				XX 575 / VTE
				XX 436 / CGK
				XX 679 / CAN
				XX 635 / TPE

Inbound 6.2

19:20	XX 577 / LPQ	XX 434 / CGK	XX 613 / KMG	XX 324 / DEL
19:25	XX 577 / LPQ	XX 434 / CGK	XX 613 / KMG	XX 324 / DEL
19:30	XX 434 / CGK	XX 613 / KMG	XX 324 / DEL	XX 671 / CTS
19:35	XX 434 / CGK	XX 613 / KMG	XX 324 / DEL	XX 671 / CTS
19:40	XX 324 / DEL	XX 671 / CTS	XX 629 / HKG	XX 302 / RGN
19:45	XX 671 / CTS	XX 629 / HKG	XX 302 / RGN	XX 669 / CAN
19:50	XX 302 / RGN	XX 669 / CAN	XX 643 / NRT	XX 322 / DAC
19:55	XX 302 / RGN	XX 669 / CAN	XX 643 / NRT	XX 322 / DAC
20:00	XX 669 / CAN	XX 643 / NRT	XX 322 / DAC	XX 414 / SIN
20:05	XX 643 / NRT	XX 322 / DAC	XX 414 / SIN	XX 619 / CTU
20:10	XX 322 / DAC	XX 414 / SIN	XX 619 / CTU	XX 320 / KTM
20:15	XX 414 / SIN	XX 619 / CTU	XX 320 / KTM	XX 611 / XMN
20:20	XX 619 / CTU	XX 320 / KTM	XX 611 / XMN	XX 685 / CKG
20:25	XX 320 / KTM	XX 611 / XMN	XX 685 / CKG	
20:30	XX 320 / KTM	XX 611 / XMN	XX 685 / CKG	
20:35	XX 320 / KTM	XX 611 / XMN	XX 685 / CKG	
20:40	XX 320 / KTM	XX 611 / XMN	XX 685 / CKG	XX 432 / DPS
20:45	XX 320 / KTM	XX 611 / XMN	XX 685 / CKG	XX 432 / DPS
20:50	XX 320 / KTM	XX 611 / XMN	XX 685 / CKG	XX 432 / DPS
20:55	XX 320 / KTM	XX 611 / XMN	XX 685 / CKG	XX 432 / DPS
21:00	XX 320 / KTM	XX 611 / XMN	XX 685 / CKG	XX 432 / DPS
21:05	XX 320 / KTM	XX 611 / XMN	XX 685 / CKG	XX 432 / DPS
21:10	XX 320 / KTM	XX 611 / XMN	XX 685 / CKG	XX 432 / DPS
21:15	XX 320 / KTM	XX 611 / XMN	XX 685 / CKG	XX 432 / DPS
21:20	XX 320 / KTM	XX 611 / XMN	XX 685 / CKG	XX 432 / DPS
21:25	XX 320 / KTM	XX 611 / XMN	XX 685 / CKG	XX 432 / DPS
21:30	XX 320 / KTM	XX 611 / XMN	XX 685 / CKG	XX 432 / DPS
21:35	XX 432 / DPS	XX 408 / SIN	XX 474 / BNE	
21:40	XX 432 / DPS	XX 408 / SIN	XX 474 / BNE	
21:45	XX 432 / DPS	XX 408 / SIN	XX 474 / BNE	
21:50	XX 432 / DPS	XX 408 / SIN	XX 474 / BNE	XX 466 / MEL
21:55	XX 432 / DPS	XX 408 / SIN	XX 474 / BNE	XX 466 / MEL
22:00	XX 432 / DPS	XX 408 / SIN	XX 474 / BNE	XX 466 / MEL
22:05	XX 432 / DPS	XX 408 / SIN	XX 474 / BNE	XX 466 / MEL
22:10	XX 432 / DPS	XX 408 / SIN	XX 474 / BNE	XX 466 / MEL
22:15	XX 432 / DPS	XX 408 / SIN	XX 474 / BNE	XX 466 / MEL
22:20	XX 432 / DPS	XX 408 / SIN	XX 474 / BNE	XX 466 / MEL
22:25	XX 432 / DPS	XX 408 / SIN	XX 474 / BNE	XX 466 / MEL
22:30	XX 408 / SIN	XX 474 / BNE	XX 466 / MEL	XX 639 / HKG
22:35	XX 408 / SIN	XX 474 / BNE	XX 466 / MEL	XX 639 / HKG
22:40	XX 474 / BNE	XX 466 / MEL	XX 639 / HKG	XX 492 / AKL
22:45	XX 474 / BNE	XX 466 / MEL	XX 639 / HKG	XX 492 / AKL
22:50	XX 474 / BNE	XX 466 / MEL	XX 639 / HKG	XX 492 / AKL
22:55	XX 474 / BNE	XX 466 / MEL	XX 639 / HKG	XX 492 / AKL
23:00	XX 474 / BNE	XX 466 / MEL	XX 639 / HKG	XX 492 / AKL
23:05	XX 474 / BNE	XX 466 / MEL	XX 639 / HKG	XX 492 / AKL
23:10	XX 474 / BNE	XX 466 / MEL	XX 639 / HKG	XX 492 / AKL

Inbound 6.3

XX 671 / CTS	XX 629 / HKG	XX 302 / RGN	XX 669 / CAN	XX 643 / NRT	XX 322 / DAC
XX 671 / CTS	XX 629 / HKG	XX 302 / RGN	XX 669 / CAN	XX 643 / NRT	XX 322 / DAC
XX 629 / HKG	XX 302 / RGN	XX 669 / CAN	XX 643 / NRT	XX 322 / DAC	XX 414 / SIN
XX 629 / HKG	XX 302 / RGN	XX 669 / CAN	XX 643 / NRT	XX 322 / DAC	XX 414 / SIN
XX 669 / CAN	XX 643 / NRT	XX 322 / DAC	XX 414 / SIN	XX 619 / CTU	
XX 643 / NRT	XX 322 / DAC	XX 414 / SIN	XX 619 / CTU	XX 320 / KTM	XX 611 / XMN
XX 414 / SIN	XX 619 / CTU	XX 320 / KTM	XX 611 / XMN	XX 685 / CKG	
XX 414 / SIN	XX 619 / CTU	XX 320 / KTM	XX 611 / XMN	XX 685 / CKG	
XX 619 / CTU	XX 320 / KTM	XX 611 / XMN	XX 685 / CKG		
XX 320 / KTM	XX 611 / XMN	XX 685 / CKG			
XX 611 / XMN	XX 685 / CKG				
XX 685 / CKG					
XX 408 / SIN					
XX 408 / SIN					
XX 408 / SIN					
XX 408 / SIN					
XX 408 / SIN					
XX 408 / SIN					
XX 408 / SIN					
XX 408 / SIN	XX 474 / BNE				
XX 408 / SIN	XX 474 / BNE				
XX 639 / HKG					
XX 639 / HKG					
XX 639 / HKG	XX 492 / AKL				
XX 639 / HKG	XX 492 / AKL				
XX 639 / HKG	XX 492 / AKL				
XX 639 / HKG	XX 492 / AKL				
XX 639 / HKG	XX 492 / AKL				
XX 492 / AKL	XX 328 / VNS	XX 665 / PVG			
XX 492 / AKL	XX 328 / VNS	XX 665 / PVG	XX 615 / PEK		
XX 328 / VNS	XX 665 / PVG	XX 615 / PEK			
XX 328 / VNS	XX 665 / PVG	XX 615 / PEK			
XX 328 / VNS	XX 665 / PVG	XX 615 / PEK			
XX 328 / VNS	XX 665 / PVG	XX 615 / PEK	XX 585 / PNH		
XX 328 / VNS	XX 665 / PVG	XX 615 / PEK	XX 585 / PNH	XX 306 / RGN	
XX 328 / VNS	XX 665 / PVG	XX 615 / PEK	XX 585 / PNH	XX 306 / RGN	
XX 328 / VNS	XX 665 / PVG	XX 615 / PEK	XX 585 / PNH	XX 306 / RGN	

Inbound 6.4

XX 414 / SIN	XX 619 / CTU				
XX 414 / SIN	XX 619 / CTU				
XX 619 / CTU					
XX 619 / CTU					
XX 685 / CKG					

Inbound 7.1

				XX 657 / ICN

Inbound 7.2

23:15	XX 466 / MEL	XX 639 / HKG	XX 492 / AKL	XX 328 / VNS
23:20	XX 466 / MEL	XX 639 / HKG	XX 492 / AKL	XX 328 / VNS
23:25	XX 466 / MEL	XX 639 / HKG	XX 492 / AKL	XX 328 / VNS
23:30	XX 466 / MEL	XX 639 / HKG	XX 492 / AKL	XX 328 / VNS
23:35	XX 466 / MEL	XX 639 / HKG	XX 492 / AKL	XX 328 / VNS
23:40	XX 639 / HKG	XX 492 / AKL	XX 328 / VNS	XX 665 / PVG
23:45	XX 492 / AKL	XX 328 / VNS	XX 665 / PVG	XX 615 / PEK
23:50	XX 492 / AKL	XX 328 / VNS	XX 665 / PVG	XX 615 / PEK
23:55	XX 328 / VNS	XX 665 / PVG	XX 615 / PEK	XX 585 / PNH
0:00	XX 328 / VNS	XX 665 / PVG	XX 615 / PEK	XX 585 / PNH
0:05	XX 328 / VNS	XX 665 / PVG	XX 615 / PEK	XX 585 / PNH
0:10	XX 328 / VNS	XX 665 / PVG	XX 615 / PEK	XX 585 / PNH
0:15	XX 328 / VNS	XX 665 / PVG	XX 615 / PEK	XX 585 / PNH
0:20	XX 615 / PEK	XX 585 / PNH	XX 306 / RGN	XX 617 / CSX
0:25	XX 585 / PNH	XX 306 / RGN	XX 617 / CSX	XX 418 / KUL
0:30	XX 585 / PNH	XX 306 / RGN	XX 617 / CSX	XX 418 / KUL
0:35	XX 585 / PNH	XX 306 / RGN	XX 617 / CSX	XX 418 / KUL
0:40	XX 585 / PNH	XX 306 / RGN	XX 617 / CSX	XX 418 / KUL
0:45	XX 306 / RGN	XX 617 / CSX	XX 418 / KUL	XX 565 / HAN
0:50	XX 617 / CSX	XX 418 / KUL	XX 565 / HAN	XX 557 / SGN
0:55	XX 617 / CSX	XX 418 / KUL	XX 565 / HAN	XX 557 / SGN
1:00	XX 617 / CSX	XX 418 / KUL	XX 565 / HAN	XX 557 / SGN
1:05	XX 418 / KUL	XX 565 / HAN	XX 557 / SGN	XX 410 / SIN
1:10	XX 565 / HAN	XX 557 / SGN	XX 410 / SIN	XX 625 / MNL
1:15	XX 565 / HAN	XX 557 / SGN	XX 410 / SIN	XX 625 / MNL
1:20	XX 557 / SGN	XX 410 / SIN	XX 625 / MNL	XX 607 / HKG
1:25	XX 607 / HKG	XX 677 / NRT	XX 575 / VTE	XX 436 / CGK
1:30	XX 607 / HKG	XX 677 / NRT	XX 575 / VTE	XX 436 / CGK
1:35	XX 575 / VTE	XX 436 / CGK	XX 679 / CAN	XX 635 / TPE
1:40	XX 436 / CGK	XX 679 / CAN	XX 635 / TPE	
1:45	XX 679 / CAN	XX 635 / TPE		
1:50	XX 635 / TPE			
1:55	XX 635 / TPE			
2:00	XX 635 / TPE			
2:05	XX 635 / TPE			
2:10				
2:15				

Inbound 7.3

XX 665 / PVG	XX 615 / PEK	XX 585 / PNH	XX 306 / RGN	XX 617 / CSX	
XX 665 / PVG	XX 615 / PEK	XX 585 / PNH	XX 306 / RGN	XX 617 / CSX	XX 418 / KUL
XX 665 / PVG	XX 615 / PEK	XX 585 / PNH	XX 306 / RGN	XX 617 / CSX	XX 418 / KUL
XX 665 / PVG	XX 615 / PEK	XX 585 / PNH	XX 306 / RGN	XX 617 / CSX	XX 418 / KUL
XX 665 / PVG	XX 615 / PEK	XX 585 / PNH	XX 306 / RGN	XX 617 / CSX	XX 418 / KUL
XX 615 / PEK	XX 585 / PNH	XX 306 / RGN	XX 617 / CSX	XX 418 / KUL	XX 565 / HAN
XX 585 / PNH	XX 306 / RGN	XX 617 / CSX	XX 418 / KUL	XX 565 / HAN	XX 557 / SGN
XX 585 / PNH	XX 306 / RGN	XX 617 / CSX	XX 418 / KUL	XX 565 / HAN	XX 557 / SGN
XX 306 / RGN	XX 617 / CSX	XX 418 / KUL	XX 565 / HAN	XX 557 / SGN	XX 410 / SIN
XX 306 / RGN	XX 617 / CSX	XX 418 / KUL	XX 565 / HAN	XX 557 / SGN	XX 410 / SIN
XX 306 / RGN	XX 617 / CSX	XX 418 / KUL	XX 565 / HAN	XX 557 / SGN	XX 410 / SIN
XX 306 / RGN	XX 617 / CSX	XX 418 / KUL	XX 565 / HAN	XX 557 / SGN	XX 410 / SIN
XX 306 / RGN	XX 617 / CSX	XX 418 / KUL	XX 565 / HAN	XX 557 / SGN	XX 410 / SIN
XX 418 / KUL	XX 565 / HAN	XX 557 / SGN	XX 410 / SIN	XX 625 / MNL	XX 607 / HKG
XX 565 / HAN	XX 557 / SGN	XX 410 / SIN	XX 625 / MNL	XX 607 / HKG	XX 677 / NRT
XX 565 / HAN	XX 557 / SGN	XX 410 / SIN	XX 625 / MNL	XX 607 / HKG	XX 677 / NRT
XX 565 / HAN	XX 557 / SGN	XX 410 / SIN	XX 625 / MNL	XX 607 / HKG	XX 677 / NRT
XX 565 / HAN	XX 557 / SGN	XX 410 / SIN	XX 625 / MNL	XX 607 / HKG	XX 677 / NRT
XX 557 / SGN	XX 410 / SIN	XX 625 / MNL	XX 607 / HKG	XX 677 / NRT	XX 575 / VTE
XX 410 / SIN	XX 625 / MNL	XX 607 / HKG	XX 677 / NRT	XX 575 / VTE	XX 436 / CGK
XX 410 / SIN	XX 625 / MNL	XX 607 / HKG	XX 677 / NRT	XX 575 / VTE	XX 436 / CGK
XX 410 / SIN	XX 625 / MNL	XX 607 / HKG	XX 677 / NRT	XX 575 / VTE	XX 436 / CGK
XX 625 / MNL	XX 607 / HKG	XX 677 / NRT	XX 575 / VTE	XX 436 / CGK	XX 679 / CAN
XX 607 / HKG	XX 677 / NRT	XX 575 / VTE	XX 436 / CGK	XX 679 / CAN	XX 635 / TPE
XX 607 / HKG	XX 677 / NRT	XX 575 / VTE	XX 436 / CGK	XX 679 / CAN	XX 635 / TPE
XX 677 / NRT	XX 575 / VTE	XX 436 / CGK	XX 679 / CAN	XX 635 / TPE	
XX 679 / CAN	XX 635 / TPE				
XX 679 / CAN	XX 635 / TPE				

Inbound 7.4

XX 565 / HAN					
XX 565 / HAN	XX 557 / SGN	XX 410 / SIN	XX 625 / MNL		
XX 557 / SGN	XX 410 / SIN	XX 625 / MNL			
XX 410 / SIN	XX 625 / MNL	XX 607 / HKG	XX 677 / NRT		
XX 410 / SIN	XX 625 / MNL	XX 607 / HKG	XX 677 / NRT	XX 575 / VTE	
XX 625 / MNL	XX 607 / HKG	XX 677 / NRT	XX 575 / VTE	XX 436 / CGK	
XX 625 / MNL	XX 607 / HKG	XX 677 / NRT	XX 575 / VTE	XX 436 / CGK	XX 679 / CAN
XX 625 / MNL	XX 607 / HKG	XX 677 / NRT	XX 575 / VTE	XX 436 / CGK	XX 679 / CAN
XX 625 / MNL	XX 607 / HKG	XX 677 / NRT	XX 575 / VTE	XX 436 / CGK	XX 679 / CAN
XX 625 / MNL	XX 607 / HKG	XX 677 / NRT	XX 575 / VTE	XX 436 / CGK	XX 679 / CAN
XX 677 / NRT	XX 575 / VTE	XX 436 / CGK	XX 679 / CAN	XX 635 / TPE	
XX 575 / VTE	XX 436 / CGK	XX 679 / CAN	XX 635 / TPE		
XX 575 / VTE	XX 436 / CGK	XX 679 / CAN	XX 635 / TPE		
XX 575 / VTE	XX 436 / CGK	XX 679 / CAN	XX 635 / TPE		
XX 575 / VTE	XX 436 / CGK	XX 679 / CAN	XX 635 / TPE		
XX 679 / CAN	XX 679 / CAN	XX 635 / TPE			
XX 679 / CAN	XX 635 / TPE				
XX 679 / CAN	XX 635 / TPE				
XX 679 / CAN	XX 635 / TPE				
XX 635 / TPE					

Outbound 1.1

	Time	Outbound		
1		1	2	3
xx 960 / ARN	0:00	xx 944 / FCO	xx 674 / PEK	xx 473 / BNE
xx 960 / ARN	0:05	xx 650 / PUS	xx 465 / MEL	xx 644 / NGO
xx 960 / ARN	0:10			
	0:15	xx 910 / LHR		
	0:20	xx 954 / OSL		
	0:25			
	0:30	xx 934 / BRU		
	0:35	xx 940 / MXP	xx 970 / ZRH	
	0:40			
	0:45			
	0:50	xx 950 / CPH	xx 924 / MUC	
	0:55			
	1:00	xx 648 / FUK		
	1:05			
	1:10	xx 662 / PVG		
	1:15			
	1:20			
	1:25	xx 960 / ARN		
	1:30			
	1:35			
	1:40			
	1:45			
	1:50			
	1:55			
	2:00			
	2:05			
	2:10			
	2:15			
	2:20			
	2:25			
	2:30			
	2:35			
	2:40			
	2:45			
	2:50			
	2:55			
	3:00			
	3:05			
	3:10			
	3:15			
	3:20			
	3:25			
	3:30			
	3:35			

Outbound 1.2

		Outbound			
4	5	6	7	8	9
xx 930 / CDG					

Outbound 2.1

				xx 461 / MEL
				xx 461 / MEL
			xx 433 / CGK	xx 461 / MEL
			xx 433 / CGK	xx 461 / MEL
			xx 433 / CGK	xx 461 / MEL
			xx 433 / CGK	xx 461 / MEL
			xx 433 / CGK	xx 461 / MEL
		xx 415 / KUL	xx 433 / CGK	xx 461 / MEL
		xx 431 / DPS	xx 415 / KUL	xx 433 / CGK
		xx 431 / DPS	xx 415 / KUL	xx 433 / CGK
			xx 431 / DPS	xx 415 / KUL
			xx 431 / DPS	xx 415 / KUL
			xx 431 / DPS	xx 415 / KUL
				xx 431 / DPS
				xx 431 / DPS
				xx 431 / DPS
				xx 431 / DPS

Outbound 2.2

				xx 580 / PNH
				xx 580 / PNH
xx 600 / HKG	xx 403 / SIN	xx 676 / NRT	xx 303 / RGN	xx 580 / PNH
xx 600 / HKG	xx 403 / SIN	xx 676 / NRT	xx 303 / RGN	xx 580 / PNH
xx 600 / HKG	xx 403 / SIN	xx 676 / NRT	xx 303 / RGN	xx 580 / PNH
xx 600 / HKG	xx 403 / SIN	xx 676 / NRT	xx 303 / RGN	xx 580 / PNH
xx 600 / HKG	xx 403 / SIN	xx 676 / NRT	xx 303 / RGN	xx 580 / PNH
xx 600 / HKG	xx 403 / SIN	xx 676 / NRT	xx 303 / RGN	xx 580 / PNH
xx 600 / HKG	xx 403 / SIN	xx 676 / NRT	xx 303 / RGN	xx 580 / PNH
xx 600 / HKG	xx 403 / SIN	xx 676 / NRT	xx 303 / RGN	xx 580 / PNH
xx 600 / HKG	xx 403 / SIN	xx 676 / NRT	xx 303 / RGN	xx 580 / PNH
xx 600 / HKG	xx 403 / SIN	xx 676 / NRT	xx 303 / RGN	xx 580 / PNH
xx 461 / MEL	xx 600 / HKG	xx 403 / SIN	xx 676 / NRT	xx 303 / RGN
xx 461 / MEL	xx 600 / HKG	xx 403 / SIN	xx 676 / NRT	xx 303 / RGN
xx 433 / CGK	xx 461 / MEL	xx 600 / HKG	xx 403 / SIN	xx 676 / NRT
xx 433 / CGK	xx 461 / MEL	xx 600 / HKG	xx 403 / SIN	xx 676 / NRT
xx 433 / CGK	xx 461 / MEL	xx 600 / HKG	xx 403 / SIN	xx 676 / NRT
xx 415 / KUL	xx 433 / CGK	xx 461 / MEL	xx 600 / HKG	xx 403 / SIN
xx 415 / KUL	xx 433 / CGK	xx 461 / MEL	xx 600 / HKG	xx 403 / SIN
xx 415 / KUL	xx 433 / CGK	xx 461 / MEL	xx 600 / HKG	xx 403 / SIN
xx 415 / KUL	xx 433 / CGK	xx 461 / MEL	xx 600 / HKG	xx 403 / SIN
		xx 431 / DPS	xx 415 / KUL	xx 433 / CGK
			xx 431 / DPS	xx 415 / KUL
			xx 431 / DPS	xx 415 / KUL
				xx 628 / HKG

Outbound 2.3

				xx 471 / SYD
				xx 471 / SYD
				xx 471 / SYD
			xx 634 / TPE	xx 471 / SYD
			xx 634 / TPE	xx 471 / SYD
			xx 634 / TPE	xx 471 / SYD
			xx 634 / TPE	xx 471 / SYD
xx 560 / HAN	xx 550 / SGN	xx 620 / MNL	xx 634 / TPE	xx 471 / SYD
xx 560 / HAN	xx 550 / SGN	xx 620 / MNL	xx 634 / TPE	xx 471 / SYD
xx 560 / HAN	xx 550 / SGN	xx 620 / MNL	xx 634 / TPE	xx 471 / SYD
xx 560 / HAN	xx 550 / SGN	xx 620 / MNL	xx 634 / TPE	xx 471 / SYD
xx 560 / HAN	xx 550 / SGN	xx 620 / MNL	xx 634 / TPE	xx 471 / SYD
xx 560 / HAN	xx 550 / SGN	xx 620 / MNL	xx 634 / TPE	xx 471 / SYD
xx 560 / HAN	xx 550 / SGN	xx 620 / MNL	xx 634 / TPE	xx 471 / SYD
xx 560 / HAN	xx 550 / SGN	xx 620 / MNL	xx 634 / TPE	xx 471 / SYD
xx 560 / HAN	xx 550 / SGN	xx 620 / MNL	xx 634 / TPE	xx 471 / SYD
xx 560 / HAN	xx 550 / SGN	xx 620 / MNL	xx 634 / TPE	xx 471 / SYD
xx 560 / HAN	xx 550 / SGN	xx 620 / MNL	xx 634 / TPE	xx 471 / SYD
xx 560 / HAN	xx 550 / SGN	xx 620 / MNL	xx 634 / TPE	xx 471 / SYD
xx 560 / HAN	xx 550 / SGN	xx 620 / MNL	xx 634 / TPE	xx 471 / SYD
xx 580 / PNH	xx 560 / HAN	xx 550 / SGN	xx 620 / MNL	xx 634 / TPE
xx 580 / PNH	xx 560 / HAN	xx 550 / SGN	xx 620 / MNL	xx 634 / TPE
xx 303 / RGN	xx 580 / PNH	xx 560 / HAN	xx 550 / SGN	xx 620 / MNL
xx 303 / RGN	xx 580 / PNH	xx 560 / HAN	xx 550 / SGN	xx 620 / MNL
xx 303 / RGN	xx 580 / PNH	xx 560 / HAN	xx 550 / SGN	xx 620 / MNL
xx 676 / NRT	xx 303 / RGN	xx 580 / PNH	xx 560 / HAN	xx 550 / SGN
xx 676 / NRT	xx 303 / RGN	xx 580 / PNH	xx 560 / HAN	xx 550 / SGN
xx 676 / NRT	xx 303 / RGN	xx 580 / PNH	xx 560 / HAN	xx 550 / SGN
xx 676 / NRT	xx 303 / RGN	xx 580 / PNH	xx 560 / HAN	xx 550 / SGN
xx 461 / MEL	xx 600 / HKG	xx 403 / SIN	xx 676 / NRT	xx 303 / RGN
xx 433 / CGK	xx 461 / MEL	xx 600 / HKG	xx 403 / SIN	xx 676 / NRT
xx 433 / CGK	xx 461 / MEL	xx 600 / HKG	xx 403 / SIN	xx 676 / NRT
	xx 668 / CAN	xx 431 / DPS	xx 415 / KUL	xx 433 / CGK
	xx 668 / CAN	xx 431 / DPS	xx 415 / KUL	xx 433 / CGK
		xx 668 / CAN	xx 431 / DPS	xx 415 / KUL
	xx 618 / CTU	xx 668 / CAN	xx 431 / DPS	xx 415 / KUL
	xx 614 / PEK	xx 618 / CTU	xx 668 / CAN	xx 431 / DPS
	xx 614 / PEK	xx 618 / CTU	xx 668 / CAN	xx 431 / DPS
	xx 614 / PEK	xx 618 / CTU	xx 668 / CAN	xx 431 / DPS
	xx 614 / PEK	xx 618 / CTU	xx 668 / CAN	xx 431 / DPS
xx 319 / KTM	xx 614 / PEK	xx 618 / CTU	xx 668 / CAN	xx 431 / DPS

Outbound 2.4

	3:40			
	3:45			
	3:50			
	3:55			
xx 323 / DEL	4:00			
xx 323 / DEL	4:05			
xx 323 / DEL	4:10			
xx 323 / DEL	4:15			
xx 323 / DEL	4:20			
xx 323 / DEL	4:25			
xx 323 / DEL	4:30			
xx 323 / DEL	4:35			
xx 323 / DEL	4:40			
xx 323 / DEL	4:45			
xx 323 / DEL	4:50			
xx 323 / DEL	4:55			
xx 323 / DEL	5:00			
xx 323 / DEL	5:05			
xx 323 / DEL	5:10			
xx 323 / DEL	5:15			
xx 323 / DEL	5:20			
xx 323 / DEL	5:25			
xx 323 / DEL	5:30			
xx 323 / DEL	5:35			
xx 323 / DEL	5:40			
xx 323 / DEL	5:45			
xx 471 / SYD	5:50			
xx 471 / SYD	5:55			
xx 634 / TPE	6:00			
xx 634 / TPE	6:05			
xx 634 / TPE	6:10			
xx 620 / MNL	6:15			
xx 620 / MNL	6:20			
xx 620 / MNL	6:25			
xx 620 / MNL	6:30			
xx 580 / PNH	6:35			
xx 303 / RGN	6:40			
xx 303 / RGN	6:45			
xx 461 / MEL	6:50			
xx 461 / MEL	6:55			
xx 433 / CGK	7:00	xx 323 / DEL		
xx 433 / CGK	7:05			
xx 415 / KUL	7:10	xx 471 / SYD		
xx 415 / KUL	7:15			
xx 415 / KUL	7:20			
xx 415 / KUL	7:25	xx 634 / TPE		
xx 415 / KUL	7:30			

Outbound 3.1

				xx 684 / CKG
				xx 684 / CKG
			xx 570 / VTE	xx 684 / CKG
			xx 570 / VTE	xx 684 / CKG
		xx 413 / SIN	xx 570 / VTE	xx 684 / CKG
		xx 413 / SIN	xx 570 / VTE	xx 684 / CKG
			xx 413 / SIN	xx 570 / VTE
			xx 413 / SIN	xx 570 / VTE
			xx 413 / SIN	xx 570 / VTE
				xx 413 / SIN

Outbound 3.2

				xx 664 / PVG
			xx 672 / KIX	xx 610 / XMN
		xx 646 / NGO	xx 672 / KIX	xx 610 / XMN
		xx 646 / NGO	xx 672 / KIX	xx 610 / XMN
xx 321 / DAC	xx 612 / KMG	xx 646 / NGO	xx 672 / KIX	xx 610 / XMN
xx 321 / DAC	xx 612 / KMG	xx 646 / NGO	xx 672 / KIX	xx 610 / XMN
xx 321 / DAC	xx 612 / KMG	xx 646 / NGO	xx 672 / KIX	xx 610 / XMN
xx 321 / DAC	xx 612 / KMG	xx 646 / NGO	xx 672 / KIX	xx 610 / XMN
xx 321 / DAC	xx 612 / KMG	xx 646 / NGO	xx 672 / KIX	xx 610 / XMN
xx 321 / DAC	xx 612 / KMG	xx 646 / NGO	xx 672 / KIX	xx 610 / XMN
xx 321 / DAC	xx 612 / KMG	xx 646 / NGO	xx 672 / KIX	xx 610 / XMN
xx 321 / DAC	xx 612 / KMG	xx 646 / NGO	xx 672 / KIX	xx 610 / XMN
xx 321 / DAC	xx 612 / KMG	xx 646 / NGO	xx 672 / KIX	xx 610 / XMN
xx 684 / CKG	xx 321 / DAC	xx 612 / KMG	xx 646 / NGO	xx 672 / KIX
xx 684 / CKG	xx 321 / DAC	xx 612 / KMG	xx 646 / NGO	xx 672 / KIX
xx 684 / CKG	xx 321 / DAC	xx 612 / KMG	xx 646 / NGO	xx 672 / KIX
xx 570 / VTE	xx 684 / CKG	xx 321 / DAC	xx 612 / KMG	xx 646 / NGO
xx 413 / SIN	xx 570 / VTE	xx 684 / CKG	xx 321 / DAC	xx 612 / KMG
xx 413 / SIN	xx 570 / VTE	xx 684 / CKG	xx 321 / DAC	xx 612 / KMG
xx 413 / SIN	xx 570 / VTE	xx 684 / CKG	xx 321 / DAC	xx 612 / KMG
xx 413 / SIN	xx 570 / VTE	xx 684 / CKG	xx 321 / DAC	xx 612 / KMG
		xx 413 / SIN	xx 570 / VTE	xx 684 / CKG
		xx 576 / LPQ	xx 413 / SIN	xx 570 / VTE
				xx 576 / LPQ
				xx 638 / HKG
				xx 638 / HKG
			xx 507 / KHI	xx 638 / HKG
				xx 507 / KHI
			xx 435 / CGK	xx 507 / KHI
			xx 435 / CGK	xx 507 / KHI

Outbound 3.3

xx 628 / HKG	xx 319 / KTM	xx 614 / PEK	xx 618 / CTU	xx 668 / CAN
xx 664 / PVG	xx 628 / HKG	xx 319 / KTM	xx 614 / PEK	xx 618 / CTU
xx 664 / PVG	xx 628 / HKG	xx 319 / KTM	xx 614 / PEK	xx 618 / CTU
xx 664 / PVG	xx 628 / HKG	xx 319 / KTM	xx 614 / PEK	xx 618 / CTU
xx 664 / PVG	xx 628 / HKG	xx 319 / KTM	xx 614 / PEK	xx 618 / CTU
xx 664 / PVG	xx 628 / HKG	xx 319 / KTM	xx 614 / PEK	xx 618 / CTU
xx 664 / PVG	xx 628 / HKG	xx 319 / KTM	xx 614 / PEK	xx 618 / CTU
xx 664 / PVG	xx 628 / HKG	xx 319 / KTM	xx 614 / PEK	xx 618 / CTU
xx 664 / PVG	xx 628 / HKG	xx 319 / KTM	xx 614 / PEK	xx 618 / CTU
xx 664 / PVG	xx 628 / HKG	xx 319 / KTM	xx 614 / PEK	xx 618 / CTU
xx 664 / PVG	xx 628 / HKG	xx 319 / KTM	xx 614 / PEK	xx 618 / CTU
xx 664 / PVG	xx 628 / HKG	xx 319 / KTM	xx 614 / PEK	xx 618 / CTU
xx 664 / PVG	xx 628 / HKG	xx 319 / KTM	xx 614 / PEK	xx 618 / CTU
xx 610 / XMN	xx 664 / PVG	xx 628 / HKG	xx 319 / KTM	xx 614 / PEK
xx 610 / XMN	xx 664 / PVG	xx 628 / HKG	xx 319 / KTM	xx 614 / PEK
xx 610 / XMN	xx 664 / PVG	xx 628 / HKG	xx 319 / KTM	xx 614 / PEK
xx 672 / KIX	xx 610 / XMN	xx 664 / PVG	xx 628 / HKG	xx 319 / KTM
xx 646 / NGO	xx 672 / KIX	xx 610 / XMN	xx 664 / PVG	xx 628 / HKG
xx 646 / NGO	xx 672 / KIX	xx 610 / XMN	xx 664 / PVG	xx 628 / HKG
xx 646 / NGO	xx 672 / KIX	xx 610 / XMN	xx 664 / PVG	xx 628 / HKG
xx 646 / NGO	xx 672 / KIX	xx 610 / XMN	xx 664 / PVG	xx 628 / HKG
xx 321 / DAC	xx 612 / KMG	xx 646 / NGO	xx 672 / KIX	xx 610 / XMN
xx 684 / CKG	xx 321 / DAC	xx 612 / KMG	xx 646 / NGO	xx 672 / KIX
xx 413 / SIN	xx 570 / VTE	xx 684 / CKG	xx 321 / DAC	xx 612 / KMG
xx 576 / LPQ	xx 413 / SIN	xx 570 / VTE	xx 684 / CKG	xx 321 / DAC
xx 576 / LPQ	xx 413 / SIN	xx 570 / VTE	xx 684 / CKG	xx 321 / DAC
		xx 576 / LPQ	xx 413 / SIN	xx 570 / VTE
xx 922 / FRA	xx 582 / PNH	xx 576 / LPQ	xx 413 / SIN	xx 570 / VTE
xx 922 / FRA	xx 582 / PNH	xx 576 / LPQ	xx 413 / SIN	xx 570 / VTE
	xx 922 / FRA	xx 582 / PNH	xx 576 / LPQ	xx 413 / SIN
	xx 922 / FRA	xx 582 / PNH	xx 576 / LPQ	xx 413 / SIN
		xx 922 / FRA	xx 582 / PNH	xx 576 / LPQ
	xx 301 / RGN	xx 922 / FRA	xx 582 / PNH	xx 576 / LPQ
	xx 916 / LHR	xx 301 / RGN	xx 922 / FRA	xx 582 / PNH
	xx 916 / LHR	xx 301 / RGN	xx 922 / FRA	xx 582 / PNH
	xx 916 / LHR	xx 301 / RGN	xx 922 / FRA	xx 582 / PNH
	xx 916 / LHR	xx 301 / RGN	xx 922 / FRA	xx 582 / PNH
	xx 916 / LHR	xx 301 / RGN	xx 922 / FRA	xx 582 / PNH
	xx 916 / LHR	xx 301 / RGN	xx 922 / FRA	xx 582 / PNH
xx 407 / SIN	xx 916 / LHR	xx 301 / RGN	xx 922 / FRA	xx 582 / PNH
xx 407 / SIN	xx 916 / LHR	xx 301 / RGN	xx 922 / FRA	xx 582 / PNH
xx 407 / SIN	xx 916 / LHR	xx 301 / RGN	xx 922 / FRA	xx 582 / PNH
xx 407 / SIN	xx 916 / LHR	xx 301 / RGN	xx 922 / FRA	xx 582 / PNH
xx 407 / SIN	xx 916 / LHR	xx 301 / RGN	xx 922 / FRA	xx 582 / PNH
xx 638 / HKG	xx 407 / SIN	xx 916 / LHR	xx 301 / RGN	xx 922 / FRA
xx 638 / HKG	xx 407 / SIN	xx 916 / LHR	xx 301 / RGN	xx 922 / FRA
xx 638 / HKG	xx 407 / SIN	xx 916 / LHR	xx 301 / RGN	xx 922 / FRA

Outbound 3.4

xx 431 / DPS	7:35			
xx 668 / CAN	7:40			
xx 668 / CAN	7:45	xx 560 / HAN	xx 550 / SGN	xx 620 / MNL
xx 668 / CAN	7:50	xx 580 / PNH		
xx 668 / CAN	7:55			
xx 668 / CAN	8:00	xx 600 / HKG	xx 403 / SIN	xx 676 / NRT
xx 668 / CAN	8:05			
xx 668 / CAN	8:10	xx 461 / MEL		
xx 668 / CAN	8:15			
xx 668 / CAN	8:20	xx 433 / CGK		
xx 668 / CAN	8:25			
xx 668 / CAN	8:30			
xx 668 / CAN	8:35			
xx 618 / CTU	8:40			
xx 618 / CTU	8:45	xx 415 / KUL		
xx 618 / CTU	8:50	xx 431 / DPS		
xx 614 / PEK	8:55			
xx 319 / KTM	9:00			
xx 319 / KTM	9:05			
xx 319 / KTM	9:10			
xx 319 / KTM	9:15			
xx 664 / PVG	9:20			
xx 610 / XMN	9:25			
xx 646 / NGO	9:30			
xx 612 / KMG	9:35			
xx 612 / KMG	9:40			
xx 684 / CKG	9:45			
xx 684 / CKG	9:50	xx 668 / CAN		
xx 684 / CKG	9:55			
xx 570 / VTE	10:00			
xx 570 / VTE	10:05	xx 618 / CTU		
xx 413 / SIN	10:10	xx 614 / PEK		
xx 413 / SIN	10:15			
xx 576 / LPQ	10:20			
xx 576 / LPQ	10:25			
xx 576 / LPQ	10:30	xx 628 / HKG	xx 319 / KTM	
xx 576 / LPQ	10:35	xx 664 / PVG		
xx 576 / LPQ	10:40	xx 672 / KIX	xx 610 / XMN	
xx 576 / LPQ	10:45	xx 646 / NGO		
xx 576 / LPQ	10:50			
xx 576 / LPQ	10:55	xx 321 / DAC	xx 612 / KMG	
xx 576 / LPQ	11:00			
xx 576 / LPQ	11:05			
xx 576 / LPQ	11:10	xx 684 / CKG		
xx 582 / PNH	11:15			
xx 582 / PNH	11:20	xx 570 / VTE		
xx 582 / PNH	11:25			

Outbound 3.5

xx 303 / RGN					

Outbound 4.1

			xx 435 / CGK	xx 507 / KHI
			xx 435 / CGK	xx 507 / KHI
		xx 616 / CSX	xx 624 / MNL	xx 660 / HND
		xx 616 / CSX	xx 624 / MNL	xx 660 / HND
		xx 616 / CSX	xx 624 / MNL	xx 660 / HND
			xx 616 / CSX	xx 624 / MNL
				xx 616 / CSX
				xx 616 / CSX
				xx 616 / CSX
			xx 678 / CAN	xx 616 / CSX
			xx 678 / CAN	xx 616 / CSX
			xx 678 / CAN	xx 616 / CSX
				xx 678 / CAN
				xx 678 / CAN
				xx 409 / SIN
				xx 305 / RGN
				xx 584 / PNH

Outbound 4.2

xx 638 / HKG	xx 407 / SIN	xx 916 / LHR	xx 301 / RGN	xx 922 / FRA
xx 638 / HKG	xx 407 / SIN	xx 916 / LHR	xx 301 / RGN	xx 922 / FRA
xx 435 / CGK	xx 507 / KHI	xx 638 / HKG	xx 407 / SIN	xx 916 / LHR
xx 435 / CGK	xx 507 / KHI	xx 638 / HKG	xx 407 / SIN	xx 916 / LHR
xx 435 / CGK	xx 507 / KHI	xx 638 / HKG	xx 407 / SIN	xx 916 / LHR
xx 435 / CGK	xx 507 / KHI	xx 638 / HKG	xx 407 / SIN	xx 916 / LHR
xx 435 / CGK	xx 507 / KHI	xx 638 / HKG	xx 407 / SIN	xx 916 / LHR
xx 660 / HND	xx 435 / CGK	xx 507 / KHI	xx 638 / HKG	xx 407 / SIN
xx 624 / MNL	xx 660 / HND	xx 435 / CGK	xx 507 / KHI	xx 638 / HKG
xx 624 / MNL	xx 660 / HND	xx 435 / CGK	xx 507 / KHI	xx 638 / HKG
xx 624 / MNL	xx 660 / HND	xx 435 / CGK	xx 507 / KHI	xx 638 / HKG
xx 624 / MNL	xx 660 / HND	xx 435 / CGK	xx 507 / KHI	xx 638 / HKG
xx 624 / MNL	xx 660 / HND	xx 435 / CGK	xx 507 / KHI	xx 638 / HKG
xx 624 / MNL	xx 660 / HND	xx 435 / CGK	xx 507 / KHI	xx 638 / HKG
xx 616 / CSX	xx 624 / MNL	xx 660 / HND	xx 435 / CGK	xx 507 / KHI
xx 616 / CSX	xx 624 / MNL	xx 660 / HND	xx 435 / CGK	xx 507 / KHI
xx 678 / CAN	xx 616 / CSX	xx 624 / MNL	xx 660 / HND	xx 435 / CGK
xx 678 / CAN	xx 616 / CSX	xx 624 / MNL	xx 660 / HND	xx 435 / CGK
xx 606 / HKG	xx 678 / CAN	xx 616 / CSX	xx 624 / MNL	xx 660 / HND
xx 606 / HKG	xx 678 / CAN	xx 616 / CSX	xx 624 / MNL	xx 660 / HND
	xx 606 / HKG	xx 678 / CAN	xx 616 / CSX	xx 624 / MNL
	xx 606 / HKG	xx 678 / CAN	xx 616 / CSX	xx 624 / MNL
xx 517 / DXB	xx 606 / HKG	xx 678 / CAN	xx 616 / CSX	xx 624 / MNL
xx 517 / DXB	xx 606 / HKG	xx 678 / CAN	xx 616 / CSX	xx 624 / MNL
xx 517 / DXB	xx 606 / HKG	xx 678 / CAN	xx 616 / CSX	xx 624 / MNL
xx 517 / DXB	xx 606 / HKG	xx 678 / CAN	xx 616 / CSX	xx 624 / MNL
	xx 417 / KUL	xx 409 / SIN	xx 517 / DXB	xx 606 / HKG
	xx 417 / KUL	xx 409 / SIN	xx 517 / DXB	xx 606 / HKG
	xx 417 / KUL	xx 409 / SIN	xx 517 / DXB	xx 606 / HKG
	xx 417 / KUL	xx 409 / SIN	xx 517 / DXB	xx 606 / HKG
	xx 417 / KUL	xx 409 / SIN	xx 517 / DXB	xx 606 / HKG
	xx 417 / KUL	xx 409 / SIN	xx 517 / DXB	xx 606 / HKG
	xx 417 / KUL	xx 409 / SIN	xx 517 / DXB	xx 606 / HKG
		xx 417 / KUL	xx 409 / SIN	xx 517 / DXB
		xx 417 / KUL	xx 409 / SIN	xx 517 / DXB
		xx 417 / KUL	xx 409 / SIN	xx 517 / DXB
	xx 564 / HAN	xx 417 / KUL	xx 409 / SIN	xx 517 / DXB
	xx 564 / HAN	xx 417 / KUL	xx 409 / SIN	xx 517 / DXB
xx 636 / TPE	xx 564 / HAN	xx 417 / KUL	xx 409 / SIN	xx 517 / DXB
xx 636 / TPE	xx 564 / HAN	xx 417 / KUL	xx 409 / SIN	xx 517 / DXB
xx 475 / SYD	xx 636 / TPE	xx 564 / HAN	xx 417 / KUL	xx 409 / SIN
xx 475 / SYD	xx 636 / TPE	xx 564 / HAN	xx 417 / KUL	xx 409 / SIN
xx 475 / SYD	xx 636 / TPE	xx 564 / HAN	xx 417 / KUL	xx 409 / SIN
xx 475 / SYD	xx 636 / TPE	xx 564 / HAN	xx 417 / KUL	xx 409 / SIN
xx 305 / RGN	xx 475 / SYD	xx 636 / TPE	xx 564 / HAN	xx 417 / KUL
xx 305 / RGN	xx 475 / SYD	xx 636 / TPE	xx 564 / HAN	xx 417 / KUL
xx 305 / RGN	xx 475 / SYD	xx 636 / TPE	xx 564 / HAN	xx 417 / KUL

Outbound 4.3

xx 582 / PNH	11:30	xx 413 / SIN		
xx 582 / PNH	11:35			
xx 301 / RGN	11:40			
xx 301 / RGN	11:45			
xx 301 / RGN	11:50			
xx 301 / RGN	11:55			
xx 301 / RGN	12:00			
xx 916 / LHR	12:05			
xx 407 / SIN	12:10			
xx 407 / SIN	12:15			
xx 407 / SIN	12:20			
xx 407 / SIN	12:25	xx 576 / LPQ		
xx 407 / SIN	12:30			
xx 407 / SIN	12:35			
xx 638 / HKG	12:40			
xx 638 / HKG	12:45			
xx 507 / KHI	12:50	xx 922 / FRA	xx 582 / PNH	
xx 507 / KHI	12:55			
xx 435 / CGK	13:00			
xx 435 / CGK	13:05			
xx 660 / HND	13:10			
xx 660 / HND	13:15	xx 301 / RGN		
xx 660 / HND	13:20	xx 916 / LHR		
xx 660 / HND	13:25			
xx 660 / HND	13:30			
xx 660 / HND	13:35			
xx 678 / CAN	13:40			
xx 678 / CAN	13:45			
xx 678 / CAN	13:50	xx 407 / SIN		
xx 678 / CAN	13:55			
xx 678 / CAN	14:00	xx 638 / HKG		
xx 678 / CAN	14:05			
xx 678 / CAN	14:10	xx 507 / KHI		
xx 606 / HKG	14:15			
xx 606 / HKG	14:20	xx 435 / CGK		
xx 606 / HKG	14:25			
xx 606 / HKG	14:30			
xx 606 / HKG	14:35			
xx 606 / HKG	14:40			
xx 606 / HKG	14:45			
xx 517 / DXB	14:50	xx 616 / CSX	xx 624 / MNL	xx 660 / HND
xx 517 / DXB	14:55			
xx 517 / DXB	15:00			
xx 517 / DXB	15:05			
xx 409 / SIN	15:10			
xx 409 / SIN	15:15			
xx 409 / SIN	15:20			

Outbound 5.1

				xx 345 / LHE
				xx 345 / LHE
				xx 315 / DEL
				xx 315 / DEL

Outbound 5.2

				xx 556 / SGN
				xx 602 / HKG
			xx 491 / AKL	xx 602 / HKG
		xx 349 / ISB	xx 491 / AKL	xx 602 / HKG
	xx 317 / BOM	xx 349 / ISB	xx 491 / AKL	xx 602 / HKG
	xx 317 / BOM	xx 349 / ISB	xx 491 / AKL	xx 602 / HKG
	xx 317 / BOM	xx 349 / ISB	xx 491 / AKL	xx 602 / HKG
xx 341 / KHI	xx 317 / BOM	xx 349 / ISB	xx 491 / AKL	xx 602 / HKG
xx 341 / KHI	xx 317 / BOM	xx 349 / ISB	xx 491 / AKL	xx 602 / HKG
	xx 341 / KHI	xx 317 / BOM	xx 349 / ISB	xx 491 / AKL
xx 401 / SIN	xx 341 / KHI	xx 317 / BOM	xx 349 / ISB	xx 491 / AKL
	xx 401 / SIN	xx 341 / KHI	xx 317 / BOM	xx 349 / ISB
xx 574 / VTE	xx 401 / SIN	xx 341 / KHI	xx 317 / BOM	xx 349 / ISB
	xx 574 / VTE	xx 401 / SIN	xx 341 / KHI	xx 317 / BOM
xx 425 / PEN	xx 574 / VTE	xx 401 / SIN	xx 341 / KHI	xx 317 / BOM
xx 425 / PEN	xx 574 / VTE	xx 401 / SIN	xx 341 / KHI	xx 317 / BOM
xx 345 / LHE	xx 425 / PEN	xx 574 / VTE	xx 401 / SIN	xx 341 / KHI
xx 345 / LHE	xx 425 / PEN	xx 574 / VTE	xx 401 / SIN	xx 341 / KHI
xx 345 / LHE	xx 425 / PEN	xx 574 / VTE	xx 401 / SIN	xx 341 / KHI
xx 315 / DEL	xx 345 / LHE	xx 425 / PEN	xx 574 / VTE	xx 401 / SIN
	xx 315 / DEL	xx 345 / LHE	xx 425 / PEN	xx 574 / VTE
	xx 315 / DEL	xx 345 / LHE	xx 425 / PEN	xx 574 / VTE
	xx 315 / DEL	xx 345 / LHE	xx 425 / PEN	xx 574 / VTE
		xx 315 / DEL	xx 345 / LHE	xx 425 / PEN
			xx 315 / DEL	xx 345 / LHE
				xx 315 / DEL

Outbound 5.3

xx 584 / PNH	xx 305 / RGN	xx 475 / SYD	xx 636 / TPE	xx 564 / HAN
xx 556 / SGN	xx 584 / PNH	xx 305 / RGN	xx 475 / SYD	xx 636 / TPE
xx 556 / SGN	xx 584 / PNH	xx 305 / RGN	xx 475 / SYD	xx 636 / TPE
xx 556 / SGN	xx 584 / PNH	xx 305 / RGN	xx 475 / SYD	xx 636 / TPE
xx 556 / SGN	xx 584 / PNH	xx 305 / RGN	xx 475 / SYD	xx 636 / TPE
xx 556 / SGN	xx 584 / PNH	xx 305 / RGN	xx 475 / SYD	xx 636 / TPE
xx 556 / SGN	xx 584 / PNH	xx 305 / RGN	xx 475 / SYD	xx 636 / TPE
xx 556 / SGN	xx 584 / PNH	xx 305 / RGN	xx 475 / SYD	xx 636 / TPE
xx 556 / SGN	xx 584 / PNH	xx 305 / RGN	xx 475 / SYD	xx 636 / TPE
xx 556 / SGN	xx 584 / PNH	xx 305 / RGN	xx 475 / SYD	xx 636 / TPE
xx 556 / SGN	xx 584 / PNH	xx 305 / RGN	xx 475 / SYD	xx 636 / TPE
xx 602 / HKG	xx 556 / SGN	xx 584 / PNH	xx 305 / RGN	xx 475 / SYD
xx 602 / HKG	xx 556 / SGN	xx 584 / PNH	xx 305 / RGN	xx 475 / SYD
xx 491 / AKL	xx 602 / HKG	xx 556 / SGN	xx 584 / PNH	xx 305 / RGN
xx 491 / AKL	xx 602 / HKG	xx 556 / SGN	xx 584 / PNH	xx 305 / RGN
xx 349 / ISB	xx 491 / AKL	xx 602 / HKG	xx 556 / SGN	xx 584 / PNH
xx 349 / ISB	xx 491 / AKL	xx 602 / HKG	xx 556 / SGN	xx 584 / PNH
xx 349 / ISB	xx 491 / AKL	xx 602 / HKG	xx 556 / SGN	xx 584 / PNH
xx 317 / BOM	xx 349 / ISB	xx 491 / AKL	xx 602 / HKG	xx 556 / SGN
xx 317 / BOM	xx 349 / ISB	xx 491 / AKL	xx 602 / HKG	xx 556 / SGN
xx 317 / BOM	xx 349 / ISB	xx 491 / AKL	xx 602 / HKG	xx 556 / SGN
xx 341 / KHI	xx 317 / BOM	xx 349 / ISB	xx 491 / AKL	xx 602 / HKG
xx 401 / SIN	xx 341 / KHI	xx 317 / BOM	xx 349 / ISB	xx 491 / AKL
xx 401 / SIN	xx 341 / KHI	xx 317 / BOM	xx 349 / ISB	xx 491 / AKL
xx 401 / SIN	xx 341 / KHI	xx 317 / BOM	xx 349 / ISB	xx 491 / AKL
xx 574 / VTE	xx 401 / SIN	xx 341 / KHI	xx 317 / BOM	xx 349 / ISB
xx 425 / PEN	xx 574 / VTE	xx 401 / SIN	xx 341 / KHI	xx 317 / BOM
xx 345 / LHE	xx 425 / PEN	xx 574 / VTE	xx 401 / SIN	xx 341 / KHI
xx 315 / DEL	xx 345 / LHE	xx 425 / PEN	xx 574 / VTE	xx 401 / SIN
xx 315 / DEL	xx 345 / LHE	xx 425 / PEN	xx 574 / VTE	xx 401 / SIN
xx 315 / DEL	xx 345 / LHE	xx 425 / PEN	xx 574 / VTE	xx 401 / SIN
	xx 315 / DEL	xx 345 / LHE	xx 425 / PEN	xx 574 / VTE
	xx 315 / DEL	xx 345 / LHE	xx 425 / PEN	xx 574 / VTE
	xx 315 / DEL	xx 345 / LHE	xx 425 / PEN	xx 574 / VTE
		xx 315 / DEL	xx 345 / LHE	xx 425 / PEN
		xx 315 / DEL	xx 345 / LHE	xx 425 / PEN
			xx 315 / DEL	xx 345 / LHE
			xx 315 / DEL	xx 345 / LHE
				xx 325 / BLR
				xx 325 / BLR
				xx 325 / BLR
				xx 329 / HYD
			xx 307 / CMB	xx 329 / HYD

Outbound 5.4

xx 417 / KUL	15:25	xx 678 / CAN		
xx 564 / HAN	15:30			
xx 564 / HAN	15:35			
xx 564 / HAN	15:40			
xx 564 / HAN	15:45			
xx 564 / HAN	15:50			
xx 564 / HAN	15:55			
xx 564 / HAN	16:00	xx 606 / HKG		
xx 564 / HAN	16:05			
xx 564 / HAN	16:10			
xx 564 / HAN	16:15			
xx 636 / TPE	16:20	xx 517 / DXB		
xx 636 / TPE	16:25			
xx 475 / SYD	16:30			
xx 475 / SYD	16:35	xx 409 / SIN		
xx 305 / RGN	16:40	xx 417 / KUL		
xx 305 / RGN	16:45			
xx 305 / RGN	16:50			
xx 584 / PNH	16:55			
xx 584 / PNH	17:00			
xx 584 / PNH	17:05			
xx 556 / SGN	17:10			
xx 602 / HKG	17:15			
xx 602 / HKG	17:20			
xx 602 / HKG	17:25			
xx 491 / AKL	17:30	xx 564 / HAN		
xx 349 / ISB	17:35			
xx 317 / BOM	17:40	xx 636 / TPE		
xx 341 / KHI	17:45			
xx 341 / KHI	17:50	xx 475 / SYD		
xx 341 / KHI	17:55			
xx 401 / SIN	18:00			
xx 401 / SIN	18:05	xx 305 / RGN		
xx 401 / SIN	18:10			
xx 574 / VTE	18:15			
xx 574 / VTE	18:20	xx 584 / PNH		
xx 425 / PEN	18:25	xx 556 / SGN		
xx 425 / PEN	18:30			
xx 315 / DEL	18:35			
xx 315 / DEL	18:40	xx 602 / HKG		
xx 315 / DEL	18:45	xx 491 / AKL		
xx 325 / BLR	18:50	xx 349 / ISB		
xx 325 / BLR	18:55	xx 317 / BOM		
xx 325 / BLR	19:00			
xx 325 / BLR	19:05			
xx 325 / BLR	19:10	xx 341 / KHI		
xx 325 / BLR	19:15			

Outbound 6.1

				xx 940 / MXP
				xx 940 / MXP
				xx 940 / MXP
		xx 950 / CPH	xx 924 / MUC	xx 940 / MXP
		xx 950 / CPH	xx 924 / MUC	xx 940 / MXP
	xx 648 / FUK	xx 950 / CPH	xx 924 / MUC	xx 940 / MXP
		xx 648 / FUK	xx 950 / CPH	xx 924 / MUC
			xx 662 / PVG	xx 648 / FUK
			xx 662 / PVG	xx 648 / FUK
				xx 662 / PVG
				xx 960 / ARN

Outbound 6.2

		xx 650 / PUS	xx 465 / MEL	xx 644 / NGO
	xx 910 / LHR	xx 650 / PUS	xx 465 / MEL	xx 644 / NGO
	xx 954 / OSL	xx 910 / LHR	xx 650 / PUS	xx 465 / MEL
		xx 954 / OSL	xx 910 / LHR	xx 650 / PUS
	xx 934 / BRU	xx 954 / OSL	xx 910 / LHR	xx 650 / PUS
xx 970 / ZRH	xx 934 / BRU	xx 954 / OSL	xx 910 / LHR	xx 650 / PUS
xx 970 / ZRH	xx 934 / BRU	xx 954 / OSL	xx 910 / LHR	xx 650 / PUS
xx 970 / ZRH	xx 934 / BRU	xx 954 / OSL	xx 910 / LHR	xx 650 / PUS
xx 970 / ZRH	xx 934 / BRU	xx 954 / OSL	xx 910 / LHR	xx 650 / PUS
xx 970 / ZRH	xx 934 / BRU	xx 954 / OSL	xx 910 / LHR	xx 650 / PUS
xx 970 / ZRH	xx 934 / BRU	xx 954 / OSL	xx 910 / LHR	xx 650 / PUS
xx 940 / MXP	xx 970 / ZRH	xx 934 / BRU	xx 954 / OSL	xx 910 / LHR
xx 950 / CPH	xx 924 / MUC	xx 940 / MXP	xx 970 / ZRH	xx 934 / BRU
xx 950 / CPH	xx 924 / MUC	xx 940 / MXP	xx 970 / ZRH	xx 934 / BRU
xx 648 / FUK	xx 950 / CPH	xx 924 / MUC	xx 940 / MXP	xx 970 / ZRH
xx 662 / PVG	xx 648 / FUK	xx 950 / CPH	xx 924 / MUC	xx 940 / MXP
xx 960 / ARN	xx 662 / PVG	xx 648 / FUK	xx 950 / CPH	xx 924 / MUC
	xx 960 / ARN	xx 662 / PVG	xx 648 / FUK	xx 950 / CPH
	xx 960 / ARN	xx 662 / PVG	xx 648 / FUK	xx 950 / CPH
	xx 960 / ARN	xx 662 / PVG	xx 648 / FUK	xx 950 / CPH
				xx 960 / ARN

Outbound 6.3

		xx 483 / PER	xx 670 / CTS	xx 642 / NRT
xx 674 / PEK	xx 473 / BNE	xx 944 / FCO	xx 483 / PER	xx 670 / CTS
xx 930 / CDG	xx 674 / PEK	xx 473 / BNE	xx 944 / FCO	xx 483 / PER
xx 930 / CDG	xx 674 / PEK	xx 473 / BNE	xx 944 / FCO	xx 483 / PER
xx 644 / NGO	xx 930 / CDG	xx 674 / PEK	xx 473 / BNE	xx 944 / FCO
xx 465 / MEL	xx 644 / NGO	xx 930 / CDG	xx 674 / PEK	xx 473 / BNE
xx 465 / MEL	xx 644 / NGO	xx 930 / CDG	xx 674 / PEK	xx 473 / BNE
xx 465 / MEL	xx 644 / NGO	xx 930 / CDG	xx 674 / PEK	xx 473 / BNE
xx 465 / MEL	xx 644 / NGO	xx 930 / CDG	xx 674 / PEK	xx 473 / BNE
xx 465 / MEL	xx 644 / NGO	xx 930 / CDG	xx 674 / PEK	xx 473 / BNE
xx 465 / MEL	xx 644 / NGO	xx 930 / CDG	xx 674 / PEK	xx 473 / BNE
xx 650 / PUS	xx 465 / MEL	xx 644 / NGO	xx 930 / CDG	xx 674 / PEK
xx 954 / OSL	xx 910 / LHR	xx 650 / PUS	xx 465 / MEL	xx 644 / NGO
xx 954 / OSL	xx 910 / LHR	xx 650 / PUS	xx 465 / MEL	xx 644 / NGO
xx 934 / BRU	xx 954 / OSL	xx 910 / LHR	xx 650 / PUS	xx 465 / MEL
xx 970 / ZRH	xx 934 / BRU	xx 954 / OSL	xx 910 / LHR	xx 650 / PUS
xx 940 / MXP	xx 970 / ZRH	xx 934 / BRU	xx 954 / OSL	xx 910 / LHR
xx 924 / MUC	xx 940 / MXP	xx 970 / ZRH	xx 934 / BRU	xx 954 / OSL
xx 924 / MUC	xx 940 / MXP	xx 970 / ZRH	xx 934 / BRU	xx 954 / OSL
xx 924 / MUC	xx 940 / MXP	xx 970 / ZRH	xx 934 / BRU	xx 954 / OSL
xx 662 / PVG	xx 648 / FUK	xx 950 / CPH	xx 924 / MUC	xx 940 / MXP
		xx 960 / ARN	xx 662 / PVG	xx 648 / FUK

Outbound 6.4

			622 / KIX	682 / HND
			622 / KIX	682 / HND
			331 / DEL	622 / KIX
		656 / ICN	331 / DEL	622 / KIX
	313 / CCU	656 / ICN	331 / DEL	622 / KIX
920 / FRA	313 / CCU	656 / ICN	331 / DEL	622 / KIX
920 / FRA	313 / CCU	656 / ICN	331 / DEL	622 / KIX
920 / FRA	313 / CCU	656 / ICN	331 / DEL	622 / KIX
920 / FRA	313 / CCU	656 / ICN	331 / DEL	622 / KIX
642 / NRT	920 / FRA	313 / CCU	656 / ICN	331 / DEL
670 / CTS	642 / NRT	920 / FRA	313 / CCU	656 / ICN
670 / CTS	642 / NRT	920 / FRA	313 / CCU	656 / ICN
483 / PER	670 / CTS	642 / NRT	920 / FRA	313 / CCU
944 / FCO	483 / PER	670 / CTS	642 / NRT	920 / FRA
944 / FCO	483 / PER	670 / CTS	642 / NRT	920 / FRA
944 / FCO	483 / PER	670 / CTS	642 / NRT	920 / FRA
944 / FCO	483 / PER	670 / CTS	642 / NRT	920 / FRA
944 / FCO	483 / PER	670 / CTS	642 / NRT	920 / FRA
944 / FCO	483 / PER	670 / CTS	642 / NRT	920 / FRA
944 / FCO	483 / PER	670 / CTS	642 / NRT	920 / FRA
944 / FCO	483 / PER	670 / CTS	642 / NRT	920 / FRA
473 / BNE	944 / FCO	483 / PER	670 / CTS	642 / NRT
930 / CDG	674 / PEK	473 / BNE	944 / FCO	483 / PER
930 / CDG	674 / PEK	473 / BNE	944 / FCO	483 / PER
644 / NGO	930 / CDG	674 / PEK	473 / BNE	944 / FCO
465 / MEL	644 / NGO	930 / CDG	674 / PEK	473 / BNE
650 / PUS	465 / MEL	644 / NGO	930 / CDG	674 / PEK
910 / LHR	650 / PUS	465 / MEL	644 / NGO	930 / CDG
910 / LHR	650 / PUS	465 / MEL	644 / NGO	930 / CDG
910 / LHR	650 / PUS	465 / MEL	644 / NGO	930 / CDG
970 / ZRH	934 / BRU	954 / OSL	910 / LHR	650 / PUS
950 / CPH	924 / MUC	940 / MXP	970 / ZRH	934 / BRU
	960 / ARN	662 / PVG	648 / FUK	950 / CPH
	960 / ARN	662 / PVG	648 / FUK	950 / CPH
		960 / ARN	662 / PVG	648 / FUK
			960 / ARN	662 / PVG

Outbound 6.5

			xx 307 / CMB	xx 329 / HYD
		xx 337 / MAA	xx 307 / CMB	xx 329 / HYD
	xx 640 / NRT	xx 337 / MAA	xx 307 / CMB	xx 329 / HYD
	xx 640 / NRT	xx 337 / MAA	xx 307 / CMB	xx 329 / HYD
	xx 640 / NRT	xx 337 / MAA	xx 307 / CMB	xx 329 / HYD
	xx 640 / NRT	xx 337 / MAA	xx 307 / CMB	xx 329 / HYD
	xx 640 / NRT	xx 337 / MAA	xx 307 / CMB	xx 329 / HYD
	xx 640 / NRT	xx 337 / MAA	xx 307 / CMB	xx 329 / HYD
	xx 640 / NRT	xx 337 / MAA	xx 307 / CMB	xx 329 / HYD
	xx 640 / NRT	xx 337 / MAA	xx 307 / CMB	xx 329 / HYD
xx 658 / ICN	xx 640 / NRT	xx 337 / MAA	xx 307 / CMB	xx 329 / HYD
xx 658 / ICN	xx 640 / NRT	xx 337 / MAA	xx 307 / CMB	xx 329 / HYD
xx 658 / ICN	xx 640 / NRT	xx 337 / MAA	xx 307 / CMB	xx 329 / HYD
xx 682 / HND	xx 658 / ICN	xx 640 / NRT	xx 337 / MAA	xx 307 / CMB
xx 682 / HND	xx 658 / ICN	xx 640 / NRT	xx 337 / MAA	xx 307 / CMB
xx 682 / HND	xx 658 / ICN	xx 640 / NRT	xx 337 / MAA	xx 307 / CMB
xx 682 / HND	xx 658 / ICN	xx 640 / NRT	xx 337 / MAA	xx 307 / CMB
xx 682 / HND	xx 658 / ICN	xx 640 / NRT	xx 337 / MAA	xx 307 / CMB
xx 682 / HND	xx 658 / ICN	xx 640 / NRT	xx 337 / MAA	xx 307 / CMB
xx 682 / HND	xx 658 / ICN	xx 640 / NRT	xx 337 / MAA	xx 307 / CMB
xx 622 / KIX	xx 682 / HND	xx 658 / ICN	xx 640 / NRT	xx 337 / MAA
xx 331 / DEL	xx 622 / KIX	xx 682 / HND	xx 658 / ICN	xx 640 / NRT
xx 331 / DEL	xx 622 / KIX	xx 682 / HND	xx 658 / ICN	xx 640 / NRT
xx 656 / ICN	xx 331 / DEL	xx 622 / KIX	xx 682 / HND	xx 658 / ICN
xx 313 / CCU	xx 656 / ICN	xx 331 / DEL	xx 622 / KIX	xx 682 / HND
xx 313 / CCU	xx 656 / ICN	xx 331 / DEL	xx 622 / KIX	xx 682 / HND
xx 313 / CCU	xx 656 / ICN	xx 331 / DEL	xx 622 / KIX	xx 682 / HND
xx 313 / CCU	xx 656 / ICN	xx 331 / DEL	xx 622 / KIX	xx 682 / HND
xx 313 / CCU	xx 656 / ICN	xx 331 / DEL	xx 622 / KIX	xx 682 / HND
xx 313 / CCU	xx 656 / ICN	xx 331 / DEL	xx 622 / KIX	xx 682 / HND
xx 313 / CCU	xx 656 / ICN	xx 331 / DEL	xx 622 / KIX	xx 682 / HND
xx 313 / CCU	xx 656 / ICN	xx 331 / DEL	xx 622 / KIX	xx 682 / HND
xx 920 / FRA	xx 313 / CCU	xx 656 / ICN	xx 331 / DEL	xx 622 / KIX
xx 670 / CTS	xx 642 / NRT	xx 920 / FRA	xx 313 / CCU	xx 656 / ICN
xx 670 / CTS	xx 642 / NRT	xx 920 / FRA	xx 313 / CCU	xx 656 / ICN
xx 483 / PER	xx 670 / CTS	xx 642 / NRT	xx 920 / FRA	xx 313 / CCU
xx 944 / FCO	xx 483 / PER	xx 670 / CTS	xx 642 / NRT	xx 920 / FRA
xx 473 / BNE	xx 944 / FCO	xx 483 / PER	xx 670 / CTS	xx 642 / NRT
xx 674 / PEK	xx 473 / BNE	xx 944 / FCO	xx 483 / PER	xx 670 / CTS
xx 674 / PEK	xx 473 / BNE	xx 944 / FCO	xx 483 / PER	xx 670 / CTS
xx 674 / PEK	xx 473 / BNE	xx 944 / FCO	xx 483 / PER	xx 670 / CTS
xx 465 / MEL	xx 644 / NGO	xx 930 / CDG	xx 674 / PEK	xx 473 / BNE
xx 954 / OSL	xx 910 / LHR	xx 650 / PUS	xx 465 / MEL	xx 644 / NGO
xx 924 / MUC	xx 940 / MXP	xx 970 / ZRH	xx 934 / BRU	xx 954 / OSL
xx 924 / MUC	xx 940 / MXP	xx 970 / ZRH	xx 934 / BRU	xx 954 / OSL
xx 950 / CPH	xx 924 / MUC	xx 940 / MXP	xx 970 / ZRH	xx 934 / BRU
xx 648 / FUK	xx 950 / CPH	xx 924 / MUC	xx 940 / MXP	xx 970 / ZRH

Outbound 6.6

xx 325 / BLR	19:20		
xx 325 / BLR	19:25	xx 401 / SIN	
xx 325 / BLR	19:30		
xx 325 / BLR	19:35	xx 574 / VTE	
xx 325 / BLR	19:40		
xx 325 / BLR	19:45	xx 345 / LHE	xx 425 / PEN
xx 325 / BLR	19:50		
xx 325 / BLR	19:55		
xx 325 / BLR	20:00	xx 315 / DEL	
xx 325 / BLR	20:05		
xx 325 / BLR	20:10		
xx 325 / BLR	20:15		
xx 325 / BLR	20:20		
xx 329 / HYD	20:25		
xx 329 / HYD	20:30		
xx 329 / HYD	20:35		
xx 329 / HYD	20:40		
xx 329 / HYD	20:45		
xx 329 / HYD	20:50		
xx 329 / HYD	20:55		
xx 307 / CMB	21:00		
xx 337 / MAA	21:05		
xx 337 / MAA	21:10		
xx 640 / NRT	21:15		
xx 658 / ICN	21:20		
xx 658 / ICN	21:25		
xx 658 / ICN	21:30		
xx 658 / ICN	21:35	xx 325 / BLR	
xx 658 / ICN	21:40		
xx 658 / ICN	21:45		
xx 658 / ICN	21:50		
xx 658 / ICN	21:55		
xx 682 / HND	22:00		
xx 331 / DEL	22:05		
xx 331 / DEL	22:10	xx 329 / HYD	
xx 656 / ICN	22:15	xx 307 / CMB	
xx 313 / CCU	22:20		
xx 920 / FRA	22:25	xx 337 / MAA	
xx 642 / NRT	22:30	xx 640 / NRT	
xx 642 / NRT	22:35		
xx 642 / NRT	22:40		
xx 944 / FCO	22:45		
xx 930 / CDG	22:50		
xx 910 / LHR	22:55		
xx 910 / LHR	23:00		
xx 954 / OSL	23:05		
xx 934 / BRU	23:10	xx 658 / ICN	

Outbound 7.1

			xx 960 / ARN	xx 662 / PVG
				xx 960 / ARN

Outbound 7.2

xx 648 / FUK	xx 950 / CPH	xx 924 / MUC	xx 940 / MXP	xx 970 / ZRH
xx 662 / PVG	xx 648 / FUK	xx 950 / CPH	xx 924 / MUC	xx 940 / MXP
	xx 960 / ARN	xx 662 / PVG	xx 648 / FUK	xx 950 / CPH
	xx 960 / ARN	xx 662 / PVG	xx 648 / FUK	xx 950 / CPH
	xx 960 / ARN	xx 662 / PVG	xx 648 / FUK	xx 950 / CPH
			xx 960 / ARN	xx 662 / PVG
			xx 960 / ARN	xx 662 / PVG
				xx 960 / ARN
				xx 960 / ARN

Outbound 7.3

xx 934 / BRU	23:15	xx 622 / KIX	xx 682 / HND	
xx 970 / ZRH	23:20			
xx 924 / MUC	23:25	xx 331 / DEL		
xx 924 / MUC	23:30	xx 656 / ICN		
xx 924 / MUC	23:35	xx 313 / CCU		
xx 648 / FUK	23:40	xx 920 / FRA		
xx 648 / FUK	23:45			
xx 662 / PVG	23:50			
xx 662 / PVG	23:55	xx 483 / PER	xx 670 / CTS	xx 642 / NRT
xx 960 / ARN	0:00	xx 674 / PEK	xx 473 / BNE	xx 944 / FCO
xx 960 / ARN	0:05	xx 650 / PUS	xx 465 / MEL	xx 644 / NGO
xx 960 / ARN	0:10			
	0:15	xx 910 / LHR		
	0:20	xx 954 / OSL		
	0:25			
	0:30	xx 934 / BRU		
	0:35	xx 940 / MXP	xx 970 / ZRH	
	0:40			
	0:45			
	0:50	xx 950 / CPH	xx 924 / MUC	
	0:55			
	1:00	xx 648 / FUK		
	1:05			
	1:10	xx 662 / PVG		
	1:15			
	1:20			
	1:25	xx 960 / ARN		
	1:30			
	1:35			
	1:40			
	1:45			
	1:50			
	1:55			
	2:00			
	2:05			
	2:10			
	2:15			

Outbound 7.4

xx 930 / CDG					

Appendix E: Flight schedule of the subsidiary airline in potential O&D markets

BKK-CNX-BKK

Route	Departure Time	Arrival Time
BKK-CNX	07:45	09:00
BKK-CNK	08:45	10:00
BKK-CNX	10:20	11:35
BKK-CNX	15:40	16:55
BKK-CNX	19:45	21:00
CNX-BKK	15:00	16:15
CNX-BKK	10:35	11:50
CNX-BKK	12:20	13:30
CNX-BKK	17:25	18:40
CNX-BKK	06:45	08:00

BKK-HKT-BKK

Route	Departure Time	Arrival Time
BKK-HKT	11:50	13:15
BKK-HKT	15:35	16:55
BKK-HKT	19:35	21:00
HKT-BKK	11:35	13:00
HKT-BKK	14:15	15:40
HKT-BKK	17:40	19:05

Appendix F: Flight schedule of the primary airline in potential O&D markets

BKK-CNX-BKK

Route	Departure Time	Arrival Time
BKK-CNX	07:50	09:10
BKK-CNX	08:45	09:55
BKK-CNX	13:15	14:25
BKK-CNX	17:20	18:30
CNX-BKK	15:20	16:30
CNX-BKK	19:20	20:30
CNX-BKK	20:50	22:10

BKK-HKT-BKK

Route	Departure Time	Arrival Time
BKK-HKT	07:45	09:10
BKK-HKT	08:30	09:55
BKK-HKT	10:00	11:20
BKK-HKT	13:20	14:45
BKK-HKT	14:05	15:25
BKK-HKT	16:45	18:05
BKK-HKT	17:25	18:45
HKT-BKK	12:15	13:40
HKT-BKK	13:55	15:25
HKT-BKK	15:45	17:10
HKT-BKK	16:25	17:50
HKT-BKK	19:00	20:25
HKT-BKK	19:35	21:00
HKT-BKK	20:35	22:00
HKT-BKK	21:25	22:50

Appendix G: Flight schedule of the competitor airline in potential O&D markets

BKK-CNX-BKK

Route	Departure Time	Arrival Time
BKK-CNX	08:00	09:15
BKK-CNX	09:45	11:00
BKK-CNX	12:10	13:25
BKK-CNX	17:10	18:25
BKK-CNX	19:35	20:50
BKK-CNX	21:15	22:30
CNX-BKK	06:55	08:15
CNX-BKK	10:00	11:20
CNX-BKK	11:45	13:05
CNX-BKK	14:10	15:30
CNX-BKK	19:10	20:30
CNX-BKK	21:40	23:00

BKK-HKT-BKK

Route	Departure Time	Arrival Time
BKK-HKT	06:20	07:45
BKK-HKT	08:05	09:30
BKK-HKT	09:10	10:35
BKK-HKT	10:00	11:25
BKK-HKT	12:30	13:55
BKK-HKT	14:35	16:00
BKK-HKT	17:30	18:55
BKK-HKT	19:45	21:10
BKK-HKT	22:00	23:25
HKT-BKK	06:55	08:20
HKT-BKK	08:45	10:10
HKT-BKK	10:20	11:45
HKT-BKK	12:20	13:45
HKT-BKK	14:50	16:15
HKT-BKK	16:50	18:15
HKT-BKK	17:30	18:55
HKT-BKK	19:45	21:10
HKT-BKK	21:55	23:20

Appendix H: The airline's feedback

Date: 1 Nov 2016

Airline Feedback

Project: Domestic flight timetabling to increase connecting passengers in a local airline

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	Excellent	Good	Fair	Poor
1. How the result of project meets airline requirements?	✓			
2. How appropriate of the approaching methodology?	✓			
3. How would you rate the overall quality of project?	✓			
4. How practical is the project?			✓	
5. How helpful is the project to the problem?	✓			
6. How satisfy of airline toward the result in overall?	✓			

Comments and suggestions

From the result, we are very appriciating to the proposed flight timetable. The new flight timetable has found to be improving the connecting passenger from Thai airline, connectivity and the fleet utilization. However, the proposed time is still invalid to the actual flight timetable due to the current availability.

Signature: ....

(Wutcharin Thatan)

Manager of Corporate Strategy & Planning Department

VITA

Ms. Natravee Deewattanarkul was born on 27, July 1989 in Bangkok, Thailand. She finished high school from Kasetsart University Laboratory school and continue her bachelor degree in faculty of computer engineering at Kasetsart University. After graduated, she worked as SAP consultant at Atos IT solutions and service for four years before quite this job and started her dual master degree of Engineering in Supply Chain Management from Chulalongkorn University, Thailand and Warwick University, United Kingdom.