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FLEET ASSIGNMENT OPTIMIZATION AND FLEET USE EVALUATION ON CREW PAIRING WITHOUT SIT TIME

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Abstrak

Meskipun penugasan armada dilakukan terlebih dahulu, namun hasil dari evaluasi pelaksanaan crew pairing ataupun crew rostering dapat menjadi masukan untuk penugasan armada berikutnya. Oleh karena itu, hasil studi diharapkan dapat memberikan pengetahuan tentang jenis dan jumlah armada yang digunakan untuk melayani sejumlah penerbangan pada salah satu penelitian crew pairing. Model dalam studi ini bertujuan untuk meminimumkan total biaya yang dikeluarkan oleh maskapai untuk menerbangkan berbagai jenis armada yang melayani semua penerbangan. Penyusunan model, konfirmasi data, verifikasi model, dan uji coba model dilakukan pada bulan September-Desember 2022. Teknik pengumpulan data yaitu dokumentasi. Jenis data yang dianalisis adalah data sekunder, yang dikelompokkan menjadi data yang berhubungan dengan penerbangan, data armada, dan data yang berkaitan dengan biaya yang dikeluarkan oleh maskapai. Penyelesaian masalah basic Fleet Assignment Model dilakukan dengan bantuan software LINGO 19.0. Berdasarkan hasil penelitian, dapat disimpulkan bahwa minimum total biaya untuk melayani 30 penerbangan yang melibatkan Bandar Udara Internasional Soekarno-Hatta, Bandar Udara Internasional I Gusti Ngurah Rai, Bandar Udara Internasional Juanda, dan Bandar Udara Komodo adalah $188,463.1. Jumlah pesawat yang dibutuhkan oleh maskapai untuk melayani semua penerbangan pada 10 Oktober 2022 tersebut yaitu 9 pesawat, yang terdiri dari 3 armada Airbus A330-300 dan 6 armada Boeing 737-800NG. Perlu dilakukan penelitian tentang strategi maskapai dalam menghadapi permasalahan crew pairing yang tidak memiliki sit time di salah satu penerbangan yang dilayani, tetapi harus terbang dengan penerbangan berikutnya menggunakan jenis armada dan pesawat yang berbeda.

Keywords: *crew pairing, maskapai, penerbangan, penugasan armada, total biaya.*

Abstract

Even though the fleet assignment is carried out first, the evaluation results of the implementation of crew pairing or crew rostering can be inputs for the next fleet assignment. Therefore, the results of the research were expected to provide information about the type and the number of fleets used to serve a number of flights on one of the crew pairing research. The model in this study aimed to minimize the total costs spent by airline to fly various types of fleets serving all the flights. Model development, data confirmation, model verification, and model trials were carried out in September–December 2022. Documentation was used to collect the data. The analyzed data were secondary data, grouped into flight-related data, fleet data, and data related to costs spent by airline. The basic Fleet Assignment Model (FAM) problem was solved using LINGO 19.0 software. Based on the research results, the minimum total cost for serving 30 flights involving Soekarno-Hatta International Airport, I Gusti Ngurah Rai International Airport, Juanda International Airport, and Komodo Airport was $188,463.1. The number of aircrafts needed by the airline to serve all flights on 10 October 2022 were 9 aircraft, consisting of 3 Airbus A330-300 fleets and 6 Boeing 737-800NG fleets. It is necessary to conduct research on airline strategies in dealing with the issue of crew pairing without any sit time on one of the flights they serve while they must serve the next flight using a different type of fleet and aircraft.

Kata kunci: *Crew Pairing, Airline, Flight, Fleet Assignment, Total Costs.*

Introduction

When Corona Virus Disease 2019 (COVID-19) was still declared a pandemic by the World Health Organization (WHO), airlines made various responses to reduce the impact of the pandemic on air transportation-related businesses. Sun *et al.* (2020) found that many companies had just to leave their fleets parked in hangars. In relation to this, airports also closed their runways until an undetermined time to provide parking spaces for non-operating aircrafts (Adrienne *et al.,* 2020). According to

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Truxal (2020), aircraft manufacturers were also affected, responding the situation by closing their production processes.

Meanwhile, in Indonesia, study by Yarlina *et al.* (2021) indicated that one of the airline strategies in responding to the decline in the number of passengers was changing aircraft type from wide body to narrow body. Based on the finding, several elements were suggested to be put in policy considerations in the efforts to control the impacts of the pandemic in the air transportation sector, one of which was aircraft optimization.

Airlines usually put in operation a number of different fleet types. Optimizing fleet assignments is an important element in operational cost management, particularly since purchasing fuel is the biggest expense for airlines (Bazargan, 2010). Following fleet assignment, the next optimization process is crew scheduling (split into crew pairing and crew rostering analyses). Even though the fleet assignment is carried out first, the evaluation results of the implementation of crew pairing or crew rostering can be inputs for the next fleet assignment.

For example, in the research conducted by Ristiani and Andi (2022), optimizing crew pairing with airline and flight service limitations on certain dates was specifically discussed. Based on the results of the research, one leg of certain crew pairings (2, 5 and 6) presumably used the same fleet because the crew did not have any sit time before serving the next flight. Should the flight schedule on that date repeat for the following days or the following week on the same day, this information can serve as an important note for the airline in their fleet assignment evaluation process to assign the same aircraft. It is hoped that this could help aircraft crew to prepare for the next flight without having to get off and move to another fleet.

Therefore, this study aims to analyze the optimization of fleet assignments on the same airline and flight dates as those discussed in the previous research conducted by Ristiani and Andi (2022) with a number of differences in the routes and flight schedules for the analysis. These differences were because flights ending at (with rest or overnight) or starting from an airport other than the crew base were included in this research. The results of the research were expected to provide information about the type and the number of fleets used to serve a number of flights on the dates. The model aimed to minimize the total costs spent by airline to fly various types of fleets serving all the flights.

Literature review

Assignment

Assignment, as defined by the Language Development and Fostering Agency (2016), is a process, method, act of assigning; giving assignment (to). Matters related to assignment are work, processing, organizing, offices, institutions (the Language Development and Fostering Agency, 2016).

Fleet

According to the Language Development and Fostering Agency (2016), fleet is a group of units. The word fleet is associated with the armed forces (Language Development and Fostering Agency, 2016).

Airline

Airline is a trading company; company (Language Development and Fostering Agency, 2016). In relation to transportation, they are usually called airlines or *maskapai* in Indonesian language (Language Development and Fostering Agency, 2016).

Fleet Assignment

Fleet assignment is the following step after making flight schedules (Bazargan, 2010). Bazargan (2020) further explained that the purpose of fleet assignment is to determine the type of aircraft of the fleet with specific route each in the flight schedule.

The followings are a number of terms in the aviation industry (Bazargan, 2010):

1. ASM (Available Seat Miles); obtained from the number of seats available for passengers during the year multiplied by the number of flight miles for those seats.
2. RPM (Revenue Passenger Miles); obtained from the number of passengers flying multiplied by the number of flight miles for all flight segments in one year.
3. Yield; is the airline's earning per mile on each seat sold.
4. RASM (Revenue per Available Seat Mile); obtained from dividing the total operating revenue by available seat miles (ASM).
5. CASM (Cost per Available Seat Mile); is the average cost per seat to fly one mile.

Minimized airline costs include the total costs of all flight routes on that day. According to Bazargan (2010), the following is the distribution of these costs:

1. Operating costs; the result of CASM of the fleet multiplied by the distance and the number of seats on the aircraft.
2. Passenger-spill costs; is the expected cost of lost passengers because they cannot be transported when the demand exceeds the fleet capacity that results in spill costs (costs calculated based on revenue from passengers who do not fly). Expected spill cost for a fleet is obtained from the expected number of passenger spills multiplied by RASM and the flight distance. Spill costs are calculated if a passenger who does not get a seat on the flight chooses to use another airline. However, if the passenger still chooses the same airline with an earlier or later flight schedule, the percentage can be measured as recapture rate.

Previous Research

This research employed a number of previous research as references for comparison and support. Pita *et al.* (2014) assisted the Norwegian public authorities in designing subsidized air transport networks. What to achieve in a fleet assignment optimization is not only the costs, but also aspects related to company revenue or income (Barnhart *et al*., 2009). Pita *et al.* (2019) introduced genuine integrated optimization approach for comprehensive flight scheduling and fleet assignment under passenger selection. The benefits of which are this modeling supports various airline strategic decision making in the context of flight frequency planning, revenue management, and post-merger integration.

Cases related to costs can be studied from a research conducted in Turkey (Ozdemir *et al*., 2012) that aimed to minimize the total cost while determining the number of aircrafts staying overnight at hangar. Another study, which is similar but conducted in Indonesia in a different year and objects (Blegur *et al*., 2014), suggested three scenarios for fleet assignment with their respective objectives, i.e. minimizing operational costs, minimizing the number of aircrafts to meet demand, and minimizing operational costs and fleet size simultaneously. Sehati *et al.* (2014) also optimized fleet scheduling for one of the airlines in Indonesia to minimize costs in serving 104 flight routes to and from 19 cities.

Research methods

Research design

This was a descriptive quantitative research. The purpose of this research was to explain the optimization of airline fleet assignments. Model development, data confirmation, model verification, and model trials were carried out in September–December 2022. The data collection technique was documentation. In addition, the type of data analyzed was secondary data, which then grouped into flight-related data, fleet data, and data related to costs spent by airline.

1. Flight data for 30 flight routes on 10 October 2022 (Table 1) for four airports, i.e. Soekarno-Hatta International Airport (CGK), Bali I Gusti Ngurah Rai International Airport (DPS), Juanda International Airport (SUB), and Komodo Airport (LBJ); from the airline' official website and the FlightAware site. The flight data included flight number, route, travel time, duration, and distance. In addition, information regarding the number of demand (pax) with their respective standard deviations for each flight route were also included; obtained from the simulation results (Bazargan, 2010).

Table 1. Flight Data

Flight Number	Route	Travel Time (UTC+7)	Duration (Minutes)	Distance (Miles)	Demand (Pax)	Standard Deviation
402	CGK–DPS	07:15–09:10	115	611	251	30
400	CGK–DPS	08:00–10:00	120	611	172	29
404	CGK–DPS	09:25–11:20	115	611	302	31
408	CGK–DPS	11:30–13:35	125	611	250	28
414	CGK–DPS	13:00–15:00	120	611	176	29
410	CGK–DPS	14:25–16:20	115	611	254	33
420	CGK–DPS	16:30–18:30	120	611	176	29
4202	CGK–DPS	18:30–20:30	120	611	175	31
306	CGK–SUB	07:05–08:45	100	430	174	31
316	CGK–SUB	08:35–10:15	100	430	173	30
322	CGK–SUB	11:10–12:50	100	430	174	32
312	CGK–SUB	13:30–15:10	100	430	176	29
320	CGK–SUB	16:00–17:40	100	430	171	30
326	CGK–SUB	17:10–18:50	100	430	174	31
401	DPS–CGK	06:00–08:05	125	611	174	29
407	DPS–CGK	11:00–13:05	125	611	251	28
409	DPS–CGK	12:30–14:25	115	611	298	27
411	DPS–CGK	14:55–17:00	125	611	253	30
403	DPS–CGK	15:20–17:25	125	611	173	28
415	DPS–CGK	16:05–18:10	125	611	172	31
417	DPS–CGK	17:40–19:45	125	611	249	34
4012	DPS–CGK	19:15–21:15	120	611	175	30
305	SUB–CGK	06:30–08:05	95	430	176	30
311	SUB–CGK	09:30–11:05	95	430	174	30
321	SUB–CGK	11:00–12:35	95	430	172	33
327	SUB–CGK	13:35–15:10	95	430	176	30
317	SUB–CGK	16:30–18:00	90	430	174	30
325	SUB–CGK	18:40–20:10	90	430	173	28

Source: airline's site and FlightAware site, 2022

Table 1. Flight Data (continued)

Flight Number	Route	Travel Time (UTC+7)	Duration (Minutes)	Distance (Miles)	Demand (Pax)	Standard Deviation
7036	DPS–LBJ	10:45–12:00	75	323	174	29
7037	LBJ–DPS	13:00–14:15	75	323	176	29

Source: airline's site and FlightAware site, 2022

The difference between the flight data in Table 1 and that in Ristiani and Andi (2022) is the addition of flights that end at airports other than Soekarno-Hatta International Airport (CGK). The data in this study did not include flight schedules connected to airports other than I Gusti Ngurah Rai International Airport (DPS), Juanda International Airport (SUB), and Komodo Airport (LBJ). There was a total of 30 flights analyzed in this study.

2. Fleet data (Table 2); consisted of information regarding fleet type, seat capacity, and the number of aircrafts for each fleet. The data was retrieved from the official websites of the airline.

Table 2. Fleet Data

Aircraft Code	Aircraft Type	Capacity (Seats)	Amount
A333	Airbus A330-300	251	17
A339	Airbus A330-900neo	301	3
B738	Boeing 737-800NG	174	42

Source: airline's site, 2022

The fleet selection was based on the information retrieved from the airline' website (2022), stating that the standard aircraft type to use was Boeing B737-800NG for short and regional routes and Airbus A330-200/300/900neo for medium-distance routes (Airbus A320-200 was used for other airlines). Table 2 indicates that the airline has a total of 62 fleets for the three aircraft types. Boeing 737-800NG was found to have the largest number of fleets than the other two types of aircraft.

3. Cost data; the full information is as follow:
   a. CASM; for Airbus A330-300, Airbus A330-900neo, and Boeing 737-800NG fleets were \$0.0465, \$0.0630, and \$0.0546, respectively. The CASM figures were hypothetical, or, in other word, only an assumption referred to similar fleet type and capacity (but not exactly the same as) discussed in Bazargan (2010).
   b. RASM; assumed to be 15% (Bazargan, 2010).
   c. Passenger-spill costs; the expected number of passenger spill data was obtained from the demand simulation (using the *IF* function), and the difference was obtained between the expected number and the fleet capacity to determine the number of passengers not transported (Bazargan, 2010).

The assumptions and limitations used in this research were the same as a number of those in the research conducted by Ristiani and Andi (2022), i.e. limitations number 1 and 2 and assumptions number 7 and 8. In addition, there were additional assumptions included here that referred to the assumptions in the study conducted by Sehati *et al.* (2014); i.e.:
1. One cycle lasts for 24 hours repeated in one week;
2. There is no deadheading, meaning the aircraft cannot fly without passengers. The implication is that an aircraft staying overnight at an airport does not have to be the same aircraft used in the morning, as long as the type of fleet is the same;
3. The number of aircraft of each type of fleet is limited;

4. The demand and the standard deviation for a number of flights (flight legs) are known;
5. The type of flight is direct flight without any transit;
6. The minimum time required for the aircraft to start landing until it can fly again (turn-around time) is not taken into account.

Suppose that F = {402, 400, 404, …,7037} is a set of flights with index i = 1, 2, …, 30, K = {A330-300, A330-900neo, Boeing 737-800NG} is a set of fleet types with index j = 1, 2, 3, while M = {CGK1, CGK2, …, CGK26, DPS1, DPS2, …, DPS18, SUB1, SUB2, …, SUB12, LBJ1, LBJ2} is the set of nodes in the network with index k = 1, 2, 58. The full list of elements of set M is shown in Table 3, Table 4, and Table 5. C = {CGK1, DPS1, SUB1, LBJ1} is the first node set, a subset of M, with index l = 1, 27, 45, 57 and D = {CGK26, DPS18, SUB12, LBJ2} is the last node set, a subset of M, with index n = 26, 44, 56, 58.

Table 3. The Elements of the Set *M* (CGK)

Number	Node	Time	Routes	Time Description
1	CGK1	07:05	CGK–SUB	Departure
2	CGK2	07:15	CGK–DPS	Departure
3	CGK3	08:00	CGK–DPS	Departure
4	CGK4	08:05	DPS–CGK; SUB–CGK	Arrival; Arrival
5	CGK5	08:35	CGK–SUB	Departure
6	CGK6	09:25	CGK–DPS	Departure
7	CGK7	11:05	SUB–CGK	Arrival
8	CGK8	11:10	CGK–SUB	Departure
9	CGK9	11:30	CGK–DPS	Departure
10	CGK10	12:35	SUB–CGK	Arrival
11	CGK11	13:00	CGK–DPS	Departure
12	CGK12	13:05	DPS–CGK	Arrival
13	CGK13	13:30	CGK–SUB	Departure
14	CGK14	14:25	CGK–DPS; DPS–CGK	Departure; Arrival
15	CGK15	15:10	SUB–CGK	Arrival
16	CGK16	16:00	CGK–SUB	Departure
17	CGK17	16:30	CGK–DPS	Departure
18	CGK18	17:00	DPS–CGK	Arrival
19	CGK19	17:10	CGK–SUB	Departure
20	CGK20	17:25	DPS–CGK	Arrival
21	CGK21	18:00	SUB–CGK	Arrival
22	CGK22	18:10	DPS–CGK	Arrival
23	CGK23	18:30	CGK–DPS	Departure
24	CGK24	19:45	DPS–CGK	Arrival
25	CGK25	20:10	SUB–CGK	Arrival
26	CGK26	21:15	DPS–CGK	Arrival

Source: researcher, 2022

Table 3 shows that CGK, located in Tangerang City, Banten Province, has 26 nodes. The time column indicates the time of departure and arrival; with the same number of departures and arrivals, i.e. 14. The CGK4 node indicates two flights arriving at CGK at the same time, i.e. one from DPS in Badung Regency, Bali Province and the other from SUB in Sidoarjo Regency, East Java Province. In addition, node 14 also indicates two flights in the same time network, i.e. flight route from Banten to Bali and flight arriving in Banten from Bali. Below are the elements of the set M in DPS (Table 4).

Table 4. The Elements of the Set *M* (DPS)

Number	Node	Time	Route	Time Description
27	DPS1	06:00	DPS–CGK	Departure
28	DPS2	09:10	CGK–DPS	Arrival
29	DPS3	10:00	CGK–DPS	Arrival
30	DPS4	10:45	DPS–LBJ	Departure
31	DPS5	11:00	DPS–CGK	Departure
32	DPS6	11:20	CGK–DPS	Arrival
33	DPS7	12:30	DPS–CGK	Departure
34	DPS8	13:35	CGK–DPS	Arrival
35	DPS9	14:15	LBJ–DPS	Arrival
36	DPS10	14:55	DPS–CGK	Departure
37	DPS11	15:00	CGK–DPS	Arrival
38	DPS12	15:20	DPS–CGK	Departure
39	DPS13	16:05	DPS–CGK	Departure
40	DPS14	16:20	CGK–DPS	Arrival
41	DPS15	17:40	DPS–CGK	Departure
42	DPS16	18:30	CGK–DPS	Arrival
43	DPS17	19:15	DPS–CGK	Departure
44	DPS18	20:30	CGK–DPS	Arrival

Source: researcher, 2022

Table 3 indicates that DPS has 18 nodes; with the same number of departures and arrivals, i.e. 9 each. There are no nodes in the same time network in the set *M* in DPS. Below are the elements of the set *M* in SUB and LBJ (Table 5).

Table 5. The Elements of the Set *M* (SUB and LBJ)

Number	Node	Time	Flight	Time Description
45	SUB1	06:30	SUB–CGK	Departure
46	SUB2	08:45	CGK–SUB	Arrival
47	SUB3	09:30	SUB–CGK	Departure
48	SUB4	10:15	CGK–SUB	Arrival
49	SUB5	11:00	SUB–CGK	Departure
50	SUB6	12:50	CGK–SUB	Arrival
51	SUB7	13:35	SUB–CGK	Departure
52	SUB8	15:10	CGK–SUB	Arrival
53	SUB9	16:30	SUB–CGK	Departure
54	SUB10	17:40	CGK–SUB	Arrival
55	SUB11	18:40	SUB–CGK	Departure
56	SUB12	18:50	CGK–SUB	Arrival
57	LBJ1	12:00	DPS–LBJ	Arrival
58	LBJ2	13:00	LBJ–DPS	Departure

Source: researcher, 2022

There are 12 nodes in SUB with 6 departures and arrivals each. Just like in DPS, there are no nodes in the same time network in the set *M* in SUB. The last elements of the set *M*, i.e. in LBJ (located in West Manggarai Regency, East Nusa Tenggara) are 2 (1 arrival and 1 departure).

Parameter $B_{i,j}$ indicates the cost of using fleet type *j* for flights *I,* while N_j indicates the number of available aircrafts from fleet j. Other parameters are:

$$S_{i,k} = \begin{cases} +1, \text{if the plane with flight number } i \text{ arrives at } node\ k \\ -1, \text{if the plane with flight number } i \text{ departs from } node\ k \end{cases}$$

Based on these definitions, the following is the integer programming model in this research.

Decision Variables

$$x_{i,j} = \begin{cases} 1, \text{if flight number } i \text{ uses fleet type } j \\ 0, \text{otherwise,} \end{cases}$$

$$G_{k,j} = \text{the number of fleets of type } j \text{ at } node\ k$$

$$Z = \sum_{j=1}^{3} \sum_{i=1}^{30} B_{i,j} x_{i,j}. \tag{1}$$

$$\sum_{j=1}^{3} x_{i,j} = 1, \qquad \forall i \in F. \tag{2}$$

$$G_{k-1,j} + \sum_{i=1}^{30} S_{i,k} x_{i,j} = G_{k,j}, \qquad \forall k \in M, k \notin C, \qquad \forall j \in K. \tag{3}$$

$$G_{n,j} + \sum_{i \in F} S_{i,l} x_{i,j} = G_{l,j}, \qquad \forall l \in C, \forall n \in D, \forall j \in K. \tag{4}$$

$$\sum_{n \in D} G_{n,j} < N_j, \qquad \forall j \in K. \tag{5}$$

$$x_{i,j} \in \{0,1\}, \quad \forall i \in F, \forall j \in K. \tag{6}$$

$$G_{k,j} \in Z^{+}, \quad \forall k \in M, \forall j \in K. \tag{7}$$

The objective function (1) aims to minimize the total costs spent by the airline to fulfill all flights in this research. Constraint (2) states that each flight can be served by one fleet type at most. Constraint (3) requires aircraft continuity at each node except the first one; the number of aircrafts from each fleet type at a node is the number of aircrafts at the previous node plus the number of arriving aircrafts or minus the number of aircrafts departing from the node. Constraint (4) confirms aircraft continuity at the first node; the number of aircrafts from each fleet type at the first node is the number of aircrafts at the last node plus the number of arriving aircrafts or minus the number of departing aircrafts from the first node. Constraint (5) creates conditions related to the number of the aircrafts; where the number of needed aircrafts should not exceed the number of aircrafts owned for each fleet type. The decision variable for $x_{i,j}$ has a value of zero or one (6), while the decision variable for $G_{k,j}$ is a positive integer (7).

Results and Discussion

The basic Fleet Assignment Model (FAM) problem was solved using LINGO 19.0 software. The computational process only took 2 seconds to provide a solution of a minimum total cost of $ 188,463.1. Based on the analysis, of the three fleet types owned by the airline, only two were used to serve flights, i.e. the Airbus A330-300 and Boeing 737-800NG. See Table 6 for a thorough fleet assignment for each flight.

Table 6. Fleet Assignment for Each Flight

Flight Number	Route	Travel Time (UTC+7)	Aircraft Code	Aircraft Type
402	CGK–DPS	07:15–09:10	A333	Airbus A330-300
400	CGK–DPS	08:00–10:00	B738	Boeing 737-800NG
404	CGK–DPS	09:25–11:20	A333	Airbus A330-300
408	CGK–DPS	11:30–13:35	A333	Airbus A330-300
414	CGK–DPS	13:00–15:00	B738	Boeing 737-800NG
410	CGK–DPS	14:25–16:20	A333	Airbus A330-300
420	CGK–DPS	16:30–18:30	B738	Boeing 737-800NG
4202	CGK–DPS	18:30–20:30	B738	Boeing 737-800NG
306	CGK–SUB	07:05–08:45	B738	Boeing 737-800NG
316	CGK–SUB	08:35–10:15	B738	Boeing 737-800NG
322	CGK–SUB	11:10–12:50	B738	Boeing 737-800NG
312	CGK–SUB	13:30–15:10	B738	Boeing 737-800NG
320	CGK–SUB	16:00–17:40	B738	Boeing 737-800NG
326	CGK–SUB	17:10–18:50	B738	Boeing 737-800NG
401	DPS–CGK	06:00–08:05	B738	Boeing 737-800NG
407	DPS–CGK	11:00–13:05	A333	Airbus A330-300
409	DPS–CGK	12:30–14:25	A333	Airbus A330-300
411	DPS–CGK	14:55–17:00	A333	Airbus A330-300
403	DPS–CGK	15:20–17:25	B738	Boeing 737-800NG
415	DPS–CGK	16:05–18:10	B738	Boeing 737-800NG
417	DPS–CGK	17:40–19:45	A333	Airbus A330-300
4012	DPS–CGK	19:15–21:15	B738	Boeing 737-800NG
305	SUB–CGK	06:30–08:05	B738	Boeing 737-800NG
311	SUB–CGK	09:30–11:05	B738	Boeing 737-800NG
321	SUB–CGK	11:00–12:35	B738	Boeing 737-800NG
327	SUB–CGK	13:35–15:10	B738	Boeing 737-800NG
317	SUB–CGK	16:30–18:00	B738	Boeing 737-800NG
325	SUB–CGK	18:40–20:10	B738	Boeing 737-800NG
7036	DPS–LBJ	10:45–12:00	B738	Boeing 737-800NG
7037	LBJ–DPS	13:00–14:15	B738	Boeing 737-800NG

Source: LINGO 19.0 output, 2022

Blegur *et al.* (2014) also analyzed fleet assignments where the optimization indicated that all fleet types (B733, B734, B738, B739, and B7444) were used, and one aircraft type (B739) was not used because out of a total of 631 domestic and international flights in one day, only 95 fleets were needed (out of a total of 96 fleets). Should this research include all domestic and international flights, it would be possible that all fleet types (even all aircrafts for each type) owned by the airline are also used to serve all flights that are up to 600 flights per day (airline's site, 2022). Another research that took all flights into account was Sehati *et al.* (2014) stating that although the airline only needed 18 aircrafts (out of a total of 29 aircrafts) to serve 104 flights, all fleet types (Airbus A320, Boeing B737-300, and Boeing B737-400) were used.

Table 6 indicates that more than 70% flights were served by Boeing 737-800NG. This finding can be attributed to the average demand (the number of passengers) which was higher than the seat capacity of Boeing 737-800NG. Meanwhile, in Ozdemir *et al.* (2012), almost half (47.82%) of the total flights on the day were served by B737 even though the number of fleets was smaller than the other fleet types. In relation to demand, indeed 54.34% of the number of passengers was still below the B737 seat capacity. In addition, another possible reason for such finding was the Cost per Available Seat Mile (CASM) and the operating cost of B737 were the lowest compared to the other three fleet types.

Still based on Table 6, it is noted that Airbus A330-300 was only used to serve a number of CGK-DPS and DPS-CGK routes. Airbus A330-300 indeed has a higher passenger seat capacity than that of the Boeing 737-800NG. Therefore, the fleet type is expected to be able to meet the passenger demand who are likely to travel using air transportation to or from Bali, for professional-related purposes as well as for personal ones such as vacation because Bali is a tourist destination for both domestic and international tourists. A total of 9 aircrafts were needed by the airline to serve 30 flights on 10 October 2022 connecting four airports, consisting of 3 (out of a total of 17) Airbus A330-300 fleets and 6 (out of a total of 42) Boeing 737-800NG fleets. See Table 7 for the details on the optimal number of aircrafts for each fleet at each airport. Other fleets (besides those mentioned in Table 7) stayed overnight at CGK. According to Ozdemir *et al.* (2012), these aircrafts were parked, required nightly maintenance, or were prepared to serve other flights beyond the cases included in this research.

Table 7. The Optimal Number of Aircrafts at Each Airport at the End of the Period

Airport Code	**Province**	**Aircraft Type**	
		Airbus A330-300	Boeing 737-800NG
CGK	Banten	3	4
DPS	Bali	0	1
SUB	East Java	0	1
LBJ	East Nusa Tenggara	0	0

Source: LINGO 19.0 output, 2022

Based on Table 7, most aircrafts (both A333 and B738) stayed overnight in Banten. One Boeing 737-800NG aircraft was used to serve the DPS-CGK route with the earliest departure time (06:00 UTC+7). Likewise, one Boeing 737-800NG (at 06:30 UTC+7) was also used to serve the SUB-CGK route.

To prove the presumption of using the same fleet type (Ristiani and Syaputra, 2022) for crew pairing with a limited waiting time, i.e. Crew Pairing 2, 5 and 6, the fleet assignment in Table 6 shall be paid a close attention to. First, for Crew Pairing 2; there was no waiting time for the crew after landing at CGK from DPS (flight number 407) before flying back to SUB (flight number 312). Flight 407 used Airbus A330-300 fleet, while flight 312 used Boeing 737-800NG. Between these two flights, there was only a 25-minute gap, during which the aircraft landed and the crew left the aircraft. If the crew must immediately serve the next flight but with a different fleet, then the suggested solution was the preparation for the next flights using these two fleets should be carried out by other crew with waiting time at CGK, both those who would fly with the Airbus A330-300 and those who had previously landed with the Boeing 737-800NG. In doing so, the newly landed crew could immediately change aircraft and serve their next scheduled flight. In addition, to facilitate the crew changing aircraft, the following fleet to use can be parked nearby (if possible adjacent to) the landing fleet's parking stand.

Next, for Crew Pairing 5; there was no waiting time for the crew after landing at CGK from SUB (flight number 311) before flying back to DPS (flight number 408). Flight 311 used Boeing 737-800NG fleet, while flight 408 used Airbus A330-300. Because this case was the same as that of Crew

Pairing 2, the suggested solutions were also similar. Finally, for Crew Pairing 6; there was also no waiting time for the crew after landing at CGK from SUB (flight number 321) before flying back to DPS (flight number 414). Based on Table 6, both flights used the same type of aircraft, i.e. Boeing 737-800NG. The LINGO 19.0 output also indicated in detail that both used the same fleet. This means, the crew did not need to get off and change aircraft, but can immediately prepare for their next flight.

Fleet assignments in this research were only in the context of scenarios or analysis examples because not only this did not include all domestic flights in one day, the cost data used in analysis was an assumption. In addition, if the flight schedule does not repeat every day, it is necessary to carry out analysis for all flight schedules every day.

Conclusion

Based on the research results, the minimum total cost for serving 30 flights involving Soekarno-Hatta International Airport, I Gusti Ngurah Rai International Airport, Juanda International Airport, and Komodo Airport was $188,463.1. The number of aircrafts needed by the airline to serve all flights on 10 October 2022 were 9 aircraft, consisting of 3 Airbus A330-300 fleets and 6 Boeing 737-800NG fleets. The results of this analysis cannot be applied to flight plans for the following days because it did not include all connections in one day and the cost data used here was only an assumption.

Therefore, it is necessary to have an exhaustive flight data and an actual cost data to allow fleet optimization to be used as one of the materials in evaluating operational activities. In addition, it is also necessary to conduct research on airline strategies in dealing with the issue of crew pairing without any sit time on one of the flights they serve while they must serve the next flight using a different type of fleet and aircraft.

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