Optimizing the Utilization of Third Runway in Soekarno Hatta International Airport using Time Space Analysis

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ABSTRACT

The aim of this research is to optimise the utilization of third runway in Soekarno Hatta International Airport by giving recommendation based on calculation and simulation of runway capacity. The flight schedule data in Soekarno-Hatta International Airport was taken from flightradar24.com from 1 to 6 January 2020. The calculation of the runway capacity uses time space analysis method and simulation in BlueSky ATM Simulator. The highest runway capacity of 44 flights per hour is reached when the runway operates as take-off only or landing-only configurationThe log data of simulation is analysed using Python programming to know the separation for every pair of flights and ensured that the minima distance due to wake turbulence is fulfilled. The results from extending the taxiway are the operation of runway 06/24 will not disturb runway 07L/25R operation, the runway capacity will increase by 60%, and the utilization of third runway will increase by 55%.
Keywords: Runway Capacity, Time Space Analysis, Runway Utilization, BlueSky ATM Simulator, Soekarno-Hatta International Airport

1.   INTRODUCTION

Air Transportation is one of the common modes transportation that used today, especially for archipelago countries like Indonesia. Jakarta as the capital city of Indonesia play a role as air transportation hub of Indonesia. Soekarno-Hatta is the entrance gate to Jakarta and Indonesia. In 2018, Soekarno-Hatta Airport Ranked as 17th busiest airport in the world and have 447.390 Aircraft Movements per year[1]. In peak hour, Soekarno-Hatta International Airport will handle almost 100 aircraft movements per hour, and it is beyond the capacity. For this reason, there will be a delay during peak hour. Furthermore, the passenger growth in Southeast Asia almost 8% per year. Thus, runway is one of the important factors in airport capacity.

Currently, Soekarno-Hatta International Airport have 3 runways. The third runway was just inaugurated in January 2020. Adding new runway is the right solution of the flight traffic and to increase aircraft movement. Ministry of Transportation claimed that the aircraft movement will increase from 81 movements per hour to 114 movements per hour. However, the Directorate General of Civil Aviation (DGCA) got a letter recommendation about third runway operation from ICAO. It mentioned some marks and task which need to be done to operate 3 runways together and the operation of the third runway should be limited.

The research aims to optimize the utilization of third runway of Soekarno-Hatta International Airport and propose suggestion to improve it.

2.   LITERATURE SURVEY

Runway capacity is defined as maximum capacity of runway and it is divided into practical hour. Every single landing or single take-off is calculated as one movement. In general, there are two type of approaches conducted by researchers in calculating runway capacity which are analytical method and simulation method.

2.1   Analytical Method

Analytical method is a mathematical calculation that can be performed to solve various problems. The analytical method that can be used to calculate runway capacity are robust, stochastic approaches, and time space analysis.

First, robust and stochastic approaches are done by Manu Kapolke in his research about pre-tactical optimization of runway utilization under certainty. They found that robust approach was the firm one which could potentially be too restrictive and generate large delay values. The stochastic method optimizes the

predicted scenario and is thus more likely than the nominal approach to remain viable in the face of disturbances. It thus provides more stable plans on average, and less preplanning is required. But robust methods of optimization provide even more reliable solutions. Using the purely robust method, we definitely know that a solution (if there is one) would work out [2].

Second, time space analysis is a method to calculate runway capacity using runway occupancy time and if the distance between plane is known. This method is one of popular methods to calculate runway capacity or to predict traffic in transportation management system[3]. This method is conducted by Tengku Annisa, Mohammardeza, Safrilah, and Andrej. In their research, they using input from time-space diagram to CNN model [3]. Time space analysis can be used to calculate runway capacity in different configuration of runway (departure only, arrival only, mixed configuration) [4]. This method is very useful and easy to understand. The spacing between aircraft considered to be the most important factor among others [5]. Andrej using this method to calculate runway capacity in Ljubljana, Brnik Airport [6].

For stochastic method and time space analysis have more focus in predicting and can be run even there is a disturbance. Robust method provides more stable solution. But this method is too restrictive and have some delay values. Time space analysis is a popular method to calculate traffic in transportation area and have been used in several studies with good feedback. Stochastic and robust well perform for calculating arrival delay and scheduling. Time space analysis is matched to calculate runway capacity since the distance unit in aviation area mostly using time.

2.2   Simulation Method

Simulation method is work or calculate based on behaviour of the process. There are some simulators that can be use for runway capacity calculateion such as Chronos, Runsim, Simmod, AirTop Simulation, Monte Carlo simulation, and BlueSky ATM Simulator. Mostly, this simulation method using software which has already dedicated to calculating traffic of many modes' transportation.

First, Chronos application is dedicated to plan or target for operator to give the information regarding take-off and landing in airport. The focus is for slot time and this software can adapt if there are disturbances such as delay due to weather or technical issue. This software is used by AirNav Indonesia's control to calculate slot time capacity in peak hour at Soekarno-Hatta International Airport [7].

Second, SIMMOD Simulation is the most popular simulation software for evaluate and calculating runway capacity [8]. This simulation was recommended by FAA to calculate runway capacity. The input for using this software is combined flight schedule and possible to analyse and calculate with complex and dynamic factors even airspace control. This simulation categorize aircraft into 3 type based on size which are heavy, medium, and light. That differences will affect the separation times or distance within aircraft. Branko using this simulation software to calculate runway capacity in Berlin-Brandenburg International Airport [9].

Third, RUNSIM tools model was initially called Quick Response Runway Capacity Models. This model focus on aircraft fleet mix, aircraft approach speed, runway occupancy time, air traffic control and separation rules, and wind to calculate runway capacity. Tools such as RUNSIM v.2.00 will help researchers, airport authorities, FAA officials and airline operators estimate the benefits of transitioning from current separation rules to more effective ones. Although in any estimate of airport efficiency the results of this model should not be viewed as appropriate elements. Analysing airport capacity using the RUNSIM model is much cheaper and safer than trying and failing to apply the new rules in the actual system [10].

Fourth, AirTop (Air Traffic Optimization) is a modular and open fast-time simulation software. This software can model the airport layout and ground movement using the fast-time simulation approach. The advantages using fast-time simulation approach is to conduct complexity and capacity research. Estimation of flight plan arrival and departure times is one of surplus for this software[11]. Calculating ROT and separation time between aircraft owned by this software well [12].

Monte Carlo Simulation is the popular simulation software also. This software is used by Dhir Varun to calculate runway capacity in Changi Airport. It helps them to decide the best scenario operation in Changi Airport [12]. The aim is to simulate each aircraft landing critical events and then link those events using simple kinematic laws. This model of fast time simulation can be used to generate cumulative density functions of runway occupancy times and exit distances which can be useful to design new runways at airports or to improve existing runways [13].

BlueSky ATM Simulator is an open-source simulator which is developed by TU Delft. Jacco Hoekstra from Delft University of Technology said that this software is user friendly air traffic simulator and can be used low and high rates of simulator. BlueSky ATM Simulator have used by students and researcher to help them for visualization and analyse about ATM.

For simulation, this software is made specially to calculate or to predict the traffic using simulation graph or media. So, every software has their specialities and most of them have a good accuracy. Since, this software is paid software and have been used with credible institution in aviation area. Chronos, SIMMOD,

RUNSIM can calculate even there is a dynamic factor such as weather problem. AirTop and Monte Carlo calculate runway capacity based on Runway Occupancy time for each runway. Monte Carlo can also calculate the exit distance which is one of the important factors for runway capacity. Chronos has a focus to calculate and plan the slot time. From that information, SIMMOD Simulation and RUNSIM will be matched if we want to calculate runway capacity using many factors even the dynamic factors. But it will make the result will not stable. AirTop simulate can presented both numerical and graphical format for analysis runway such as delay distribution which will affect when the airport is operating within certain schedules. Monte Carlo simulation can demonstrate the airport when is operating using video.

Based on literature survey above, analytic method is more suitable for this research because we focus on runway capacity and using static variables. More spesific, time space analysis method is selected because this method has been used for many research and this method has a good accuracy to calculate or predict the traffic such us runway capacity. For validation, the result of calculate will be simulated using BlueSky ATM Simulator.

3. BACKGROUND THEORY

Aircraft movement is calculated for every aircraft which want to take-off or landing at airport. For one arrival and one departure is calculated as two aircraft movements. The following are several factors which are affecting the capacity of the runway[14]:

- Number of runway and geometry layout of runway
- Separation between aircraft which related with air traffic management
- Weather condition
- Type of aircraft which will be operated (Small, Large, and Heavy)
- Movement for each runway (Departures only, Arrivals only, or mixed)
- The type and location of the exit taxiway from runway
- Capability of the air traffic management
- Noise and other environmental considerations and constrain

This section will explain about runway occupancy time, wake vortex turbulence with relation to flight separation and time space analysis.

3.1 Runway Occupancy Time

Runway occupancy time (ROT) is how long the aircraft is occupyng the runway. It is an important factor which related to runway capacity. Less ROT will increase runway capacity. In Indonesia, ROT is regulated by DGCA as follows [15].

ROT take off (ROTT) is the time counted when departing aircraft start entering runway in use until lift off the runway. ROT landing (ROTL) is the time counted when landing aircraft is over threshold until turning into rapid exit taxiway. ROTT and ROTL is shown in Table 2.1.

Table 2.1 Runway Occupancy Time at Soekarno Hatta [15]

Runway Occupancy Time	Time (in Second)
OTT	90
ROTL	55

Time in Runway Occupancy Time is not binding or must exactly the same. That number is the maximum times for aircraft on runway is needed. ROT depends on size of aircraft which is operate.

3.2 Wake Vortex Turbulence

Wake vortex turbulence is characterized as turbulence that is induced by an aircraft's passage in flight [16]. For this reason, there will be wake vortex separation rules between aircraft to prevent incidents. FAA classified airplane based on wake vortex into 3 group which is small, large, and heavy. Wake vortex turbulence separation apply when aircraft is approaching for landing.

Lifting is created by generating a differential pressure over the surface and bottom of the wing. The lowest pressure arises over the top of the upper wing and the highest beneath the floor, such differential friction causes the circulation upstream of the vent, culminating in spinning air masses trailing downstream of the tips

of the plane. After the roll is done, the wake vortex will be consisted of two counter rotating cylindrical vortices as shown in Figure 2.1 [16]. The detail information regarding the classification of aircraft based on wake turbulence is shown in Table 2.2 and 2.3.
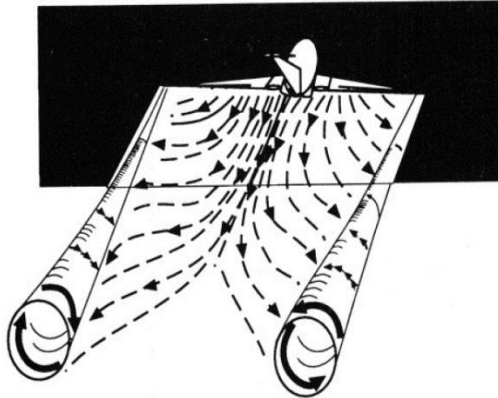

Figure 2.1 Wake Vortex Generation [4]

Table 2.2 FAA Wake Turbulence Aircraft Classification [16]

Group	Take-off Gross Weight (lb)	Example Aircraft
Small	< 41,000	All single engine aircraft, light twins, most business jets and commuter aircraft
Large	41,000-255,000	Large turboprop commuters, short and medium range transport aircraft (MD80, B737, B727, A320, F100, etc.)
Heavy	> 255,000	Boeing 777, Boeing 747, Boeing 787, Airbus A330, Airbus A-340, Airbus A350

Table 2.3 Wake Turbulence Rules for Aircraft Separation [16]

Category of leading aircraft	Category of following aircraft	Minima
HEAVY	HEAVY	4 NM
	MEDIUM	5 NM
	LIGHT	6 NM
MEDIUM	HEAVY	3 NM
	MEDIUM	3 NM
	LIGHT	4 NM
LIGHT	HEAVY	3 NM
	MEDIUM	3 NM
	LIGHT	3 NM

Based on group of aircraft which have classified by FAA. FAA make an aircraft separation rules based on that group. The aim of separation rules is to prevent the incident or accident because of wake turbulence. This is in line with enforcing the rules of airworthiness. Another classified of aircraft from FAA based on Landing Speed as shown in Table 2.4.

Table 2.4 Aircraft Category based on landing speed [14]

Category	Landing Speed
A	< 91 knots
B	91 knots - 120 knots
C	121 knots - 140 knots
D	141 knots - 165 knots
E	> 166 knots

3.3 Time Space Algorithm

Time space analysis is a technique to assess runway and airspace capacity if the headway between aircraft is known [17]. The idea is to estimate an expected headway, E(h), and the estimate capacity as the inverse of the expected headway. The landing speed will affect to headway aircraft.

$$C = \frac{1}{E(h)} \tag{3.1}$$

Where: C = capacity
E(h) = time units between consecutive flights [hours]

Since aircraft approaching a runway with randomly pattern, there are 2 scenarios:

a. Closing case

When the approach of the lead aircraft is less than that of the trailing aircraft ($V_i \le V_j$). Headway ($T_{ij} = T_j - T_i$)

$$Tij = \frac{\delta ij}{Vj} \tag{3.2}$$

b. Opening case

When the approach of lead aircraft is higher than trailing aircraft ($V_i > V_j$). Headway ($T_{ij} = T_j - T_i$)

$$Tij = \frac{\delta ij}{Vj} + \gamma\left(\frac{1}{Vj} - \frac{1}{Vi}\right) \tag{3.3}$$

$$E(Tij) = (P_{H-H} * T_{H-H}) + (P_{L-H} * T_{L-H}) + (P_{H-L} * T_{H-L}) + (P_{L-L} * T_{L-L}) \tag{3.4}$$

Where: δ_{ij} = minimum separation matrix [NM]
T_i = arrival time (to the runway) of the lead aircraft [s]
T_j = arrival time (to the runway) of the following aircraft [s]
T_{ij} = headway between two successive aircraft [s]
γ = minimum arrival-departure separation [NM]
V_i = the speed of lead aircraft [kts]
V_j = the speed of trailing aircraft [kts]
E(Tij) = expected headway between lead aircraft and trailing aircraft [hours]
P_{H-H} = probability matrix of aircraft combination: heavy and heavy [%]
P_{L-H} = probability matrix of aircraft combination: large and heavy [%]
P_{H-L} = probability matrix of aircraft combination: heavy and large [%]
P_{L-L} = probability matrix of aircraft combination: large and large [%]

The separation based on category of the aircraft (Small, Large, Heavy) and the position (Lead Aircraft/Trailing Aircraft). The separation can be in times (second) or distance (NM)

Formula to calculate aircraft movement is the number of take-off aircraft plus number of landing aircraft.

$$AM = TO + L \tag{3.5}$$

Where: AM = Aircraft Movement
TO = Aircraft which want to take-off
L = Aircraft which want to landing

$$CH = \frac{AM}{OD} \tag{3.6}$$

Where: CH = Capacity of runway per hour
AM = Aircraft Movement
OD = Operational Duration of runway

The calculation of runway capacity of each runway will be done with 3 scenarios which are take-off only, landing only, and mixed configuration. After getting the number of runways with several configuration, the total runway capacity of airport

For calculating the utilization, the general formula for utilization will be used to calculate the

percentage of utilization. Actual output rate will be the number of actual schedules in Soekarno-Hatta International Airport in peak hours. The researcher will be taking a day which have the greatest number of flights per day.

$$U = \frac{OR}{C} \times 100\%$$
(3.7)

Where: U   = Utilization
        OR   = Actual Output Rate
        C   = Capacity

4. Research Methodology

The research process consists of data collection, data processing, simulation, and data analysis. The data for this research are the actual schedule of Soekarno-Hatta International Airport, distribution of aircraft type, and peak hour. Those data are obtained from flightradar24.com.

Based on that data, the runway capacity will be calculated using time space analysis method. The result of the calculation will be simulated using BlueSky ATM Simulator. The simulation will be analysed using Python Programming to check whether the separate distance between each aircraft is obeyed. The flow of process is shown in Figure 4.1.
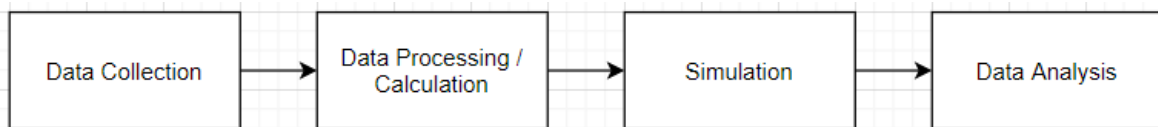

Figure 4.1 Process Flow of reseach methodology

4.1 Data Collection

The data collection for this research is the basis to do the calculation and simulation to support the thesis purposes. The data collected are as follow.

4.1.1 Departure and Arrival Schedule in Soekarno Hatta International Airport

The schedule of departure and arrival aircraft in Soekarno Hatta International Airport was taken from flighradar24.com. The data collection was taken during 7 days from 1 January 2020 until 6 January 2020. That week is the backflow of New Year's Holiday and also peak season.

The highest day of the week will be taken to calculate peak hour. The highest day of aircraft movement in a week will be analyzed for every hour. The highest number of aircraft movement in an hour called as peak hour. The aircraft movement is the summing of departure aircraft and arrival aircraft.

The data of aircraft type based on aircraft which take-off and landing in Soekarno Hatta International Airport. This data is needed to know the limitation, wake turbulence, and landing speed of each aircraft which affect to runway capacity.

4.1.2 Runway Data Soekarno Hatta International Airport

The information regarding runway data was taken from AIM Indonesia as an official information by Ministry of Transportation in Indonesia. The runways specification is shown in Table 4.1 and the layout of runway of Soekarno-Hatta International Airport can be seen in Figure 4.2.

Table 4.1 Runway Specifications in Soekarno-Hatta Airport

Runway	Direction	Runway Dimension	Approach Instrument
07R/25L	067° / 247°	3660 x 60 meters	ILS
07L/25R	067° / 247°	3600 x 60 meters	ILS
06/24	068° / 248°	3000 x 60 meters	PAPI

Currently, there is a problem regarding the operation of third runway of Soekarno-Hatta International Airport. The distance between runway 07R/25L and 06/24 is 480 meters and below the normal standard (780 meters). It makes the operation for both runways is limited. Based on ICAO regulations, at present because of

wake turbulence, parallel runway which the distance is less than 760 m will be considered as single runway [18]. Both runways can be used as segregated operation runway. Segregated mode of operations is the operation which one runway will be used as landing only and the other will be used for landing only [18]. Both runways should install ILS for safety reasons and support the segregated runway operation.

4.2 Simulation

Simulation for this research will use BlueSky ATM simulator. It is an open-source simulator to simulate the Air Traffic Management and Air Traffic Flows. This simulator is developed by TU Delft to help everybody who wants to visualize, analyse or simulate air traffic without any limitation and can be accessed free of charge [19]. For downloading the application and the tutorial, this is the link https://github.com/TUDelft-CNS-ATM/bluesky.
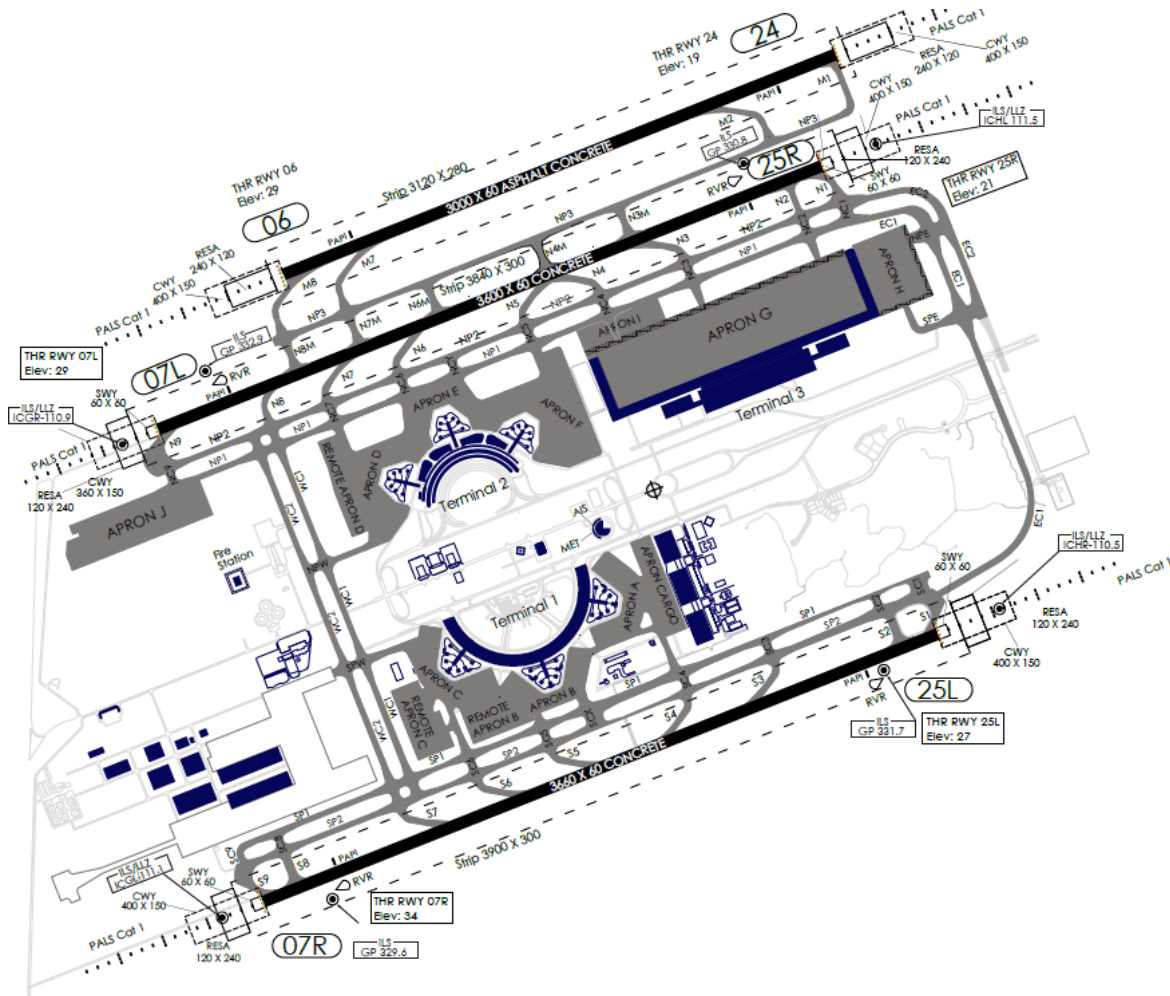

Figure 4.2 Layout of Soekarno-Hatta International Airport [20]

The user interface of BlueSky ATM Simulator can be seen in Figure 4.3. Some features in the main user interface are operate, hold, fast, fast 10 seconds, initial conditions, and command box. The polygon with blue stripe is an area filter. In this simulation, this area is named as Cengkareng. Area Filter is part of the set of BlueSky ATM Simulator tools to make aircraft disappeared after leaving or exit the area. The area is made by input latitude and longitude for every point.

For arrival aircraft, the aircraft will be disappeared after the aircraft passing the touch down area of the runway. For departure aircraft, the aircraft will be disappeared after the aircraft passing the area boundary which around 6 km from the runway.
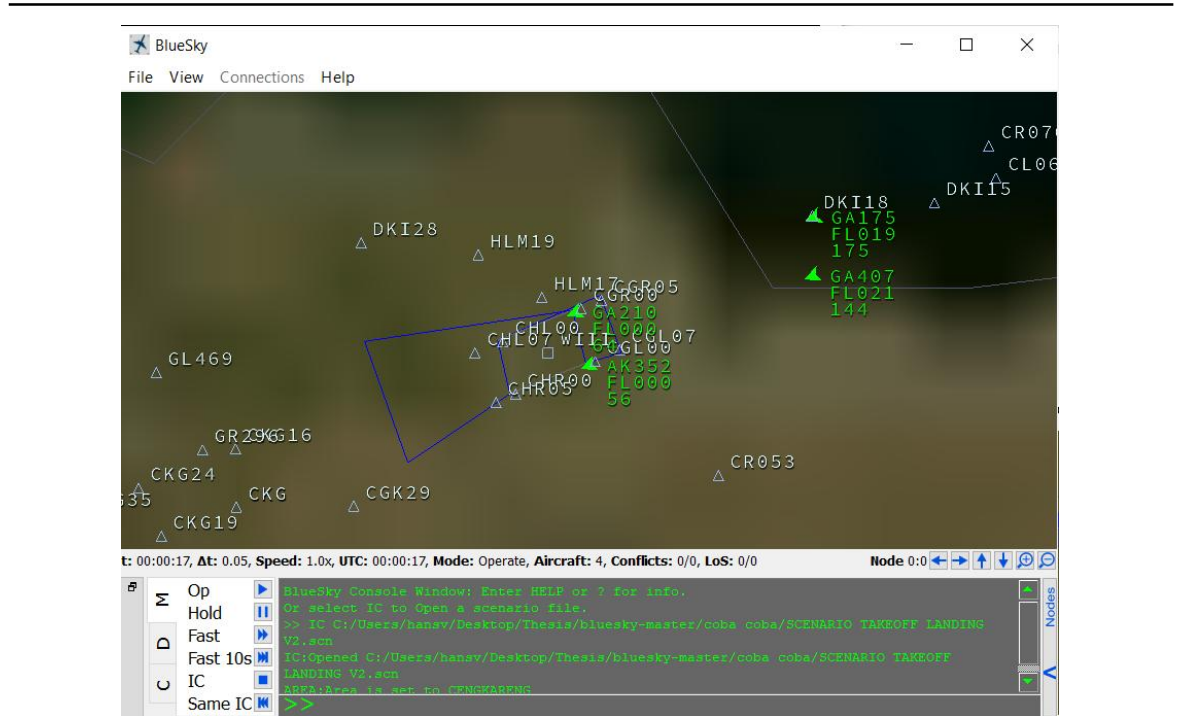
Figure 4.3 BlueSky ATM Simulator User Interface

There will be 3 scenarios of simulations for this research, which are:

- Scenario 1

Scenario 1 will be shown 2 runway configuration using actual schedule based on Flightradar24.com. This schedule is the peak hour in 4 January 2020. Both of runway in mixed configuration.

- Scenario 2

Scenario 2 will be shown 3 runway configuration and simulate in maximum capacity based on calculation which have been done. This scenario using the actual layout currently of Soekarno-Hatta. One runway will be as mixed configuration, one runway for take-off only and one runway for landing only.

- Scenario 3

Scenario 3 will be shown. In this scenario, the operation of runway 24 will not affect the operation of runway 25R. It will happen if someday in the future, there will be a development for extending taxiway NP2 and NP3.

5. Result Discussion

This section will present the result from time space analysis, utilization calculation and analysis of simulation result.

5.1 Time Space Analysis

For calculating using time space analysis method, aircraft will be grouped based on approach speed and size of the aircraft. Based on landing speed, aircrafts which are operating on 4 January group into 2 categories which are category C and category D. Based on aircraft size, aircraft which are operating in 4 January group into 2 categories which are Large and Heavy. Characteristic of aircraft which are operating on 4 January 2020 during peak hour can be seen in Table 5.1 and 5.2.

Table 5.1 Aircraft Characteristic on 4 January 2020 during peak hour

Category	Landing Speed (knot)	Take off speed (knot)	ROT (minutes)	
			Arrival	Departure
C	135	143	0.35	0.45
D	149	148	0.36	0.51

Table 5.2 Aircraft Size Characteristics on 4 January 2020

Category	Departure	Arrival	Total
Large	672	688	1360
Heavy	37	29	66
Total	709	717	1426

For calculating the headway of Aircraft, the Equation (3.4) will be used. The result of this calculation is 107.28 seconds. For calculation, the runway capacity for mixed operation, Equation (3.1) will be used. The result of the calculation is 40 flights per hour. The summary of runway capacity for each configuration is shown in Table 5.3.

Table 5.3 Summary of Runway Capacity Calculation for one runway

Type of Operation	Runway Capacity
Take-off Only	44 flights per hour
Landing Only	44 flights per hour
Mixed Operation	40 flights per hour

5.1.1 Two Runways Configuration

The current capacity of Soekarno-Hatta using 2 runways is shown in Table 5.4.

Table 5.4 Soekarno-Hatta Runway Capacity with Two Runways

Runway	Operation	Capacity
Runway 1	Mixed	40 flights per hour
Runway 2	Mixed	40 flights per hour
Total Airport Capacity		80 flights per hour

Runway 1 and Runway 2 will be use as mixed configuration. From the calculation, the total of runway capacity for both runways is 80 flights per hour. This configuration often uses in Soekarno Hatta Airport.

5.1.2 Three Runways Configuration

The location of runway 24 make the operation of runway 25 limited. Every single take-off and landing in runway 24 will intersect runway 25R. The time for intersection process will take approximately around 20 seconds. For that fact, it will reduce runway 07L/25R operation time if runway 06/24 in operate. The ground movement of Runway 06 for Landing and Take-off are shown in Figure 5.1 and 5.2.
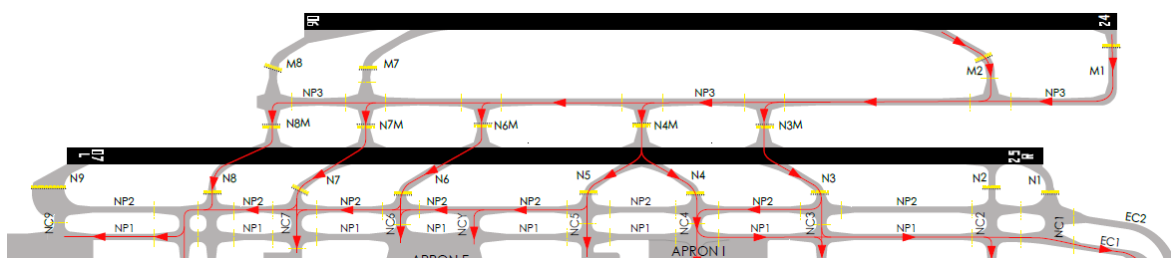

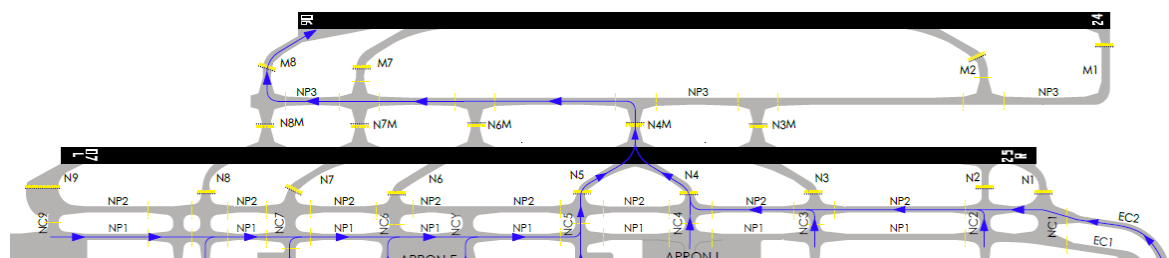Figure 5.1 Ground Movement for Landing Runway 06

Figure 5.2 Ground Movement for Take-off Runway 06

The maximum capacity of every runway is 44 flights per hour using take off only configuration and landing only configuration. For mixed configuration, the maximum capacity is 40 flights per hour. From that fact, below is the calculation of three runway configuration. Every single take-off or landing in runway 06/24 will reduce around 20 seconds operational duration of runway 07L/25R because runway intersections. For 44 flights in runway 06/24 will take 14 minutes and 40 seconds for runway intersection in runway 07L/25R, the operation of 07L/25R will reduce to 45 minutes and 20 seconds. Based on previous calculation, time needed for landing is 81.82 seconds and the runway capacity will be 33 flights per hour. For take-off, time needed based on previous calculation is 82.25 seconds. So, the runway capacity will 33 flights per hour.

Runway 07L/25R and 06/24 must operate as segregated operation where one runway operates as landing only and the other operate as take-off only. Based on the calculation, the total capacity of third runway using actual layout of Soekarno-Hatta International Airport is shown in Table 5.5.

Table 5.5 Soekarno Hatta Runway Capacity with 3 runways

Runway	Operation	Capacity
Runway 1	Mixed	40 flights per hour
Runway 2	Take off only	33 flights per hour
Runway 3	Landing only	44 flights per hour
Total Airport Capacity		117 flights per hour

5.1.3 Three Runway Configuration with some improvement in airport layout

For increasing runway capacity and airworthiness, it is suggested to extend taxiway NP3 around 1 km and extend NP2 taxiway around 1 km. NP3 Extension and NP2 Extension will be connected with NP2 and NP3 Connector. So, the operation in runway 06/24 will not intersect runway 07L/24R. It is prefered to extend the taxiway near runway 25R and runway 24 because the location is near Terminal 3, and the distance is not so far if compared to extend the taxiway near runway 07L and 06. The proposed taxiway extention is shown in Figure 5.3.
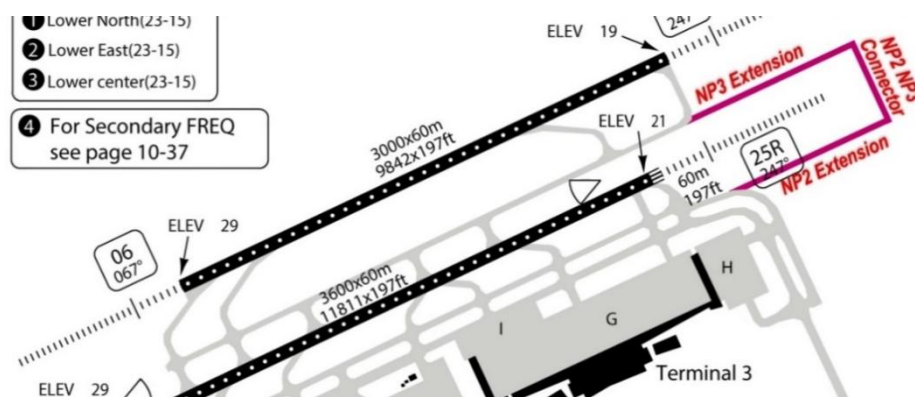

Figure 5.3 The layout of extension NP2 taxiway and NP3 taxiway

The extension of taxiway of NP2 and taxiway NP3 make the operation of runway 06/24 will not affect the operation of runway 07R/25L. For that reason, the runway 06/24 and runway 07R/25L will operate as segregated operation runway. Segregated operation runway makes one of runway must be operated as take-off only and the other must be as landing only and cannot mixed configuration. The calculation of runway capacity if the taxiway is extended is shown in Table 5.6.

Table 5.6 Soekarno Hatta Runway Capacity with 3 runways with improvement

Runway	Operation	Capacity
Runway 1	Mixed	40 flights per hour
Runway 2	Take off only	44 flights per hour
Runway 3	Landing only	44 flights per hour
Total Airport Capacity		128 flights per hour

5.2 Calculating of the Utilization

The actual condition because the distance of runway 06/24 and runway 07L/25R is below the

minimum. So, both of runways are considered as single runway. From this fact, the capacity of both runways is 40 flights per hour or 20 flights per hour for single runway.

The calculating the utilization of third runway, using equation (3.7). For actual condition of runway 3, the utilization of third runway is 45%. After some improvement, the utilization of third runway is 100% and it is increases 55%.

5.3 Analyse the Simulation Result

The data analyzed is a log data obtained from every scenario in BlueSky ATM Simulator. Log data is processed using Python programming to know the distance between every aircraft to aircraft in front or aircraft behind. The result is be shown as boxplot in Figure 5.4.
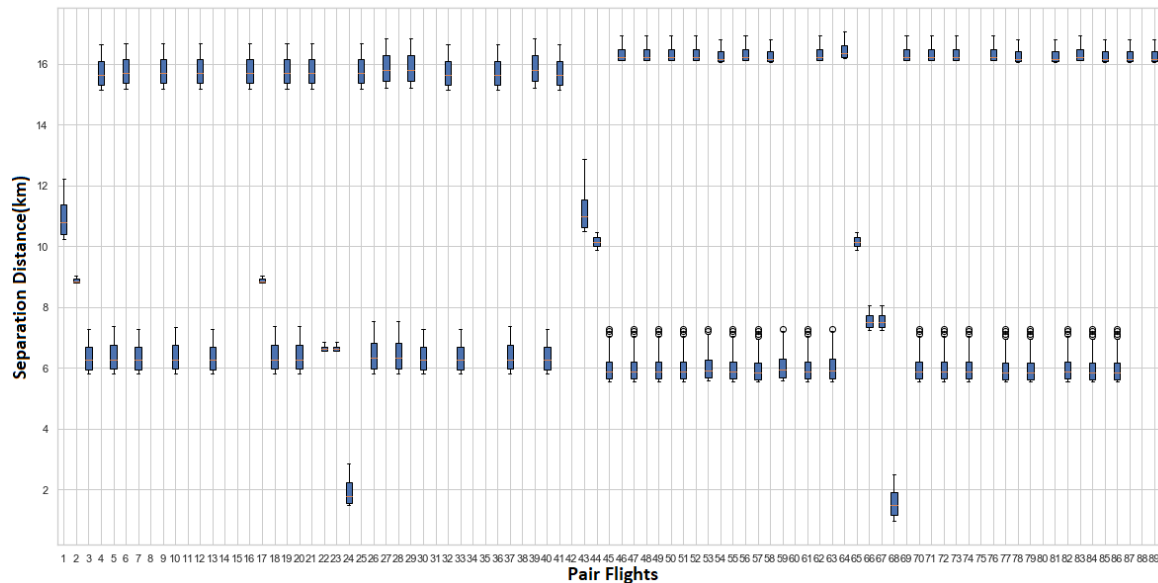

Figure 5.4 The result of simulation of Scenario 1

Based on simulation of Scenario 1, there are some pair of flights which the distance is below standard. It means, that schedule is not enough for the runway capacity and It might create some delay.

Based on simulation of Scenario 2 and Scenario 3, all the flights are fulfilled the minimum distance of separation. But there is possibility to increase the runway capacity while some pair flights have large separatio above the standard. The simulation result of Scenario 2 and 3 is shown in Figure 5.5 and 5.6.
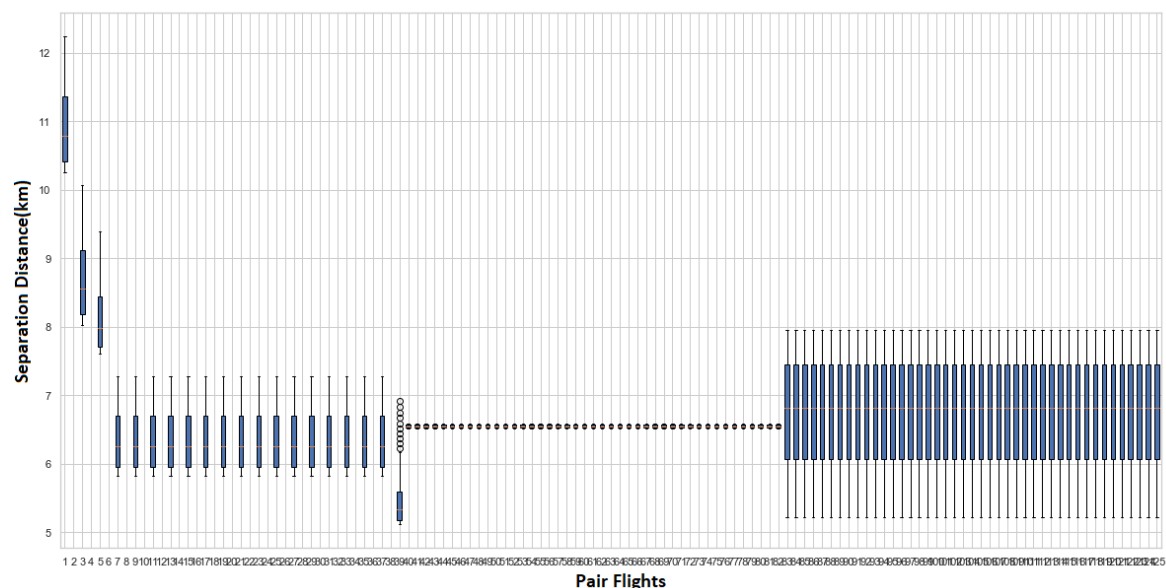
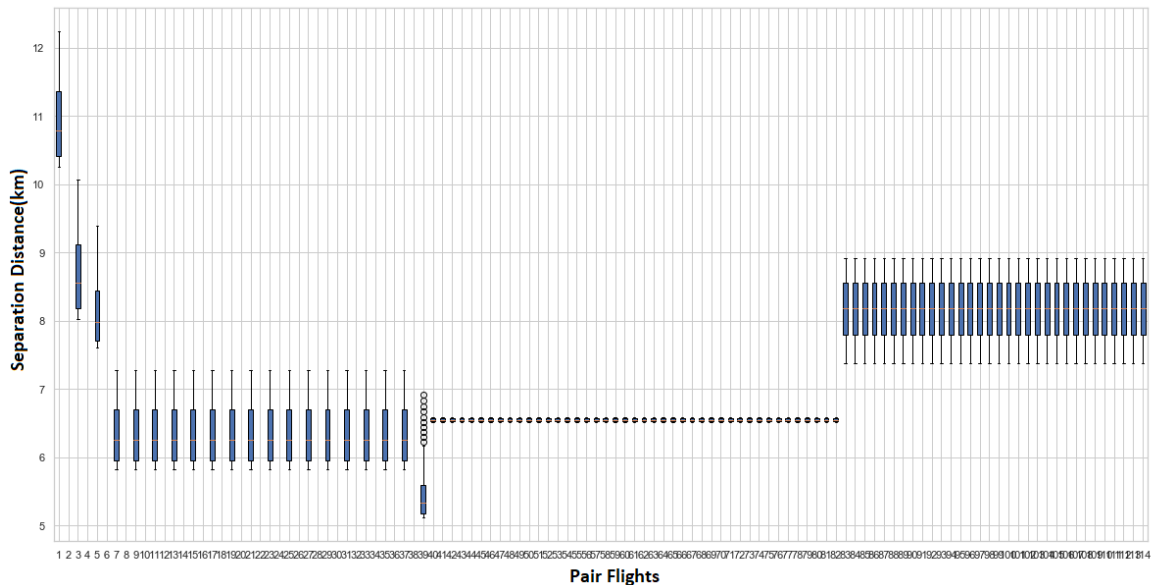

Figure 5.5 The Result of Simulation of Scenario 2

Figure 5.6 The Result of Simulation of Scenario 3

6. Conclusion and Recommendation

Based on the description, discussion, analysing in the previous chapters, the conclusions are as the following:

- The result of the calculation of runway capacity using Time Space Method are the highest runway capacity during take-off only and landing only operations by 44 flights per hours. For mixed configuration, the runway capacity is 40 flights per hours.

- The current runway capacity with 3 runways in operation is 117 flights per hour.

- The suggestion to impove the runway capacity is by extending taxiway NP2 and NP3. Thus the runway capacity will increase into 128 flights per hour.

- By using third runway configuration and extending the taxiway, the runway capacity of Soekarno-Hatta International Airport will increase by 60% or 48 flights per hour and the utilization of third runway increases by 55%.

- The highest possible scenario to increase utilization is Runway 1 operate as mixed runway configuration, runway 2 as take-off only, and runway 3 as landing only.

There are some recommendations for increasing the utilization of third runway in Soekarno Hatta International Airport.

- For supporting the segregated parallel operation, runway 06/24 have to installed ILS.

- The taxiway NP2 and NP3 should be extended to increase runway capacity and reduce the risk of incident.

- Schedule management must be better managed, allocation of the schedule should be divided equally. Schedule which only focus in one hour will increase delay possibility.

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